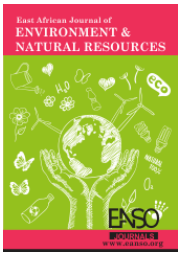

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Original Article

Apiculture for Sustainable Land Use and Enhanced Community Livelihoods in Dryland Ecosystems: The Case of Makueni in Kenya

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ABSTRACT

The scarcity of water in drylands is a major cause of crop failure, food insecurity, and consequent human ill-being. Relying on tilling and crop farming is therefore a risky investment and a direct threat to sustainable livelihoods. This calls for a shift in land use to practices that exert less pressure on land and water. Though apiculture is such a land-use practice, its adoption in the context of changing climate and increasing ecosystem vulnerability is still low. In pursuit of this dimension, the objectives of this research were: (i) to determine the extent to which apiculture is practised, (ii) to assess the challenges facing apiculture, and (iii) to assess measures required to scale-up apiculture among resource-poor farmers using Kathonzweni as a case study. Primary data was collected using a questionnaire survey that targeted 379 farmers. Additional data was obtained from secondary sources. Results showed that the majority of respondents (34.2%) relied on crop and animal production as their main sources of income, while 25.8% engaged in apiculture as an extra livelihood activity. Only 6.7% viewed apiculture as a source of food. As such, tilling the land rather than purchasing food using income from other sources remains the mindset in food security planning. Individual farmers harvested an average of 83.53 kg of honey/year and sold on average 60.67 kg/year. The income generated was an average of Kenyan Shillings 15,166.67 (USD 150) per year. Prolonged dry seasons, lack of community sensitisation, high cost of beehives, poor apiculture husbandry practices and difficulties in individually negotiating for better prices for their honey were the main limiting factors undermining this land use. Farmers were however aware of the huge market potential of hive products and the ecological suitability of the area for apiculture. Correlation analysis of quantities harvested, sold and income generated nationally revealed the existence of a very strong and significant positive relationship ($r = 0.92$; $p=0.000$). Therefore, investing in apiculture can alleviate household income limitations and the perennial food insecurity challenge in drylands while maintaining natural land cover and hence environmental resilience. Therefore, public-private synergistic partnerships based on a win-win business model are needed for increased adoption of apiculture in the context of changing climate.

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INTRODUCTION

Dryland ecosystems (also called ASALs) make up 89% of Kenya's land mass and host approximately 36% of the population (Republic of Kenya, 2012). Despite their immense potential for development, these ASALs have the lowest development indicators in the country (Republic of Kenya, 2019). Persistent drought, coupled with high product prices and poor trade conditions, persistently impacts food insecurity (IPC, 2022). Crop farming remains risky and unreliable due to low and erratic rainfall and farmers' inability to consistently afford critical farm inputs, which significantly undermine yields (Lemba et al., 2012), thus exacerbating food insecurity and the consequent human indignity. Further, without adequate soil moisture, the application of nitrogenous fertiliser does not result in any significant change in yields (Muniafu & Kinyamario, 2007). As a result, the default fall-back position for resource-poor land users remains traditional farming practices which have a high chance of crop failure besides increasing the risk of land degradation. This vicious cycle of drought-food-insecurity-poverty-environmental degradation must be stopped in favour of resilient land use practices that do not exert immense pressure on land. As a type of agroforestry system, apiculture is such a land use practice that could guarantee regular income besides enhancing natural land cover, particularly indigenous trees. ASALs have many diverse flora that are important for bee feeding. Shifting from crop farming to apiculture would naturally increase the land area under such flora and help farmers tap into the unexploited annual honey production of about 100,000 metric tons (Muma, 2020).

As an economic activity, apiculture does not require much land, which does not have to be fertile by any standards. Water demand is insignificant when compared to other farming systems like rain-fed crop farming (Syed, 2015**)**. In addition, as an agricultural business, apiculture may not require land ownership. The labour requirement is low, which lessens the drudgery imposed on women, who are the main source of farm labour in traditional African farming systems. Apiculture can be started with requisite equipment and tools that can be sourced locally and, in many instances, skills and knowledge already found within local traditions. From an ecological point of view, apiculture, which is a form of agroforestry, exerts less pressure and perturbation on land. This contributes to more natural conservation of biodiversity, including maintenance of tree cover, which bees require for pollen collection. The medicinal value (Apitherapy) of most hive products is currently gaining momentum. Despite the myriad benefits in the apiculture value chain (UNEP, 2022), adoption of this environment-friendly land use is

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still low, even in the ASALs where it is naturally suited.

A study in the vast semi-arid Makueni County in Kenya showed that whereas 73% of farmers considered beekeeping as a viable economic activity, only 30% practised beekeeping (Kathila, 2017). Most apiculture in Kenya is based on ancient technology such as the use of log hives, which account for about 73% of all the beehives in the country and contribute about 80% of the honey produced (National Farmers Information Service [NAFIS], 2020**)**. The use of improved and high-yielding beehives like the Langstroth and the Kenya Top Bar started toward the end of 1960 but is still low (Wambua et al., 2016). Furthermore, the majority of beekeepers in Kenya are small-scale subsistence farmers who produce poor quality honey due to a variety of reasons, including reliance on traditional beehives whose yield is also low, effects of pests and overall inadequate extension services on the potential of apiculture as a game changer in community livelihood options (Bett, 2017). The potential of apiculture is similarly high in other African regions, such as Southern Ethiopia but benefits to communities are undermined by similar challenges observed in Kenya, which generally reduce the technical efficiency in honey production and hence the yield (Ayele, 2020). Addressing these challenges through community-driven interventions has the possibility of enhancing community livelihoods as they take advantage of the huge domestic and export market for honey and other hive products.

