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ASSESSING THE ECONOMIC RETURNS OF MODERN AND TRADITIONAL BEEHIVES

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Abstract. Beekeeping is a vital economic activity for smallholder farmers; therefore, it is essential to provide beekeepers with information regarding the profitability and productivity of box hives to encourage them to embrace the technology. However, scant information is available to comprehensively compare the profitability and output of traditional and modern beehives. This study seeks to compare the performance of traditional and modern beehives in Baringo South Sub-County. Simple random sampling was used in conjunction with a cross-sectional survey to collect data from the 197 beekeepers who participated in the study. A gross margin analysis was performed to understand the returns of traditional and modern hives. According to the findings, individuals who used traditional beehives had a higher overall operational cost of Ksh. 1449.44 per hive, whereas those who used modern hives had a total operational cost of Ksh. 1000.73. In addition, the study also demonstrated that those that utilised modern beehives received larger gross margins in Kenyan shillings 7917.74, whilst those who used traditional beehives received Ksh. 5590.59. According to the study's findings, modern beekeeping generates higher returns than traditional beekeeping. As a result, farmers should be encouraged to employ modern beehives to generate higher returns.

Keywords: gross margin, profitability, beekeeping, beehive, income, returns

INTRODUCTION

Beekeeping or apiculture agri-enterprise is the act, science, and/or business of managing honey bees to produce honey, beeswax, and other bee products for consumption and industrial use (Madras-Majewska and Majewski, 2016; Muhammad and Madu, 2016). The worldwide demand for honey has elevated beekeeping as a valuable resource. Beekeeping offers numerous advantages, such as conserving natural flora that bees rely on for nectar and the medicinal applications of honey. Beekeeping can substantially benefit rural communities by offering an additional income stream with minimal investment (Nagma et al., 2021). In the past, honey production was a primary industry in the African economy, and honey was a vital factor in African culture and was used in many ways as an article of trade (Wambua et al., 2016; Zocchi et al., 2020).

Beekeeping in Kenya is practised in arid and semi-arid areas where other agriculture models do not thrive well. It contributes to income and food security through the provision of honey, beeswax, propolis, and royal jelly, which is medicinal. Furthermore, pollination contributes to seed and food crop production (Berem et al., 2011). According to estimates by FAO from 2018, natural honey production in Kenya was 20,525 metric tons

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(mt) and beeswax amounted to 2,504 metric tons (mt) in the previous year. Natural honey exports were 9 metric tons (mt), worth KES 2.5 million, and beeswax was 195 metric tons (mt), worth KES 17 million. Honey imports were 135 metric tons (mt), worth KES 31.7 million, and beeswax amounted to 6 metric tons (mt), valued at KES 5.4 million.

According to Hecklé et al. (2018), improved apiculture, in particular, contributes to environmental protection and sustainable agriculture by reducing environmental effects from tree felling for traditional beehive construction and fire hazards from the smoking of hives. Encouragement of apiculture and increased output of hive products would follow many African governments' agricultural sector policies. These often seek to improve household food security concurrently with raising incomes and stabilising cash flows through enhancing the productivity of various agricultural and diversified agricultural activities.

Modern beekeeping practices involve modernised, improved technologies that can be manipulated with ease. The main types of modern beehives used are the movable comb hives and the movable frame hives. Other pieces of equipment used are a catcher box, protective gears, a honey extractor, a bee brush, a hive tool, honey refining equipment, and a smoker. Improved management methods such as pest control, colony inspection, colony division, and artificial feeding are part of modern beekeeping practices.

In beekeeping, profit is measured in terms of yield per colony. This figure is arrived at by deducting the entire amount of product sales from the total amount of costs incurred by the apiary and then dividing the result by the number of colonies. In addition, profitability is defined as the difference between the income produced from the sale of items and the costs incurred during manufacturing. This difference is known as the gross margin. In Uganda, independent of profitability, upgraded (top-bar) hives were shown to produce fifty percent more honey than traditional hives (Al-Ghamdi et al., 2017). This finding highlights the significance of better beekeeping technology in increasing honey yield.

