Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Constraints to adoption and sustained use of modern apiculture among marginal households in Baringo and Makueni Counties, Kenya

Enock Nyamorambo Nyamira *, Dickson Lubanga Makanji and Benjamin Sosi

Department of Natural Resources, Faculty of Environment and Resources Development, Egerton University, P.O Box 536-20115, Egerton, Nakuru, Kenya.

Open Access Research Journal of Science and Technology, 2024, 11(01), 100–111

Publication history: Received on 16 April 2024; revised on 21 May 2024; accepted on 24 May 2024

Article DOI: https://doi.org/10.53022/oarjst.2024.11.1.0073

Abstract

Apiculture is globally embraced and offers considerable income-generating potential. This potential is significant in Kenya, especially in arid and semi-arid regions (ASALs). Despite efforts by government agencies, Non-governmental Organizations (NGOs), and development partners to encourage adoption of modern apiculture techniques, usage remains low. Most farmers continue to use traditional methods, resulting in minimal economic output. Understanding the challenges to adopting modern practices is crucial for promoting effective uptake.

The primary objective of this study was to identify the obstacles to the adoption and sustained use of modern apiculture among marginal households in Baringo and Makueni Counties, Kenya. A total of 250 respondents were chosen using a multi-stage sampling method, with 130 from Baringo and 120 from Makueni. Data collection involved semi-structured questionnaires, and descriptive statistics were used for analysis.

The findings reveal that farmers face various obstacles, including inadequate equipment and materials (25.6%), insufficient capital (22.4%), drought and famine (14.0%), market inaccessibility (11.6%), lack of knowledge and skills (11.2%), cultural barriers (8.8%), predators (4.8%), destruction of woody vegetation, and insufficient time (1.6%). This study will serve as a basis for formulating policies that promote the adoption of modern apiculture practices among beekeepers in Baringo and Makueni Counties of Kenya.

Keywords: Market access; Predators; Descriptive statistics; Multi-stage sampling

1. Introduction

One of the world's most significant commercial enterprises is honey production, with global annual output estimated at over 1.7 million metric tonnes (FAOSTAT, 2021). China leads in honey production, generating over 485,960 metric tonnes annually, followed by Turkey with 96,344 tonnes, Iran with 77,152 tonnes, Argentina with 71,318 tonnes, and Ukraine with 68,558 tonnes (FAO, 2021).

Modern apiculture methods were established as far back as the mid-eighteenth century in Europe. During this period, beekeepers began constructing movable comb hives, allowing them to harvest honey without destroying the entire bee colony. These innovations were brought to North America by European immigrants, who continued the practice of beekeeping. In contrast, many African countries still engage in honey gathering and the use of traditional beehives. This form of beekeeping has a rich history and remains widely practiced across Africa today (Bunde *et al*., 2016; Keiyoro *et al*., 2016).

Numerous nations have recognized importance of apiculture in fostering rural development (Ladino *et al*., 2023). Apiculture offers inherent health advantages by providing nutritious food, requiring little maintenance, and flourishing

* Corresponding author: Enock Nyamorambo Nyamira

on ample pollen and nectar from pollinated flora (UNEP, 2022). Particularly in developing countries, apiculture has demonstrated significant advantages for rural populations owing to the economic opportunities presented by its produce (Infonet-Biovision, 2021).

Annually, Kenya boasts a production of 140 metric tonnes of beeswax alongside over 25,000 metric tonnes of honey. However, this output merely captures 20 percent of the total potential yield, leaving approximately 80 percent of the production capacity untapped (Kiingwa *et al.,* 2020; KIPPRA, 2019). Beekeeping emerges as a pivotal means of livelihood in Kenya's arid and semi-arid regions (ASALs), where a substantial 80% of honey production takes place (KIPPRA, 2019). Nonetheless, it's worth noting that apiculture exhibits feasibility beyond these ASAL areas, extending its reach into non-arid and semi-arid regions as well (Mutua *et al*., 2023).

Apiculture holds significant promise for income generation, poverty alleviation, forest conservation, and diversifying export opportunities (Narang *et al*., 2022). Baringo County stands out as a key hub for beekeeping in Kenya, boasting considerable potential in this sector. Leading the pack, Baringo County yields 882 metric tonnes of honey valued at KES 350 million, along with 162.596 metric tonnes of beeswax, representing just 10% of its potential output (Baringo County Government, 2023). However, this falls short of its capabilities, notably because majority of honey production relies on traditional log hives, which make up 70% of beehives in the Sub-County (Kiprono *et al*., 2021).

Apiculture stands as a notably profitable venture in Makueni County, serving as one of the foremost revenue streams and boasting significant potential for expansion in productivity. Market indicators illustrate a pricing spectrum for honey, with rates fluctuating between 600 to 1000 Kenyan shillings per kilogram (KCSAP, 2021). Data from the Makueni County Government report a notable increase in the region's yearly honey yield, with figures climbing from 514 metric tonnes in 2019 to 694 metric tonnes in 2020 (Makueni County Government, 2022).

Apiculture offers the potential to generate significant foreign exchange earnings while simultaneously improving the quality of life in rural areas (UNEP, 2022). In Kenya, numerous honey-processing businesses serve markets in Europe, Japan, and the United States. Exportation is the primary focus of the nation's honey industry, with approximately 70 percent of total shipments directed towards these three countries (Farmers Trend, 2023; Gok, 2018). For instance, in Baringo County, an estimated 40% increase in potential could result in an annual revenue of USD 9 million, equivalent to over 1.2 billion shillings. This growth is attributed to the County government's investments in the beekeeping value chain, leading to a rise in honey production from an average of 500 metric tonnes to 882 metric tonnes (Baringo County Government, 2023).

