ASSESSMENT OF COOPERATIVE INTERVENTIONS ON BEEKEEPING, HOUSEHOLD INCOMES AND FOREST CONSERVATION: A CASE OF KAMAKI FARMERS' COOPERATIVE SOCIETY IN KITUI COUNTY, KENYA

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DECLARATION

I understand that plagiarism is an offense and I therefore declare that this research thesis is my original work and has not been presented to any other institution for any other award.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	:	Arid and Semi-Arid Lands
CDPO	:	Community Development Programme Officer
FAO	:	Food and Agriculture Organization
FAOSTAT	:	Food and Agriculture Organization Corporate Statistical Database
GoK	:	Government of Kenya
HDI	:	Human Development Index
IUCN	:	International Union for Conservation of Nature
KAMAKI	:	Kalivu, Athi, Maluma, Kasaala and Ikutha
KCIDP	:	Kitui County Integrated Development Plan
KNBS	:	Kenya National Bureau of Statistics
KTBH	:	Kenya Top Bar Hive
MOALFC	:	Ministry of Agriculture, Livestock, Fisheries and Cooperatives
NEMA	:	National Environment Management Authority
NGOs	:	Non-Governmental Organizations
NPC	:	National Planning Commission of Ethiopia.
NRM	:	Natural Resources Management
PDR	:	People's Democratic Republic
SNV	:	Netherlands Development Organization
TEK	:	Traditional Environmental Knowledge
UNCOMTRADE	:	United Nations Conference on Trade and Development
UNDP	:	United Nations Development Programme
WCA	:	West and Central Africa

DEFINITION OF SIGNIFICANT TERMS

Cooperative Interventions: This refers to actions, programmes, or initiatives implemented by cooperative societies to support and enhance the productivity, sustainability, and economic outcomes of their members. In the context of beekeeping, these may include training, financial support, provision of equipment, and market access (Borgen *et al*., 2020).

Beekeeping: This involves the practice of maintaining bee colonies, typically in man-made hives, for the purpose of harvesting products such as honey, beeswax, propolis, and royal jelly. It also involves the management and care of bee populations to ensure their health and productivity (Groot *et al*., 2023).

Household Incomes: This includes the total earnings received by all members of a household from various sources, including wages, salaries, agricultural activities, business profits, and remittances. It reflects the financial well-being and economic stability of a household (World Bank, 2023).

Forest Conservation: This refers to the practice of managing and protecting forest ecosystems to maintain their biodiversity, health and productivity. It involves sustainable management practices to prevent deforestation, degradation, and to promote the restoration of forests (FAO, 2023).

KAMAKI Farmers': Cooperative Society
This refers to a specific cooperative society based in Kitui County, Kenya, which provides support and services to local farmers, including beekeepers. The cooperative aims to improve agricultural practices, enhance productivity, and promote sustainable development among its members (Muthoni & Kilonzo, 2023).

Kitui County, Kenya:
A region in southeastern Kenya known for its agricultural activities, particularly beekeeping. It has favorable conditions for beekeeping due to its expansive lands, rich bee forage flora, and a tradition of honey production (Wambua *et al*., 2023).

ABSTRACT

This study assesses cooperative interventions on beekeeping, household incomes and forest conservation in KAMAKI, Kitui County, Kenya, a leading honey-producing region. The objectives were to determine awareness level among beekeepers on the direct link between forest conservation and beekeeping, assess the contribution of beekeeping to household income and examine the effects of KAMAKI cooperative interventions on honey production, household income and forest conservation. Data were collected from 215 households through purposive sampling, Focus Group Discussions, Key Informant Interviews, and field observations. Descriptive statistics, ANOVA and Pearson correlation were used for analysis. The findings revealed high awareness of the forest-beekeeping link, with significant differences in awareness levels among respondents (F = xyz, df = a, b, $P > 0.005$, $P > 0.001$). The study identified three types of beehives used for honey production and income generation: Log hives, Langstroth hives and KTBH. Respondents using Log hives produced an average of 9.5 kg of honey per hive, earning KES 2,400 per hive. Those using Langstroth hives produced an average of 8.7 kg per hive, with an income of KES 2,190 per hive. Trained beekeepers (157) using Log hives produced an average of 10.31 kg per hive, generating KES 53,267 per hive, while untrained beekeepers (58) produced 5.36 kg per hive, earning KES 12,716. For Langstroth hives, trained beekeepers (157) averaged 9.5 kg per hive, with an income of KES 4,153, while untrained beekeepers (58) produced 6.76 kg per hive, generating KES 3,517. Additionally, trained beekeepers (73.4%) contributed more to forest conservation than untrained farmers (26.5%). The study recommends prioritizing beekeeping training, adopting advanced technologies, integrating forest conservation education, and continuous monitoring of cooperative interventions to ensure sustainable development.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Beekeeping is a significant economic activity worldwide, with an estimated annual honey output exceeding 1.7 million metric tonnes (FAOSTAT, 2021). Major honey producers include China, which leads with over 485,960 tonnes annually, followed by Turkey, Iran, Argentina, and Ukraine (FAO, 2021). The evolution of modern apiculture techniques dates back to 18th-century Europe, where the development of mobile comb hives enabled honey harvesting without destroying colonies. European immigrants introduced these innovations to North America, where beekeeping thrived. Beekeeping contributes not only to livelihoods but also to forest conservation, with honeybees playing a critical role in pollination services (UNEP, 2022). Despite its global importance, traditional beekeeping methods remain prevalent in many regions, particularly in Africa, where the activity is both a source of income and a contributor to biodiversity conservation (Bunde *et al*., 2016; Keiyoro *et al*., 2016).

Beekeeping also holds considerable potential in rural development. Its low maintenance requirements and compatibility with sustainable agricultural practices make it a viable livelihood activity in developing countries (Infonet Biovision, 2021). The global beekeeping sector is increasingly aligned with Sustainable Development Goals (SDGs), particularly Goals 1 (poverty reduction) and 2 (zero hunger), emphasizing sustainable agriculture and food security (UNEP, 2022).

In Africa, beekeeping is deeply intertwined with rural livelihoods and forest conservation. Countries such as Zambia, Ethiopia, Tanzania, and Cameroon have incorporated beekeeping into forest management strategies. For example, forest-based beekeeping in Zambia involves over 40,000 individuals utilizing 60,000 hectares of forest, contributing significantly to household incomes (Dan, 2014-2016). In Ethiopia, honey production serves as a primary income source, with the number of hives often regarded as an indicator of wealth (Van *et al*., 2004; Endalamaw, 2005). Similarly, in Cameroon, honey constitutes over half of household income for thousands of beekeepers (Ingram and Njikeu, 2011).

Beekeeping's role in forest conservation in Africa is highlighted by projects in regions like Kilum-Ijim in Cameroon, Inyonga Forest in Tanzania, and Mount Elgon in Uganda. These initiatives demonstrate the dual benefits of beekeeping in enhancing livelihoods and promoting sustainable forest use (Hausser and Savary, 2002; IUCN, 2012). Despite its potential, the scientific understanding of the precise relationship between beekeeping and forest conservation remains underexplored, necessitating further research to bridge this gap (Mickels-Kokw, 2006; Bradbear, 2009).

African landscapes present significant opportunities for honey and beeswax production, with minimal chemical contamination compared to other regions, making them attractive for organic and fair-trade markets (Shackleton *et al*., 2007; Muli *et al*., 2014;). However, challenges such as outdated techniques and limited resources hinder the full realization of this potential (Kalanzi *et al*., 2015; Kuboja *et al*., 2017).

In Kenya, beekeeping is a vital economic activity, particularly in arid and semi-arid regions (ASALs), which account for 80% of honey production (KIPPRA, 2019). The country produces over 25,000 metric tonnes of honey annually, with significant contributions from regions like Baringo and Makueni Counties (Baringo County Government, 2023; Makueni County Government, 2022). Despite this, only 20% of Kenya's potential in honey and beeswax production has been exploited (KIPPRA, 2019). Traditional log hives dominate, limiting productivity, but initiatives promoting modern beekeeping methods have shown promise in increasing yields and incomes (Kiprono *et al*., 2021).

Beekeeping aligns with Kenya’s Vision 2030 by contributing to poverty reduction, job creation and environmental conservation. Additionally, the enterprise supports Sustainable Development Goals (SDGs) through pollination services that enhance crop productivity and ecosystem health (ICIPE, 2019). However, barriers such as limited access to modern equipment, training and extension services hinder the adoption of modern apiculture practices (Chelagat, 2022). Addressing these challenges is critical to unlocking the sector's potential and enhancing its contributions to national development goals.

The current study focused on five (5) administrative wards within South-east region of the county that are actively involved in honey production. The wards Kalivu, Athi, Maluma, Kasaala and Ikutha collectively make up the acronym "KAMAKI". The study area also constitutes amalgamated communities within the five operating areas of KAMAKI Farmers' Cooperative Society (https://kamaki.or.ke/). These areas are typical semi-arid environments and beekeeping is an essential component of the farming communities. The majority of households in these areas keep bees mainly for income generation and household consumption, but also for the benefits bees offer as important components of biodiversity ultimately promoting sustainable forest conservation.

For the past fifteen (15) to twenty (20) years, the KAMAKI Farmers' Cooperative Society has been operating in KAMAKI. Its goals include educating small-scale farmers about the diverse opportunities that beekeeping offers as well as providing technical trainings on improved beekeeping activities and technologies, fostering relationships and trust between beekeepers and honey traders, marketing honey and offering information and training on technical and business management issues related to beekeeping. This ensures that the KAMAKI beekeepers are exposed to modern beekeeping, possess beekeeping skills that led them to be more resilient to shocks, seasonality and stressors enabling them to produce adequate honey yields that generate income opportunities without exacerbating environmental degradation, enhancing forest conservation, crop production and improving the profitability of bee products and services in the present and future. This study seeks to assess cooperative interventions in beekeeping, household incomes and forest conservation, providing insights into how this activity can be harnessed to achieve broader development and conservation objectives for farmers within the KAMAKI farmers' cooperative framework.

1.2 Statement of the problem

The study investigates a critical issue facing beekeeping communities across KAMAKI areas, the need to evaluate the effectiveness of cooperative interventions in enhancing beekeeping practices, increasing household incomes and promoting forest conservation. Specifically, the KAMAKI Farmers' Cooperative Society, operating across various KAMAKI locations, has implemented numerous programmes aimed at addressing the challenges faced by beekeepers in its operational areas. These initiatives include the introduction of improved beekeeping technologies such as Kenya Top Bar Hives (KTBH) and Langstroth hives, capacity-building programs on colony management, pest control, and honey harvesting, as well as facilitation of market linkages for hive products. Additionally, the cooperative supports sustainable practices to conserve forest ecosystems, which are vital for successful apiculture.

Despite these concerted efforts, there remains a significant gap in evidence-based data on the tangible impacts of these interventions. It is unclear to what extent the KAMAKI cooperative's initiatives have influenced honey production, improved household incomes, or contributed to forest conservation within the KAMAKI beekeeping communities. This lack of empirical data underscores the need for a comprehensive assessment to understand the effectiveness of the cooperative's strategies and their alignment with broader goals of economic empowerment and environmental sustainability.

This study was motivated by the pivotal role played by the KAMAKI cooperative of beekeeping in enhancing rural livelihoods, the significant economic potential of honey production, and the vital ecological importance of forest conservation. It was undertaken to address the existing knowledge gap in understanding the impacts of cooperative interventions on these interconnected aspects. By assessing the impacts of the KAMAKI Farmers' Cooperative Society's interventions, the research seeks to provide insights into how cooperative-driven programmes can enhance the socio-economic and environmental outcomes of beekeeping communities. This investigation is particularly relevant for shaping future policy, refining cooperative strategies and ensuring sustainable development in the beekeeping sector.

1.3 Justification of the study

Beekeeping is a vital livelihood strategy in arid and semi-arid regions, offering rural farmers a sustainable source of income due to its relatively low capital, labour and time requirements (Kihwele *et al*., 2001; Ngaga *et al*., 2005). Cooperative interventions enhance agricultural enterprises by fostering collaboration, improving resource access, and addressing systemic challenges such as poverty and market inefficiencies. These interventions play a critical role in promoting food security, increasing household incomes, improving honey production efficiency, and contributing to forest and biodiversity conservation (Bernard *et al*., 2008; IUCN, 2012). Specifically, cooperatives engaged in beekeeping, such as the KAMAKI Farmers' Cooperative Society, empower smallholder farmers by providing access to improved technologies, training and organized marketing platforms. Such efforts reduce transaction costs, enhance product value and contribute to the conservation of forest habitats essential for beekeeping success (Williamson, 1979). This aligns with global and national development priorities, including the United Nations Sustainable Development Goals (SDGs) (Patel *et al*., 2021; Prodanović *et al*., 2024).

Despite the potential of cooperative interventions, their specific impacts on beekeeping, household incomes and forest conservation in arid and semi-arid areas remain underexplored. This study seeks to address this gap by assessing the role of the KAMAKI Farmers' Cooperative Society in Kitui County, Kenya. The research will evaluate how cooperative support influences honey production, marketing dynamics, and household economic outcomes, as well as its contributions to forest and biodiversity conservation.

The findings will offer evidence-based insights to governmental and non-governmental organizations for planning and implementing beekeeping projects in resource-constrained regions. By examining the interplay between advanced beekeeping technologies, training and habitat preservation, this study will provide practical recommendations for enhancing honey yields, household incomes and environmental sustainability. Furthermore, it will assess the broader contributions of cooperatives in strengthening Kenya's honey industry and promoting sustainable livelihoods in semi-arid regions.

Academically, this research will enrich the body of knowledge on apiculture and cooperative models, serving as a valuable baseline for future studies. By highlighting the potential of cooperative interventions in fostering sustainable development, the study underscores their relevance in achieving socio-economic and environmental goals in arid and semi-arid ecosystems.

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of the study was to assess cooperative interventions on beekeeping, household income and forest conservation.

1.4.2 Specific objectives

The specific objectives of the study were as follows:

i. To determine awareness levels among beekeepers on the link between forest conservation and beekeeping in the study area.
ii. To assess the contributions of beekeeping on household incomes in the study area.
iii. To examine KAMAKI Farmers' Cooperative Society interventions on honey production, household incomes and forest conservation in the study area.

1.5 Limitations of the Study

The limitations of the study were defined by its academic scope and the geographical context of the research area. Notable challenges included language barriers, poor road infrastructure and inadequate financial resources. Language constraints were effectively addressed by engaging local stakeholders, including members and staff of the KAMAKI Farmers' Cooperative Society, who were fluent in the local language and familiar with the study area. Additionally, the poor road network was mitigated through the use of cost-effective transportation options such as motorcycles, enabling access to remote study sites. Financial limitations were carefully managed through prudent allocation of resources, ensuring the study's objectives were achieved despite the constraints.

Efforts by the National and County governments in Kitui County to enhance road infrastructure provide further prospects for improving access to the region. These developments are anticipated to facilitate the efficient delivery of honey from production sites to the KAMAKI honey market, supporting the long-term goals of the cooperative. Throughout the study, the involvement of village elders, extension officers, and cooperative representatives was instrumental. Their contributions provided critical qualitative and quantitative data, enriching the study and reinforcing its findings with local insights and contextual accuracy.

1.6 Scope of the study

This study was geographically confined to the operational areas of the KAMAKI Farmers' Cooperative Society within Kitui South sub-county, one of the eight sub-counties in Kitui County. To ensure data validity, respondents were specifically selected from KAMAKI cooperative beekeepers' record, key livestock cooperative field officers and the Community Development Programme Officer (CDPO).

The academic scope of the study included three primary objectives: determining the awareness level among bee farmers regarding the link between forest conservation and beekeeping, assessing the contributions of beekeeping on household incomes and evaluating the effects of KAMAKI Farmers' Cooperative Society's interventions on honey production, household incomes and forest conservation. The study analyzed socio-economic characteristics such as age, gender, income level, household size, beekeeping experience, occupation and education level. It also gathered data on the number and types of hive technologies used, honey production yields and income contributions from honey-related products among both trained and untrained beekeepers.

1.7 Assumptions of the study

This study assumes the reliability of the records maintained by the KAMAKI Farmers Cooperative Society, as well as the accuracy of the respondents' interpretations of the questionnaire. It is further assumed that the KAMAKI cooperative's beekeepers' records are dependable, and that the staff responsible for contacting the beekeepers enjoy the trust and confidence of the cooperative members. Additionally, it is assumed that the respondents provided honest and voluntary responses to the study's questions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter is focused on review of earlier research on the contribution of beekeeping to household incomes, livelihoods, honey production and forest conservation at the local, national, regional and worldwide levels. Previous peer reviewed research articles and technical research, books and journals and other sources provided the data on literature of this study. A review of the literature was conducted to identify any knowledge gaps in relation to the study.

2.2 Theoretical Perspectives and Empirical Investigations: Contributions of Beekeeping to Forest Conservation

Globally, sustainable development necessitates a deliberat**e** effort by individuals to make informed decisions, plan effectively, and pursue viable alternatives that optimize forest resources to serve current and future human needs (Ma *et al*., 2022). Theoretical perspectives highlight that beekeeping is a sustainable development effort among smallholder farmers aimed at adapting to climate change and conserving forest biodiversity. Empirical evidence shows that bees are critical for human survival, playing a crucial role in maintaining the balance of ecosystems (Belay *et al*., 2017). Beekeeping practices promote forest conservation by increasing the population of bees and other biodiversity, which are key in pollination services and enhancing agricultural production (Brosi and Armsworth, 2008; Diriba, 2021). This symbiotic relationship significantly benefits human beings now and in the future by ensuring food security and ecological stability (Hom and Penn, 2021).

Bees are essential pollinators that contribute significantly to the reproduction of many plant species, thereby maintaining ecosystem health and food security. Theoretical perspectives emphasize the importance of pollination by bees in enhancing the yield and quality of crops, supporting agricultural economies worldwide and sustaining livelihoods (Potts *et al.*, 2016). Empirical evidence supports the economic value of honey, beeswax, and other bee products (Klein *et al*., 2007). Beekeeping fosters biodiversity by promoting the growth of plant species that depend on bees for pollination. This, in turn, supports various animal species that rely on these plants for food and habitat, creating a robust and healthy ecosystem (Garibaldi *et al*., 2013).

In Sub-Saharan Africa, rural households rely heavily on wild plant species for fruits, foods, medicines, crafts, and cultural uses. Theoretical perspectives highlight the continued productivity and population stability of many plants depend on pollinators, including bees (Maroyi, 2017). Empirical evidence shows that beekeeping supports species diversity and productivity, which is fundamental to promoting the resilience of forests or ecosystems. Bees are intricately linked to the health of forests and other ecosystems, ensuring the survival and stability of these environments (Brockerhoff *et al*., 2017; Senapathi *et al*., 2022).