The art of beekeeping is carried out across different regions in Kenya utilizing various hives and honey bee strains. On the other hand, to this day, no adequate comparison study has been carried out on the profitability and productivity of traditional and modern hives. As a result, the objective of the study is to investigate and evaluate the relative levels of profitability and productivity achieved by traditional beehives and modern hives, taking into account the annual costs of operation and returns.

METHODOLOGY

Study area and sampling techniques

The study was conducted in Kenya, Baringo South Sub-County. The location was chosen because it has good potential for beekeeping, and there is information readily available about it that is relevant to the particular aim of the study. As a result, the wards of Marigat, Ilchamus, Mukutani, and Mochongoi in the sub-county were selected, and 73, 63, 37, and 24 respondents were randomly chosen from within those four wards, respectively. Therefore, the total number of participants in the study was 197 beekeepers. The following figure shows the map of the study area.

Data analysis

Gross margins analysis will be used to compute the returns of traditional and modern beehives. Gross margin is the difference between total revenue and the total variable cost (FAO, 1985), specified as:

$$GM = TR - TVC \tag{1}$$

Where:

GM – gross margin
TR – total revenue
TVC – total variable cost.

The above equation can be expanded to describe how each right-hand side variable is calculated.

$$\sum_{j=1}^{m} p_{ij} q_{ij} - \sum_{g=1}^{n} p_{ig} x_{ig} \tag{2}$$

Where:

p_{ij} – is unit price of j^{th} output in relation to i^{th} respondent
q_{ij} – is the quantity of the j^{th} output (j = 1, 2, 3,. m)
p_{ig} – is unit price of i^{th} variable input in relation to i^{th} respondent
x_{ig} – is the quantity of the i^{th} variable output (i = 1, 2, 3,. n)
Σ – is summation sign.

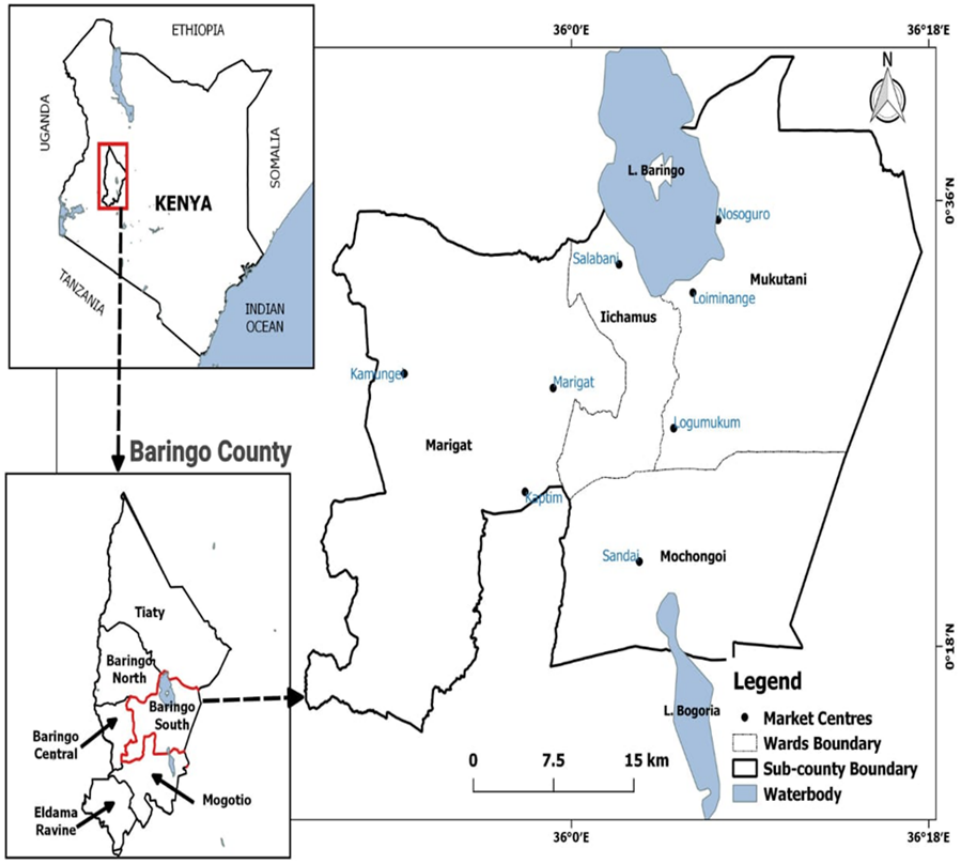

Fig. 1. Map of Baringo County
Source: Egerton University, Department of Geography, 2023.