The pattern of agricultural production in Kathonzweni Sub-County is characterised by considerable seasonal fluctuations in effective rainfall, which contributes to widespread food shortages in most households. The almost total dependence on crop and livestock farming in dryland ecosystems makes households unable to withstand external shocks like drought (World Bank, 2014). This vulnerability triggers a boomerang effect that traps households in poverty by exacerbating other human ill-being components like physical weakness, isolation, powerlessness and material lack. Failed harvests and disruption of local food market systems are challenges farmers must routinely overcome in Kathonzweni Sub-County. Drought-driven food insecurity can however be alleviated through food purchases, where farmers have alternative and predictable income sources. For not needing much water, not requiring much land, and contributing to environmental conservation, apiculture offers such a possibility for households in Kathonzweni Sub-County and by extension, most arid and semi-arid parts of Kenya. This study assessed the potential of apiculture with the aim of promoting it as a reliable and farmer-land-friendly livelihood alternative against food insecurity challenges in such dryland ecosystems. For having sufficient financial capital, households could be food secure through purchases of food and not be bothered by actual production under unreliable natural constraints characteristic of dryland ecosystems. The risk of food insecurity under such unpredictable conditions is made worse by the financial poverty that is the signature of most households in these areas. A land use system that reduces pressure on agricultural land minimises the risks of land degradation and enhances overall environmental health as evidenced by increasing density and longevity of natural floral biodiversity. Apiculture can therefore be viewed as a necessary climate-smart land use system. While county-integrated development plans mention bee farming as a possible intervention area for ASAL development, the national strategic development plan for ASALs (Republic of Kenya, nd) and National Drought Management Authority (NDMA) strategic plan 2018-2022 (Republic of Kenya, nd) do not mention apiculture even once. This is indicative of the deficiency in emergency responses when it comes to long-term solutions that yield multiple benefits.

According to the Makueni County Integrated Development Plan (2018), increased household income for sustainable livelihoods was adopted as the rallying theme in the development agenda of the county. To deliver this agenda, interventions have tended to focus on community economic empowerment, water resource management, lands, urban planning and development socio-

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economic development and enablers (infrastructure, cooperatives, financial infrastructure, energy, ICT, institutional capacity, market infrastructure) (Government of Makueni County, 2018). A situation analysis today shows that not much positive impact has been realised since 2010 when the devolution of government and some selected functions were actualised. The impact of drought still causes untold suffering and indignity among the majority of land-dependent households. The inclusion of honey development as a deliberate focal area suggests increasing awareness of the positive impact the apiculture value chain can deliver in the development process. The current annual honey production is 110,000 Kg. The county intends to increase the production to 180,000 Kg by supporting farmers to establish apiaries, establish a training and demonstration farm in apiculture, promote the establishment of a honey processing plant and strengthen community forest associations. It is the opinion of this paper that much more benefits to both the land and households can be realised by prioritising apiculture above physical infrastructure projects that have remained elusive to date. Apiculture works more within the inherent variability in drylands and does not attempt to change such ecosystems. Accordingly, as demonstrated by Krätli, S. (2015), apiculture is more likely to enhance environmental performance and human well-being than conventional structural interventions that appear to have failed or delivered little positive impact, the huge capital investments there-in notwithstanding.

Objective

Assessment of the potential of apiculture in the context of sustainable land management, here-in understood to mean use, care, and improvement, was guided by the following specific objectives:

- To assess the potential of apiculture as a sustainable land management practice in dryland ecosystems
- To analyse the challenges facing apiculture as an environment-friendly land use system
- To assess measures required to promote apiculture value-chain among resource-poor farmers in drylands.

METHODOLOGY

This study was carried out in Kathonzweni Sub-County in Makueni County, Kenya. The Sub-County occupies an area of about 881 km^2 with a population of about 79,980 people (Kenya National Bureau of Statistics [KNBS], 2009**)**. With annual rainfall ranging from about 300-400 mm, the Sub-County is a typical dryland ecosystem, where crop farming is constrained by unreliable rainfall and recurrent drought. This makes other options necessary to supplement livelihoods from the main food crops grown (i.e., maise and beans) and the rearing of goats. A social survey design (Freund & Wilson, 2003**)** using a questionnaire and interview schedule was used to collect data from respondents. This design was preferred because of its suitability for participatory research, which yields tacit knowledge that can be critical in understanding farmers' behaviour and decision-making dynamics.

The survey used a sample size of 379 respondents arrived at using a standard table for determining sample size developed by Darley and Robert (1970**)**. This procedure is based on standardised figures of sample sizes for different populations at a 95% confidence level. From a target population (N) of 31,227 households, the corresponding sample size (n) was 379 was selected using simple random sampling within villages in the study area. Since the scope of this study was to determine general trends and establish the basis for further targeted investigation, the possible effect of extraneous factors like household size and education level were not considered. Their consideration would require another detailed multi-variable study for targeted policy recommendations. Ten samples of honey obtained from 10 different producers were subjected to quality analysis based on the European standard (FAO/WHO, 1981)

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Additional information was sourced by interviewing key informants who included officers from relevant ministries at the county government and heads of some local NGOs and CBOs. Consensus on emerging issues from the questionnaire survey was arrived at in three focus group discussions that were held in the study area. The questionnaire data was subjected to descriptive statistics, while interview data from key respondents was used to enrich the discussion through content analysis. As part of social survey data management, cross-tabulations and correlation analysis were done to establish the relationship between quantities of honey harvested, sold, and income generated. Trends in national honey production and trade were analysed using Pearson correlation, focusing on bivariate associations among variables. In terms of honey quality, ten samples of honey were obtained from 10 different farmers randomly selected from the study area and analysed using established standard procedures (Arida et al., 2012).