The modernization of beekeeping traces its roots to the 1950s, when the Kenyan government initiated training programs for beekeepers (Kiingwa *et al.,* 2020; Silvica, 2019). Significant progress was marked by the establishment of honey-producing industries primarily concentrated in Makueni, Baringo, Samburu, and Kitui Counties (Kathila, 2017). (Kathila, 2017). These advancements were crucial in sectoral growth, creating jobs and boosting income for vulnerable households. A major milestone in Kenya's beekeeping sub-sector was the introduction of the National Beekeeping Policy in 2009 (Republic of Kenya, 2009). This policy aimed to enhance food security, create jobs, and promote environmental conservation. Before this, the sub-sector had lacked a comprehensive framework since the 1950s. The 2013 policy built on this by addressing production, disease and pest management, pesticide regulation, value addition, quality standardization, research, and training (Republic of Kenya, 2013). It also recognized the importance of beekeeping in forest reserves and near national parks and game areas.

The industry contributes to preserving the environment and enhancing crop yields through pollination services (ICIPE, 2019). It has the potential to significantly impact poverty reduction, aligning with Kenya's vision 2030. Honey serves as a crucial source of nutrients such as energy, protein, vitamins, minerals, and amino acids, while also supporting Sustainable Development Goals by poverty reduction (SDG 1) and ending hunger (SDG 2) through promoting food security, sustainable agriculture, and job creation. Despite advancements in technology, modernizing beekeeping practices in rural areas remains a challenge.

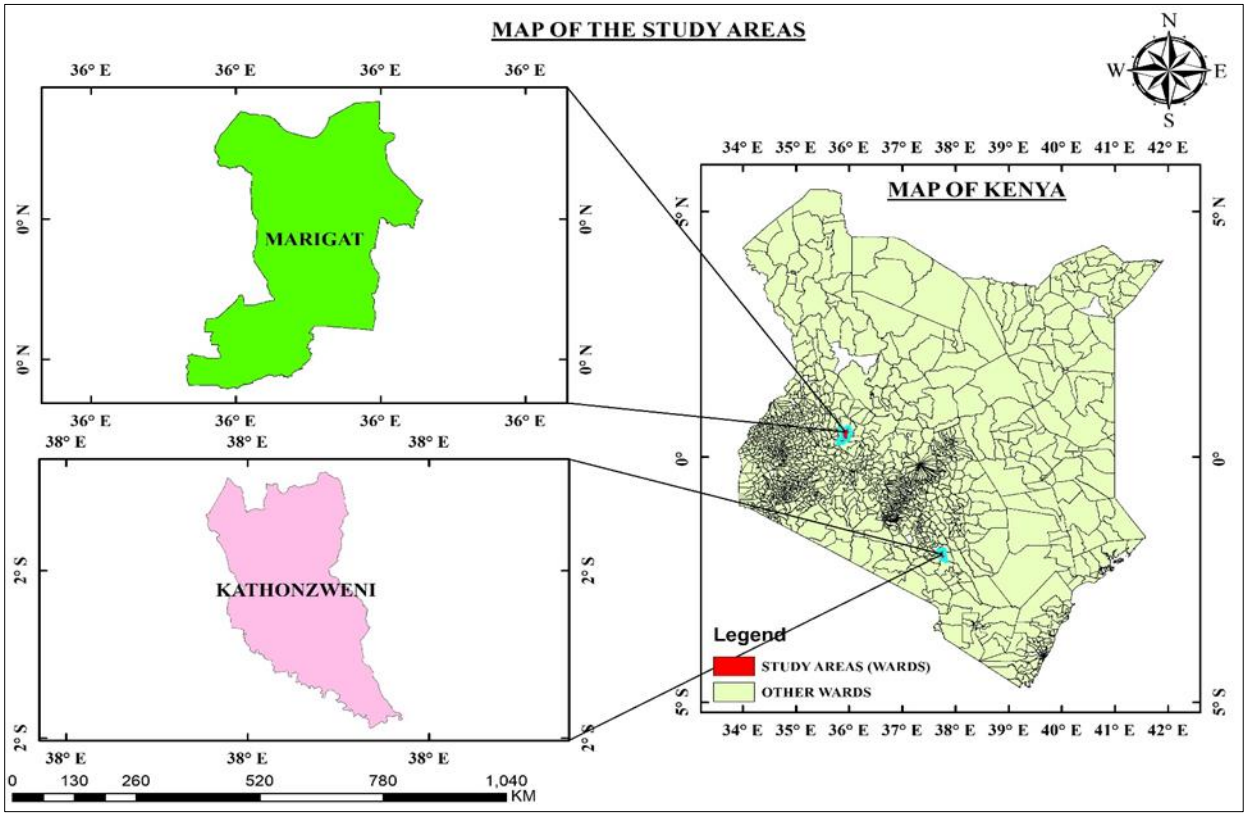
Many development efforts, both governmental and non-governmental, have faced difficulties in modernizing beekeeping, particularly in Kenya's semi-arid regions. However, progress has been hindered by various obstacles such as production inefficiencies, labor shortages, limited access to finance, and inadequate extension services (Chelagat, 2022; Kipruto, 2016; Muriuki, 2016). Adoption of modern equipment, although crucial for increasing production and income, remains a challenge (Kuboja *et al.,* 2017). Despite these obstacles, there is insufficient clarity in the literature regarding the current state of modern apiculture adoption and the challenges involved. Therefore, this study aims to address this gap.

2. Material and method

2.1. Study Areas

The studies were undertaken in Marigat ward, Baringo South Sub County, Baringo County, Kenya. Marigat is a semi-arid region around 260 kilometers northwest of Nairobi, with a total size of 1,514.9 kilometers. The geographic coordinates are approximately 0.4695°N and 35.9833°E. The other study area was Kathonzweni Ward within Makueni County Sub County, which is also located in the arid to semi-arid regions zones of the nation's Eastern area with latitude 1.9131°S and longitude 37.7317°E (GoK, 2014). Figure 1 below shows the location of the study sites.