Total revenue was calculated using the stated price of honey multiplied by the quantity of honey production, as shown above. Quantity of production includes the total amount produced and marketed, consumed at the household level, or gifted out. The only direct and measurable return was obtained from the sale of honey. Total variable costs included transport, family labour, hired labour, packaging materials, labelling, pesticide cost, baiting materials, and feeding and servicing costs. The gross margins were computed by summing up all the variable costs incurred during the entire production season of honey per beehive and then subtracted from the revenue generated from the sale of honey. The gross margin obtained from the sale of honey from those using modern and traditional beehives were then compared to ascertain the performance of the two production systems.

RESULTS AND DISCUSSION

Descriptive results

Socioeconomic characteristics of modern and traditional beehive users

The results of comparing household characteristics between the beekeepers who have adopted the modern beehives and those who have not are presented in Table 1.

Many adopters of modern beehives (87.84 per cent) were males, while females constituted only 12.16 per cent. However, among the non-adopters, males were fewer (46.53 per cent), while females constituted 53.66 per cent. The chi-square test shows that there was a significant association between gender and the decision to uptake. The large number of male adopters of modern beehives is mainly because honey production is the fundamental economic activity permitted by the existing

Table 1. Comparison of household characteristics by farmer type for dummy variables

Variable		Uptake (%)	Non-uptake (%)	Aggregate	x^2
Gender	male	87.84	46.34	61.93	6.4066***
	female	12.16	53.66	38.07	
Ownership of beehives	head	70.27	76.42	74.11	6.7568
	spouse	25.68	13.82	18.27	
	child	2.70	8.13	6.09	
	relative	1.35	0.82	1.02	
Marital status	married	91.89	78.05	83.25	22.1844**
	widowed	1.35	4.88	3.55	
	single	6.76	17.07	13.20	

**, * Denotes significance at 1% and 5%, respectively.
Source: own elaboration.

ecological conditions practised. This finding corroborates with Bunde and Kibet (2016); Jebesa (2017); Wotro et al. (2018), who found gender to be playing a significant role in the adoption of modern beekeeping technologies.

The ownership of modern beehives revealed that 70.27 per cent were owned by family heads, 25.68 per cent spouses, 2.70 per cent children, and lastly, 1.35 per cent relatives. On the other hand, among non-adopters, 76.42 per cent were household heads, 13.82 per cent were spouses, 8.13 per cent were children, and 0.82 per cent were relatives. However, the chi-square test statistics indicated no significant association between this variable and the uptake of the modern beehive.

The marital status of the household head revealed that for adopters of the modern hives, 91.89 per cent were married, 1.35 per cent were widowed, and 6.75 per cent were single. However, married beekeepers were 78.05 per cent for non-adopters, while widowed and single beekeepers reported 4.88 per cent and 17.07 per cent, respectively. The chi-square test indicates that there was a significant association between this variable and the uptake of modern beehives. The significance of marital status is that married households can make joint decisions derived from different ideas of the family members, compared to single and divorced households. This result is in line with Wotro et al. (2018), who found that marital status played a significant role in the adoption of modern beehives.

The results of differences in household characteristics between adopters and non-adopters of modern beehives using continuous variables are presented in Table 2. The t-test result of the means shows that only four variables were significant: age, education, household size, and experience. The mean aggregated age was 43.32 years. The mean age of adopters was 45.92 years, and that of non-adopters was 41.92 years. The age difference was significant at 5 per cent. It shows that adopters were older than non-adopters. The age of the adopter plays an imperative role in the uptake of new agricultural technologies such as modern beehives. This may be attributed to older beekeepers' knowledge of traditional beehives, which may inform the uptake of modern beehives. This result is supported by Abadi et al. (2018), who established that the farmer's age played a significant role in adopting the exotic chicken breed production system. Table 2 presents the results of household characteristics by farmer type.