Evidence from Congo, Benin, Zambia, Kenya, Ethiopia, Cameroon, and Tanzania illustrates the direct link between forest management and beekeeping. In these regions, empirical investigations show that beekeeping activities significantly contribute to forest conservation (Mala, 2009; Bradbear *et al*., 2009; Minja and Nkumilwa, 2016). In Cameroon, for instance, beekeeping contributes to environmental integrity as some beekeepers actively protect the forest. Although beekeepers do not often identify as active conservationists, their pragmatic interventions effectively protect forests, watershed catchments, and biodiversity, showcasing the indirect conservation benefits of beekeeping (Ingram and Njikeu, 2011).

In Zambia, communities involved in forest beekeeping heavily depend on income from selling honey and beeswax. Theoretical perspectives emphasize the importance of beekeeping in promoting sustainable livelihoods and forest conservation. Empirical evidence from Mwinilunga, North West Zambia, shows that 40,000 people rely on forest beekeeping, utilizing 60,000 hectares of forest, with 1,000 tonnes of honey purchased from beekeepers in 2016 (Dan, 2014-2016). This dependence highlights the significant economic and environmental benefits of beekeeping.

In Kenya, the beekeeping industry is gaining traction as it contributes to forest conservation and provides economic benefits. Theoretical perspectives emphasize the role of beekeeping in supporting biodiversity and improving livelihoods. Empirical evidence shows that rural farmers engage in afforestation activities that maintain the integrity of degraded sites and water catchment areas by planting forest trees and bee forages around these areas. This practice not only supports biodiversity but also improves the livelihood of the farmers involved. One notable example of commercial NTFP (Non-Timber Forest Product) production managed in natural forests is honey and beeswax from beekeeping in Africa's natural woodlands (Kalaba *et al*., 2013). This highlights the significant role that beekeeping plays in supporting livelihoods and promoting forest conservation, demonstrating its importance in local economies and environmental management.

2.3 Theoretical Perspectives and Empirical Investigations: Contributions of Beekeeping to Household Incomes and Livelihood Improvement

Beekeeping has emerged as a pivotal enterprise globally, intertwining environmental sustainability with economic growth (Dossou *et al*., 2021). Theoretical frameworks underscore that beekeeping is not only an environmentally friendly, non-farm venture but also a commercial activity that catalyzes local and national economic growth (Gidey and Mekonen, 2010; Ajao & Oladimeji, 2012; Hinton *et al*., 2020). Unlike many agricultural activities, beekeeping adapts to limited resources, requiring minimal land and capital, making it accessible even to marginalized rural communities. Empirical research strengthens these assertions, demonstrating how beekeeping alleviates poverty, sustains rural employment, and enhances livelihoods through its multifunctional benefits. It is a cornerstone of sustainable rural development, offering nutritional security through honey, economic stability through product sales, and ecological balance through pollination (Messely *et al*., 2007; Bradbear, 2009). Studies reveal that integrating beekeeping into rural economies provides farmers with a consistent income source despite challenges such as limited credit access (Cristina & Molly, 2015; Khun & Serey, 2024).

Theoretical perspectives assert that beekeeping is a potent driver of rural economic empowerment, particularly for small-scale and marginalized farmers. By offering opportunities for productive employment within the home environment, it enhances food security, monetary revenue, and overall economic well-being (Verma, 1990; Buzzwell, 2024). Moreover, it provides a safety net for households during agricultural off-seasons, ensuring continuous income streams. Empirical evidence highlights the broad spectrum of economic contributions from beekeeping, including honey production, pollination services, and value addition to agricultural and forestry sectors (Ahmad *et al*., 2015). Honey production alone is credited with numerous socio-economic benefits, ranging from health improvement to environmental conservation, making it a preferred income diversification strategy for rural communities (Morse and Calderone, 2000; Bradbear, 2009; Famuyide *et al*., 2014; Matias *et al*., 2017).

In Sub-Saharan Africa, beekeeping serves as a critical livelihood strategy, particularly for rural households with limited land or financial resources. Theoretical insights reveal that the practice aligns well with the subsistence economy, providing essential economic benefits without demanding extensive inputs (Duah *et al*., 2017; Joni, 2018). Empirical investigations provide vivid examples of its transformative impact. In Ethiopia, for instance, beekeeping not only supports household incomes but also promotes environmental conservation by encouraging tree preservation (Kumsa *et al*., 2014). Similarly, in Cameroon, honey production accounts for over half of household income for many families, contributing to financial stability, improved nutrition, and social cohesion without the need for significant capital investment (Ingram, 2010).

Beekeeping's dual role as an economic and environmental asset is well-documented globally. Theoretical perspectives illustrate its capacity to integrate seamlessly with sustainable agricultural practices, fostering biodiversity through pollination and reducing environmental degradation (Dossou *et al*., 2021). In developed countries, beekeeping has evolved into a lucrative enterprise, with investments in advanced apiculture practices and product diversification unlocking its full potential (Staveley, 2014). Empirical studies show that countries with well-established apiculture industries achieve better economic outcomes, such as higher export revenues from honey and related products. Comparative analyses reveal that, while beekeeping is often supplemental in Africa, it is a mainstream economic activity in Europe, backed by greater institutional support and market standardization (Kinsella *et al*., 2013; Hilmi *et al*., 2012).

Kenya boasts a rich tradition of beekeeping, deeply rooted in its cultural and socio-economic fabric. Theoretical insights emphasize its integration into traditional practices, such as dowry payments and medicinal uses, particularly among indigenous communities like the Ongiek, where honey played a vital role in food security and trade (Affognon *et al*., 2015). Empirical evidence highlights Kenya's untapped potential in honey production. Despite hosting an estimated two million hives, the country's annual production of 4,000 metric tons of honey falls far below capacity, with much of the honey sold in local supermarkets imported from neighboring Tanzania (Carroll *et al*., 2013; Gitimu *et al*., 2017). Beekeeping contributes approximately 4.3 billion shillings annually to Kenya’s economy, primarily through the commercial use of bee products such as honey, beeswax, and propolis. These products find applications in diverse industries, including pharmaceuticals, cosmetics and food production, underscoring their economic significance (Muli *et al*., 2007).

2.4 Theoretical Perspectives and Empirical Research: Contribution of Cooperatives to Honey Production and Marketing

Cooperative activity in agricultural production plays a pivotal role in the empowerment of farmers globally, contributing to both social and economic transformation. Cooperatives serve as vehicles of change, particularly in the context of agricultural marketing systems (Ijere, 1992). Despite the liberalization and globalization of trade in sub-Saharan Africa, the transformation of rural agricultural marketing systems remains sluggish. The rural markets in developing nations, such as in sub-Saharan Africa, often fail to meet the evolving demands in terms of both quality and quantity (Jayne *et al*., 2010). The challenges faced by rural highlands in various African regions, as outlined by Gabre-Madhin, (2001), include poor economic conditions, imperfect input and product markets, the high number of smallholder farmers, and elevated transaction costs, all of which hinder the efficiency of food supply chains. Further contributing to these inefficiencies are the weak institutions for market information, grading, standardization, labeling, and contract enforcement, which further disrupt the agricultural marketing process. In addition, poor infrastructure, including roads and communication, and underdeveloped monetary systems, exacerbate the situation in rural African economies (Dorward *et al*., 2007).

Theoretical perspectives and empirical investigations suggest that cooperatives can significantly enhance the development and marketing of smallholder agriculture by offering access to honey products and technology, as well as by mitigating transaction costs (Williamson, 1979; Maertens and Swinnen, 2009). Empirical studies from regions such as Eastern Europe, Africa, and Latin America indicate that cooperative contracts, which provide access to credit, inputs, better pricing, and extension services, allow honey producers to increase productivity and secure better economic outcomes (Minten *et al*., 2007; Dries et al., 2009; Maertens *et al*., 2011). Additionally, cooperatives can facilitate access to credit, often supported by the state and development partners, thus improving the economic stability of smallholder beekeepers (Key and Runsten, 1999; Bijman and Hu, 2011). The collective ownership model promoted by cooperatives, which includes farm investments and processing technologies, helps empower farmers, leading to enhanced production capacity (Hendrikse and Bijman, 2002). Marketing cooperatives, in particular, have proven influential in fostering smallholder commercialization in Kenya, Ethiopia, and Rwanda, though the benefits are often skewed towards larger farmers (Bernard *et al*., 2008; Francesconi and Nico, 2010; Verhofstadt and Maertens, 2014).

The role of cooperatives in food supply chains is widely supported by researchers and policymakers who emphasize their potential in transforming traditional agricultural practices into more modern, efficient supply chains (Abebaw and Hail, 2013). However, the impact of cooperatives on the performance of honey production and marketing among smallholder farmers remains a subject of debate. Several studies on contract farming in Ethiopia and Uganda specifically in honey and organic coffee production show positive income gains from cooperative involvement (Maertens and Swinnen, 2009; Miyata et al., 2009; Bolwig *et al.*, 2010). In these contexts, farmers have gained improved access to inputs, technology, and extension services, which has allowed them to boost productivity and income levels. In China and Uganda, for example, farmers in contract schemes have been found to be more efficient due to the extension services they receive, which enable better management of inputs, labor, and capital (Miyata *et al.*, 2009; Bolwig *et al*., 2010).

Despite the positive outcomes associated with cooperatives, many farmers struggle to access contracts, often due to their small size. In such cases, cooperatives and rural development agencies can step in to provide credit and inputs (Abebaw and Haile, 2013; Bernard *et al*., 2008). Cooperatives facilitate access to specific assets, reduce information asymmetries, and empower smallholders in the market, thus improving their ability to compete and succeed in agricultural markets (Bernard *et al*., 2008; Bijman and Hendrikse, 2003; Bijman and Hu, 2001; Blandon *et al*., 2009). Additionally, cooperatives can help lower transaction costs by offering extension services and information (Masakure and Henson, 2005), thereby fostering the adoption of new technologies (Nwankwo *et al*., 2009; Abebaw and Haile, 2013). Much of the existing literature on cooperatives focuses on high-value or modern food supply chains, such as export chains dominated by large international supermarkets or foreign direct investment (Melaku *et al*., 2008), though there is a growing body of work examining cooperative impacts in local food supply chains, particularly in Ethiopia (Dorward *et al*., 2006).

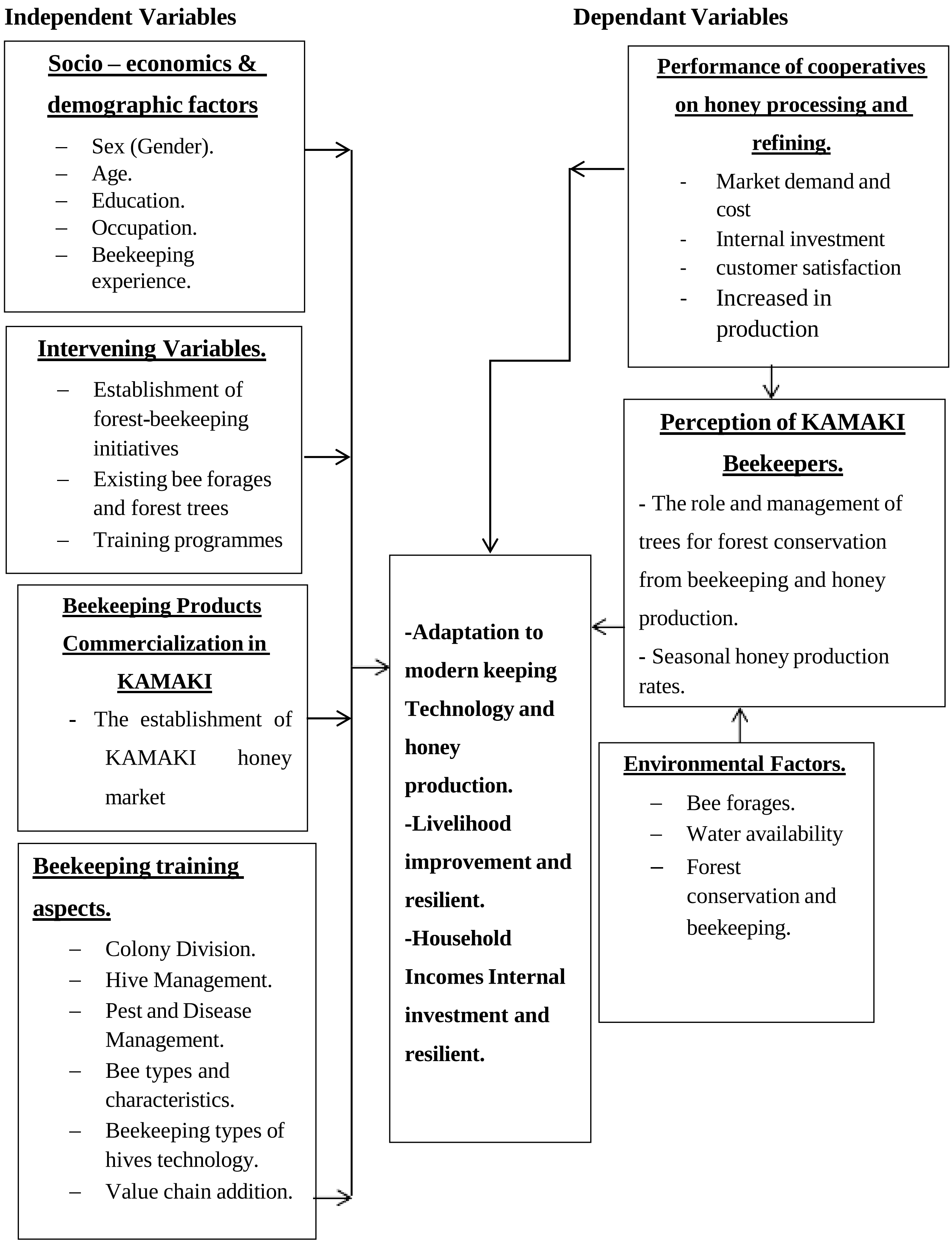
In the honey sub-sector, much of the honey is exported informally, primarily through local agents and transitory channels involving beekeepers, honey processors, and honey marketing cooperatives. These cooperatives play a crucial role in supplying honey to processing plants, either in a partially refined form or as raw honey (Beyene *et al*., 2007; Jacobo, 2017). Kenya, for example, hosts more than 30 companies engaged in the buying and processing of honey for both local and export markets (Affognon *et al.*, 2015). Beekeepers, honey and beeswax collectors, retailers, brewers, processors, and exporters form the key actors in the honey value chain, which operates through three main channels: the brewery channel, the honey processing and exporting channel, and the beeswax channel (SNV, 2009). The complexity and interconnectedness of these channels are largely attributed to the lack of organized marketing systems and formal linkages between the actors in the beekeeping sector (SNV, 2009). In Ethiopia, for instance, much of the honey produced is sold through the brewery channel, where beekeepers directly sell to local honey collectors or cooperatives, which then deliver the honey to local breweries or transport it to larger dealers for processing (Abrol, 2012; Gardner *et al*., 2017).

From the above literature review, it can be logically established that beekeeping has proven to be an alternative livelihood option with potential of providing household income security, honey production efficiency and marketing systems, contributions of cooperatives to sustainable forest conservation and beekeeping among smallholder farmers. Exploring these options in the unique context of KAMAKI Farmers' Cooperative Society operational areas could be of specific interest to many beekeeping researchers, evaluation professionals, development practitioners and development organizations working with beekeeping projects.

2.5 Research Gaps

Since the establishment of KAMAKI Farmers' Cooperative Society for over 15 to 20 years, no studies or project reviews have been carried out to evaluate the impacts of KAMAKI cooperative interventions on promoting sustainable forest management and conservation, improving honey production through training and introduction of new hive technologies and impacts of beekeeping on the livelihoods of rural communities in the KAMAKI operation areas. Similarly, information is not available on KAMAKI Farmers' Cooperative Society interventions on market access for honey products.

2.6 Conceptual Framework of the Study



CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter presents in-depth methodology used in this research. A summary of the research includes qualitative and quantitative data, information on fieldwork protocols, datasets and methods used to obtain them and the stages involved in data processing are among the primary concepts covered in this chapter. Secondary data sources such as the Kenya National Technical Reports were also used in this study.

3.2 Description of the Study Area

The research area is situated within the operational area of the KAMAKI Farmers' Cooperative Society. The acronym 'KAMAKI' represents the locations Kalivu, Athi, Maluma, Kasaala and Ikutha in Kitui County, South-Eastern Kenya. These areas are typical semi-arid regions where beekeeping plays a significant role in the local economy. Most households maintain beehives in order to generate income from honey sales. The study areas are as shown in the map below.