In the (KNBS, 2019) census, the Kenya National Bureau of Statistics reported that Marigat Ward had a population of 90,952 residents, with 45,706 males and 45,246 females, living in 19,854 houses. The population density was relatively low at 63 people per square kilometer. Kathonzweni Ward, on the other hand, recorded a population of 79,780 individuals, with 39,335 men and 40,442 women, residing in 18,365 homes. The population density for Kathonzweni Ward was also low, with 91 people per square kilometer.



Source (Survey of Kenya, 2022)

Figure 1 Map of Kenya showing Geographical Location of the study areas

2.2. Research Design

The study adopted a descriptive research approach to obtain statistical data on the hurdles to the adoption and continued use of modern apiculture. This design allowed data collection, organization, display, and interpretation simpler while preserving every variable (Sileyew, 2019). It allowed the investigator to arrive at conclusions and make generalizations about the population of interest based on the information collected.

2.3. Target Population

The study's target population was women and youth beekeepers.

2.4. Sampling Procedure and Sampling Size

The study employed a multi-stage sampling approach, deliberately selecting the two counties due to the significance of apiculture as one of the primary income sources and its growth potential. Since the majority of farmers were engaged in beekeeping, these counties were chosen purposefully. Stratified random sampling was then utilized to divide farmers into smaller groups, followed by proportionate sampling to determine the sample size for each group. Systematic random sampling ensured that respondents from both areas were representative. The Ministry of Agriculture provided the sampling frame for both study regions. A total of 250 respondents were selected from the population, and the sample sizes were determined by the use of the Creswell formula (Creswell *et al*., 2007). Which is;

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where;
n was the required sample size,
N was the accessible population,
C was the coefficient of variation (25%), and
e the standard error value (0.02)

According to statistics from the Baringo South Sub-County, 784 households in Marigat Ward were involved in beekeeping, with a sample size of 130, as shown below.

$$n = \frac{NC^2}{c^2 + (N-1)e^2}$$

$$n = \frac{784x0.0625}{0.0625 + 783x0.0004}$$

$$n = 130$$

In Makueni Sub County's Kathonzweni Ward, there were 521 accessible households, and 120 beekeeping farmers were sampled, as shown below.

$$n = \frac{NC^2}{c^2 + (N-1)e^2}$$

$$n = \frac{521x0.0625}{0.0625 + 520x0.0004}$$

$$n = 120$$

2.5. Instruments

Semi-structured questionnaires were used to collect primary data, consisting of both closed and open-ended questions. Trained enumerators conducted the surveys following rigorous pre-testing to ensure data reliability and effectiveness.

2.6. Data Analysis

To ensure completeness, each survey was thoroughly verified before data processing commenced. SPSS (version 24) was adopted for data analysis, while descriptive statistics was a key instrument used to describe the findings.

3. Results and Discussion

This component explores various challenges of adopting and maintaining modern beekeeping among marginalized households.

3.1. Socio-demographic characteristics

3.1.1. Age of the respondents by Ward

Table 1 Age of the respondents

Age of the respondents	N	Kathonzweni (n=120)	Marigat (n=130)
18-26	23	6	17
27-35	84	36	48
36-45	56	26	30
46 and above	87	52	35
Total	250	120	130

In the two regions, age of the bee producers shown in Table 1 indicates that 87 of the respondents were aged 46 years and above, 84 aged between the ages 27 to 35, 56 aged between 36 to 45 years and 6 aged between ages of 18 to 26 years. This indicates that most producers in Apiculture were adults while fewer were youths but fell in the economically active age group. In Kathonzweni ward, 6 of the respondents aged between 18-26 years, 36 aged 27 years to 35 years, about 26 ranged within 36 to 45 years and around 52 aged above 46 years. However, in Marigat ward, it was noted that 17 of the respondents were youths consistent with the age criterion in Kenya between 18 to 35 years. Around 48 of the respondents fell between the ages of 18 to 26 years, 30 fell between 27 to 35 %, 35 were between 36 to 45 and 26.9% were 46 and above. The findings align with Mwangi and Bula (2021) who noted that individuals in productive age groups are typically very active, face numerous financial obligations, and show a strong willingness to learn new skills. Similarly, Lokuruka (2021) found that agricultural activities, particularly apiculture, significantly enhance income for producers in semi-arid and arid regions, thereby improving their food security. The combination of these findings suggests that the dynamism and financial pressure of the productive age group drive engagement in profitable and sustainable agricultural practices, such as beekeeping, which in turn supports economic stability and food security in these challenging environments.

3.1.2. Marital status of the respondent

Table 2 Marital status of respondents

Marital status of respondents	N	Kathonzweni (n=120)	Marigat (n=130)
Single	46	19	27
Married	133	52	81
Widowed	62	45	17
Divorced	9	4	5
Total	250	120	130

Among the respondents, 133 were married, 62 were widowed, 46 were single and 9 were divorced (Table 2). From the results above, Kathonzweni Ward had 19 respondents who were single, 52 were married, 45 were widowed and 4 were divorced. At Marigat, 27 were single, 81 were married, 17 were widowed and 5 were divorced. This indicates that majority of those involved in the enterprise were married hence partners helping in decision-making. The finding echoes Mwangi and Bula (2021) who argued that apiculture is an economically viable venture, prompting families to embrace and invest in it. Similarly, Tadesse *et al*. (2021) discovered that the overwhelming majority of those engaged in apiculture, totaling 94.65%, were married, with a mere 5.35% being single. In contrast, Yohana and Saria (2020) depicted beekeepers as predominantly divorced, separated, or widowed. These disparities underscore the dynamic interplay of socio-economic variables and cultural influences shaping the demographic composition of beekeepers across diverse regions. Such variations highlight the need for tailored approaches in beekeeping interventions to accommodate local contexts effectively.