The pooled mean level of education was 7.43 years of schooling. However, adopters' mean year of schooling was 11.59 years, which was 5.24 years for non-adopters. The t-test is significant at 1 percent. It implies that adopters had more years of schooling compared to non-adopters, thus they were able to uptake modern beehives faster than those with fewer years of schooling. More years of education enables a farmer to understand new technologies quicker, hence propelling uptake. These results tally with Affognon et al. (2015),

Table 2. Mean difference of household characteristics by farmer type

Variable	Adopters = 74		Non-adopters = 123		Aggregate = 197	t-test
	mean	std. dev	mean	std. dev	mean	
Age	45.92	12.17	41.92	13.42	43.42	2.1014**
Education	11.59	3.27	5.24	2.55	7.63	15.2011*
Household size	5	2.53	4.93	1.97	4.95	0.2262*
Experience	10.15	6.58	4.04	1.91	6.34	9.6572***
Farm size	4.18	4.1	4.47	3.93	4.36	–0.4974

**, * Denotes significance at 1% and 5% level respectively.
Source: own elaboration.

who found that level of education positively affected the adoption of modern beehive technologies.

The pooled mean of household size was 5 members. However, the mean household size for both adopters and non-adopters was 5 members. The t-test results statistics showed that there was no significant difference between adopters and non-adopters with respect to the size of household size.

The pooled mean years of beekeeping experience was 6.34 years. Adopter beekeepers had 10.15 years of experience, while the non-adopter beekeepers had 4.04 years of experience. The t-test result statistics show a statistical significance at 1 per cent level. This shows that adopters had more years of experience than non-adopters. Experience gives beekeepers an edge when it comes to adoption, since they can distinguish the difference in performance between traditional and modern beehives. This finding corroborates the findings of Tarekegn et al. (2018) and Wotro et al. (2018). However, Mujuni et al. (2012) found that beekeeping years of experience were not significant in determining the adoption of the modern beehive and associated technologies.

The pooled mean farm size was 4.36 acres. However, the mean size of the farm for adopters was 4.18 acres and 4.47 acres for non-adopters. The t-test result statistic showed no significant difference in land size between adopters and non-adopters. This result aligns with Bunde and Kibet (2016), who found that land size did not play a significant role in adopting modern beekeeping technologies.

There was also a need to understand the institutional characteristics of adopters and non-adopters of modern beehives and the results are presented in Table 3.

Most adopters (94.59 per cent) were members of a group. Among non-adopters, 30.89 per cent were members of a group. The chi-square test statistic showed that there was a positive significance at 1 per cent between group membership and the decision to uptake modern

Table 3. Institutional characteristic results of adopters and non-adopters

Variable		Adopters = 74	Non-adopters = 123	x^2
Group membership	Yes	70(94.59)	38(30.89)	75.6958***
	No	4(5.41)	85(69.11)	
Extension Access	Yes	60(81.08)	41(33.33)	42.1615***
	No	14(18.92)	82(66.67)	
Credit access	Yes	67(90.54)	43(34.96)	57.8824***
	No	7(9.46)	80(65.04)	

* Denotes significance at 1% level.
Source: own elaboration.

beehives. The result matches the findings of Albore et al. (2019); Gebiso (2015); Tarekegn et al. (2018), who found that group membership played a significant role in adopting modern beekeeping technologies.

On extension access, 81.08 per cent of adopters accessed extension services, compared to 33.33 per cent of non-adopters. Access to extension services positively and significantly influenced modern bee hives' 1 per cent level uptake. This finding corroborates Tulu et al. (2020), who found that extension service played a vital role in determining the adoption of modern beehives.

Many adopters at (90.54 per cent) had access to credit. The *chi-square* test statistic showed that credit access positively and significantly influenced modern beehives' uptake at a 1 per cent significance level. This result aligns with Yeheula et al. (2013), who concluded that credit access plays a significant role in the adoption of modern beehives. Credit access allows beekeepers to purchase modern beehives that are more expensive than traditional ones.