RESULTS AND DISCUSSION

Overview of Respondents' Socio-economic Background

Apiculture was dominated by men at 67%. In terms of education level, 66% of the respondents had completed their secondary education and 7.7 % had no formal education. Since secondary education is not skills-oriented, commercial apiculture in this area would require targeted community capacity building in beehive types, production, modern harvesting techniques, honey processing, storage, marketing and value-addition. In terms of residency in the sub-County, 72% of the respondents had stayed there for at least 10 years. Therefore, they were familiar with the socio-cultural landscape and livelihood activities that are dominant in the area, which could be entry points in the promotion of apiculture in the sub-county, especially when compared to historical livelihood practices.

Regarding sources of income, 34.2% of the respondents relied on crop and animal production as their main sources. Only 25.8% engaged in apiculture as an extra livelihood activity. Another 13.6% got extra income from indigenous poultry farming. In 13.9% of the cases, extra household income was also obtained from wages/salaries, while 12.6% of respondents indicated boosting their household incomes from remittances from working members of the family. These patterns were indicative of the potential for livelihood diversification in pursuit of income security. Given its proven potential in income generation, apiculture could just provide the needed safety valve in enhancing household incomes. When it comes to food availability, 54.6% of the respondents indicated being food insecure (i.e., not able to guarantee three meals per day for their households). About 17.7% of them felt that food scarcity was a daily affair, while 27.7% said that food shortage occurred less often. Overall, 80% of the respondents experience food insecurity and its indignity. Responses from focus group discussions attributed this food insecurity in the majority of the households to unreliable rainfall and financial constraints that limited their purchasing power for food commodities. National data covering the period 2015-2022 also shows that annual rainfall and rainfall days are declining (Republic of Kenya (2023). Reliance on crop farming for household food security will thus remain a risky investment in the drylands, which calls for livelihood diversification based on semi-intensive farm practices like apiculture.

Trends in National Honey Production and Trade (2007-2015)

The period between 2007 and 2015 recorded an increase in production, consumption, imports, and market prices in Kenya. The greatest increase was a 335% increase in national production value from 34 million dollars to 148 million dollars (*Tables 1* and *2*). The value of consumed honey also increased by 227% from 40 million dollars to 132 million dollars. However, there was a 48% decline in export volume from 61 thousand dollars to 59 thousand dollars. Despite this decline, the years 2012 and 2013 recorded export values of 238 thousand dollars and 119 thousand dollars, respectively. The quantity of honey exported was

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low, with the maximum recorded being 70 tons in 2012. Linear correlations among the market indicators showed that per capita consumption was positively correlated with consumption value, production, and export price (Table 3). An increase in per capita consumption leads to an increase in any of these variables. However, the association between per capita consumption and export price needs further investigation because many other factors determine global market prices. Other significant positive correlations were between production volume and consumption and also between production value, consumption value and production value and production volume. None of the negative associations were significant. The negative values were also close to zero, suggesting a weak association.

Trends in production and export trade must have since increased but still fall short of leveraging on the existing huge international market. Herein is the opportunity of diversifying livelihoods from extensive land tillage to more trees and apiculture and meet food security more from a purchase dimension and not the unpredictable rainfed agriculture

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Table 1: National Trends in Honey Production and Trade (2007-2015)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Consumption volume (000 tons)	14.7	12.1	7	9	9.9	11.7	8.3	29.8	34.8
Consumption Value (Million USD)	40.4	33.4	20.6	28.9	29.1	39	28.5	110.9	132.1
Production volume (000 tons)	14.7	12	7	8.9	9.8	11.7	8.3	29.7	34.8
Production value (Million USD)	34	28.2	18.7	28.4	26.3	39.4	29.6	122.8	148
Import volume (Tons)	75.5	48.7	29.1	82	87.3	157.8	90.2	55.9	89.9
Import value (000 USD)	205.5	151.3	104.2	228.6	319.8	552.2	284.6	170.8	290.7
Export volume (Tons)	26.7	7.4	12.2	18.9	22.8	70.4	33.3	10	13.9
Export value (000 USD)	61.8	17.4	33	60.2	61.3	238	119.2	41.4	59
Import price (USD/Ton)	2724	3106	3579	2788	3662	3500	3153	3053	3235
Export price (USD/Ton)	2317	2344	2694	3189	2687	3382	3584	4128	4257
Per capita consumption (kg/1000 persons)	386	308.5	173.4	216.8	231.9	268.9	185.3	647.2	737.5
Net export volume (Tons)	-48.8	-41.3	-16.9	-63.1	-64.5	-87.4	-57	-45.9	-76
Net export value (USD)	-143.8	-133.8	-71.2	-168.4	-258.5	-314.3	-165.4	-129.4	-231.7

Source: Free Data Honey Kenya https://app.indexbox.io/table/0409/404/ (Retrieved on May 8 2023)