3.1.3. Education level of respondents

Table 3 Level of Education of respondents

Level of Education	N	Kathonzweni (n=120)	Marigat (n=130)
Below primary	54	33	21
Primary	99	41	58
Secondary	52	23	29
Tertiary/ College	45	23	22
Total	250	120	130

The number of youth and women with less than primary level education were 54, primary level were 99, secondary were 52 and tertiary were 45 (Table 3). In Kathonzweni ward 33 had less than primary level education, 41 had primary level, 23 secondary level, and 23 at tertiary level. In Marigat, 21 had less than a primary level of education, 58 had primary education, 29 had secondary education and 22 had tertiary education. Literacy levels in Marigat ward were higher than Kathonzweni ward that is 110 of respondents in Marigat had at least a primary level of education and 87 of the respondents in Kathonzweni ward had at least primary education. A fundamental aspect of literacy is its role in facilitating producers' understanding of concepts, opportunities, and skills conveyed during training sessions Yalo *et al*. (2019); Mohamed-Brahmi *et al*. (2022). Literacy proficiency enables individuals to engage meaningfully with training materials, grasp new information, and apply it effectively in their respective fields. This underscores the importance of literacy as a catalyst for enhancing agricultural knowledge dissemination and fostering sustainable development within farming communities Ogunmodede *et al*. (2020).

3.1.4. Gender of the respondents

Table 4 Gender of the respondents

Gender of respondent	N	Kathonzweni	Marigat
Male	70	40	30
Female	180	80	100
Total	250	120	130

According to Table 4, majority of the respondents were women whereby, 180 were women and 70 were men. This reveals domination of women in beekeeping activities in the study area as compared to youth who were male. In Kathonzweni Ward, 40 were male youth while women were 80. Similarly, Marigat ward had 30 of youth males in apiculture and 100 females. This statement is supported by Mwangi & Bula (2021) who revealed that Modern beekeeping has considerably increased the number of women involved. Women had a lot of family support to start beekeeping and experienced the same challenges as Men. This is in contrast to a study by Akinwale *et al*. (2021) who argued that males were more involved in agricultural activities than females. Agricultural activities are deemed to be time-consuming, tedious, and labor-intensive. Equally, females are involved in household chores.

3.1.5. Number of Dependants

Table 5 Number of dependants

Name of ward	N	Mean	Std. Deviation
Kathonzweni	120	4.78	1.769
Marigat	130	4.56	2.376
Overall	250	4.67	2.105

On average, 4.67 members were dependants in the study areas. In Kathonzweni ward 4.78 members depended on the household heads in the target group while 4.56 were dependants in Marigat. From the results in Table 5, the overall standard deviation stood at 2.105, Kathonzweni ward had 1.769 and Marigat had 2.376. The number of dependents

directly impacts the adoption of agricultural technology, with larger families often requiring more efficient methods to sustain production and meet household needs (Dimelu *et al*., 2020). Similarly, Yussuf and Mohamed (2022) assert that household size plays a crucial role in determining food consumption patterns, thereby significantly influencing decisions related to agricultural activities within the household. Larger households often require increased food production, leading to strategic adjustments in farming practices and resource allocation.

3.1.6. Group participation, duration and benefits

Table 6 Membership in groups and duration

Ward	**Membership in farmer groups**			
	Number of bee farmers	**Producers in farmer groups (%)**	**Number of bee farmers in groups (*f*)**	**No of years in groups**
Kathonzweni	120	72.5	87	3.00
Marigat	130	90.0	117	2.56
Overall	250	81.3	204	2.78

The findings from Table 6 indicates that the majority of the respondents belonged to a group. On average, 81.6% of apiculture farmers had membership in farmer groups, 72.5% (87) from Kathonzweni ward belonged to a group while 90% (117) of farmers in Marigat had group member subscriptions. Averagely, the members have been in the group for 2.77 years, Kathonzweni was leading by 3 years, and Marigat for 2.56 years. Group membership benefits apiculture farmers by promoting interaction and information sharing. These networks provide access to markets, financial institutions, and price information, enabling informed decision-making and enhanced economic participation (Gichungi *et al*., 2023).

Table 7 Benefits of being in groups

Ward	**Number of bee farmers**	**Honey Markets**	**Training**	**Loans**
Kathonzweni	*120*	54.2	16.7	8.3
Marigat	*130*	56.2	28.5	13.8
Overall	*250*	55.2	22.6	11.1

The data in Table 7 indicates that 54.2% of the apiculture producers joined groups to access markets for hive products in Kathonzweni while 56.2% in Marigat. Correspondingly, at least 16.7% joined to receive training from the groups in Kathonzweni and 28.5% in Marigat there were 22.6% of youth and women. Comprehensive training provides beekeepers with the knowledge they need to make informed decisions in the market. This enables them to stay updated with current trends and adjust their strategies for success (Bellemare & Novak, 2017; Barreti *et al*., 2022; Maertens & Velde, 2017). Of the respondents, 11.1% accessed loans, with 8.3% in Kathonzweni and 13.8% in Marigat, demonstrating engagement with financial institutions. These institutions improve farm liquidity by investing capital in agricultural activities, allowing farmers to meet financial obligations, pursue growth opportunities, and promote resilience and sustainability in their businesses (Nyamamba *et al*., 2022).

3.2. Constraints to adoption and sustained use of modern apiculture by marginal households in Marigat and Kathonzweni Wards

Figure 2 below highlights the constraints faced by women and youth engaged in apiculture. The primary challenge identified inadequate equipment and materials, which significantly hindered the adoption of sustainable modern apiculture practices. Approximately 26% (64) of respondents pointed out this issue, as many relied on outdated tools and methods to harvest honey due to the unavailability of appropriate and modern equipment. Research by Bojago (2023); Mohammed & Hassen (2021) supports this finding, noting that access to modern hives and improved tools is largely out of reach for most apiculture farmers, even those willing to invest. Additionally, some farmers who managed to acquire modern hives still lacked essential instruments for their maintenance, such as queen excluders, smokers, and honey extractors. Similarly, Gratzer *et al.* (2021) revealed that many apiculture producers were entirely without beekeeping gear and tools. This widespread inadequacy of equipment not only affects the efficiency of honey production but also discourages the adoption of advanced beekeeping techniques, thereby limiting the potential for growth and development in the sector.