Gross margin analysis

To compare the performance of modern and traditional beehives, gross margins were computed. The unit of analysis of gross margins was the beehive to allow the comparison between the production systems. Revenues and variable costs were collected for the two production systems. The yields, price, and variable costs were based on the 2020 honey-harvesting seasons. The variable cost consisted of all inputs and labour related to honey production, including transport, family labour, hired labour, feeding, pesticide, servicing, packaging, labelling, and baiting costs. The partial budget for modern and traditional production techniques excludes fixed costs such as land, bee colonies, and beehives because they are unchanging costs across practices.

The variable costs shown in Table 4 vary across the two modes of production due to the differences in input requirements. Beekeeping does not require a lot of production input, compared to other agricultural enterprises like dairy farming and poultry farming.

The cost of hired labour to manage a modern beehive was the most expensive input for farmers, coming in at KES 218.69, while the cost of feeding the bees was the least costly at KES 102.85. The cost of labelling was the costliest required input for traditional beekeepers, at KES 367.65, while the cost of pesticides was the least costly: KES 53.48.

Table 4. Average input cost of modern and traditional beekeeping production techniques

Cost type	Modern	Traditional
Transport	121.65	104.96
Family labour	196.47	107.27
Hired labour	218.69	247.95
Feeding cost	102.85	66.10
Pesticide	148.52	53.48
Servicing	204.16	53.69
Packaging materials	202.29	111.5
Labelling cost	136.40	367.65
Baiting materials	118.37	99.53

Source: own elaboration.

From the results in Table 5, the honey yield for modern and traditional beehives was 21 Kilograms and 15 Kilograms, respectively. The total revenue was obtained by

Table 5. Computation of gross margins for modern and traditional beehives

Item	Incomes	
	modern	traditional
Average honey yield (kg/hive)	21.93	15.878
Average honey selling price (KES/kg)	427.14	415.12
Revenue (Ksh/hive)	9 367.18	6 591.32
	Input cost	
Transport	121.52	104.95
Family labour	196.47	107.27
Hired labour	218.69	247.95
Feeding cost	102.85	66.10
Pesticide	148.52	53.48
Servicing	204.16	53.69
Packaging materials	202.29	111.53
Labelling modern	136.40	367.64
Baiting materials	118.37	99.53
Total variable cost (KES/hive)	1 449.44	1 000.73
Gross margin (KES/hive)	7 917.74	5 590.59

Source: own elaboration.

multiplying the average honey yield per hive by the average selling price. The total variable cost was obtained by summing up all variable costs. The gross margins for the two production systems were obtained by calculating the differences between total revenue and total variable costs, as shown in Table 5.

On average, farmers who used modern beehives received a higher gross margin of KES 7917.74, compared to those using traditional beehives, who received KES 5590.59. This result agrees with the findings of Workneh and Puskur (2011), who found that the total incremental net benefit from box hives exceeds the benefit from traditional hives by more than two times. The author further underlined the importance of popularising box hives together with accessories and basic training. Similarly, Belet and Berhanu (2014) reported that the adoption of box hives makes smallholder beekeepers more profitable than with traditional hives, with a 20% increase in the variability of input cost and output prices. The finding is also in line with Al-Ghamdi et al. (2017), who reached a similar conclusion that box hives were more beneficial and remunerative.

CONCLUSION AND POLICY RECOMMENDATION

The findings showed that farmers who used modern beehives obtained the highest gross margins of KES 7917.74, while farmers who used traditional beehives had the lowest gross margins of KES 5590.59. This was determined by comparing the gross margins of modern and traditional beehives. According to the findings, it is possible to significantly increase one's income by producing honey utilising modern beehives.

Based on the findings, it is evident that farmers using modern beehives achieved the highest gross margins, compared to those using traditional beehives. This suggests a significant potential for income increase through the utilisation of modern beehives in honey production. To facilitate this transition and enhance beekeepers' capacity for uptake, streamlining access to modern beehives is recommended. This can be achieved by the county government providing modern beehives at discounted rates, thereby encouraging their adoption. This study also suggests that farmers should be encouraged to work in groups, which are crucial for information dissemination and increasing economies of scale. We utilised gross margin to measure performance; future studies could employ econometric models to understand the factors that affect beekeepers' gross margin.

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