Table 2: Summary statistics of the Kenya honey sector between 2007 and 2015

Variable	Annual mean	% increase over 9 years	Annual rate of increase
Value consumed (USD)	51,433,333.3	227	11,462,500.00
Production volume (Tons)	15,211.1	137	2,512.50
Production value (USD)	52,822,222.2	335	14,250,000.00
Import volume (Tons)	79.6	19	1.80
Import value (USD)	256,411.1	41	10,650.00
Export volume (Tons)	24.0	-48	-1.60
Export value (USD)	76,811.1	-5	-350.00
Import price (USD/Ton)	3,200.0	19	63.88
Export price (USD/Ton)	3,175.8	84	242.50
Per capita consumption (kg/person)	0.4	91	0.04

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Table 3: Correlations among various honey market indicators

	Value consumed (USD)	Production volume (Tons)	Production value (USD)	Import volume (Tons)s	Import value (USD)	Export volume (Tons)	Export value (USD)	Import price (USD/Ton)	Export price (USD/Ton)
Production volume (Tons)	0.994**								
Production value (USD)	0.998**	0.986**							
Import volume (Tons)	0.012	-0.010	0.024						
Import value (USD)	-0.007	-0.034	0.008	0.981**					
Export volume (Tons)	-0.265	-0.285	-0.253	0.899**	0.900**				
Export value (USD)	-0.149	-0.183	-0.129	0.915**	0.919**	0.982**			
Import price (USD/Ton)	-0.134	-0.175	-0.109	0.157	0.340	0.245	0.265		
Export price (USD/Ton)	0.776**	0.709*	0.810**	0.281	0.264	0.061	0.229	0.007	
Per capita consumption (kg/person)	0.978**	0.995**	0.963**	-0.039	-0.070	-0.305	-0.217	-0.232	0.641*

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed)*

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Honey Production and Marketing at Farm Level

A market survey in 2017/2018 showed that one kilogram of honey was sold for Kenya shillings (KES) 250 (i.e., USD 2.5), which was much more than dry maise that generally sold at about KES 100 (1 USD) for 2kg. On average, farmers in the sampled location harvest 83.53kg of honey with a variation of ±39.58kg. The average sales were 60.67kg ± 25.90kg, while the average income was KES 15,166.67 ± 6,475.69 (*Table 4* and *5*). Further analysis showed that there is a positive and statistically significant correlation (r = 0.920, p =.000) among the three variables considered (*Table 6*). A unit increase in the quantity harvested is likely to increase sales and income significantly. This means that investing in more hives has the potential to significantly increase household incomes and hence address the perennial food insecurity challenges.

Table 4: Yearly honey yield and income from sampled farmers in Kathozweni

Sample Number	Quantity Harvested (kg)	Quantity Sold (kg)	Income in Kenya Shillings	Approx. Income in US $
1	88	60	15,000	150
2	200	120	30,000	300
3	92	65	16,250	163
4	75	50	12,500	125
5	122	80	20,000	200
6	55	40	10,000	100
7	60	30	7,500	75
8	84	70	17,500	175
9	40	25	6,250	62
10	73	60	15000	150
11	50	45	11,250	113
12	105	90	22,500	225
13	65	45	11,250	113
14	96	90	22,500	225
15	48	40	10,000	100

Note: Mean yield was 10 kg of honey per hive. Harvesting was twice per year.

However, since the selling of honey occurs rather informally during the local market days and routine interactions, farmers are not able to exploit the huge market available outside their local settings. The honey that is not sold is consumed at the household level as food or in social ceremonies. Farmers face challenges when selling individually because of the low prices offered for their unprocessed honey or poorly processed honey by middlemen. To regulate and harmonise prices in their favour, farmers need to organise themselves in farmers' groups or cooperatives and engage markets as collective units. This arrangement was noted to work and benefit farmers more in the late 1980s when World Neighbours East Africa negotiated a tripartite business model of itself as a trainer and loan giver, farmers as honey producers, and the private sector as buyers and market guarantors (Waswa et al., 2014**)**.

Table 5: Descriptive statistics of harvested and sold quantities

Descriptive statistics	Mean	Std. Deviation	N
Quantity Harvested (kg)	83.53	39.578	15
Quantity Sold (kg)	60.67	25.903	15
Income (KES)	15,166.67	6,475.687	15

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Table 6: Pearson Correlation of honey quantities harvested, sold and income

		Quantity Harvested (kg)	Quantity Sold (kg)	Income (KES)
Quantity Harvested (kg)	r	1	0.920**	0.920**
	Sig. (2-tailed)		0.000	0.000
	N	15	15	15
Quantity Sold (Kg)	r	0.920**	1	1.000**
	Sig. (2-tailed)	0.000		0.000
	N	15	15	15
Income (KES)	r	0.920**	1.000**	1
	Sig. (2-tailed)	0.000	0.000	
	N	15	15	15

***. Correlation is significant at the 0.01 level (2-tailed).*

Similarly, a working partnership between farmers in Transzoia East Kenya and Honey Care Africa seemed to give farmers a head-start in modern apiculture (Bett, 2017). However, honey quality in this area was undermined by common pests like rodents, ants, mites and beetles, which ate and contaminated the honey while still in the hives. This situation reinforces the need for capacity and competence development in modern and commercial production of beekeeping.

A cross-tabulation of household income sources and total monthly earnings showed that apiculture was the main source of income for most of the respondents (51.2%), followed by animal and crop production at 29%. Very few respondents drew their monthly income from salaries (14.5%) and remittances (5.5%) respectively (*Table 7*). Moreover, most of the respondents (37.7%) belonged to the monthly income bracket of KES 10001-20000 (i.e., approx. USD 100-200), followed by 24.3% who belonged to the KES 20001-30,000 (i.e., approx. USD 200-300) monthly income bracket. The Chi-Square statistic suggests that there was a significant association between sources of income and monthly earnings. These results suggest that investments in developing the apiculture sector will likely be well received by the community. When it comes to reasons for investing in apiculture, the majority of the respondents singled it out as a source of income that supplemented other farming activities, besides being more cost-effective than tilling the land (*Table 8*).