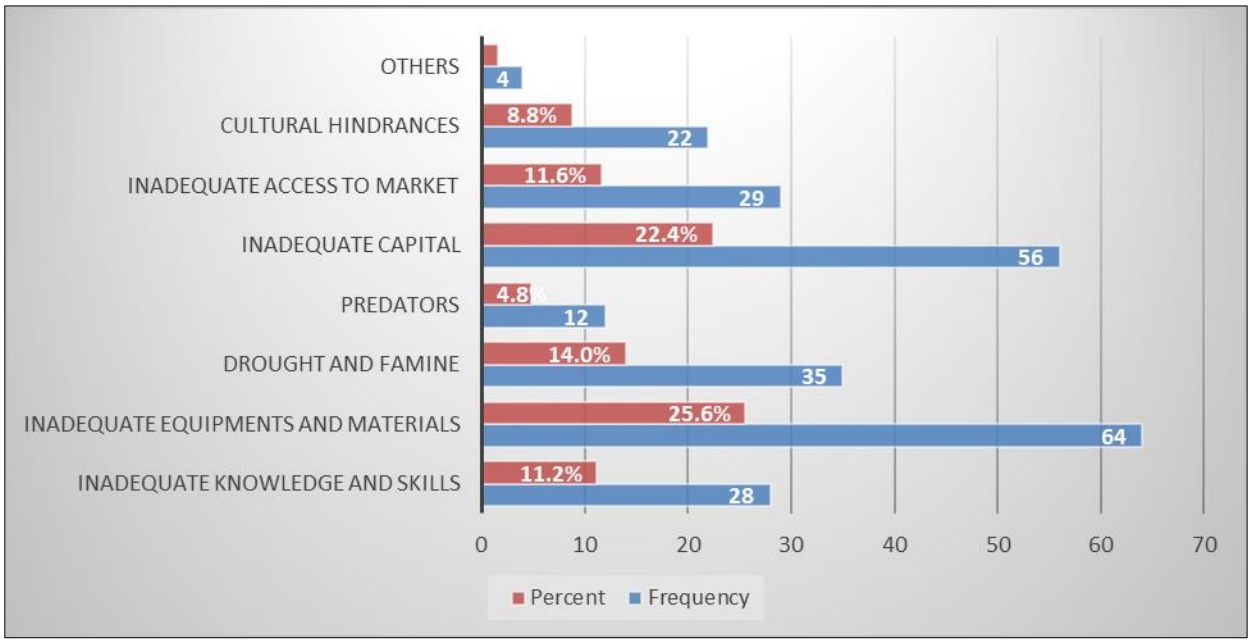


Figure 2 Constraints to adoption and sustained use of modern apiculture

A significant 22.4% (56) of survey participants have highlighted insufficient capital as a major obstacle to upgrading their beekeeping operations. This financial challenge restricts their ability to invest in essential protective gear, modern hives, and packaging materials, leaving women and youth beekeepers with no choice but to make do with locally available, often subpar equipment. Embracing modern hive systems requires higher initial investments compared to traditional methods, which compels many beekeepers to stick to using traditional log hives (Gratzer *et al*., 2021). The respondents' inability to secure financial backing significantly hampers their ability to modernize their production methods. Due to funding shortages, they are unlikely to acquire the necessary equipment and vital technical expertise, resulting in a slowdown in their beekeeping operations (Mwakatobe *et al*., 2021). Their capacity to expand and compete in larger markets is further hindered by their inability to invest in modern hives, which also impacts the quality and quantity of their output. Due to financial challenges, women and youth in the beekeeping industry are caught in a cycle of low output and limited growth (Juma *et al*., 2022).

Drought and famine emerged as the third most significant challenge, cited by 14% of respondents, amounting to 35 individuals. The persistent variability in weather, particularly fluctuations in temperature and humidity, poses a substantial threat to the growth of bee colonies and the production of bee products (Bihonegn & Begna, 2021). Increased temperatures lead to a decline in honeybee activity, while annual floral plants wither, causing a mismatch in nectar availability and subsequently hindering the growth of bee colonies (Andaregie & Astatkie, 2021). This issue is particularly pronounced in the study areas, which are classified as arid and semi-arid land (ASAL) regions, further discouraging women and youth from adopting modern beekeeping practices. Heat stress variability reduces the number of pollinators, with pollinator activities decreasing during rainy seasons. Consequently, bees are often forced to consume their stored honey, resulting in lower harvest yields. This combination of climatic challenges and environmental stressors significantly impacts the viability and productivity of apiculture in the region, making it difficult for beekeepers to maintain and expand their operations (Juma *et al*., 2022).

Market inaccessibility for hive products emerged as a significant challenge, with 11.6% (29) of respondents highlighting this issue. This problem stems from insufficiency of established marketing systems and adequate infrastructure. As illustrated in Figure 2 above, apiculture farmers do not have organized markets for their hive products, often depending on specific customers for product sales. These findings align with studies conducted by Juma *et al*. (2022); Ngomo (2021) and Tadesse *et al*. (2021) which also noted the absence of collective markets for apiculture products. As a result, farmers are forced to sell individually, which fragments their market approach, reduces their bargaining power, and ultimately leads to lower prices for their products. Additionally, inadequate road infrastructure in the study area exacerbates the issue, as beekeepers are often required to travel long distances to reach markets. Tadesse *et al*. (2021) pointed out that these long journeys not only increase the physical strain on beekeepers but also elevate transportation and transaction costs associated with moving bee products. Nyamamba *et al*. (2022) further emphasized that the increased distances contribute to higher transaction costs, making it even more challenging for apiculture farmers to maximize their profits and efficiently access markets.