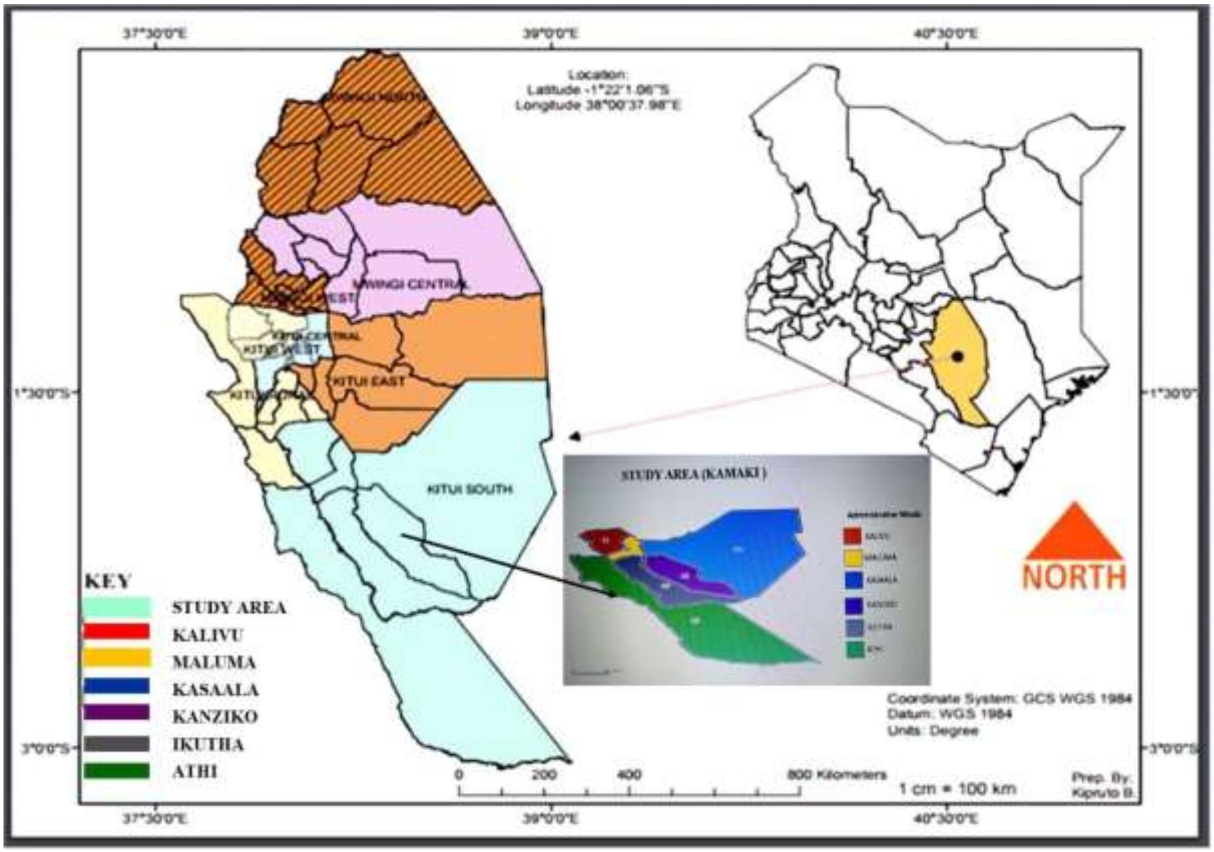


Figure 3.1*: Map showing the Study Area.*

3.2.1 Environmental Factors Influencing Forest Conservation and Beekeeping in KAMAKI, Kitui County, Kenya

Kitui County, located in the southeastern part of Kenya, spans altitudes from 400m to 1,830m above sea level, with the highest regions being Kitui Central and Mutitu Hills (KICD, 2018). The topography slopes from west to east, contributing to the region's semi-arid climate. This area experiences unpredictable rainfall, with temperatures ranging from a minimum of 14-22°C to a maximum of 26-34°C, making it generally hot and dry throughout the year. The region's rainfall is bi-annual, ranging from 500-1050mm, with a reliability of about 40%. The long rains occur between March and May, while the short rains between October and December are more reliable and often lead to higher farm yields (GoK, 2014).

The region's vegetation primarily consists of semi-arid woodland dominated by Acacia species, Commiphora and Terminalia trees. These species are crucial for forest conservation, as they prevent soil erosion and contribute to biodiversity. Their flowers provide essential forage for bees, thereby enhancing honey production and supporting sustainable beekeeping practices. The variety of flowering plants ensures a continuous supply of nectar and pollen throughout the year, benefiting bee colonies and promoting forest health through pollination (Kariuki *et al.*, 2020).

The soils of Kitui County are primarily derived from metamorphic parent materials and influenced by the region's rainfall patterns. The soil types in the area include red sandy soils, black cotton soils, and lateritic soils, with varying fertility and drainage characteristics. Red sandy soils, which dominate the region, have good drainage, whereas black cotton soils, typically found along riverbanks, are poorly drained and prone to erosion. The latter can lead to water quality deterioration due to sediment deposition (Sanders, 2007). These soils play a significant role in both forest conservation and beekeeping, as the erosion of fertile soil can affect plant growth and the quality of bee forage, while well-drained soils support healthier vegetation that benefits both ecosystems.

3.2.2 Socio-Economic Activities

In KAMAKI, Kitui County, beekeeping emerges as a viable and sustainable livelihood option compared to activities such as green gram and maize farming, livestock management, pasture production, trade in different crops and poultry rearing (SNV, 2008; Mwende and Bosma , 2019) . Beekeeping requires relatively low capital investment, minimal land, and labour inputs, making it particularly suitable for the resource-constrained conditions in Kitui County. Furthermore, it provides steady income through honey production and value-added products, with cooperative support enhancing market access and profitability (Carroll and Kinsella, 2013). In contrast, traditional crop farming is highly susceptible to erratic rainfall patterns, while livestock management and poultry rearing face challenges such as diseases and limited grazing resources (Behnke and . Muthami, 2011; Kivunzya, 2018; Kavili, 2013). Beekeeping also contributes to environmental sustainability by promoting forest conservation, aligning with the ecological needs of the semi-arid region and supporting broader sustainable development goals (Ngugi & Mungai, 2020).

Kitui County, including the KAMAKI area, faces significant socio-economic challenges, with indicators highlighting widespread poverty and limited access to essential services. As of 2019, the County's Human Development Index (HDI) was 0.48, substantially below the national average of 0.52 (UNDP, 2022). The HDI combines measures of income, life expectancy, and educational attainment, reflecting the multifaceted nature of development. In KAMAKI, poverty is pervasive, with limited access to healthcare, education, clean water, and adequate nutrition. Unemployment, particularly among the youth, is a pressing concern, with agricultural activities serving as the primary source of income due to the scarcity of formal employment opportunities (KNBS, 2020). Approximately 47.5% of the population lives in absolute poverty, compared to the national average of 36.1%. Moreover, half of the population lacks access to clean water sources, and 57.6% of households spend over 30 minutes obtaining drinking water (KIPPRA, 2019; KMA, 2008).

3.2.3 Population and Economic Growth in Kitui County

Kitui County has experienced rapid population growth in recent years, largely due to its high fertility rate, which ranges between 60.0 and 129.6 people per square kilometer (GoK, 2014). The county's total fertility rate stands at 5.1, significantly higher than the national average of 4.6 (KCIDP, 2018). This youthful demographic is further characterized by a large proportion of the population being under the age of 30, with approximately 50% of the population being under 15 years old (KIPPRA, 2019). The youthful population structure suggests that the county's population will continue to grow rapidly for the foreseeable future, which could have long-term economic and social implications, particularly in terms of education, employment, and healthcare (KIPPRA, 2023).

The youthful population also presents both challenges and opportunities for Kitui County's economy. With a growing young population, there is an increasing demand for education, skills development and job creation to harness the potential of this demographic. The county's economy, primarily based on agriculture, may face pressure to provide sufficient resources and infrastructure for this expanding population. However, the youthful workforce could also provide a dynamic labor force that can contribute to the region's economic development through innovation, entrepreneurship, and increased labor participation in key sectors like agriculture, forestry, and beekeeping (KIPPRA, 2023).

Furthermore, Kitui's rapid population growth necessitates sustainable resource management, especially in sectors like agriculture and natural resource conservation, to avoid overexploitation and degradation of the environment. With a growing need for food security, the county's agricultural practices must evolve to accommodate the changing population dynamics, ensuring that both economic growth and environmental sustainability are achieved (Wang *et al.*, 2024).

3.2.4 Agriculture and Land Use

Rain-fed small-scale farming is the main source of income for the majority of people living within KAMAKI with 90% of people living in rural areas. The main drivers of the local economy are crop farming, cattle raising and beekeeping which account for about three quarters of household incomes (GoK, 2014). The mostly grown crops for sale include; maize (*Zea mays*), sunflower (*Helianthus annuus*), tomato (*Solanum lycopersicum*), carrot (*Daucus carota*), lettuce (*Lactuca sativa*), sorghum (*Sorgum bicolor*), avocado (*Persea Americana*), Pearl millet (*Pennisetum glaucum*), sweet potatoes (*Ipomoea batatas*), cabbage (*Brassica oleracea*), paw-paw (*Carica papaya*) and other tropical fruits. Due to population pressure, food crops and animals are being raised in the less fertile semi-arid ranching areas. Since most farmers rely on rain-fed agriculture, crop failures are a common occurrence (KCIDP, 2018).

3.3 Research Design

The study adopted both qualitative and quantitative and descriptive research design to generate statistical data for determinants or respondents influencing the adoption of modern apiculture across KAMAKI locations. The design allowed the researcher to collect data, compile, organize, display and interpret. This design was appropriate as it allowed the researcher to collect and present data without altering any of the variables (Sileyew, 2019).

The researcher was able to arrive at conclusions and draw generalizations on the population of interest. The target population were beekeepers within the study areas

3.4 Validity and Reliability of Research Questionnaires / Instrument

Validity is a measure of how accurately a research tool or instrument (such as questionnaire) assesses what it is intended to measure (Bajpai and Bajpai, 2014). It evaluates whether the instrument accurately captures the construct or concept under investigation. Reliability refers to the consistency and stability of a measurement over time or different conditions. A reliable instrument produces consistent results when administered repeatedly. Content validity is a non-statistical type of validity that involves the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be measured (Abdul *et al*., 2014). To ensure that that both construct validity and reliability were achieved for this study, the researcher first appraised the instrument as outlined below.

The questionnaires were pre-tested by conducting a pilot test - a trial run designed to identify weakness in research design and data collection tools (Bolarinwa, 2015). During the pilot, critical aspects of the questionnaire were evaluated. The phrasing and clarity of the questions were evaluated to ensure ease of understanding by household respondent bee farmers. Ambiguous or confusing questions were revised. The order of questions was assessed to ensure a coherent and logical sequence. Questions that posed challenges or needed further clarification were revised to minimise confusion during the main study. The pilot study also helped to estimate the average time needed to complete the questionnaire effectively, avoiding excessive response time that could discourage potential respondents. Respondent fatigue also been shown to result and biased results (Elangovan and Sundaravel, 2021). Overall, the pilot test allowed the researchers to adjust or fine-tune the research instrument and to ensured it was well-structured, comprehensible and efficient. Fifteen (15) respondents were selected randomly for the pilot study, but were not involved in the main study. Consequently, the final sample considered in this study were consisted of 250 household respondents.

3.5 Sampling Procedure and Sample Size Determination

The study employed a multi-stage sampling design. Since apiculture was one of the five KAMAKI locations' primary sources of income and had the biggest potential for productivity and growth, they were selected on purpose. Additionally, the majority of the farmers practiced beekeeping. Through stratified random sampling, beekeepers were grouped into smaller units. Then, proportionate sampling was used to obtain the total sample size for each location, and systematic random sampling was used using a systematic random selection technique to guarantee that the respondents in the five KAMAKI research areas were representative. The sampling frame was obtained from the KAMAKI Farmers' Cooperative Society for the five KAMAKI areas. A total sample of 250 respondents were selected from the population. The sample sizes were determined by the use of 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: the coefficient of variation (25%), and

e: the standard error value (0.02)

According to KAMAKI cooperative record, 74 households in Kalivu location were engaged in beekeeping, with a sample size of 50, as shown below.

The required sample size using the given formula with a total number of 74 beekeepers in Kalivu location.

Given:

N (accessible households) = 74

C (coefficient of variation) = 25% = 0.25

e (standard error) = 0.02

Using the formula:

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

$$n = \frac{74 \cdot 0 \text{ x } 0.0625}{0.0625+73 \cdot 0.0004} \qquad n = \frac{4.625}{0.0625+0.0292}$$

$$n = \frac{4.625}{0.0917} \qquad n \approx 50.44$$

In Athi location, 74 marginal households were sampled, with a sample size of 50 beekeeping farmers, as shown below.

Given:

N (accessible population) = 74

C (coefficient of variation) = 25% = 0.25

e (standard error) = 0.02

Using the formula: $n = \frac{NC^2}{C^2 + (N-1)\, e^2}$

$$n = \frac{74 \cdot 0 \text{ x } 0.\ 0625}{0.0625+73 \cdot 0.0004} \qquad n = \frac{4.625}{0.0625+0.0292}$$

$$n = \frac{4.625}{0.0917} \qquad n \approx 50.44$$

In Maluma location, 73 households were sampled, with a sample size of 50 beekeeping farmers, as shown below.

Given:

N (accessible population) = 73

C (coefficient of variation) = 25% = 0.25

e (standard error) = 0.02

Using the formula: $n = \frac{NC^2}{C^2 + (N-1)\, e^2}$

$$n = \frac{73 \text{ x } 0.0625}{0.0625+72 \cdot 0.0004} \qquad n = \frac{4.5625}{0.0625+0.0288}$$

$$n = \frac{4.5625}{0.0913} \qquad n \approx 49.97$$

So, the required sample size in Maluma is approximately **50 beekeepers**.

In Kasaala location, 72 households were sampled, with a sample size of 50 beekeeping farmers, as shown below.

Given:

N (accessible population) = 72

C (coefficient of variation) = 25% = 0.25

e (standard error) = 0.02

Using the formula: $n = \dfrac{NC^2}{C^2 + (N-1)\,e^2}$

$n = \dfrac{72 \text{ x } 0.0625}{0.0625+71\cdot 0.0004}$ $n = \dfrac{4.5}{0.0625+0.0284}$

$n = \dfrac{4.5}{0.0909}$ $n \approx 49.5$

So, the required sample size in Kasaala is approximately 50 beekeepers**.**

In Ikutha location, 74 households were sampled, with a sample size of 50 beekeeping farmers, as shown below.

Given:

N (accessible population) = 74

C (coefficient of variation) = 25% = 0.25

e (standard error) = 0.02

Using the formula: $n = \dfrac{NC^2}{C^2 + (N-1)\,e^2}$

$n = \dfrac{74 \text{ x } 0.0625}{0.0625+73\cdot 0.0004}$ $n = \dfrac{4.625}{0.0625+0.0292}$

$n = \dfrac{4.625}{0.0917}$ $n \approx 50.44$

So, the required sample size in Ikutha is approximately 50 beekeepers**.**

3.6 Sample size of the study

The target population of this study were derived from the households of KAMAKI bee farmers in the five operational areas of KAMAKI Farmers' Cooperative Society. A total of 250 households were sampled across the five KAMAKI locations with one respondent chosen per household. Out of 250 set of questionnaires distributed, 215 were responded to translating to a return rate of 86%. According to Mugenda and Mugenda (2003), a return rate of 50% is considered adequate, making this study's return rate of 86% quite favourable.

Table 3.0: Target population and sample size

Category	Frequency	Percent
Questionnaires distributed	250	100
Questionnaires returned	215	86
Not-response	35	14%

Source: Primary data or Author's data (2023)

3.7 Research methodology

This research employed purposive sampling, which enables the researcher to select data sources, target study areas, sample sizes, and topics that align with the specific purpose, needs, and objectives of the study. Purposeful sampling is particularly effective for pilot studies and in-depth investigations of a small number of representative samples (Palinkas *et al*., 2015). The study was conducted in five locations; Kalivu, Athi, Maluma, Kasaala, and Ikutha, collectively referred to as KAMAKI, situated in the south-eastern region of Kitui County. These locations were selected based on their varying levels of interest in beekeeping and honey market sales, and their connection to the KAMAKI Farmers Cooperative Society, which facilitated the assessment of cooperative interventions on beekeeping, household income and forest conservation.

The targeted sample size comprised 250 households, with 50 households selected from each of the five KAMAKI locations. Sample sizes for each location were determined using Creswell's formula (Creswell *et al*., 2007), with the aim of obtaining 50 valid responses per location. The allocation of respondents across the five locations was as follows: Kalivu (74 respondents, 50 valid responses), Athi (74 respondents, 50 valid responses), Maluma (73 respondents, 50 valid responses), Kasaala (72 respondents, 50 valid responses), and Ikutha (74 respondents, 50 valid responses). This allocation ensured that a total of 250 respondents were sampled, with a final focus on 50 valid responses per location. Demographic data, including gender, age, education level, occupational status and beekeeping experience were recorded for each respondent. Data collection employed semi-structured questionnaires, along with a combination of methods such as Focus Group Discussions, Key Informant Interviews, and field observations.

3.8 Awareness levels among bee-farmers on the link between forest conservation and beekeeping

Semi-structured questionnaires with both open ended and closed questions were administered to 215 respondents from beekeeping households to gain insights into community members' perceptions on the direct link between forest conservation and beekeeping and five aspects were considered including; bees obtain food from forest cover, bees collect pollens and nectars from trees, bees utilized forest for pollination, tree planting contributes to forest conservation that enhance bee population and trees planted for climate change mitigation are essential for bees (bees attractants). Data was also collected on the list of common bee forages and forest tree species significance to beekeeping and forest conservation among respondents. Data was also collected on various aspects of training programmes on forest conservation and beekeeping and four aspects were considered including; the roles of bees in pollination, sustainable beekeeping practices and conservation, improving beekeeping techniques and promoting sustainable practices, how to relate with bees within study area and training on forest and beekeeping relevance and sustainability among respondents. Additionally, the discussions also aimed at determining if respondents were involved in conservation practices that protect the existing forest trees and vegetation in the study area.

3.9 Contributions of beekeeping on household incomes among bee farmers in the study area.

For this study component, 215 respondents consisting of mainly family heads of beekeeping households were identified from the KAMAKI Cooperative members' list using semi-structured questionnaires. Data was collected on honey yields and income returns among respondents, various hives technology used for honey production and the estimated crude honey yields per hive (in kilograms), total household honey production estimates per season and year, prevailing honey production yields per hive. Others included; price variations per hive and amounts of honey sold and income generated per season and year, type of beehives yielding the highest and lowest honey yields in the study area. During apiary visit to determine the types and number of hive technologies used for honey production and income generation, respondents were further probed to discuss on detailed comparative analysis on honey production from varied types and number of hives technology utilization and household income generation per season and year and the perceived livelihood changes associated to contribution of beekeeping to household incomes relative to other agricultural activities and respondents household utilization of incomes from beekeeping.

3.10 Assessment of KAMAKI Farmers' Cooperative Society interventions on honey production, household incomes and forest conservation

To evaluate the impact of KAMAKI Farmers' Cooperative Society's interventions on honey production, household incomes and forest conservation, comparative methods including Focus Group Discussion, Key informant Interviews and field observation were used and trained bee farmers were considered the test group while the untrained respondent bee farmers served as the control group to cover this objective. The respondent bee farmers were selected based on the availability of household heads during the research. Data were collected among trained and untrained respondents on various aspects of KAMAKI cooperative beekeeping-mediated training topics as one of the major interventions including; colony division, hive management, how to relate with bees in the study surroundings, colony management and hive products value addition. Data were also collected among trained and untrained respondents on comparison of average household yields and income, identification skills of forest trees and bee forages, impact of KAMAKI cooperative on honey production and income contributions from Log hives and Langstroth hives. Additionally, data were also collected on reasons for selling or marketing honey yields to KAMAKI honey market.

3.11 Data Analysis

Data collected for the three specific objectives of the study were analyzed using the Statistical Package for the Social Sciences (SPSS). For the first objective, a proximity matrix was employed to assess the interrelationships among respondents on various variables related to beekeeping and forest conservation. This matrix facilitated the exploration of how these variables were interconnected across the study areas. Additionally, Analysis of Variance (ANOVA) was applied to assess differences in awareness levels among respondents regarding the direct link between forest conservation and beekeeping. ANOVA was used to determine whether there was a significant increase, decrease or variability in the awareness levels of the respondents.