Table 7: Cross-tabulation of household income sources and total monthly earning

Monthly Earning	Sources of Household Income				Total
	Animal and crop production	Apiculture	Salary /Wages	Remittances	
2001-5000	7.12	0.00	0.00	0.00	7.12
5001-10000	1.85	10.03	0.00	1.85	13.72
10001-20000	7.39	23.22	5.28	1.85	37.73
20001-30,000	6.07	7.12	9.23	1.85	24.27
30001-40000	6.33	10.82	0.00	0.00	17.15
Total	28.76	51.19	14.51	5.54	100

n=379; Calculated $\chi 2 = 157.91$; Critical $\chi 2 = 21.03$ ($\alpha = 0.05$), df = 12

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Table 8: Reasons why farmers practice apiculture

Reason	Frequency	Valid %	Importance Rank
1. Is a sure source of income	59	30.4	1
2. Is a source of food	13	6.7	5
3. To supplement other farming activities	58	29.9	2
4. Is more cost-effective than tilling land	46	23.7	3
5. Conserves the environment	18	9.3	4

That only 6.7% viewed apiculture as a source of food could mean that the mindset on food security is still tilling and cultivating the land and not through purchasing food using income generated from various off-farm sources, including bee farming. Awareness creation to reverse such a mindset is needed to secure the well-being of households and reduce pressure on land whose resilience is already constrained by natural factors like persistent droughts. A similar approach is needed to help farmers appreciate apiculture as a land-use system that conserves the environment through reduced land perturbations and exposure to erosion risks. Overall, the consensus from the focus group discussions showed that diligent beekeepers in the sub-County were more food secure throughout the year, unlike those who relied on crop and or animal farming alone.

According to the Strategic Integrated Value Chain Action Plan 2017-2022 of West Pokot County in Kenya, farmers using the traditional or the Kenya Top Bar Hive (KTBH) enjoy only two harvesting seasons in a year (i.e., March to May and September to December). On average, each hive produces 10 kg of crude honey, whose farm-gate price ranges from Kenya shillings 250-300 (USD 2.5 to 3) per kilogram, contingent on seasonal (E4Impact 2019). With 50 hives per household, 500 kg of honey can be expected per harvest, hence 1000 kg per year, fetching approximately US $2000 (KES 200,000 per year). This amount is much higher than what maise cropping can fetch in the same period. To earn higher incomes, some producers carry out semi-processing, which entails sieving out wax and brood, then sell the semi-processed honey at a price of between Kenya shillings 300- 400 (USD 3-4) per kilogram. The sieved-out residue is either washed to get wax or brewed to make a local brew. Wax collected is sold at a price of between Kenya shillings 80-100 (approx. 1 USD) per kilogram.

A farmer in Kajiado County (also an arid and arid region) uses the Langstroth hives and affirms that farmers can enjoy up to 4 harvests in a year because, with this kind of hive, the comb is not destroyed (*Personal Communication, 2022*). Only honey is extracted, and the comb is returned for the bees to refill them. The yield for the standard hive ranges from 8-12 kg. In a year, a farmer can harvest 32-48 kg. At a farm gate price of Kenya shillings 500 (5 US $), a farmer can earn on average KES 20,000 (200 US $) per hive per year. Therefore, with 50 standard hives and good apiculture husbandry, a farmer can earn US $ 10,000 per year (i.e., approx. Kenya Shillings 1,000,000, which translates into KES 83,000 per month). In comparison, FarmBiz Africa (2000) observed that farmers growing early maturing varieties of maise in dryland ecosystems could harvest up to 10-15 bags of 90 kg bags per acre of land per season. In the typical two rainy seasons, 20-30 bags are feasible but not guaranteed due to unpredictable drought. As of September 2022, the National Cereals and Produce Board set the price of a 90 kg bag of maise in Kenya at KES 3000 (US $ 30) (Kenya News Agency, 2022). Locality-specific and time-bound commodity prices can be tracked on the Soko Directory (2008). A farmer who sells all the maise produce in a year, i.e., 30 bags (though very unlikely), would earn US $ 900 (KES 900,000). Based on land area in use, production risks faced, and overall environmental benefits expected, there is no doubt that bee farming can put much more money in the hands of farmers

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than traditional crop farming and livestock production does. Extension service needs to invest in the promotion of apiculture, the need to tap into the huge international market for hive products, and the need to increase the number of hives per household. At a spacing of 3m between hives, 1/8th of an acre can accommodate 50 hives. With a steady supply of income, food security without or with very minimum pressure on already vulnerable drylands can be guaranteed. As a result, much of households' land remains naturally undisturbed, which enhances its resilience, thus contributing to efforts towards land degradation neutrality.

Challenges Facing the Adoption of Apiculture

Overall, constraints faced in the honey value chain development initiative in Kenya's semi-arid lands include inadequate access to modern hives and accessories, poor beekeeping practices, limited access to credit, unethical marketing practices, and limited access to market information. These constraints or challenges were also similar in Kathonzweni in Makueni. Based on a Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree), the respondent strongly agreed with the statement that prolonged dry season affected beekeeping, as evidenced by a mean score of 1.88 and a standard deviation of 1.04 (*Table 9*). This assertion also underscores the impact of climate change on water availability and flora quality, which are critical in making hive products. The second most important challenge was the lack of sensitisation by the extension service of the community on beekeeping, with a mean value of 2.03.