The study found that 11.2% (28) of the respondents had insufficient knowledge and skills in modern beekeeping. Key shortfalls included hive management, colonization, disease and pest-related surveillance, and supplemental feeding all of which considerably impede success (Juma *et al.,* 2022). The shortcoming is largely attributed to a shortage of extension services that provide practical beekeeping advice. Adequate education is crucial for increasing farmers' confidence with emerging beekeeping practices. This conclusion is in agreement with the studies of Bihonegn and Begna (2021); Mohammed and Hassen (2021); Mwakatobe *et al*. (2021) highlighted the insufficient skills and knowledge among beekeepers in effectively managing bee colonies due to the limited availability of training opportunities. Well-informed beekeepers are more likely to increase their adoption rate through investing more time in the practice.

The study found that cultural barriers hinder women's involvement in beekeeping, with 8.8% of respondents, including 22 individuals in the study areas, mentioning this constraint. Hanging hives on high tree branches requires physical strength and skill, and the nocturnal nature of this activity adds intensity. This leads women to prioritize safety concerns and other cultural responsibilities, such as household chores. This aligns with the findings of Gratzer *et al*. (2021) and Yator and Chesikaw (2021), who similarly noted that women's involvement in beekeeping during the daytime was limited due to time constraints imposed by household roles. However, women contributed to product processing and marketing, indicating their partial inclusion in the beekeeping process. Modern beekeeping systems, such as backyard setups instead of forest-based systems, encourage women's participation, as a single person can manage it. By keeping beekeeping activities closer to households, women can assist their husbands and even start their apiaries (Gratzer *et al.,* 2021). Traditional gender roles, limited land access, insufficient exposure to modern apiculture practices, cultural attitudes, and inadequate support prevent youth from fully engaging in apiculture (Gikunda *et al*., 2021).

Predators such as ants, birds, wax moths, lizards, snakes, small hive beetles, and honey badgers are posing significant challenges to modern apiculture, affecting 4.8% (12) of farmers in the study areas. These predators are causing damage to honey bee colonies and honey products. This aligns with the findings of Mohammed & Hassen (2021) and Bihonegn & Begna (2021) who noted that predators are causing substantial harm to apiculture by damaging bee colonies and products.

The destruction of woody vegetation and insufficient time were mentioned by 1.6% of respondents. The loss of woody vegetation reduces the availability of floral resources, which are crucial for bees to gather sufficient pollen and nectar. This reduction in diverse forage significantly impacts the sustainability of beekeeping, making it less viable (Mensah *et al*., 2017). Consequently, it discourages participation, particularly among women and youth who might otherwise consider entering the industry. The decline in available forage not only affects bee health and productivity but also poses a substantial barrier to those seeking to develop and sustain beekeeping enterprises. Moreover, Mburu *et al*. (2017) highlight the problem of insufficient time, pointing out that honey harvesting typically occurs at night, when women are engaged in household responsibilities.

4. Conclusion

The beekeeping industry, despite its economic viability, faces several challenges. The study recommends the improvement of access to modern apiculture materials for rural farmers through streamlined distribution networks and increased governmental support. Both levels of government to guarantee market access and upgrade the road network. Implementation of subsidized loan programs and facilitating access to credit in rural areas. Broadening of extension services and training to expand farmers' knowledge and skill sets. Gender mainstreaming at all levels Implementation of sustainable water management strategies, afforestation initiatives, and diversified farming techniques to mitigate the impact of drought, famine, and forest destruction, and lastly, support the formation of working cooperatives for beekeepers that will create a platform for exchanging knowledge, market access, and a voice in negotiation. This will promote long-term utilization of natural resources in Arid and Semi-arid Lands (ASALs) while supporting the quest towards food security. Further studies should be done to evaluate the impact of deforestation on apiculture production in the two regions.

Compliance with ethical standards

Acknowledgments

This research was funded by the MasterCard Foundation through RUFORUM and TAGDev Scholarship Program.

Disclosure of conflict of interest

The authors state that there are no conflicts of interest in the publication of this article.

Statement of ethical approval

Before conducting fieldwork, ethical clearance was obtained from the Egerton University Institutional Scientific and Review Committee. Additionally, a research permit was acquired from National Commission for Science, Technology, and Innovation (NACOSTI). Finally, informed consent was obtained from all individual participants included in the study.

References

[1] Akinwale, J. A., & Oyeyemi, O. V. (2021). Effectiveness of linking vegetable farmers to formal markets in Lagos state, Nigeria. Journal of Agriculture and Natural Resources, 4(2), 273

[2] Andaregie, A., Worku, A., Worku, A., Atinkut, L., & Astatkie, T. (2022). The drivers and intensity of adoption of beekeeping in northwest Ethiopia. Agriculture & Food Security, 11(1). https://doi.org/10.1186/s40066-022-00378-1

[3] Baringo County Government (2023). Agriculture and Livestock, Baringo Honey. https://www.baringo.go.ke/385/agriculture-livestock-baringo-honey-100-natural/?tk=NzQ1MQ

[4] Barreti, C. B., Islam, A., Pakrashi, A. D., Mohammad, M. A., & Ruthbah, U. (2022). Experimental evidence on adoption and impact of the system of rice intensification. American Journal of Agricultural Economics, 104(1), 4-32. https://doi.org/10.1111/ajae.12245

[5] Bellemare, M. F., & Novac, L. (2017). Contract farming and food security. American Journal of Agricultural Economics, 99.2, 357-378.

[6] Bihonegn, A., & Begna, D. (2021). Beekeeping production system, challenges, and opportunities in selected districts of south Wollo zone, Amhara, Ethiopia. Advances in Agriculture, 2021, 1-10. https://doi.org/10.1155/2021/2278396

[7] Bojago, E. (2023). Adoption of modern hive beekeeping technology: Evidence from Ethiopia. Honey - Composition and Properties. https://doi.org/10.5772/intechopen.106890

[8] Bunde, A. O., & Kibet, K. (2016). Socio-economic factors influencing adoption of modern bee keeping technologies in Baringo County, Kenya. International Journal of Science and Research, 5(6), 960-969.