For the second objective, ANOVA was also used to analyze differences in honey production levels and income generation among beekeepers, assessing whether there were statistically significant variations between the group of respondents based on hive types and other factors. Pearson's Correlation was then employed to evaluate the strength and direction of relationships between honey production levels and income generation, specifically comparing trained and untrained beekeepers. The Pearson correlation coefficient provided insights into whether these relationships were strong, moderate or weak, further indicating the economic impact of beekeeping practices among the different groups of trained and untrained respondents.

3.12 Ethical Consideration

This study adhered to ethical guidelines set forth by the Board of Postgraduate Studies (BPS), and approval for the research was granted by the South Eastern Kenya university. The researcher obtained formal authorization letter from the Board of Postgraduate Studies (BPS) to conduct data collection within the designated geographical locations of KAMAKI, ensuring that all ethical standards were met throughout the research process. Prior to participation, informed consent was obtained from all respondents, who were fully briefed on the purpose, procedures and potential risks of the study in simple, accessible language. Participation in the research was entirely voluntary, with respondents having the freedom to withdraw at any point without penalty.

Confidentiality and privacy of respondent information were paramount. All personal details and responses were anonymized during data processing to protect participants' identities. The study emphasized transparency in its aims and methods to ensure that no participant was misled or prejudiced by the research procedures. Throughout the study, the researcher maintained a high standard of professionalism by ensuring accurate data analysis, presenting findings impartially, and reporting the results with integrity. All ethical considerations were rigorously followed to uphold the trust of the participants and ensure the validity and reliability of the research.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This chapter presents the results based on each of the specific objectives of the study. The first section generally highlights the social demographic information of the respondents across villages of KAMAKI. The second part presents the results on the determination of awareness level of KAMAKI beekeepers between forest conservation and beekeeping. The third section provides results of assessment on the impact of beekeeping on household incomes. The fourth section of this chapter provides results on the impacts of KAMAKI Farmers' Cooperative interventions on honey production and livelihood.

4.2 Socio-economics and demographic information of respondents

The study considered several demographic features, including gender, age, education level, occupation, and beekeeping experience.

The findings for socio-economic demographic features were as described and summarised in Table 4.1 below. The majority (73.5%) of the respondents were male, while only 26.5% were female. About 44.2% of the surveyed respondents fell into the age bracket of 36-60 years, 36.7% were aged between 18-35 years, while those above 60 years of age were 19.1%.

The bulk of respondents 56.7% had non-formal educational background, 17,7% and 22.3% had completed primary and secondary school education, respectively. Only 3.3% of respondents had completed their tertiary education. Only 17.7% of respondents had completed their primary education.

With respect to employment status, most of the respondents (88.4%) were predominantly farmers, while 8.8% of respondents were involved in business. Merely 2.8% of the respondents were employed. With regard to the experience of respondents in beekeeping, out of the 215 respondents, 20 beekeepers (9%) had practiced beekeeping for 5-10 years, 100 beekeepers (47%) had had over 10- 15years. Accordingly, 54 beekeepers (25%) fell into the 15-20 years' experience range while some farmers (9%) had practiced beekeeping for 20-30 years. Only a single bee keeper had experience spanning 20-40 years.

Table 4.1: The Socio-economics and demographic Characteristics of Respondents

Socio-demographic Features	**Respondents features**	**No. of respondents**	**Percent**	**Cumulative percent**
Gender percentage of respondents	Female	57	26.5	26.5
	Male	158	73.5	**100.0**
Age categories	>60	41	19.1	19.1
	18-35	79	36.7	55.8
	36-60	95	44.2	**100.0**
Education demographics	Non-formal education	122	56.7	56.7
	Primary education	38	17.7	74.4
	Secondary education	48	22.3	96.7
	Tertiary education	7	3.3	**100.0**
Occupational status	Business	19	8.8	8.8
	Employed	6	2.8	11.6
	Farmer	190	88.4	**100.0**
Beekeeping experience	5-10	20	9.3	9.3
	10-15	100	46.5	55.8
	15-20	54	25.1	80.9
	20-25	10	4.6	85.5
	25-30	20	9.3	94.8
	30-35	10	4.7	99.5
	35-40	1	0.5	**100.0**

4.3 Awareness levels among beekeepers on the link between forest conservation and beekeeping

The study sought to explore respondents' opinions of forest conservation-beekeeping connection. Five aspects were considered namely: i) Bees obtain food from forest cover; ii) Bees collect pollens and nectars from trees; iii) Bees utilized the forest for pollination; iv) Tree planting contributes to forest conservation, and v) Trees planted for climate change mitigation are essential for bees (bees' attractants). Table 4.2 below shows the relative distribution of household respondents' responses with respect to these five aspects.

A significant proportion of respondent bee farmers (37.5%) indicated that bees obtain food from forest cover. Notably, a moderate percentage of household respondents (27.9%) indicated that bees collect pollens and nectars from trees. A moderate proportion of household respondents (20.9%) believe that bees utilize forests for pollination. A smaller percentage of respondents (6.9%) recognized that tree planting contributes to forest conservation, which in turn enhances bee populations. This indicates a recognition of the indirect benefits of afforestation on bees. Another household respondent beekeepers (6.9%)mentioned that trees planted for climate mitigation are essential for bees as attractants.

Table 4.2: Perception on the link between forest conservation and beekeeping among bee farmers in KAMAKI

Criteria	No.of Household respondents	Percent
Bees obtain food from forest cover	80	37.5
Bees collect pollens and nectars from trees	60	27.9
Bees utilized forest for pollination	45	20.9
Tree planting contributes to forest conservation that enhance bees	15	6.9
Trees planted for climate mitigation are essential for bees (Bees attractants)	15	6.9
Total	215	**100**

During key respondent interviews and Focus Group Discussions, respondents were asked to identify from a prior generated list of indigenous plants, the species they considered of significance to beekeeping and forest conservation. The exercise aimed to gauge their ability to recognize specific tree species beneficial for both beekeeping and forest conservation. Table 4.3 provides a summary of the species identified among respondent bee farmers.

The highest proportion of respondents (n=50) representing 23.3% of the sampled individuals indicated that *Melia volkensii* was the commonly planted species in the study area. *Acacia tortilis* and *Acacia mellifera* also showed high frequencies at 20.9% and 20.5%, respectively. A moderate number of individuals (n=25) representing 11.6% of the respondents indicated that *Acacia Senegal* as a common species planted for beekeeping and forest conservation. *Commiphora spp., Phiostima* thonningii and *Albizia lebbeck* each had around 6% of the respondent beekeepers indicating moderate presence in the study area. *Azadirachta indica* had 5.1% suggesting it is the least common species among those surveyed for beekeeping and forest conservation.

Table 4.3: Common bee forages and plant species of significance to beekeeping and forest conservation in KAMA

Scientific Names	Common name	Family	No. of households	Percent
(*Azadirachta indica*)	Neem	Meliaceae	11	5.1
(*Senegalia senegal*)	Gum Arabic Tree	Fabaceae	25	11.6
(*Commiphora spp*)	Myrrh	Burseraceae	14	6.5
(*Acacia tortilis*)	Umbrella Thorn Acacia	Fabaceae	45	20.9
(*Melia volkensii*)	Mukau	Meliaceae	50	23.3
(*Phiostima* thonningii*)*	Monkey Bread Tree	Bignoniaceae	13	6.0
(*Albizia lebbeck*)	Woman's Tongue Tree	Fabaceae	13	6.0
(*Acacia mellifera*)	Black Thorn	Fabaceae	44	20.5
Total			**215**	**100.0**

Respondents were prompted to identify from a list of four beekeeping training thematic areas which they considered of relevance to beekeeping and forest conservation. This included: (i) The role of bees in pollination, sustainable beekeeping practices and conservation, (ii) Improving beekeeping techniques and promoting sustainable practices and conservation, (iii) How to relate with bees within KAMAKI surroundings and (iv) Training on forest and beekeeping relevance and sustainability among KAMAKI farmers. Table 4.4 below shows the various training aspects respondents considered relevant to beekeeping and forest conservation. The highest percentage of respondent bee farmers (n=74) representing 34.4% indicated that improving beekeeping techniques and promoting sustainable practices was the most important aspect of beekeeping training that enhanced forest conservation and beekeeping. Another important aspect of beekeeping training was on forest and beekeeping relevance and sustainability among KAMAKI farmers (n=63) representing 29.3%. A moderate percentage of respondent bee farmers (21%) highlighted the importance of understanding the role of bees in pollination, sustainable beekeeping practices and conservation. Notably, 15.3% of respondents expressed the need for training on how to relate with bees within the KAMAKI surrounding. Additionally, a lower percentage of respondents (14.9%) indicated that they had training on the sustainability of forest and beekeeping practices among farmers. An equally low number (n=31) representing 14.1% of the respondent bee farmers indicated that they had training on relevance and sustainability of forest and beekeeping.

Table 4.4: Training aspects relevant to forest conservation and beekeeping among the respondent bee farmers.

Beekeeping Training Aspects	No. of Household	Percent
The role of bees in pollination, sustainable beekeeping practices and conservation	45	21
Improving beekeeping techniques and promoting sustainable practices-	74	34.4
How to relate with bees within KAMAKI surroundings	33	15.3
Training on forest and beekeeping relevance and sustainability among KAMAKI farmers	63	29.3
Total	**215**	**100.0**

4.3.1 Interrelationships among various variables related to beekeeping and forest conservation

To evaluate the relationships of the three variables discussed below to forest conservation and bee keeping, a proximity matrix was computed for the 215 beekeepers (Table 4.5). This proximity matrix is symmetric, meaning the off-diagonal elements in the upper triangle are equal to the off-diagonal elements in the lower triangle. A strong positive correlation of 0.930 was found between direct link between forest conservation and beekeeping and common forage and plant species identified for beekeeping and forest conservation. A very strong correlation and weak correlation was observed between aspects of training establishment on forest conservation and beekeeping and common forage and plant species identified for beekeeping and forest conservation with 0.803 and 0.050 respectively.

Table 4.5: Proximity matrix of the interrelationships among various variables related to beekeeping and forest conservation.

Metrics	**The link between forest conservation and beekeeping**	**Common forage and plant species identified for beekeeping and forest conservation**	**Aspects of training establishment on forest conservation and beekeeping**
The link between forest conservation and beekeeping	1.00	0.930	.740
Common forage and plant species identified for beekeeping and forest conservation	0.930	1.00	.803
Aspects of training establishment on forest conservation and beekeeping	.740	.050	1.000

4.4 Contributions of beekeeping on household income

Table 4.6 presents honey yields and household income returns among 215 households across various locations of KAMAKI. In Kalivu, a single respondent with 250 log hives produced 3,500 kilograms of honey annually, averaging 14 kg per hive and earning 875,000 KES. Additionally, 27 respondents with 540 log hives yielded 5,400 kilograms of honey annually, averaging 10 kg per hive, with an income of 50,000 KES per household. Another 15 respondents with 150 log hives collectively produced 750 kilograms annually, averaging 5 kg per hive, and earning 12,500 KES per household. In Maluma, 37 respondents with 740 log hives produced 7,400 kilograms annually, averaging 10 kg per hive, with a household income of 50,000 KES. Six other respondents with 60 log hives produced 300 kilograms annually, averaging 5 kg per hive, and earning 12,500 KES per household.

In Athi, 33 households with 825 log hives collectively produced 8,250 kilograms of honey annually, averaging 10 kg per hive, with an income of 62,500 KES per household. Another 10 respondents with 100 log hives produced 500 kilograms annually, averaging 5 kg per hive, with an income of 12,500 KES per household. In Kasaala, 30 respondents with 600 log hives produced 6,000 kilograms of honey annually, averaging 10 kg per hive, and earning 50,000 KES per household. An additional 13 households with 100 log hives yielded 700 kilograms annually, averaging 7 kg per hive, and earning 13,461 KES per household. In Ikutha, 29 respondents with 290 log hives produced 2,900 kilograms annually, averaging 10 kg per hive, with a household income of 25,000 KES, while 14 respondents with 140 log hives produced 700 kilograms annually, averaging 5 kg per hive, and earning 12,500 KES per household.

Table 4.6: Honey yields (kgs) and income returns (KES) among 215 respondent bee farmers using log hives in KAMAKI.

Study locations	No. of household	Total No. of log hives utilized per year	Total honey yields produced (kg/year)	Average yields (kg/hive)	Total household income-per year (KES)	Average Income per Household (KES/year)
Kalivu	1	250	3,500	14	875,000	875,000
	27	540	5,400	10	1,350,000	50,000
	15	150	750	5	187,500	12,500
Maluma	37	740	7,400	10	1,850,000	50,000
	6	60	300	5	75,000	12,500
Athi	33	825	8,250	10	2,062,500	62,500
	10	100	500	5	125,000	12,500
Kasaala	30	600	6,000	10	1,500,000	50,000
	13	100	700	7	175,000	13,461
Ikutha	29	290	2,900	10	725,000	25,000
	14	140	700	5	175,000	12,500
Total	**215**	**3,795**	**36,400**		**9,100,000**	

Table 4.7: Honey yields (kgs) and income returns (KES among 215 respondent bee farmers using langstroth hives in KAMAKI

Study Location	No.of Households	Total No. of Langstroth Hives Utilized per Year	Total Honey Yields Produced (kg/year	Average Yield (kg/hive)	Total Household Income per Year (KES)	Average Income per Household (KES/year)
Kalivu	28	54	540	10	135,000	4,821
	15	30	210	7	52,500	3,500
Maluma	37	74	740	10	185,000	5,000
	6	12	84	7	21,000	3,500
Athi	33	66	528	8	132,000	4,000
	10	10	100	5	25,000	2,500
Kasaala	30	60	600	10	150,000	5,000
	13	26	182	7	45,500	3.500
Ikutha	29	20	200	10	50,000	1,724
	14	28	140	7	35,000	2,500
	215	**380**	**3,324**		**831,000**	

Table 4.7 above show the honey yields and household incomes returns among 215 household respondent beekeepers. Out of the 215 household respondent bee farmers across locations of KAMAKI, In Kalivu, 28 beekeepers had 54 langstroth hives and collectively produced 540 kilograms of honey annually, averaging 10 kg per hive with an average income of 4,821KES and 15 respondent beekeepers had 30 langstroth hives, yielding 210 kilograms of honey yields per year and an average of 7 kg per hive with average income of 3,500KES per household. In Maluma, 37 respondents utilized 74 langstroth hives, producing 740 kilograms of honey yields annually, averaging 10 kg per hive with an average income of 500KES per household. In Athi, 33 respondents' had 66 langstroth hives, producing a total honey yield of 528 kilograms annually, with an average of 8 kg per hive with an average income of 4,000KES per household. Additionally, 10 respondent beekeepers had 10 log hives, producing a total honey yield of 100 kilograms, with an average of 5 kg per hive and average income of 2,500KES per household. In Kasaala, 30

respondents log had 60 langstroth hives and collectively produced a total honey yield of 600 kilograms with an average of 10kg per hive with an average income of 5,000KES per household and 13 respondent beekeepers had 26 langstroth hives and collectively produced a total honey yield of 182 kilograms with an average of 7kg per hive with an average income of 3,500KES per household. In Ikutha, 29 respondents had 20 langstroth hives and collectively produced a total honey yield of 200 kilograms with an average of 10kg per hive with an average income of 1, 724 KES per household and 14 household respondents had 28 langstroth hives and collectively produced a total honey yield of 140 kilograms of honey yields with an average of 7kg per hive with an average income of 2,500KES per household.

Table 4.8: Honey yields (kgs) and income returns (KES) for a single respondent beekeeper using Kenya Top Bar Hive

No. of households	Hive Types	No. of hives utilized per farmer	Honey yields per farmer (kg/year)	Average Yield (kg/hive)	Household income per year (KES)
1	KTBH	2	14	7	3,500
1					

The findings in table 4.8 above show that out of the 215 sampled respondents, only one household had been utilizing the Kenya Top Bar Hive and produced 14 kilograms of honey yields and generated 3,500KES per year with an average of 7kg per hive.

Table 4.9: Contribution of beekeeping to household incomes relative to other economic activities among respondent beekeepers.

Economic Activity	No. of Households	Percentage (%)	Contribution to Household Income
Beekeeping	100	46.5	High
Trade in different Food Crops	45	20.9	Moderate
Livestock and Poultry Rearing	40	18.6	Moderate
Maize and Green Gram Farming	30	14.0	Low
TOTAL	215	100.0	

Table 4.9 above reveals the contribution of beekeeping compared to other economic activities among the respondent households. Beekeeping emerges as the most prevalent activity, with 46.5% of households engaged in it, highlighting its prominence as a key income-generating practice. Trade in different food crops follows as the second most common activity, involving 20.9% of households, suggesting its role as a supplementary economic pursuit. Livestock and poultry rearing, which constitutes 18.6% of the households, also serves as a significant but secondary income source for many respondents. The least common economic activity is maize and green gram farming, with only 14.0% of households involved, indicating that it contributes minimally to household income compared to the other activities.

Table 4.10 below presents the respondents' responses regarding the various ways in which household incomes from beekeeping is spent for different purposes. Out of the 215 respondents, 99 (46.0%) indicated that they invest the money earned from beekeeping in business ventures; 56 (26.0%) indicated that, they use the money generated from beekeeping to pay for education-related costs; 35 (16.3%) said they typically use the money earned from beekeeping to pay their expenditures on food; and 25 (11.6%) stated that, they have used the money earned from beekeeping to pay for electricity bills and medical expenses for themselves and children.

Table 4.10: The KAMAKI beekeepers' household utilization of incomes from beekeeping.

	No. of household	Percent
Invest in Business	99	46.0
Paying school and university fees	56	26.0
Expenditures on different food	35	16.3
Paying hospital and electricity bills	25	11.6
Total	**215**	**100.0**

4.5 Assessment of KAMAKI Farmers' Cooperative Society interventions on honey production, household incomes and forest conservation

4.5.1 Common beekeeping training topics covered by KAMAKI Farmers' Cooperative Society

The respondents identified only five areas that they had been trained namely: colony division, hives management, how to relate with bees within KAMAKI surrounding, colony management and hive products value addition. Hives management was the most common training aspect with a significant proportion 74 (34.42%) of respondents indicating they had received training on the topic (Table 4.10). Training on colony division had the second highest number (n=45) representing 20.93% of the respondents. This was followed closely by trainings on how to interact with bees, colony management and hives production with 33 (15.35%), 32 (14.88%) and 31 (14.33%), respectively, of the respondents indicating they had been trained on the topics (Table 4.11).

