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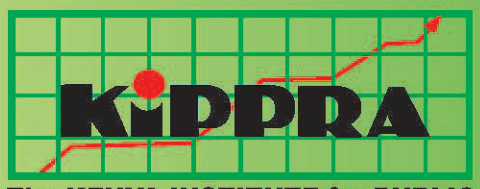

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

Drivers of Honey Production and Commercialization in Kenya's Arid and Semi-Arid Lands

Elvis Kiptoo and Purity Machio

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING PROGRAMME

Drivers of Honey Production and Commercialization in Kenya's Arid and Semi-Arid Lands

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Kenya Institute for Public Policy Research and Analysis

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Abstract

Honey production and commercialization is a key source of income for households in ASAL regions of Kenya where other forms of agriculture are limited due to climatic conditions. Beekeeping is important for the economy; however, Kenya has not utilized its production potential. Kenya is also a net importer of natural honey. Beekeepers in ASALs face several challenges, including limited access to credit, markets, and market information. This study examines the factors influencing honey production and commercialization in ASAL regions of Kenya, using data from the Kenya Integrated Budget Household Survey (KIBHS 2015/16). A total of 173 beekeeping households extracted across three ASAL regions: non-arid, semi-arid, and arid were studied. The results show that the type of beehive used, access to credit, and pesticide usage significantly influence honey production. Beekeepers who use modern beehives produce more honey than those who use traditional beehives. Access to credit allows beekeepers to invest in necessary resources and infrastructure, which leads to higher honey production. Pesticide usage is associated with lower honey production, as it can kill bees directly, weaken them, and contaminate nectar and pollen. The results also show that credit access and market access are significant factors in honey commercialization, especially in the arid region. The study recommends that policymakers tailor beekeeping support programs to the specific needs of each region, support beekeepers in arid and semi-arid areas by providing them with access to credit and promote sustainable beekeeping practices.

Abbreviations and Acronyms

ASALs	Arid and Semi-Arid Lands
MOALD	Ministry of Agriculture and Livestock Development
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
KVDA	Kerio Valley Development Authority
TARDA	Tana River Development Authority
KTBH	Kenya Top Bar Hive
KPHC	Kenya Population and Housing Census
HCI	Honey Commercialization Index
KIHBS	Kenya Integrated Household Budget Survey
KPHC	Kenya Population and Housing Census
NIPFN	National Information Platforms for Food Security and Nutrition

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1. Introduction

Honey production is a viable economic activity that could alleviate poverty and sustain rural employment in the arid and semi-arid lands (ASALs). Beekeeping offers an attractive alternative source of income in areas where traditional agriculture is limited, making it suitable for ASALs. ASAL areas provide favorable climatic conditions for beekeeping, with an abundance of nectar-rich flora notable from Acacia trees. Beekeeping is an environmentally friendly activity that integrates seamlessly with other agricultural practices, including crop cultivation and animal husbandry. In addition to the direct benefits of bees majorly from honey, bees also enhance crop yield through their actions as pollinating agents. Other than honey, there are diverse arrays of bee-derived products which include beeswax, propolis, and royal jelly, which are raw materials used in various industries such as cosmetics, pharmaceuticals, and honey-based food products. The diverse range of honey products signifies that beekeeping can offer significant opportunities for economic development while improving the welfare of local communities and the economy.

Honey production has emerged as a viable income-generating activity in the ASAL regions this is after the national government strategy for development of apiculture and emerging livestock identified it as so. This has presented an opportunity for honey commercialization. Honey commercialization has the potential of uplifting the economic prospects of local communities by transitioning traditional beekeeping practices into commercially viable enterprises. This shift is particularly critical in regions where alternative income sources are constrained by challenging climatic conditions, offering improved livelihoods for beekeepers and their families. The shift toward commercialization encourages the adoption of modern beekeeping techniques, ultimately enhancing productivity and raising the bar for product quality. Investment in advanced hive management, honey extraction methods, and refined packaging can lead to superior-quality honey products that command premium prices in the market, resulting in increased demand.

The transition to commercial beekeeping also presents an opportunity for communities that are heavily reliant on subsistence agriculture to diversify their income streams. This diversification mitigates vulnerability to climate-induced shocks by introducing an additional revenue source that is less contingent on unpredictable weather patterns. The commercialization of honey production generates employment across various stages of the value chain, including processing, packaging, transportation, and marketing. This ripple effect along the value chain can stimulate local economies and counteract rural-urban migration. The export potential of honey is also a key factor that drives its commercialization because of its potential to access lucrative international markets and boost foreign exchange earnings.