[9] Chelagat, J. J. (2022). Assessing the Influence of Adoption and Use of Modern Honey Extracting Technologies on Household Income of Smallholder Beekeeping Farmers in Baringo County [Doctoral dissertation].

[10] Creswell, J. W., Hanson, W. E., Clark Plano, V. L., & Morales, A. (2007). Qualitative Research Designs: Selection and Implementation. The Counseling Psychologist, 35(2), 236–264. https://doi.org/10.1177/0011000006287390

[11] Dimelu, M. U., Umoren, A. M., & Chah, J. M. (2020). Determinants of youth farmers' participation in agricultural activities in Akwa Ibom state, Nigeria. Journal of Agricultural Science, 12(12), 201. https://doi.org/10.5539/jas.v12n12p201

[12] FAO (2021). Largest Natural Producers of Honey. Food and Agriculture Organization of the United Nations. https://rankingroyals.com/agriculture/largest-natural-honey-producers-top-115-countries/.

[13] FAOSTAT (2021). Good Beekeeping Practices for Sustainable Apiculture. Food and Agriculture Organization of the United Nations. www.fao.org

[14] Farmers Trend (2023). Bee Farming in Kenya, The Underrated Money Maker. https://farmerstrend.co.ke/trending/bee-farming-in-kenya/

[15] Gichungi, H. M., Muriithi, B. W., Kirscht, H., Mohamed, S. A., Ndlela, S., & Menale, K. (2023). Does empowerment influence women's willingness to pay for integrated pest management practices? A case study of mango growers in Zambia. Research in Globalization, 6, 100115. https://doi.org/10.1016/j.resglo.2023.100115

[16] Gikunda, R. M., Ooga, D. M., Okiamba, I. N., & Anyuor, S. (2021). Cultural barriers towards women and youth entry to apiculture production in Maara Sub-County, Kenya. Advancements in Agricultural Development, 2(2), 73–85. https://doi.org/10.37433/aad.v2i2.113

[17] GoK. (2018). Integrated National Export Development and Promotion Strategy (INEDPS). Ministry of Industry Trade and Cooperatives, Government of Kenya (GoK), Nairobi, Kenya. https://www.tralac.org/documents/resources/by-country/kenya/2057-kenya-integrated-national-export-development-and-promotion-strategy-july-2018/file.html

[18] GoK. (2014). Agricultural Sector Development Support Programme (ASDSP). Ministry of Agriculture Livestock and Fisheries (MoALF), Government of Kenya (GoK), Nairobi, Kenya.

[19] Gratzer, K., Wakjira, K., Fiedler, S., & Brodschneider, R. (2021). Challenges and perspectives for beekeeping in Ethiopia. A review. Agronomy for Sustainable Development, 41(4). https://doi.org/10.1007/s13593-021-00702-2

[20] ICIPE (2019). Bee Research. International Centre of Insect Physiology and Ecology. http://www.icipe.org/research/environmental-health/bee-research

[21] INFONET (2021). Beekeeping. Biovision Foundation for Ecological Development. https://infonet-biovision.org/animal-species/beekeeping

[22] Juma, S. M., Ali, A. I., Khamis, S. A., Rashid, R. J., & Kombo, M. D. (2022). Assessment of value chain for honey and beeswax initiatives in Zanzibar. European Journal of Agriculture and Food Sciences, 4(1), 1-9. https://doi.org/10.24018/ejfood.2022.4.1.423

[23] Kathila, G. M. (2017). Factors Influencing the Uptake of Beekeeping as an Economic Activity in Kenya: A Case of Farmers in Makueni County.

[24] KCSAP (2019). Inventory of Climate Smart Agriculture Apiculture technologies, Innovations & Management Practices. Kenya Climate Smart Agriculture Project. https://www.kcsap.go.ke/sites/default/files/manuals

[25] Keiyoro, P. N., Muya, B. I., Gakuo, C. M., and Mugo, K. (2016). Impact of Sociocultural factors on adoption of modern technologies in beekeeping projects among women groups in Kajiado County - Kenya. International Journal of Innovation Education and Research, 4 (4): 55 - 64.

[26] Kiingwa, K. M., Philomena, M., & Joseph, M. (2020). Determinants of modern box hives adoption in Kitui County, Kenya. International Journal Education and Research, 8(10), 121-132.

[27] KIPPRA (2019). Bee Bulking and Farmer Capacity Building in Bee Keeping: An Opportunity for Increasing Youth Employment and Food Security in Rural Areas. The Kenya Institute for Public Policy Research and Analysis. https://kippra.or.ke/bee-bulking-and-farmer-capacity-building-in-bee-keeping-an-opportunity-for-increasing-youth-employment-and-food-security-in-rural-areas/

[28] Kiprono, N., Lagat, J., & Gitau, R. (2021). Determinant Factors Affecting the Uptake of Modern Beehives. International Journal of Science and Research (IJSR). https://www.researchgate.net/publication/355875482

[29] Kipruto, C. C. (2016). Factors Influencing Honey Production in Marigat, Baringo County - Kenya. Moi University.

[30] KNBS, (2019). Kenya Population and Housing Census. Kenya National Bureau of Statistics Nairobi, Kenya.

[31] Kuboja, N. M., Isinika, A. C., & Kilima, F. T. M. (2017). Comparative Economic Analysis of Beekeeping Using Traditional and Improved Beehives in the Miombo Woodlands of Tabora and Katavi Regions, Tanzania. 15.

[32] Ladino, R. C., Domínguez, O. F., & Jiménez-Hernández, C. N. (2023). Analysis of productivity and competitiveness in beekeeping: A case study of Cundinamarca, Colombia. International Journal of Professional Business Review, 8(10), e03328. https://doi.org/10.26668/businessreview/2023.v8i10.3328.