Other less important challenges included a poor market for honey and hive products, difficulties in harvesting honey and declining availability of nectar harvesting trees at mean values of 3.68, 3.89 and 3.97, respectively. This implies that farmers are aware of the huge market potential of hive products and the ecological suitability of the area for bee farming and are generally competent when it comes to harvesting honey. In terms of improved livelihoods, the challenge to overcome is how to exploit the huge market potential, both locally and internationally. With targeted commodity-based extension, bee farming stands out as a feasible and viable livelihood option whose multiplier effects on community development and environmental health cannot be overemphasised.

Table 9: Challenges facing Apiculture in Kathonzweni Sub-County (n = 379)

Challenge	Min.	Max.	Mean	Std. Dev.	Rank
1. Poor local market for honey and hive products	2.00	5.00	3.68	1.10	6
2. Lack of skills in beekeeping	1.00	5.00	2.56	1.31	5
3. Expensive Beehives	1.00	5.00	2.35	0.99	3
4. Prolonged dry season	1.00	4.00	1.88	1.04	1
5. Menace of Honey Badgers	1.00	4.00	2.25	1.09	4
6. Honey harvesting is difficult	2.00	5.00	3.89	0.99	7
7. Poor extension on beekeeping	1.00	4.00	2.03	0.92	2
8. Declining tree cover	2.00	5.00	3.97	1.00	8

The opinion of the unavailability of tree species for nectar collection is indicative of the rampant harvesting of inherent indigenous trees like the acacia family for charcoal burning. This trend can be reversed by demonstrating that the same income drive causing deforestation can be realised through commercialised bee farming. In terms of the quality of honey harvested, responses from key informants and from focus group discussions identified poor harvesting methods, which resulted in the mashing of honey, pollen, honeycombs and dead bees; and excess smoking, which changes the flavour of honey, was a major drawback. Lack of processing

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machines and poor storage methods were also of concern.

When asked why farmers in the study area found it difficult to practice beekeeping, 74% blamed it on expensive beehives, 48% blamed it on a lack of skills in beekeeping, and 39% attributed it to a lack of readily accessible markets for honey and hive products. About 15% blamed it on lack of awareness, while 9% thought that tilling of land still gave better income than beekeeping. It is the cost factor that brought about the tripartite arrangement with World Neighbours East Africa and already alluded to in the preceding sections. Although not mentioned, it is also possible that the phobia of bees as dangerous insects was an intrinsic factor limiting the adoption of this practice. This aspect only requires training on safety in apiculture to be diffused.

The cost of a modern beehive averages KES 5000 (US $ 50), and imported ones cost as much as KES 10000 (US $ 100). To break even and begin making profits as a supplier of raw honey, a farmer needs a minimum of 25 such hives, hence KES 125,000 (US $ 1250). Compared to the cost of living in Kenya, this figure is high and generally out of reach for the majority of farmers (Affognon et al., 2015**).** Financial assets that significantly influence the adoption of beekeeping are farmers' income, savings and access to credit. Access to credit eases the production and marketing processes by facilitating the purchase of tools, equipment, packaging materials and transport to the market. Lack of start-up capital to buy beehives, inefficient technologies, inadequate knowledge, environmental depletion, and low production are some of the major constraints negatively affecting the adoption of apiculture by prospective beekeepers.

Honey Quality

In terms of honey quality, laboratory analysis showed that physicochemical properties from six out of ten samples studied were within the European Commission Standards (FAO/WHO, 1981; Bogdanov et al., 1999). For the four (40%) that failed the test, moisture was low, with an average value of 8.73%, while the hydroxymethylfurfural content of between 5.16 and 19.83 mg/kg was quite low (*Tables 10*). This is a pointer to the need to train farmers on honey quality control along its value-chain stages. Overall, honey produced in this sub-County showed fairly good quality characteristics and can be further improved through proper capacity and competence development in apiculture as an enterprise within the farming community. Other studies have also shown that Kenyan honey produced locally can tap into the existing regional and international markets based on their quality which can be attributed to their botanical origin, which should be an incentive for the conservation of bee floral sources like the acacia tree (Nganaga et al., 2013; Warui et., 2019**).**

Table 10: Physicochemical analysis of Kathonzweni honey (N=10)

Quality Parameter	Mean value	Min–Max values	Limits of International Honey Standards[3]	Samples exceeding the limits of EU standards
HMF[1] mg/1000g	14.23	5.17 – 19.83	Max.40	not detected
Moisture content (%)	8.7	7.3-9.9	Max. 20	not detected
Free Acidity (mg/kg)	46.67	30.64 – 53.01	Max. 50	3 samples
Sugar[2] content (%)	91.26	89.80 – 92.66	Min. 60	Not detected
pH at 23.5^{0}C	3.8	3.4-4.2	3.9	4 samples

Notes: *[1]Hydroxymethylfurfural; [2]Fructose and Glucose combined; [3]International honey standards are specified in a European Honey Directive and in the Codex Alimentarius Standard for Honey. Quality analysis done at Kenya Bureau of Standards is based on the international honey standards are specified in a European Honey Directive and in the Codex Alimentarius Standard for Honey.*