Table 4.11: Common beekeeping training topics by KAMAKI cooperative society

Beekeeping Topic	No. of trained respondents	Percentage
Colony division	45	20.93
Hives management	74	34.42
How to relate with bees within KAMAKI surroundings	33	15.34
Colony management	32	14.88
Hive products value addition	31	14.43
Total	**215**	**100.0%**

With log hive technology, 137 trained beekeepers managed a combined total of 3,245 hives, producing an annual honey yield of 33,450 kilograms and generating a total income of 8,362,500 KES per year. This translates to an average of 10.3 kg per hive per household and an average household income of 53,267 KES per year (Table 4.12). In contrast, 58 untrained beekeepers with a combined total of 550 log hives produced an annual honey yield of 2,950 kilograms, with a total income of 737,500 KES per year. This translates to an average of 5.36 kg per hive and an average household income of 12,716 KES (Table 4.12).

Similar patterns were observed among farmers using langstroth hive technology. Approximately 157 trained beekeepers using 274 langstroth hives collectively produced 2,608 kilograms of honey, with a total income return of 652,000 KES per year. This translates to an average of 9.52 kg per hive per household and an average income of 4,153 KES. On the other hand, 58 untrained beekeepers using 106 langstroth hives collectively produced 716 kilograms of honey, with a total income return of 204,000 KES. This results in an average of 6.76 kg per hive per household and an average income of 3,517 KES from beekeeping (Table 4.12).

Table 4.12: Comparison of average household honey yields and income among trained and untrained respondent using log hives and langstroth hives.

Hive Types	Respondent Category	Total No. of Households	Total No. of Hives	Total Honey yields per Year (Kg)	Average Honey yields per hive (Kg)	Total Household Income per Year (KES)	Average Household Income per Year (KES)
Log hives	Trained	157	3,245	33,450	10.31	8,362,500	53,267
	Untrained	58	550	2,950	5.36	737,500	12,716
Langstroth Hives	Trained	157	274	2,608	9.52	652,000	4,153
	Untrained	58	106	716	6.76	204,000	3,517

To evaluate the correlation between honey yields, income returns and training among the respondents, a Pearson correlation analysis was conducted for both log hives and Langstroth hives. For log hives, the results indicated that trained respondents had a strong positive correlation with total honey yields (r = 0.85, p = 0.012), average yields per hive and income per year (r = 0.77, p = 0.045), total honey yields and income per year (r = 0.92, p = 0.001), and a strong positive correlation for the log hives correlation coefficient (r = 0.91, p = 0.000). In contrast, the untrained respondent category exhibited moderate to strong correlations with total honey yields (r = 0.70, p = 0.05), average yields per hive and income per year (r = 0.55, p = 0.20), total honey yields and income per year (r = 0.80, p = 0.10), and a moderately strong correlation for total log hives (r = 0.80, p = 0.000) (as indicated in Table 4.13).

Similarly, for Langstroth hives, trained respondents had a strong positive correlation with average yields versus total honey yields (r = 0.85, p = 0.012), average yields versus income per year (r = 0.77, p = 0.045), total honey yields versus income per year (r = 0.92, p = 0.001), and a strong correlation (r = 0.94, p = 0.090). Untrained respondent bee farmers had a moderately strong positive correlation with average yields versus total honey yields (r = 0.56, p = 0.160), average yields versus income per year (r = 0.50, p = 0.245), total honey yields versus income per year (r = 0.62, p = 0.120), and a moderately strong correlation for total Langstroth hives (r = 0.89, p = 0.058) (Table 4.13) (as indicated in Table 4.13).

Table 4.13: Pearson correlation analysis on honey production and income impact among trained and untrained respondent beekeepers using log hives and Langstroth hives in KAMAKI.

Hive Type	Respondent category	Variable	Relative Coefficient	P value
Log Hives	Trained bee farmers	Total honey yields	0.85	0.012
		Average yields and income per year	0.77	0.045
		Total honey yields and income per year	0.92	0.001
		Total log hives	0.91	0.000
	Untrained bee farmers	Total honey yields	0.70	0.05
		Average yields and income per year	0.55	0.20
		Total honey yields and income per year	0.80	0.10
		Total log hives	0.84	0.000
Langstroth hives	Trained bee farmers	Total honey yields	0.85	0.012
		Average yields & income per year	0.77	0.045
		Total honey yields and Income per year	0.92	0.001
		Total langstroth hives	0.94	0.090
	Untrained bee farmers	Total honey yields	0.56	0.160
		Average yields and income per year	0.50	0.245
		Total Honey yields and income per year	0.62	0.245
		Total langstroth hives	0.89	0.058

4.5.2 Assessment of KAMAKI Cooperative's Forest Conservation Initiatives

The study evaluated the efforts of the KAMAKI Farmers' Cooperative Society in establishing forest conservation initiatives, with a focus on planting and maintaining forest trees and bee forage plants to support honey production and income generation among trained and untrained beekeepers. The findings revealed that all respondents recognized the KAMAKI cooperative as a pivotal organization in promoting tree planting and sustainable forest management practices within the study area.

Key forest conservation practices implemented by both trained and untrained beekeepers included protecting existing tree populations, reforestation efforts and other forest management activities aimed at combating deforestation. These practices not only contribute to forest conservation, but also support the availability of bee forage, thereby enhancing honey production and reinforcing the connection between sustainable forestry and beekeeping livelihoods. The results in table 4.15 suggest that greater number of 37 (17.2%) trained bee farmers were more heavily involved in planting *Acacia mellifera* compared to 6 (2.8%) untrained beekeepers and 33 (15.3%) trained beekeepers were also highly involved in planting and conserving *Euphorbia tirucalli* compared to 10 (4.7%) untrained beekeepers. Additionally, 30 (13.9%) household trained beekeepers compared to 13 (6.0%) untrained beekeepers were involved in planting and conserving *Balanites aegyptiaca*, while 29 (13.9%) trained beekeepers planted *Acacia polyacantha* compared to 13 untrained beekeepers (6.0%). Lastly, 28 trained beekeepers (13%) compared to 15 (6.9%) untrained beekeepers, were more involved in planting and conserving *Terminalia mantaly* for forest conservation.

Table 4.14: Identification skills of forest trees and bee forages among trained and untrained bee farmers.

Scientific Names	Respondent Category	Common name	Family name	No.of Respondents	Percent
Terminalia mantaly	Trained beekeepers	Umbrella	Combretaceae	28	13.0
	Untrained beekeepers	Tree		15	6.9
Euphorbia tirucalli	Trained beekeepers	Pencil	Euphorbiaceae	33	15.3
	Untrained beekeepers	Cactus		10	4.7
Balanites aegyptiaca	Trained beekeepers	Desert Date	Balanitaceae	30	13.9
	Untrained beekeepers			13	6.0
Acacia polyacantha	Trained beekeepers	White Thorn	Fabaceae	29	13.5
	Untrained beekeepers	Acacia		14	6.5
Acacia mellifera	Trained beekeepers	Black Thorn	Fabaceae	37	17.2
	Untrained beekeepers			6	2.8
Total				**215**	**100.0**

The findings presented in table 4.15 below indicate that, majority respondents of 51.2% stated that, they specifically sell their honey products to the KAMAKI honey market because of its better price and reliability, while 16.3% indicated they do so because of the specific marketing skills they have been trained in and the establishment of beekeeping marketing initiatives among KAMAKI beekeepers. Thirty respondents or 14.0% of the sample said they sell their honey products because the KAMAKI honey market has assisted them in bypassing brokers, which means the price per honey product is not encouraging from brokers. While 25 respondents (11.6%) indicated that, they sell their honey products to the KAMAKI honey market because they typically receive bonuses and dividends from the KAMAKI Farmers' Cooperative Society at the end of the year and 15 respondents, or 7.0% of the sample, said they sell their honey products because there is availability of market for honey products in the study area. The results show that all respondents value the role played by the KAMAKI Farmers' Cooperative Society in encouraging modern beekeeping among KAMAKI beekeepers as a means of generating their household incomes and ensuring livelihood and stable standard of living in KAMAKI.

Table 4.15: Reasons for selling /marketing honey yields to KAMAKI honey market in KAMAKI.

	No.of household	Percent
Availability of market for honey	15	7.0
Establishment of beekeeping marketing initiatives to KAMAKI beekeepers	35	16.3
Help in bypassing brokers	30	14.0
Receiving dividends and bonuses at the end of the year	25	11.6
Reliability market and better price	110	51.2
Total	**215**	**100.0**

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Socio-economics and demographic characteristics of respondents

The socio-economic and demographic characteristics of the respondents provide valuable insights into the beekeeping community within the study area. Notably, the gender distribution reveals a significant male majority, with 73.5% of the respondents being male and only 26.5% female. This aligns well with prior research, which consistently highlights beekeeping as a predominantly male-dominated activity, possibly due to the physical demands and traditional gender roles associated with the practice (Mburu *et al*., 2017).

The age distribution data show that the majority of beekeepers (44.2%) fall within the 36–60-year age bracket, followed by 36.7% in the 18–35 years range, and 19.1% above 60 years. This pattern suggests that beekeeping is predominantly undertaken by individuals in their productive years, with younger people yet to fully embrace the activity. This trend is consistent with common rural trends, where the majority of youths migrate to urban centres in pursuit of white-collar jobs (Kinati *et al*., 2012). However, the authors emphasize the potential of beekeeping and related activities as a sustainable livelihood option for youths, while also contributing to environmental conservation efforts. The involvement of older individuals in the current study highlights the potential for knowledge transfer and mentorship within the KAMAKI community, further ensuring the sustainability of beekeeping. This is supported by Maderson (2023), who emphasized the role of beekeepers' Traditional Environmental Knowledge (TEK) and practical experience in supporting the development of sustainable beekeeping enterprises. Traditional Environmental Knowledge (TEK) plays a crucial role in beekeeping practices and may include local knowledge on optimal hive placement, seasonal timing guided by observation of natural cues, swarm prevention, and plant selection (Maderson, 2023).

The varied educational backgrounds of the respondents indicate that beekeeping is practiced by people with different levels of education. However, there is a need for targeted training programs, considering the varying levels of understanding among bee farmers with different educational backgrounds. The occupational status reveals that the vast majority of respondents (88.4%) are farmers, with a smaller percentage involved in business (8.8%) and employment (2.8%). This underscores the importance of beekeeping as a supplementary income-generating activity for farmers, contributing to household incomes and livelihoods. These findings are consistent with those of Dinka and Kumsa (2016), who emphasized beekeeping as an important source of supplementary income for rural farmers. The beekeeping experience among respondents varies, with over 90% having more than 10 years of experience. This indicates a well-established beekeeping practice within the study area. The presence of experienced beekeepers suggests a strong foundation for sustainable honey production and offers potential mentorship opportunities for newer beekeepers. The findings align with the findings of Abuje *et al*. (2017) and Mwangi and Karuiki (2020), who reported that the coefficient of experience in beekeeping indicates that a 1% increase in experience per beekeeper will lead to a 9% increase in honey yield.

Overall, the socio-demographic characteristics highlight the diverse backgrounds of beekeepers in the study area. The findings suggest that beekeeping is a viable economic activity that can be integrated into various demographic segments, contributing to household incomes and forest conservation efforts. The data also points to opportunities for targeted interventions by KAMAKI Farmers' Cooperative Society to enhance beekeeping practices and support the involvement of younger and female beekeepers.

5.2 Level of Awareness among farmers on the link between forest conservation and beekeeping

This section provides a comprehensive analysis of the perceptions and knowledge of beekeepers regarding the interdependence between forest conservation and beekeeping. The study revealed that all respondents recognized the essential link between forest conservation and beekeeping. This awareness stemmed from their ongoing engagement in planting bee forages, forest trees, and other forest management practices. Notably, respondents acknowledged that bees forage for food within forest cover, emphasizing the vital role of forests as natural feeding grounds for these pollinators. Consequently, maintaining healthy forests becomes crucial for ensuring adequate nutrition for bee colonies. Additionally, it was found that respondents understood that bees collect pollen and nectar from trees, highlighting the essential resources provided by trees for bee nutrition. Furthermore, the acknowledgment that bees utilize forests for pollination emphasizes the intricate ecological relationship between bees and forest ecosystems. Forest conservation directly impacts pollination services, benefiting both apiculture and wild plants. Moreover, the recognition that tree planting contributes to forest conservation, albeit by a small proportion of respondents, underscores the farmers' appreciation for the indirect benefits of afforestation on bee populations. Similarly, the acknowledgment by some respondents that trees planted for climate mitigation serve as suitable habitats and natural attractants for bees highlights the dual role of afforestation in supporting environmental conservation and promoting bee health and overall biodiversity.

These findings align with those of Bradbear (2009), who observed a positive link between beekeeping and forest management among farmers in Congo, Benin, Zambia, and Tanzania. This connection highlights the potential benefits of integrating beekeeping practices with sustainable forest management efforts. Bradbear posits that apiculture’s unique feature lies in its ability to foster the maintenance of entire ecosystems through pollination, rather than focusing solely on a single crop or species. Similar findings were also reported by Lowore (2021), who studied forest beekeeping and the nexus between sustainable forest management and the commercial honey trade among farmers in Zambia. His thesis findings highlighted that beekeeping contributes to forest conservation by providing economic incentives for communities to protect and sustainably manage forests. He also demonstrated that beekeepers in Zambia recognize the importance of maintaining healthy forest ecosystems, as they provide the necessary floral resources for honey production. This understanding leads to active efforts among beekeepers in Zambia to conserve forest areas, thereby reducing deforestation and forest degradation.

The study findings also revealed that most of the KAMAKI beekeepers had been planting a variety of bee forages and forest trees. Specifically, the respondents in this study consistently prioritize the planting and protection of forest trees that serve as the primary honeybee forages across the landscape of KAMAKI (as evidenced in Table 4.3).

Respondents also identified specific forest fodders, such as *Piliostigma thonningii* and *Albizia lebbeck*, which were deemed useful for hanging hives and fumigation or baiting. Notably, forest trees like *Melia volkensii* and *Acacia mellifera* played multifaceted roles due to their widespread presence in all KAMAKI locations. These two species also emerged as the most frequently used tree species for beekeeping in KAMAKI. *Senegalia senegal* and *Acacia tortilis* are used as hive-making and fodder trees. This affirms that there is an increased level of awareness of the link between forest conservation and beekeeping among respondent beekeepers in KAMAKI (as evidenced in Tables 4.2 and 4.3). The study findings are similar to those reported by Nshama (2003) and Lalika and Machangu (2008), who highlighted several plant and forest tree species including *Acacia spp*., *Commiphora spp*., *Faurea saligna*, *Prosopis cineraria*, *Albizia lebbeck*, and *Melia volkensii* as most favored by honeybee foragers. According to these authors, beekeepers typically safeguarded these specific forest trees and bee fodder plants around their hives while also actively discouraging timber harvesting.

The respondents demonstrated a significant understanding of the critical training areas that can enhance beekeeping and conservation within the KAMAKI region. Many emphasized the necessity of training to improve beekeeping techniques and promote sustainable practices. This recognition underscores their awareness of the need to acquire skills aligning beekeeping practices with forest conservation for better outcomes in their locations. Additionally, a significant proportion of respondents highlighted the importance of training to enhance farmers' understanding of the relevance and sustainability of both forests and beekeeping, emphasizing their appreciation of how healthy forests support bee populations and vice versa. Furthermore, many respondents identified the need for training on the critical role bees play and how beekeeping benefits not only crops but also wild plants and overall biodiversity.

Additionally, some respondents expressed the need for training on effective interaction with bees, ensuring safe hive management and harmonious co-existence for more successful beekeeping. Lastly, training on the sustainability of forest and beekeeping practices was also identified, suggesting that the farmers were keen on learning about responsible resource use and long-term planning. By emphasizing sustainability, respondent beekeepers can contribute to the preservation of natural resources and the health of their local environment in KAMAKI. The study findings were similarly reported by Maertens and Swinnen (2009), who demonstrated that beekeepers who participated in training programmes experience a reduction in poverty levels. Their findings highlighted that beekeepers who receive training are more likely to adopt sustainable practices that contribute to the long-term viability of beekeeping as an economic activity.

The proximity matrix findings revealed strong correlations and robust interrelationships between forest conservation and beekeeping among respondent beekeepers (as summarized in Table 4.5). These connections are driven by the mutual benefits they provide each other among respondent bee farmers. The respondent bee farmer's ability to identify common bee forages and forest tree species emerges as a pivotal factor in this relationship, emphasizing the necessity for comprehensive training programmes, such as those organized by the KAMAKI Farmers' Cooperative Society. This integrated approach is essential for promoting the health and sustainability of both forest ecosystems and beekeeping practices among respondent bee farmers in KAMAKI.

The study findings are correlated with the study of Diriba (2021), who conducted research on the importance of beekeeping for forest conservation, ecosystem preservation, and poverty reduction among beekeepers in Ethiopia. His study demonstrated that beekeeping and forest conservation are mutually beneficial activities. Diriba indicated that beekeeping contributes to forest conservation by providing an alternative income source for local communities, which helps reduce deforestation rates. Beekeepers have a vested interest in preserving forest habitats, which are crucial for maintaining healthy bee populations. Additionally, he highlighted that the presence of bees promotes the growth of native plant species through pollination, supporting forest regeneration and biodiversity conservation. Overall, Diriba emphasized that beekeeping is a crucial practice for ecosystem preservation, primarily through its support of pollination services. He asserted that bees are vital pollinators for many crops and wild plants, contributing to ecosystem health and stability. Furthermore, he demonstrated that beekeeping encourages biodiversity, as bees pollinate various plants, leading to a more robust and resilient ecosystem, which can prevent soil erosion, improve water quality, and maintain ecological balance.

The ANOVA analysis (Appendix II) reveals significant interrelationships between forest conservation and beekeeping among the respondent beekeepers. Specifically, the link between forest conservation and beekeeping shows a highly significant result, indicating that forest conservation efforts directly impact beekeeping practices, supporting the hypothesis that sustainable forest ecosystems are vital for successful beekeeping. Additionally, training on forest conservation and beekeeping aspects yields an extremely significant outcome, emphasizing the importance of comprehensive training programmes for enhancing both forest health and beekeeping productivity. However, the analysis of forage and plant species identified for both beekeeping and forest conservation shows no significant relationship, suggesting that the diversity of plant species may not directly affect the mutual benefits of beekeeping and forest conservation.