[33] Lokuruka, M. N. (2021). Improving food and nutrition security in Kenya's arid Lands-A mini review. Asian Research Journal of Agriculture, 45-63. https://doi.org/10.9734/arja/2021/v14i330129

[34] Maertens, M., & Vande Velde, K. (2017). Contract-farming in staple food chains: The case of rice in Benin. World Development, 95, 73-87. https://doi.org/10.1016/j.worlddev.2017.02.011

[35] Makueni County Government (2022). Makueni County Annual Development Plan (CADP) 2022-2223. https://makueni.go.ke

[36] Mburu, P. D., Affognon, H., Irungu, P., Mburu, J., & Raina, S. (2017). Gender roles and constraints in beekeeping: A case from Kitui County, Kenya. Bee World, 94(2), 54-59. https://doi.org/10.1080/0005772x.2016.1275490

[37] Mensah, S., Veldtman, R., & Seifert, T. (2017). Potential supply of floral resources to managed honey bees in natural mistbelt forests. Journal of environmental management, 189, 160-167.

[38] Mohamed-Brahmi, A., Tsiokos, D., Ben Saïd, S., Boudalia, S., Smeti, S., Bousbia, A., Gueroui, Y., Boudebbouz, A., Anastasiadou, M., & Symeon, G. K. (2022). Challenges and opportunities of the Mediterranean Indigenous bovine populations: Analysis of the different production systems in Algeria, Greece, and Tunisia. Sustainability, 14(6), 3356. https://doi.org/10.3390/su14063356

[39] Muriuki, J. (2016). Special Edition Honey Production, Bee Health and Pollination Services. Animal Health and Production in Africa.

[40] Mutua, C., Waswa, F., & Mcharo, M. (2023). Apiculture for sustainable land use and enhanced community livelihoods in Dryland ecosystems: The case of Makueni in Kenya. East African Journal of Environment and Natural Resources, 6(1), 198-216.

[41] Mwakatobe, A., Ntalwila, j., Lesio, N., Leweri, C., Haule, L., & Kilimba, N. (2021). Challenges and opportunities of beekeeping in Mvomero district, Morogoro region, Tanzania. Journal of Entomology and Zoology Studies 2021, 9(2), 01-05. www.entomoljournal.com

[42] Mwangi, R. W., & Bula, H. (2021). Factors Influencing Growth of Entrepreneurship in the Beekeeping Sector, Makueni County, Kenya. International Journal of Economics, Commerce and Management United Kingdom, Vol. IX, (Issue 5,). https://www.researchgate.net/publication/355408180

[43] Narang, A., Kumar, D., & Gupta, G. (2022). Political, economic, social, technological and SWOT analysis of beekeeping as a successful enterprise in India: An overview. Journal of Applied and Natural Science, 14(1), 194-202. https://doi.org/10.31018/jans.v14i1.3312.

[44] Ngomo, L. K. (2021). Determinants of Production and Performance of Honey Processing Projects: the Case of Kitui County [Doctoral dissertation]. http://erepository.uonbi.ac.ke/handle/11295/1603

[45] Nyamamba, J. S., Ayuya, O. I., & Sibiko, K. W. (2021). Determinants of side selling behavior in emerging sorghum supply chains in Kisumu County, Kenya. Cogent Economics & Finance, 10(1). https://doi.org/10.1080/23322039.2021.1986932.

[46] Ogunmodede, A. M., Ogunsanwo, M. O., & Manyong, V. (2020). Unlocking the potential of agribusiness in Africa through youth participation: An impact evaluation of N-power Agro empowerment program in Nigeria. Sustainability, 12(14), 5737. https://doi.org/10.3390/su12145737.

[47] Republic of Kenya. (2009). National Beekeeping Policy. 30.

[48] Republic of Kenya. (2013). National Beekeeping Policy. Sessional paper 7.

[49] Shek Mohammed, S., & Hassen, A. (2021). The current constraints and opportunities of beekeeping in Ethiopia: A review. Agriculture, Forestry and Fisheries, 10(6), 262. https://doi.org/10.11648/j.aff.20211006.16.

[50] Sileyew, K. J. (2019). Research design and methodology. Cyberspace, 1-12.

[51] Silvica (2019). A Blog Course of Beekeeping in Kenya. https://silvica.site/a-blog-course-of-beekeeping-in-kenya/

[52] Tadesse, B., Tilahun, Y., Woyamo, W., Bayu, M., & Adimasu, Z. (2021). Factors influencing organic honey production level and marketing: Evidence from Southwest Ethiopia. Heliyon, 7(9), e07975. https://doi.org/10.1016/j.heliyon.2021.e07975.

[53] UNEP (2022). Why Bees Are Essential to Man and Planet. United Nations Environment Programme.https://www.unep.org/news-and-stories/story/why-bees-are-essential-people-and-planet.

[54] Yalo, M. I., Enimola, D. J., & Nafiu, A. T. (2019). Effects of Marketing Strategies on the Performance of Small and Medium-Scale Enterprises in Kogi State. European Journal of Business and Management, Vol.11, No.7, 2019. DOI: 10.7176/EJBM.

[55] Yator, J. C., & Chesikaw, L. (2021). Gender roles and women participation in bee keeping: A focus on Baringo south Sub-County, Baringo County. Advances in Sciences and Humanities, 7(2), 32. https://doi.org/10.11648/j.ash.20210702.14.

[56] Yohana, Z. E., & Saria, J. (2020). Assessment of beekeeping as an adaptation strategy to climate change in Iramba District. *Huria: Journal of the Open University of Tanzania*, *27.1*.

[57] Yussuf, B. A., & Mohamed, A. A. (2022). Factors influencing household livelihood diversification: The case of Kebri Dahar district, Korahey zone of Somali region, Ethiopia. Advances in Agriculture, 2022, 1-14. https://doi.org/10.1155/2022/7868248.