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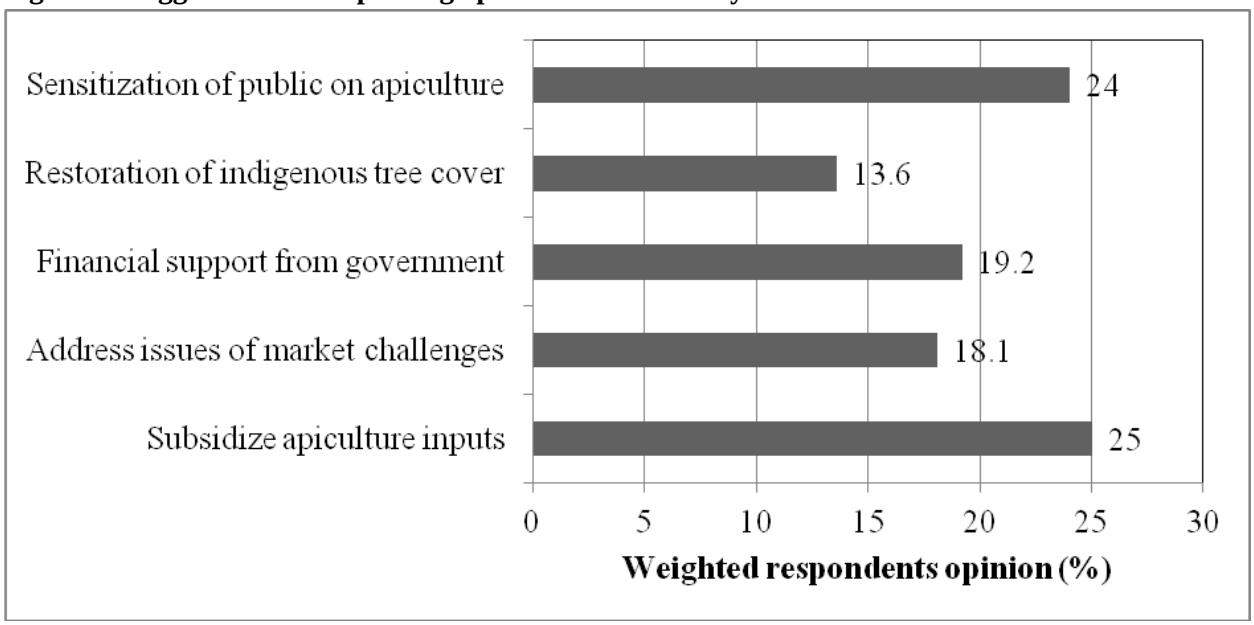
Only diastase activity and Hydroxymethylfurfural (HMF) proved to be the only possible criteria to discriminate between samples which satisfied and those that did not satisfy the minimum standards. Muli et al. (2007) showed that traditional honey harvesting and processing methods did not seem to have negative effects on the major honey constituents. However, excessive smoking during harvesting compromised the aroma and flavour of some samples. Essentially, Kenyan honey can sale on the international market. Exploiting this potential could help improve the income levels of households in dryland ecosystems, where crop farming is often constrained by water scarcity.

Scaling-out Apiculture as a Land Use Option Designed for the Environment

About 25% of the respondents suggested that the prices of apiculture resources such as beehives needed to be subsidised. Another 24% felt that the general public should be sensitised on the benefits of apiculture. Other recommendations given included the need to have a more readily available market (18.1%), accessing financial support from the government (19.2%) and afforestation initiatives (13.6%) (*Figure 1*). The consensus from the focus group discussions pointed to local producers' desire to acquire honey extraction machines in order to improve the quality of honey and reduce costs in the long run. They also advocated for good coordination in the marketing of honey and other hive products. No mention was however made of the potential in other hive products like propolis, pollen, royal jelly, and bee venom. This observation underscored limited knowledge on the part of respondents on other potentially lucrative benefits from apiculture. This pointed to poor public extension services.

Figure 1: Suggestions for improving apiculture in the study area



The apiculture value chain (*Figure 2*) provides many opportunities where-in the extension service and other agencies like the Kenya Forest Service could use as entry points for livelihood diversification and environmental management. The following interventions merit consideration when planning for the future of apiculture in Kenya

- The guiding ethos should be "apiculture for resilient ecosystems".
- A multi-agency partnership involving farmers, extension service, private sector, and local administration to facilitate farmers to procure requisite bee farming infrastructure like the