These findings underscore the critical role of targeted training and forest management in advancing beekeeping practices, reinforcing the essential connection between conservation and sustainable livelihoods for bee farmers in KAMAKI. The study findings align with those of Agera (2011), who evaluated the role of beekeeping in forest conservation. Agera's research highlighted that beekeeping significantly contributes to forest conservation by providing economic incentives for protecting forested areas. His study demonstrated that beekeepers are motivated to maintain healthy forest environments because these environments supply essential resources for honey production, such as nectar and pollen. Additionally, the research showed that beekeeping supports biodiversity conservation by promoting diverse plant species through pollination, thereby maintaining ecosystem balance and aiding the regeneration of forest vegetation. Agera's findings also emphasized that beekeepers often engage in and support broader conservation initiatives, underscoring the connection between beekeeping practices and community involvement in forest conservation.

5.3 Contributions of beekeeping on household incomes among beekeepers in the study area

The descriptive analysis of household honey yields and income from beekeeping reveals substantial variations among the respondents. On average, beekeeping contributes significantly to household income, with some respondent beekeepers reporting considerably higher earnings than others. This variation in income distribution underscores the pivotal role of beekeeping in enhancing household livelihoods. However, the extent of its impact varies across different households and locations within KAMAKI. For instance, Kalivu emerges as a location with notably high average income per household, reflecting the success of beekeepers in this area in managing their hives and optimizing honey yields (as evidenced in Table 4.7). This success can likely be attributed to several factors, including the adoption of best practices in hive management, favourable environmental conditions, and the presence of a robust local market for honey established by the KAMAKI cooperative. The elevated income levels in Kalivu highlight the potential of beekeeping as a significant contributor to household livelihoods when effectively managed.

Athi similarly demonstrates a relatively high average income per household, suggesting that beekeepers in this area benefit from efficient hive utilization and higher productivity per hive (as evidenced in Table 4.6). The income outcomes in Athi reflect the economic viability of beekeeping in this location, emphasizing the importance of sustaining the practices that underpin this success. Comparable findings were reported by Abro *et al*. (2022), who evaluated the impact of beekeeping on household income among farmers in North-western Ethiopia. Their study illustrated how beekeeping diversifies household income sources, reduces reliance on traditional agricultural activities, and provides financial stability for farming communities.

In contrast, other locations such as Maluma and Kasaala exhibit more moderate average incomes among beekeepers. This disparity may reflect differences in the intensity of beekeeping activities, hive productivity, or access to KAMAKI market opportunities (as evidenced in Table 4.7). While these locations still derive economic benefits from beekeeping, they may require additional support to enhance their income levels. Key areas of improvement include training on advanced beekeeping techniques, better hive management practices, and improved market access facilitated by the KAMAKI Farmers' Cooperative Society. The observed income variations across study locations highlight the necessity of tailored interventions that address specific challenges and leverage local strengths. By analyzing factors contributing to higher incomes in areas such as Kalivu and Athi, similar strategies can be adopted to uplift economic outcomes in Maluma, Kasaala, and other locations. Such an approach ensures that beekeeping remains both sustainable and economically viable across all regions within KAMAKI.

The findings further reveal the critical importance of location-specific strategies in maximizing the economic benefits of beekeeping. Successful examples from Kalivu and Athi serve as models for other locations within KAMAKI to emulate. This aligns with the study by Qaiser *et al.* (2013), who examined the impact of beekeeping on sustainable rural livelihoods in Pakistan and found that beekeeping significantly contributes to rural household incomes through honey sales and other bee products. Their research highlighted the role of beekeeping as an additional revenue source, improving the economic conditions of rural households. Similarly, Kuboja (2017) investigated the economic efficiency of beekeeping in the Tabora and Katavi regions of Tanzania, demonstrating that beekeeping is a viable economic activity. Kuboja's findings revealed that the income generated from honey and other bee products provides a crucial supplement to household livelihoods, underscoring the broader potential of beekeeping as an income-generating venture.

Differences in honey yields and income among respondents were influenced by the type of hive used. Traditional hive types consistently produced higher yields and generated more income compared to modern hives, such as Langstroth hives and Kenya Top Bar Hives (KTBH). Notably, among the 215 respondents sampled across KAMAKI, only one beekeeper utilized a KTBH for honey production. This hive type yielded significantly lower honey yields and income compared to the average production from Log Hives and Langstroth hives. While it is challenging to draw broad conclusions based on a single respondent using the KTBH, the findings highlight the practical and economic limitations associated with this hive type in the study area.

The results emphasize the need to adopt and improve traditional beekeeping techniques to maximize income potential among beekeepers in KAMAKI. This aligns with the findings of Abdullahi *et al*. (2014), who conducted a comparative economic analysis of modern and traditional beekeeping in Lere and Zaria local government areas of Kaduna State, Nigeria. Their study identified several challenges faced by beekeepers, including inadequate knowledge of modern techniques and poor management of pests and diseases. Addressing these challenges through targeted training and improved hive management practices can significantly enhance honey production and income generation for beekeepers.

The ANOVA analysis revealed significant effects of beekeeping on household incomes among respondents using traditional log hives (as evidence in appendix III). The results indicate that the average income generated from log hives varies considerably between beekeepers, suggesting that income levels differ significantly depending on individual practices. Similarly, honey yields from log hives also demonstrated significant differences, highlighting that the volume of honey harvested plays a crucial role in income generation. Additionally, the total number of log hives managed by respondents strongly influenced both honey yields and income, emphasizing the importance of hive numbers in maximizing productivity. These findings reinforce the critical role of log hive management in enhancing the economic outcomes of beekeeping, particularly for rural households in the KAMAKI region.

Similar results were found by Ahikiriza (2016), who investigated beekeeping as an alternative livelihood source for farmers in Uganda. His study showed that beekeeping is a viable income-generating activity, providing significant economic benefits, especially in rural areas where alternative income sources may be limited. Ahikiriza highlighted that beekeeping contributes to income diversification, thus reducing reliance on traditional agriculture and improving resilience to economic and environmental challenges. Likewise, Hilmi *et al*. (2012) conducted an evaluation of beekeeping and sustainable livelihoods across the globe, emphasizing its role in enhancing income and food security, particularly in rural communities. Their findings, supported by case studies from various regions, illustrated how beekeeping contributes to community resilience and sustainable development.

The ANOVA analysis on the impact of beekeeping using Langstroth hives reveals significant findings regarding household incomes among the 215 respondents (as evidence in appendix iv). The results indicate that average income returns from Langstroth hives vary significantly among beekeepers, suggesting that households using these hives experience differing income levels. This variation points to the crucial role of effective hive management in enhancing income generation. However, honey yields from Langstroth hives showed no significant differences, implying that the volume of honey produced remains relatively consistent among respondents. Additionally, the number of Langstroth hives managed by respondents had no notable impact on income or honey yields, suggesting that simply increasing hive numbers without proper management does not substantially boost income returns. These findings underscore the importance of adopting optimal hive management practices to maximize the economic benefits of beekeeping, as income variation is more strongly influenced by management than the number of hives or honey yields.

Similar results were reported by Chuma *et al*. (2012), who evaluated resilient livelihood strategies through beekeeping among farmers in Chitanga village, Mwenezi district, Zimbabwe. Their research demonstrated that beekeeping was a resilient livelihood strategy, contributing to income diversification and reducing the vulnerability of farmers to environmental and economic challenges. Chuma *et al.* (2012) found that beekeeping offered a low-cost method of supplementing income, particularly in regions with limited agricultural opportunities. Their study highlighted the potential of beekeeping to support rural development and sustainability, especially in dryland areas where traditional farming is challenging.

The study revealed two key pathways among respondents regarding their engagement with beekeeping. The first pathway highlights the impact of beekeeping on household incomes, demonstrating how respondents utilized these incomes for various purposes. The second pathway illustrates how respondents generated income through beekeeping in KAMAKI. These findings underscore the fact that beekeeping is an income-driven activity that has significantly increased household incomes among beekeepers in KAMAKI. This aligns with the findings of Hilmi *et al*. (2011), who reported on beekeeping and sustainable livelihoods in Rome, Italy. Their study emphasized that beekeeping contributes to household income not only through the sale of honey but also other hive products such as beeswax, propolis, royal jelly, and pollen. These economic benefits are particularly notable in developing countries, where alternative income sources are limited.

Furthermore, the study emphasizes the importance of beekeeping as the primary income source among respondents in the KAMAKI region. Of the 215 respondents, nearly half (46.5%) listed beekeeping as their primary livelihood, followed by trade (20.9%), livestock and poultry rearing (18.6%), and farming (14%). This diversification in income generation plays a crucial role in enhancing economic stability and resilience. These findings are consistent with the research by Aydin *et al*. (2019), who analyzed the economic aspects and efficiency of beekeeping among farmers in Turkey. Their study demonstrated the economic viability and profitability of beekeeping, emphasizing its positive contribution to rural household income. Additionally, Honeycutt (2023) found that beekeeping serves as a profitable alternative income source, significantly improving the quality of life and economic stability for rural households worldwide.

Regarding the utilization of household incomes from beekeeping, the research findings showed that income generated from beekeeping had various uses, including investments, education support, expenditures on different food and payments for utility and health-related expenses. These multiple benefits demonstrate how beekeeping enhances individual households' ability to meet immediate needs and desires, thereby improving the quality of life for farmers. Furthermore, these impacts collectively contribute to the socio- economic development of respondent beekeepers, highlighting the vital role of beekeeping in improving household livelihoods. Additionally, the multiple benefits derived from beekeeping not only enhance individual beekeepers' livelihoods but also contribute to the broader economic development of respondent beekeepers by increasing overall agricultural productivity and income levels in KAMAKI.

Similar findings were reported by Duah *et al*. (2017), who evaluated income sustainability and poverty reduction among beekeeping value chain actors in the Berekum Municipality, Ghana. Their findings indicated that beekeeping significantly contributes to the sustainability of income for individuals involved in the value chain. They also demonstrated that beekeepers, honey processors, and sellers reported having steady income flows from beekeeping activities, which helped them maintain their livelihoods. Furthermore, their findings showed that beekeeping promotes economic diversification among rural households in the Berekum Municipality.

5.4 Assessment of KAMAKI Farmers’ Cooperative Society interventions on honey production, household incomes and forest conservation

The interventions implemented by KAMAKI Farmers’ Cooperative Society have played a pivotal role in enhancing honey production, boosting household incomes, and promoting forest conservation among trained beekeepers. These positive outcomes were significantly more pronounced compared to their untrained counterparts. The improvement in honey production can be attributed to several factors facilitated by KAMAKI Farmers’ Cooperative Society, including access to better beekeeping technical training and the adoption of best practices in hive management. These findings are consistent with those of Abebe and Molla (2019), who studied the impact of beekeeping training on honey production and household income among farmers in Ethiopia. Their findings highlighted that the quality of honey produced by trained beekeepers was generally higher due to better harvesting and processing techniques compared to untrained beekeepers.

Schouten *et al*. (2020) similarly found that optimizing beekeeping development programs significantly enhanced honey productivity, income, and welfare for farmers in Papua New Guinea. Trained beekeepers using both log hives and langstroth hives, in particular, seem to benefit significantly from KAMAKI Farmers' Cooperative Society training interventions and support. The traditional design of log hives, combined with the cooperative's training and resources, enables trained respondent beekeepers to optimize honey production more effectively than their untrained counterparts. However, the cooperative's support also positively impacts trained beekeepers using langstroth hives, though the gains in honey production are generally more pronounced among those using traditional hives.

Regarding income returns, trained beekeepers involved with the Cooperative reported significantly higher earnings. The income benefits of KAMAKI Farmers' Cooperative Society membership are evident for trained beekeepers using both log hives and langstroth hives, compared to untrained beekeepers. However, the economic impact also appears to be more substantial for trained beekeepers using log hives, who not only achieved higher production levels but also realized better financial returns per unit of honey produced compared to untrained beekeepers. This dual benefit underscores the synergistic effect of modern beekeeping practices combined with KAMAKI Farmers' Cooperative Society support among trained beekeepers, compared to their untrained counterparts. This suggests that further support, or a transition to improved traditional hives, could be beneficial for maximizing honey production and income returns. In a related study evaluating the impact of supply chain coordination on honey farmers' income, Alemu *et al*. (2016) highlighted positive gains in honey production and improved economic well-being for farmers participating in contract engagements among honey farmers in Tigray, Northern Ethiopia. The Pearson correlation analysis for trained beekeepers showed a high correlation between total honey yields and annual income. This indicates that as honey production increases, there is a corresponding increase in economic returns among trained beekeepers, compared to their untrained counterparts. Similar findings were reported by Hendrikse and Bijman (2002), who focused on agri-food chains and the economic outcomes for beekeepers. Their study demonstrated that trained beekeepers who are part of cooperatives typically achieve higher yields and, consequently, higher income returns compared to untrained beekeepers. This correlation among trained beekeepers is attributed to the adoption of improved beekeeping techniques and better management practices learned through cooperative training programmmes.

The study also established that the KAMAKI Farmers' Cooperative Society focused on key beekeeping training topics to improve honey production and hive management. These trainings equipped beekeepers with essential skills, leading to better outcomes compared to untrained beekeepers. The training covered various practices, from hive management to enhancing hive products. Similar studies, such as those by Lal *et al*. (2012) and Annard (2008), showed that beekeeping training improved skills, increased honey yields, and positively impacted forest conservation. The widespread participation in KAMAKI's training programs suggests that trained beekeepers saw significant improvements in productivity and income. Bhupender and Singh (2019) also reported that beekeeping training enhanced knowledge in hive management, pest control, and honey processing.

The findings of this study also underscore the positive impact of KAMAKI Farmers' Cooperative Society-targeted trainings in enhancing the awareness levels among trained bee farmers on the relationship between beekeeping and forest conservation, compared to untrained beekeepers. For instance, the training and awareness initiatives led by KAMAKI Farmers' Cooperative Society seemed to enhance the trained beekeepers' ability to identify and conserve bee flora and forest trees in this study. Similar studies by Breeze *et al*. (2019) and Degu and Megerssa (2020) support these findings, showing that enhanced ecological knowledge and conservation efforts benefit beekeeping. Trained beekeepers are more likely to engage in activities that support forest growth, which, in turn, benefits their beekeeping operations. Untrained beekeepers, on the other hand, tend to engage less in conservation practices, with potential negative consequences for the success of their beekeeping ventures. Endalamaw (2005) also found that sustainable forest management is crucial for beekeeping, as beekeepers avoid activities like logging and overgrazing that could harm forest ecosystems and honey production.

The research findings showed that (as evidenced in Table 4.14) trained beekeepers were more likely to make informed decisions and adopt sustainable practices, enhancing forest conservation efforts. The KAMAKI Cooperative's training programs fostered practices that support both productive beekeeping and forest conservation, leading to a healthier environment compared to untrained beekeepers in the study area. These practices benefit not only bees but also other wildlife and ecosystem services, promoting ecological balance and resilience. In Kenya, Sialuk and Koring'ura (2014) found that beekeeping positively affects biodiversity in arid and semi-arid regions by maintaining flowering plants and trees, supporting diverse plant and animal species. Similarly, Lalika and Machangu (2008) highlighted that beekeeping supports the health and sustainability of coastal forests in Tanzania by providing essential resources for bees, promoting diverse plant species, and enhancing forest habitats. This, in turn, supports the regeneration of forest vegetation through pollination, which is crucial for both conservation and the economic well-being of local communities.

Beekeepers in the study area prefer selling their honey to the KAMAKI honey market rather than to brokers or smallholder industries. This preference is attributable to better accessibility, training, increased annual yields, and competitive prices provided by KAMAKI Cooperative Society's market improvement efforts. Dorward *et al.* (2007) found similar results, showing that cooperatives offer better market access, stable and fair prices, and additional support services like training and technical assistance. These benefits make cooperatives more attractive than private enterprises. Gabre-Madhin (2001) also highlighted that cooperatives reduce transaction costs by aggregating produce and streamlining the sales process, making them a more efficient option by minimizing the time and effort required to find buyers and negotiate prices. Overall, KAMAKI Cooperative's support has strengthened beekeepers' incomes and stability, enhancing their profitability and livelihoods.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion of the study

The study aimed to achieve three main objectives: (1) to assess the awareness level among beekeepers regarding the direct link between forest conservation and beekeeping, (2) to assess the contribution of beekeeping to household income, and (3) to examine the impact of the KAMAKI cooperative on honey production, household income and forest conservation. For the first objective, the findings revealed varying levels of awareness among the 215 respondents regarding the direct link between forest conservation and beekeeping across KAMAKI locations. A noticeable increase in awareness was observed, with respondents showing a growing understanding of the direct relationship between these two practices.

Regarding the second objective, the study found that honey production and income generation varied among beekeepers using different hive types. Respondents using log hives demonstrated the highest honey production yields and income generation compared to those using Langstroth hives. However, those using Kenya Top Bar Hives (KTBH) exhibited lower yields (14 kg) and income (KES 3,500) per year, with only one beekeeper using this type of hive, suggesting limited adoption of this method in the study area.

For the third objective, the study assessed the impact of KAMAKI Cooperative and found that trained beekeepers produced significantly higher honey yields and experienced increased household income compared to their untrained counterparts. Furthermore, trained beekeepers exhibited a stronger ability to implement effective conservation practices, including identifying various bee forages and forest tree species that are crucial for both forest conservation and beekeeping in KAMAKI.

6.2 Recommendations of the study

The recommendations of the study are directed to specific stakeholders in order to facilitate the effective implementation of sustainable forest conservation with beekeeping projects and improvement of household incomes of bee farmers in KAMAKI.

(i) It is recommended that the KAMAKI Cooperative enhance its training and outreach programmes to support sustainable forest conservation initiatives and beekeeping practices. Tailored educational initiatives should focus on bridging knowledge gaps and promoting a more consistent understanding of beekeeping, sustainable forest conservation and the link between forest conservation and beekeeping. This approach will empower beekeepers increase the overall productivity of the cooperative and foster sustainable practices that provide both environmental and economic benefits.

(ii) It is recommended that the KAMAKI Cooperative encourage the use of traditional Log and Langstroth hives, which demonstrated higher productivity and income potential for beekeepers in KAMAKI. Additionally, the KAMAKI cooperative should provide targeted support and training for beekeepers using the Kenya Top Bar Hive (KTBH) to improve its performance, thus enhancing overall honey yields and income generation. This approach will maximize the economic benefits of beekeeping and ensure a more sustainable and profitable practice for all members.

(iii) It is recommended that the KAMAKI Cooperative expand its training programmes. The cooperative should prioritize providing comprehensive training on beekeeping practices, hive management and forest conservation techniques to untrained beekeepers in KAMAKI. This will enhance honey yields, improve income generation and promote sustainable forest management, ultimately benefiting both the environment and the livelihoods of the cooperative members.

6.3 Scientific Suggestion for Future Studies

Future research should investigate the effectiveness of various cooperative models in fostering the integration of beekeeping, income generation and forest conservation. Specifically, studies could focus on the role of KAMAKI Farmers Cooperative Society in promoting sustainable beekeeping practices. Comparative analyses of KAMAKI cooperative's interventions and those of other cooperatives in similar ecological contexts would provide valuable insights. Additionally, research could examine the long-term socio-economic impacts of beekeeping on household income across diverse socio-demographic groups within the cooperative framework.

Another critical area for future investigation would be the ecological contributions of beekeeping, particularly in relation to pollination services and biodiversity conservation within forest ecosystems surrounding cooperative operations. Furthermore, exploring the scalability of KAMAKI cooperative's model is essential, as it may offer a framework for replicating successful interventions in other regions of Kenya or Sub-Saharan Africa, where beekeeping is pivotal for both conservation and economic development. Longitudinal studies would be particularly beneficial in assessing the sustainability of cooperative-led beekeeping initiatives and their ability to promote forest conservation while enhancing household resilience to climate change.

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APPENDICES

Appendix I: Research Questionnaires

General Instructions

The purpose of this questionnaire is to collect data on the '**Impacts of Cooperatives to Honey Production, Household Incomes and Forest Conservation among beekeepers in Kitui County, South-east of Kenya.** Please be honest and thoughtful as possible in your response. All responses will be kept strictly confidential. The questionnaires entail two checklists; **Checklist for Key Informants Interviews** and **Checklist for Focus Group Discussion** which constitutes open ended and semi-structured questions for respondents. Thank you in advance for your cooperation.

Section A: Background Information

Checklist for Key Informants Interviews (KII) OR Household Survey

Date………../………../…………...

County………Rural Municipality…………………Ward……………. Village ………………

A: Socio Demographic Information

Please, can you kindly give me your time and attention to ask you few questions on beekeeping activities in KAMAKI areas? Please tick accordingly:

1. What is your gender? Male ☐ Female ☐ Other ☐
2. Which age group do you belong to?
   Age: 18-35 years ☐ 36- 60 years ☐ Above 60 years ☐

3.What is your level of education? No formal education ☐ Primary Education ☐ Secondary Education ☐ Tertiary Education ☐

4. What is your occupation? Employed ☐ Farmer ☐ Business ☐ Others ☐

B: Beekeeping to household incomes, marketing and Livelihood Information

5. Do you know KAMAKI Cooperative Society? Yes ☐ No ☐

6. For how long have you known KAMAKI? Tick all that apply

1-5 years ☐ 5-10 ☐ 10-15 years ☐ 15-20 years ☐ others specify ☐

7. Which area of beekeeping do you work with KAMAKI?

Training ☐ equipment ☐ Marketing ☐ Tree planting ☐ others ☐

8. What aspect of beekeeping training have you received? Pest Management ☐

Colony Management ☐ Honey quality production ☐ Setting of hives ☐

9. Has the training been useful?

Yes ☐ No ☐

10. How has the training helped you improved honey production?

11. Have you received any equipment from KAMAKI?

Yes ☐ No ☐

12. Which equipment?

(a) Hives ☐ (b) Protective gear (c) Smokers ☐ d) Honey bucket ☐ (e) Others ☐

13. How has this equipment improved your beekeeping?

14. Where do you sell your honey?

(a) KAMAKI honey Cooperative Society ☐ (b) nearby villages ☐ (c) Others ☐

15. Why do you sell your honey to KAMAKI?

(a)Better price ☐ Reliability of market ☐ Others ☐

16. Has the presence of the KAMAKI market improved your beekeeping?

Yes ☐ No ☐

17. If yes, how and why?

(a) Reliability and better price ☐ (b) Helping in boycotting brokers ☐ (c) Through establishment of beekeeping marketing initiatives to the KAMAKI beekeepers ☐

(d) Because of training on better quality honey product ion ☐ (e) Getting dividends and bonuses at the end of the year ☐ (f) Availability of market for honey ☐

18. What challenges do you face when selling the honey to KAMAKI honey Cooperative Society?

(a) Remittance of funds immediately after delivery ☐

(b) Money delays after delivery honey to KAMAKI honey cooperative ☐

(c) High transportation cost from honey production destination to KAMAKI Cooperative office ☐

19. How do you think these challenges to be addressed?

(a) Provision of adequate or reliable means of transport (vehicle) for KAMAKI beekeepers ☐

(b) Honey products to be collected directly from the KAMAKI farmers in their respective locations ☐

(c) Money should be paid directly to KAMAKI beekeepers after delivery honey products to KAMAKI honey cooperative ☐

(d) Aggregators/staff of KAMAKI honey production should get in touch of KAMAKI beekeepers throughout honey production process ☐

(e) Establishment of village honey collection centres ☐

(f) Provision of electrical money transfer facilities to respective destination of KAMAKI beekeepers ☐

20. Apart from beekeeping, what other activities is KAMAKI honey Cooperative Society involved in?

(a) Modern farming activities ☐ (b) Planting forest trees for climate change mitigation

(c) Climate change activities; eg. Forest conservation and food crop production ☐

(d) Green gram value addition project implementation activities ☐

(e) Establishment of aggregator centres across the KAMAKI honey production areas ☐

(f) Involved in SACCO-Savings and credit operations from cooperative society (ies) ☐

21. For how long have you kept bees?

(a) 5 -10 years ☐ (b) 10-15 years ☐ (c) 15 -20 years ☐ (d) 20-25 years

(e) 25-30 years ☐ (f) 30-35 years ☐ (g) 35-40 years ☐

22. Have you noticed any changes in bee population over time?

(a) Yes ☐ (b) No ☐ (c) I don't know ☐

23. What Changes?

(a) Decrease of bee population during drought periods in my area of apiary ☐

(b) Some years, hives occupation rate goo high, sometimes it go low ☐

(c) Establishment of proper harvesting through the use of smoker and other equipment to help in quality control ☐

24. Why the reduction of bee population?

(a) Drought ☐ (b) reduction of bee forages ☐ (c) Pesticides ☐

(d) Poor beekeeping Management practices ☐ (e) Increased human population ☐

(f) Others ☐

25. What do bees get from forest/vegetation?

(a) Pollens ☐ (b) Nectars ☐ (c) Water ☐ (d) Nesting Sites ☐ (e) Others ☐

26. Is there a direct link between beekeeping and Forest Conservation?

(a) Yes ☐ (b) No ☐

27. If yes, explain?

(a) Bees get food from forest cover ☐ (b) Different species of trees give different products; eg. Nectar, pollen and seeds ☐ (c) Bees obtain pollens and nectars from trees ☐ (d) Trees planting to maintain forest conservation ☐ (e) Trees planted to mitigate climate change, mostly bees get flowers from it (Bees attractants) ☐

(f) Forage enhances the availability of pollens thus conserving trees suitable for beekeeping ☐

28. Are you involved in planting bee forages?

Yes ☐ (b) No ☐

29. If yes, list the type of bee forages in your local language

(a) Mukau (*Melia vocansii*) ☐(b) Muthia (*Acacia melifera*) ☐(c) Mua (*Acacia cortilis*) ☐ (d) Mulului (*Balanitis egyptsca*) ☐(d) Musewa (*Acacia polyacantha*) ☐(e) Mukuyu (*Euphoribia tirucallis*) ☐(f) Mbemba / Mukoloso (*Aazadracchta indica*) ☐(g) Muku (*Terminali mentalis*) ☐(h) Mukokolo (*Phiostima thoningi*) ☐

(i) Mukungu (*Albizia lebbek*) ☐ (j) Others specified ☐

30. Do you receive any training programmes on Forest conservation and beekeeping?

(a) Yes ☐ (b) No ☐

31. What are some of the training programmes?

(a) Training on forest and apiculture relevance and sustainability ☐
(b) How to relate with bees within KAMAKI surrounding ☐
(c) Improving beekeeping techniques and promoting sustainable practices ☐
(d) The role of bees in pollination,sustainable beekeeping and conservation ☐

32. How long have you been keeping bees?

(a) 5-10 years ☐(b) 10-15 years ☐(c) 15 -20 years ☐(d) 20-25 years ☐

(e) 25-30 years ☐ (f) 30-35years ☐ (g) 35-40 years ☐

33. Where did you get the skills to keep bees?

(a) Parents ☐(b) KAMAKI honey Cooperative Society ☐(c) Line Ministries ☐

(d) Government of Kenya ☐ (e) Other ☐

34. What type of hive you are using?

(a) Traditional hive ☐(b) KTBH ☐(c) frame hive ☐

34. Why are you using this type of hive?

(a) Easy access or availability ☐ (b) Less expensive (cost) ☐

(c) Skills to use them ☐

35. Have you ever been trained on beekeeping?

(a) Yes ☐ (b) No ☐

36. If yes, what aspect were you trained on?

(a) Colony division ☐ (b) Hives management ☐ (c) Pest and disease management ☐ (d) Types and Hives ☐ (e) Bee types and Characteristics ☐ (f) How to relate with bees within KAMAKI surrounding ☐ (g) Colony management ☐ (h) Bees Husbandry ☐ (i) Hive Products Value Addition ☐ (j) introduction to beekeeping ☐ (k) How to harvest pure honey without interfering with the life of bees ☐

37. How much honey do you harvest per hive per year (Kgs) Using the:

(1) Traditional hive (a) 10kgs (b) 15kgs (c) 20kgs (d) 30kgs (e) 40kgs (f) 50kgs

(2) KTBH(a) 30kgs (b) 40kgs (c) 50kgs (d) 100kgs (e) 7kgs (f) 5kgs

(3) Langstroth hive (a) 30kgs (b) 40kgs (c) 50kgs (d) 100kgs (e) 200kgs (f) 300kgs

38. How much do you sell raw honey from traditional log hive when raw at a Kg, 10kgs, 15kgs, 20kgs, 30kgs, 40kgs and 50kgs?

(a) A kg of raw honey (250kes) (b) 15kgs of raw honey (3,750kes) (c) 20kgs (5,000kes) (d) 30kg (7,500kes) (e) 40kgs (10,000kes) (f) 50kgs (12, 500kes).

39. How much do you sell honey from KTBH when raw at a Kg, 30kgs, 40kgs, 50kgs, 100kgs, 200kgs and 300kgs

(a) A kg of raw honey (250kes) (b) 30kgs of raw honey (7,500kes) (c) 40kgs (10,000kes) (d) 50kg (12,500kes) (e) 100kgs (25,000kes) (f) 200kgs (, 50,000kes).

(g) 7kgs (1, 750kes).

40. How much do you sell extracted liquid honey from Langstroth hives when raw at a Kg, 10kgs, 15kgs,30kgs, 40kgs, 50kgs, 100kgs, 200kgs and 300kgs.

(a) A kg of raw honey (250kes) (b) 30kgs of raw honey (7,500kes) (c) 40kgs (10,000kes)

(d) 50kg (12,500kes) (e) 100kgs (25,000kes) (f) 200kgs (, 50,000kes).

(g) 300kg (75,000kes)

41. Do you produce any other products, apart from honey?

(a) Yes ☐ (b)No ☐

42. If yes, what type of products?

(a) Bee wax ☐ (b) Propolis ☐ (c) Royal jelly ☐ (d) Others ☐

43. How does beekeeping ranks as a source of income?

(a) Livestock ☐ (b) Crops ☐ (c) Beekeeping ☐ (d) trade ☐ (e) Others ☐

44. How do you spend the money from beekeeping?

(a) Invest in Business ☐ (b) Pay school and university fees ☐ (c) Paying electricity bills ☐ (d)Paying hospital bills ☐ (e) Others ☐

Appendix ii: ANOVA analysis on the interrelationships among various variables related to beekeeping and forest conservation

Source		Sum of Squares	df	Mean Square	F	Sig.
The link between forest conservation and beekeeping	Between Groups	3188.231	4	797.058	18.014	.000
	Within Groups	9291.601	210	44.246		
	Total	12479.833	214			
Common forage and plant species identified for beekeeping and forest conservation	Between Groups	1.104	4	.276	.466	.761
	Within Groups	124.477	210	.593		
	Total	125.581	214			
Aspects of training establishment on forest conservation and beekeeping	Between Groups	2434.667	4	608.667	390.956	.000
	Within Groups	326.942	210	1.557		
	Total	2761.609	214			

The null hypothesis is

$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

against

$H_1 : At\ least\ \mu_i\ is\ different$

$at\ \alpha = 0.05\ level\ of\ significance$

Appendix iii: ANOVA analysis on honey yields and income returns among 215 respondents using traditional log hives

Variable(s)	**Source**	**Sum of Squares (SS)**	**df**	**Mean Square (MS)**	**F**	**Sig.**
Average Income returns from log hives	Between Groups	66.352	4	16.588	37.37	.000
	Within Groups	931.26	210	4.434		
	Total	997.612	214			
Total quantity honey Yields from log hives	Between Groups	82.352	4	20.588	46.42	.000
	Within Groups	931.26	210	4.434		
	Total	1013.612				
Total number of log hives	Between Groups	50.644	210	12.661	28.52	.000
	Within Groups	931.26	214	4.434		
	Total	981.904				

The null hypothesis is

$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

against

$H_1 :$ *At least* μ_i *is different*

at $\alpha = 0.05$ *level of significance*

Appendix iv: ANOVA analysis on honey yields and income returns among 215 respondents using langstroth hives

Variable(s)	Source	Sum of Squares (SS)	df	Mean Square (MS)	F	Sig.
Average income returns from langstroth hives	Between groups	285.544	4	16.588	16.11	.000
	Within groups	931.26	210	4.434		
	Total	1216.804	214			
Total quantity honey Yields from langstroth hives	Between groups	1.88	4	0.470	0.11	.000
	Within groups	931.26	210	4.434		
	Total	933.14	214			
Total Number of langstroth hives	Between groups	30.7	210	7.675	1.73	.876
	Within groups	931.26	214	4.434		
	Total	961.96				

The null hypothesis is:

$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

against

$H_1 : At\ least\ \mu_i\ is\ different$

$at\ \ \alpha = 0.05\ \ level\ of\ \ significance$

Appendix v: Images of Traditional Log Hive, Langstroth hives and KTBH hanging on top of trees for honey production in KAMAKI.

Image of Traditional log hive hanging for honey production in KAMAKI

Image of Langstroth hive hanging for honey production in KAMAKI

Images of the Kenya Top Bar Hive hanging for honey production in KAMAKI

Appendix vi: Research publication.

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(Research Article)

Impacts of cooperatives interventions on forest conservation and beekeeping: a case study of Kamaki farmers' cooperative society in Kitui county, Kenya

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Abstract

This study was designed to examine the impact of KAMAKI Farmers Cooperative Society interventions on forest conservation and beekeeping in five locations within the South Eastern part of Kitui County, Kenya. The locations included Kalivu, Athi, Maluma, Kasaala and Ikutha, collectively abbreviated as KAMAKI for the purposes of this study. Cooperative interventions empowered and provided trainings to KAMAKI bee farmers on beekeeping activities, facilitating knowledge sharing and exchange on beekeeping activities with natural resource conservation among bee farmers in KAMAKI. The specific objective of the study was to determine awareness level on the link between forest conservation and beekeeping among bee farmers in KAMAKI. Data were collected on the perception of bee farmers on the link between forest conservation and beekeeping, how bees linked to forest that enhance beekeeping, perception of KAMAKI bee farmers on the ability to plant and identify forest tree types and bee forages for beekeeping. The study adopted a purposive sampling with a sample size of 215 household respondent bee farmers across KAMAKI. Data were gathered through field explorations and observations, Focus Group Discussions and Key Informant Interviews. The data collected was analyzed through descriptive statistics by use of frequency tables. Out of the 215 household respondents bee farmers, 170 trained household respondent bee farmers (79.1%) demonstrated a better understanding on the link between forest conservation and beekeeping compared to 45 untrained household respondent bee farmers (20.9%) who had less awareness on this link. Therefore, the in-depth of the study recommends to KAMAKI Farmers Cooperative Society and Community Based Organizations to continuously provide more trainings that support beekeeping with forest conservation in order to increase household incomes of KAMAKI bee farmers.

Keywords: Cooperatives**;** Forest conservation; Honey production; Natural Resource Management; Afforestation

1. Introduction

Forests are vital sources of bee forages and synergistically beekeeping contributes to the sustainability of forests and to the overall biodiversity wellbeing. Beekeepers can significantly contribute to the sustainability of forests as well as water catchment areas by conserving the existing bee flora and promoting the growth of new plant species (Shackleton *et al*., 2011; Harugade *et al*., 2013; Krishnan *et al*., 2020). In addition to providing honeybee products, honeybees are vital to the pollination of food crops worldwide and the replication of floral diversity. For instance, on average, bee pollination has been shown to increase by 40% the production yields of crops such as sunflower, passion fruits and beans in small scale farms (Kasina, 2007).

The native *Apis mellifera* bee colonies in Africa live in forests where they collect nectar and pollen from a wide variety of flowering plants and forest beekeeping necessitates the construction and installation of artificial beehives in order to increase the number of bee nest sites suitable for honey production in a particular region (Brown, 2014). In light of the expanding human population and associated demand for land, beekeeping offers not only an economical supplement to traditional subsistence agriculture but also an ecologically friendly avenue to promote the conservation of natural ecosystems (Munthali *et al*., 1992; Degu and Megerssa, 2020).

The current study focused on five (5) administrative wards within South-east region of Kitui County, Kenya that are actively involved in honey production and forest conservation initiatives. The wards Kalivu, Athi, Maluma, Kasaala and Ikutha collectively make up the acronym "KAMAKI". The study area also constitutes amalgamated communities within the five operating areas of the KAMAKI Farmers' Cooperative Society (https://kamaki.or.ke/). These areas are typical semi-arid environments and beekeeping is an essential component of the farming communities. The majority of households in these areas kept bees mainly for income generation and household consumption, but also for the benefit bees offer as important components of biodiversity ultimately promoting sustainable forest conservation

For the past fifteen (15) to twenty (20) years, the KAMAKI Farmers' Cooperative Society has been operating in KAMAKI. Its goals include educating small-scale farmers about the diverse opportunities that beekeeping offers as well as providing technical trainings on improved beekeeping activities with forest conservation fostering more awareness level on the link between forest conservation and beekeeping among bee farmers in KAMAKI. This ensures that the KAMAKI beekeepers are exposed to modern beekeeping, possess beekeeping skills that led them to be more resilient to shocks, seasonality and stressors enabling them to produce adequate honey yields that generate income opportunities without exacerbating environmental degradation, enhancing forest conservation, crop production and improving the profitability of bee products and services in the present and future. Additionally, a significant forest cover of beekeeping is being conserved within the study area through the concerted efforts by the KAMAKI beekeepers. However, there is no evidence based data on the impacts of the cooperative's interventions among the KAMAKI beekeeping communities. In particular, it remains largely unknown and unquantified how the KAMAKI Farmers’ Cooperative Society interventions have impacted forest and biodiversity conservation at large through beekeeping.