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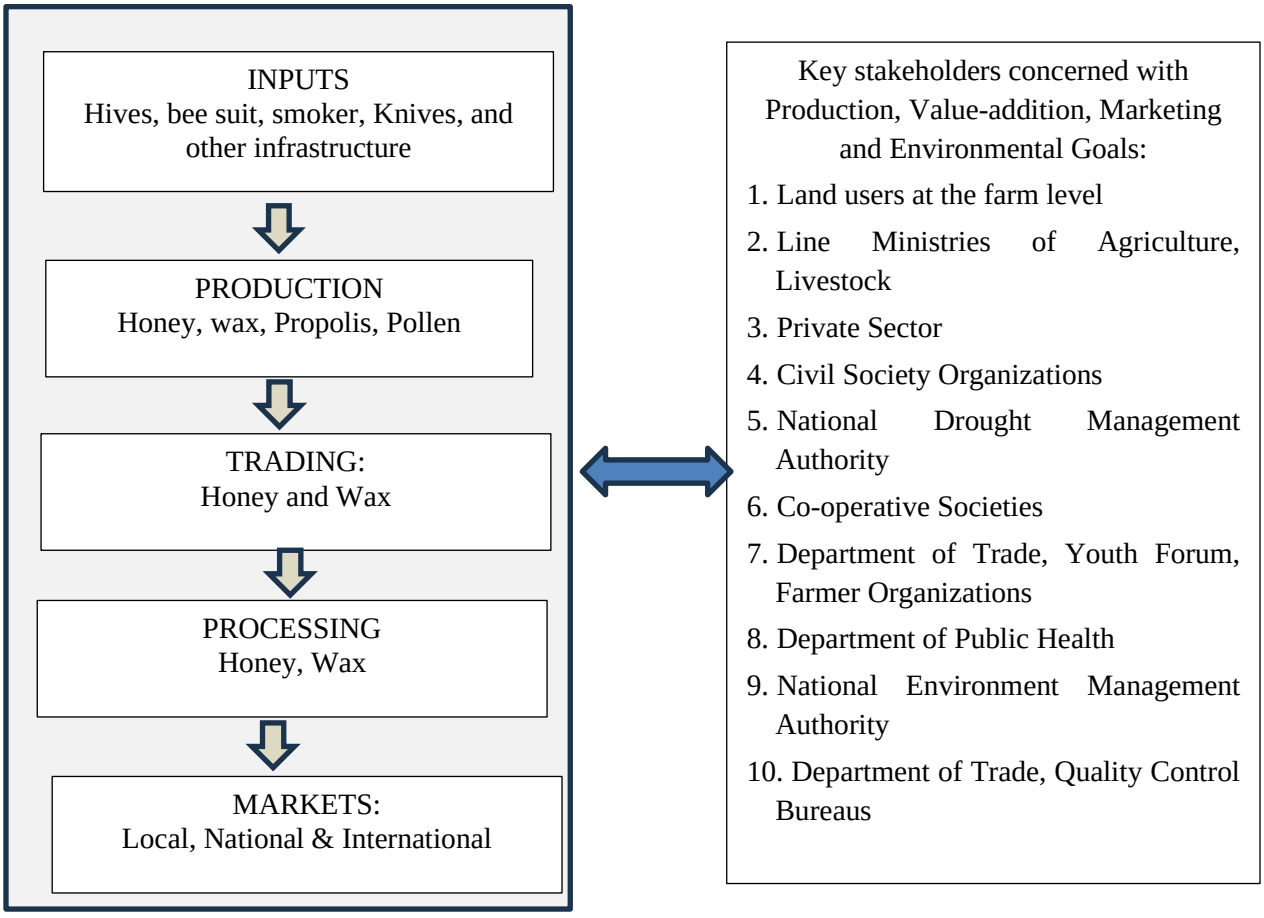
recommended Langstroth beehive that can afford farmers four harvests per year.

- Orderly trading of raw honey would require guidance provided by the Department of Trade. Farmers would be able to determine competitive prices if they worked within farmer organisations or cooperatives.
- To maximise financial returns to farmers, there is a need to invest in honey processing and extraction of by-products. The initial high-cost calls for resource mobilisation through collective effort.
- For trading, the national and county governments need to create and sustain a conducive environment that allows farmers to benefit from apiculture and thus prevent a fall back to intensive land use practices like cropping, its risk of land degradation notwithstanding.
- Continuous improvement at all stages in the value chain requires financial capital that could be available from banks and other lending institutions.
- Conserving land and maximising financial benefits through alternative livelihood practices should be the rallying motto championed by the extension service, Kenya Forest Service, and the National Drought Management Authority, among others.

Figure 2: A Simplified Apiculture Value Chain and key stakeholders.



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CONCLUSIONS AND RECOMMENDATIONS

Although apiculture exerts considerably low pressure on land while being more beneficial than conventional small-scale crop and livestock production systems, its popularity is still relatively low in dryland ecosystems in Kenya. This is attributed to, among others, minimum awareness of its potential within local farming communities, under-developed local markets, and recurrent and more persistent droughts. The local supply of honey is thus still very low. Most households still rely on high-risk crop farming for their livelihoods. The few committed beekeepers were, however relatively more food secure than those who did not practice beekeeping. Instead of struggling to raise maise on an acre piece of land, the risk of crop failure notwithstanding, a farmer can successfully install 50 Langstroth beehives on an eighth of an acre and deliver a substantial amount of income for household food security through purchases only. With much effort directed at "off-farm" income generation, only small portions of land may be set apart as kitchen gardens while leaving the rest fallow perpetually, thus effectively reducing pressure thereto. As a result, the risk of land and vegetative degradation is reduced, which ultimately enhances the resilience of land as trees become the dominant cover with time.

Since the quality of the local honey met the recommended international standards, apiculture can be developed into an alternative and reliable land use practice in the drylands. The extension service in partnership with other stakeholders, should, however, be intentional in fixing the key challenges undermining this industry, thus: the low sensitisation of the farmers on the potential of beekeeping as an alternative income source, high prices of beehives and their accessories, the uncoordinated market for honey and hive products, and lack of adequate skills in beekeeping. Farmers who accept that food security can be achieved through purchases and not only by tilling the land are better placed to overcome the challenge of poverty in the drylands.

A multi-agency approach involving farmers, the county extension services, the national drought management authority, the private sector, civil society, and faith-based organisations is required to promote bee farming as an alternative yet reliable, sustainable land management practice in dryland ecosystems.

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AUTHOR CONTRIBUTIONS

Caroline Mutua did the primary research during her Master's study program at Kenyatta University. Fuchaka Waswa was the main supervisor to Caroline Mutua. Mwamburi Mcharao assisted with quantitative data analysis. All authors reviewed the drafts of the paper and approved its submission to the journal.

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