The present study aimed to investigate the impacts of the interventions of KAMAKI Farmers' Cooperative Society on forest conservation through beekeeping. The study also aimed to examine the impact of the cooperative’s interventions on the awareness levels of the link between forest conservation and beekeeping.

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2. Materials and methods

2.1. Description of the study area

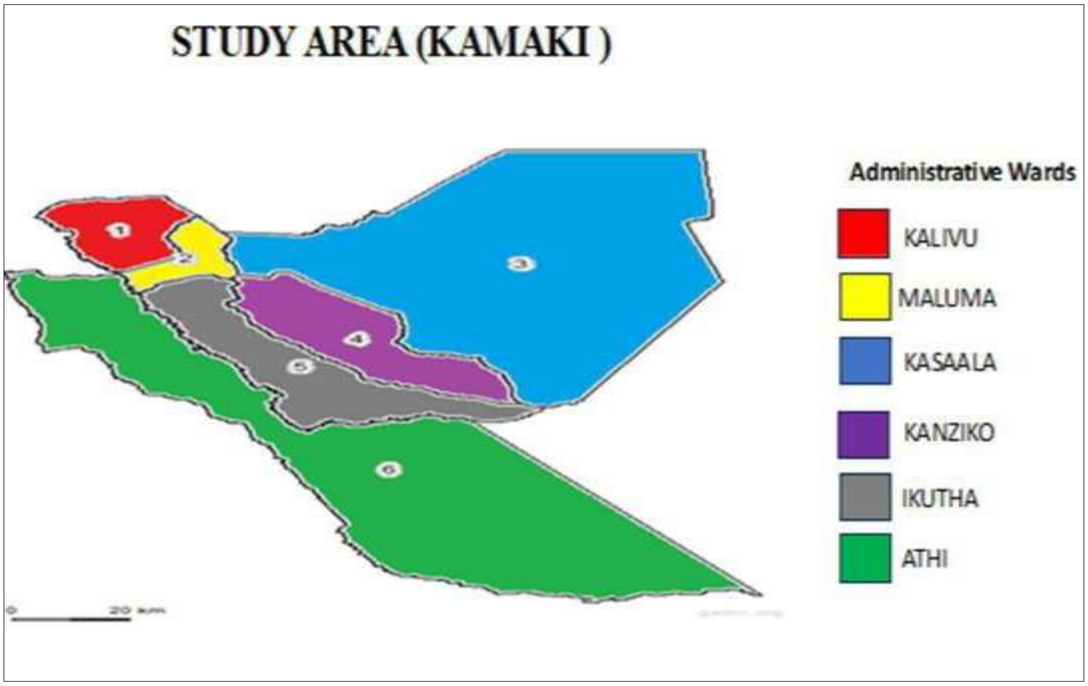

Figure 1 Map showing the Study Area

The research area lies in KAMAKI Cooperative Society's operational areas. The acronym "KAMAKI" stands for; Kalivu, Athi, Maluma, Kasaala and Ikutha in Kitui County; South-eastern of Kenya. These locations are typical Semi-Arid areas and beekeeping is a major economic activity. In these locations. The majority of homes maintained bees in order to generate cash from the sale of honey. The study areas are shown in the map below:

2.2. Research Methodology

This research employed purposive sampling which allows the researcher to select data sources, target study areas, sample sizes and topics aligned with the specific purpose, needs and objectives of the study (Palinkas *et al*.,2015). Purposeful sampling is particularly useful for pilot studies and for in-depth investigation of a small number of representative samples for research purposes (Palinkas *et al.*, 2015). Consequently, the locations of Kalivu, Athi, Maluma, Kasaala and Ikutha – collectively abbreviated as KAMAKI within the south-eastern region of Kitui County were chosen for the study. These locations exhibit varying levels of interest in beekeeping and honey market sales and are home to the KAMAKI Cooperative Society which facilitates the evaluation of cooperative impacts on beekeeping activities. Initially, 250 individuals were selected for the study, representing 50 respondents from each location of KAMAKI. Demographic data including gender, age, education levels, occupational status and beekeeping experience were recorded for each interviewed respondents. The study employed semi-structured questionnaires and a combination of data collection methods such as Focus Group Discussions, Key Informant Interviews, field explorations and observations.

2.2.1. Awareness levels among bee-farmers on the link between forest conservation and beekeeping

The first objective of evaluating the awareness level on the link between forest conservation and beekeeping, the researcher focused on honey-producing areas with bee-farming households. Semi-structured questionnaires were administered to 50 respondents to gain insights into community organization and members' perceptions of this relationship. Data included insights from respondents on the link between forest conservation and beekeeping, the types of forest trees and bee forages. Additionally, representative study participants such as; local government administrative staff and honey retailers were also included in the study due to their perceived knowledge of the bee keeping community's lifestyle. Most of the discussion with respondents focused on assessing the beekeeper's awareness of how forests support sustainable beekeeping and honey production. Leading questions were posed to help identify the types of trees and bee forages considered of relevance to beekeeping. Open-ended questions allowed the beekeepers to list tree species and bee forage types they considered more important in beekeeping. During apiaries and home visits, the researcher explored how beekeepers viewed the impacts of their every-day practices such as frequency of bee hives construction, replacement, and fumigation on the environment. Additionally, the discussions also aimed at determining if the KAMAKI beekeepers were involved in conservation practices that protect or enhance the existing vegetation.

2.3. Statistical Analysis

Descriptive statistical was used to analyze data on perception of trained and untrained bee farmers on the link between forest conservation and beekeeping and ability among trained and untrained bee farmers to identify forest trees and bee forages for honey production and forest conservation.

2.3.1. Awareness levels among bee farmers on the link between forest conservation and beekeeping

The study sought to explore respondent's opinions of forest conservation-beekeeping connection. Five aspects were considered namely: i) Bees obtain food from forest cover; ii) Bees collect pollens and nectars from trees; iii) Different trees give different products (nectar, pollen and seed); iv) Tree planting contributes to forest conservation, and v) Trees planted for climate mitigation are essential for bees (bees' attractants). The table below shows the relative distribution of respondent's responses with respect to these five aspects.

Table 1 Perception on the link between forest conservation and beekeeping in KAMAKI

Criteria	**No.of Households**	**Percent**	**Valid Percent**	**Cumulative percentage**
Bees obtain food from forest cover	80	37.5	37.5	37.5
Bees collect pollens and nectars from trees	60	27.9	27.9	65.4
Different trees give different products (nectar, pollen and seed)	45	20.9	20.9	86.3
Tree planting contributes to forest conservation	15	6.9	6.9	93.2
Trees planted for climate mitigation are essential for bees(Bees attractants)	15	6.9	6.9	100
Total	215	100	100	

Trained bee farmers in Table 4.1 above had a better understanding on the link between forest conservation and beekeeping than untrained beekeepers. Compared to untrained beekeepers (9.3%), trained beekeepers (27.9%) had a greater grasp of the link between forest conservation and beekeeping indicating that bees get food resources from forests. In contrast to untrained beekeepers (4.7%), trained beekeepers (23.3%) indicated that bees obtain pollens and nectars from trees. Compared to untrained beekeepers (2.3%), trained beekeepers (18.6%) indicated that different species of trees give different products, e.g., nectar, pollen and seeds. Compared to untrained beekeepers (2.3%), trained beekeepers (18.6%) indicated that tree planting was necessary to maintain forest conservation. Lastly, trained beekeepers (4.7%) indicated that tree planted was necessary to mitigate climate change, mostly bees get flowers compared to untrained beekeepers (2.3%) from it respectively.

3. Results

Table 4.1 above show that, trained bee farmers had a better understanding on the link between forest conservation and beekeeping than untrained beekeepers. Compared to untrained beekeepers (9.3%), trained beekeepers (27.9%) had a greater grasp of the link between forest conservation and beekeeping indicating that bees get food resources from forests. In contrast to untrained beekeepers (4.7%), trained beekeepers (23.3%) indicated that bees obtain pollens and nectars from trees. Compared to untrained beekeepers (2.3%), trained beekeepers (18.6%) indicated that different species of trees give different products, e.g., nectar, pollen and seeds. Compared to untrained beekeepers

(2.3%), trained beekeepers (18.6%) indicated that tree planting was necessary to maintain forest conservation. Lastly, trained beekeepers (4.7%) indicated that tree planted was necessary to mitigate climate change, mostly bees get flowers compared to untrained beekeepers (2.3%) from it respectively.

3.1. Perception of KAMAKI Farmers on the significance of common bee forages and forest tree types for beeping and forest conservation

During key respondent interviews and Focus Group Discussions, respondents highlighted the positive impacts of various tree species and bee forages for beekeeping, honey production and sustainable forest conservation. They further identified the KAMAKI Farmers' Cooperative Society as the leading organization involved in promoting tree planting and forest management practices through training programs followed by the Kenya Agricultural Research and Livestock Organization. The predominant forest conservation practices among the KAMAKI beekeepers included protecting existing trees, re-afforestation and other forest management practices to counter deforestation.

With regard to the forages and forest trees of relevance to beekeeping, table 4.2 below gives the relative distribution of the common types planted by KAMAKI farmers. *Melia volkensii* was the most common planted plant with about 23.2% of the respondents indicating the planted the species. This was followed by *Acacia cortilis and Acacia melifera both at 20.95*% and *Acacia Senegal at* 11.6% respondents. A paltry 6.0% and 5.1% of respondents expressly planted *Phiostima thoningii, Albizia lebbek and Aazadracchta indica* respectively.

Table 2 Common Forage and plant species identified among KAMAKI bee farmers

Common/Scientific Names	**Frequency**	**Percent**	**Valid Percent**	**Cumulative percentage**
Mukoloso *(Aazadracchta indica)*	11	5.1	5.1	5.1
Kimweya *(Acacia Senegal)*	25	11.6	11.6	16.7
Ikuu *(Commiphora spp)*	14	6.5	6.5	23.2
Mua (*Acacia cortilis)*	45	20.9	20.9	44.1
Mukau (*Melia volkensii)*	50	23.2	23.2	67.3
Mukokolo (*Phiostima thoningii)*	13	6.0	6.0	73.3
Mukungu (*Albizia lebbek)*	13	6.0	6.0	79.3
Muthia (*Acacia melifera)*	45	20.9	20.9	100.0
Total	215	100.0	100.0	

4. Discussion

4.1. Awareness level on the link between forest conservation and Beekeeping in KAMAKI

The study findings showed a greater understanding among trained beekeepers compared to untrained beekeepers on awareness level on the direct link between forest conservation and beekeeping and there was higher turnout in the identification and planting of forest trees and bee forages and involvement in forest management practices for trained beekeepers compared to untrained beekeepers that enhanced and maintained the link between forest conservation and beekeeping in KAMAKI (Table 4.2). The percentage of trained beekeepers were greater compared to untrained beekeepers on varied explanation elicited on awareness level on the direct link between forest conservation and beekeeping (Table 4.1). The research findings are similar to Bradbear, (2009) who drew evidence of the positive link between beekeeping and forest management from Congo, Benin, Zambia, and Tanzania and explains that ‘‘Apiculture’s unique feature as an activity and the fact that its continuation through pollination fosters the maintenance of an entire ecosystem and not just a single crop or species. Most of the bee forages identified in the study areas were dominated by trees followed by herbs and shrubs. According to the research findings; KAMAKI beekeepers typically protected forest trees, herbs and shrubs that are predominated as honeybee forages across the landscape of KAMAKI. Similar findings were reported by Nshama, (2003) and Lalika and Machangu, (2008) who identified and reported that *Acacia spp.*, *Anacardium accidentale* , *Adasomia digitata, Phiostima thoningi, Dalbergia sissoo, Acacia cortilis, Eucalyptus canaldulunsis, Dobera glabra, Commiphora spp, Fanrea saligna, Prosopis cineraria, Albizia lebbek, Melia volkensii, Ribina pseudoacacia, Terminalia prunioides, Grensia tenax, Gliricidia sepium* were the forest trees and pollen types that honeybee foragers most favoured and beekeepers typically protected and sustained specific forest trees and bee fodder plants around their hives and actively discouraged people from cutting timbers. Similar findings of this study also indicate where KAMAKI Beekeepers also reported and identified few forest fodders like *Phiostima thoningii and Albizia lebbek* were mentioned as useful fodders for hanging hives and fumigation/baiting. Forest trees like *Melia volkensii* and *Acacia melifera* served several functions because of its abundance in all locations of KAMAKI which also found to be the most frequently used tree species for beekeeping in KAMAKI. The KAMAKI beekeepers also reported that the flowering month and flowering period depend on the activity of honeybees related to the frequency, time of visits and duration of foraging for a single type of honeybee plant (Table 4.2). Trainings and awareness raising establishment by KAMAKI Farmers Cooperative Society on knowledge about the identification of bee flora and forest trees for beekeeping helps KAMAKI beekeepers to recognize the honey harvesting season and the management of forests in KAMAKI.

Overall, the researcher discovered that all the sampled 215 household respondent bee farmers representing 100.0 % considered the existential link between forest conservation and beekeeping most of the times due to continuous engagement of planting bee forages and forest trees as well as other forest management practices. In summary, most farmers had been planting varieties of bee forages and forest trees including; *Melia volkensii*, *Acacia melifera*, *Acacia cortilis* and *Phiostima thoningii and Albizia lebbek* are the best bee forage and forest trees for beekeeping and honey production, while *Aazdracchta indica* and *Acacia senegal* are given the top priority by KAMAKI beekeepers as the major hive making trees. Forest tree species like; *Acacia melifera*, *Acacia cortilis*, *Phiostima thoningii and Albizia lebbek* are the most preferred trees and shrub for fumigation of hive technologies. Some tree species have cross-cutting use like *Melia volkensii* and trees like *Aazdracchta indica* and *Acacia senegal* are mentioned by respondents as useful fodder, fumigation/baiting and hanging of hive technologies for honey production. *Acacia senegal* and *Acacia cortilis* are used as a hive making and fodder trees. This affirms that there is a significant level of awareness on the link between forest conservation and beekeeping among KAMAKI beekeepers in KAMAKI (Tables 4.1 and 4.2).

The descriptive results have demonstrated a significant coverage of beekeeping forest trees and bee forage types in the study area. The descriptive data analysis also showed how KAMAKI beekeepers made it very clear that various beekeeping trees and forage types typically enhanced sustainable forest conservation, beekeeping and high honey production levels. For this reason, the KAMAKI Farmers' Cooperative Society highly motivated KAMAKI beekeepers' participation in several forest management practices through forest conservation initiatives and beekeeping training programs. The KAMAKI beekeepers typically worked on protecting and conserving smaller trees as well as large ones. in order to strengthen the awareness level on the direct link between forest conservation and beekeeping. The KAMAKI beekeepers normally engaged in some planting operations such as planting seedlings and various kinds of bee forages and bee forest trees across the landscape of KAMAKI (Table 4.2).

5. Conclusion

The analysis of awareness level on the direct link between forest conservation and beekeeping was significantly positive and related among trained and untrained household respondent bee farmers in KAMAKI. The KAMAKI bee farmers have benefited from different aspects of beekeeping and forest conservation trainings establishment by KAMAKI Farmers Cooperative Society on sustainable forest management practices which are environmentally friendly for beekeeping and honey production. The study environment was likely under minimal pressure due to KAMAKI Farmers Cooperatives

Society intervention in the implementation of beekeeping projects and forest conservation initiatives establishment to farmers.

5.1. Recommendations

This study recommends that KAMAKI Farmers Cooperative Society should continuously educate bee farmers on the essential role of forests in sustaining bee populations and honey production. It also recommends to National Environment Management Authority (NEMA) and Kitui County government should to implement appropriate environmental laws to minimize forest deforestation and pollution in water catchment areas thereby conducting awareness campaigns specifically focused on forest conservation and beekeeping that emphasized on how healthy forests contribute to better bee habitats and in turn higher honey production. KAMAKI Farmers Cooperative Society should continue to incorporate the aspect of sustainability in the design and implementation of forest conservation management practices and beekeeping projects in Arid and Semi-Arid Lands (ASALs). Such sustainable forest conservation initiatives and beekeeping projects are very important in the Arid and Semi-Arid Lands (ASALs) as beekeeping projects are very important for both biodiversity, forest and water conservation. This might also help to minimize misuse of forest resources and water resources as to avoid the risk of climate change.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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Appendix vii: Letter of Authorization for data collection

SOUTH EASTERN KENYA UNIVERSITY
OFFICE OF THE DIRECTOR BOARD OF POST GRADUATE STUDIES
P. O. BOX 170-90200 TEL: 020-4213859 (KITUI)
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Our Ref: I422/MAI/ 20033/2021 **DATE**: 1st November 2023

Gassimu Bai-Sesay
Masters of Science in Biodiversity
C/O Dean, School of Science and Computing

Dear Gassimu

RE: PERMISSION TO PROCEED FOR DATA COLLECTION

This is to acknowledge receipt of your Master in of Science in Biodiversity Conservation and Management Proposal document titled: - "***Impact of Cooperative Interventions on Household Incomes and Forest Conservation among Beekeepers: A Case Study of Kamaki Farmers' Cooperative in Kitui county, Kenya***".

Following a successful presentation of your Masters Proposal, the School of Science and Computing, in conjunction with the Directorate, Board of Postgraduate Studies (BPS) has approved that you proceed on and carryout research data collection in accordance with your approved proposal.

During your research work, you will be supervised by Prof. Elliud Muli and Dr. Geraldine Dorcas Kavembe. You should ensure that you liase with your supervisors at all times. In addition, you are required to fill in a Progress Report *(SEKU/ARSA/BPS/F-02 & SEKU/ARSA/BPS/F-14)* which can be downloaded from the University Website.

The Board of Postgraduate Studies wishes you well and a successful research data collection exercise as a critical stage in your Master of Science in Biodiversity.

Yours Sincerely,

Dr. Carol Hunja
Ag. Director, Board of Postgraduate Studies

Copy to: Deputy Vice Chancellor, Academic, Research & Innovation (Note on File) Dean, School of Science and Computing
Chairman, Department of Life Science Prof. Elliud Muli
Dr. Geraldine Dorcas Kavemb

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