Honey production in Kenya's ASAL regions has consistently remained significantly short of its estimated potential. For instance, in 2021, the Kenya’s annual actual honey production was 17,265 tons, and the five-year average between 2017 and 2021 was 18,521 tons (FAOSTAT). Production of honey falls short of the projected

potential, which stands at 100,000 metric tons of honey and 10,000 metric tons of beeswax (MOALFC, 2020). The trade data shows that Kenya imported more natural honey than it exported between 2013 and 2021, with imports totaling to $3,307,572 and exports amounting to $2,542,457 during the same period (UNCOMTRADE). This trade deficit indicates that Kenya's honey production falls short of the demand from industries like beauty and pharmaceuticals, therefore highlighting the need to not only increase honey production but also ensure its effective distribution to the market. Realizing the full potential of honey production and its commercialization in ASAL regions is essential for the development of local communities and the national economy.

There exists a substantial gap of 80 per cent (MOALFC, 2020) between current production levels and the estimated potential in honey production. Bridging this production and commercialization gap is crucial for maximizing the benefits of honey production for ASAL communities and advancing the broader economic prospects of the nation. This study aimed to investigate the underlying factors driving both honey production and commercialization in ASAL regions. Specifically, the first objective of the study was to investigate the factors influencing the level of honey production in ASAL, and the second was to investigate the factors influencing honey commercialization in ASALs. The rest of the study is structured into sections covering stylized facts on honey production in Kenya, theoretical literature, empirical literature, methodology, discussion and findings, and conclusions and recommendations.

2. Honey Production in Kenya

Regional development bodies, such as the Kerio Valley Development Authority (KVDA) and the Tana and Athi River Development Authority (TARDA) are involved in programs that support local farmers in the honey industry in their respective jurisdictions. KVDA, driven by its commitment to promoting sustainable development, actively supports pastoral communities in the North Rift region by diversifying into beekeeping as an alternative source of livelihood. In its comprehensive programs, KVDA places a strong emphasis on capacity-building for farmers, equipping them with essential skills in honey handling and production. By encouraging the adoption of modern beekeeping techniques, the authority empowers farmers to produce greater quantities of high-quality honey than traditional methods, which often results in lower yields and compromised honey quality, thereby reducing its market value. The training provided covered various aspects, from recognizing the readiness of honey for harvest to the extraction process, proper handling, and sensitive storage practices.

KVDA also aims to enhance the technology used in the beekeeping industry by supplying improved beehives, such as Langstroth and Kenya Top Bar Hives (KTBH). Modern hives not only contribute to higher honey quality but also increase production to meet the growing market demand. To further increase production, KVDA engages local artisans in the mass production of hives, providing economic opportunities to many community members in arid and semiarid areas (ASALs). As the largest buyer of honey in the North Rift region, KVDA plays a pivotal role in regulating market pricing and safeguarding farmers from potential exploitation by middlemen.

The Tana and Athi River Development Authority offers crucial support to beekeepers and ensures a thriving market for honey products. The Kiambere Honey refinery project, strategically located within the Tana River Basin, provides local farmers with a reliable market for honey and boosts the region. Traditional log hives are known to adversely affect both the quantity and quality of harvested honey, yet they represent a high proportion of beehives used in Kenya. According to data from National Information Platforms for Food Security and Nutrition (NIPFN), there are 897,598 traditional log hives nationwide, whereas the improved hives, including the KTBH, Langstroth hive, and box hives, are significantly fewer in number—281,733 KTBH, 221,990 Langstroth hives, and 25,148 box hives. The Kenya Population Census 2019 reveals the regions with the highest distribution of beehives and households that practice beekeeping. Nationally, Kenya reported 1,157,162 beehives, and 201,406 households actively engaged in beekeeping. Kitui County has the highest number of beehives at 224,113 followed by Baringo County has 154,388 beehives, West Pokot (91,636 beehives), Makueni (57,594) Embu County (57,408), Tharaka Nithi (56,748 beehives), Mandera (54, 007) and Meru County has 50,151 beehives (KNBS 2019). These eight counties have a beehive count of more than 50,000 and account for a percentage of the total beehives nationally. Other counties with a significant number of beehives include Narok, Nakuru, Machakos, and Elgeyo Marakwet Counties. The common factor among the top-performing counties in terms of beekeeping distribution is that they are

all semi-arid counties that offer the best climatic and environmental conditions for beekeeping.

The distribution of households engaged in beekeeping activities across counties follows a pattern like that of beehives. Kitui County emerges as the top county for beekeeping, with 30,134 households actively participating in beekeeping practices, followed by Baringo County with 17,720 households. Other counties with substantial household engagement in beekeeping of above 10,000 households include West Pokot (15,207 households), Makueni (12,302 households), Meru (12,278 households), Embu (11,926 households), and Narok (10,552 households). Honey production across counties varies depending on the potential, with Kitui leading closely followed by Turkana and West Pokot, demonstrating the potential for honey production in arid and semi-arid regions. Temperate counties, such as Embu and Narok, also contributed significantly, with 1,107,466 kg and 920,109 kg, respectively. However, urbanized Nairobi County has a lower production of 24,870kg, reflecting implications space limitations on honey production in urban areas.

The apiculture industry faces several challenges. The sessional paper No. 3 of 2020 on the Livestock Policy provides a glimpse into the state of apiculture industry in Kenya. The Sessional Paper No. 3 of 2020 identifies the unstructured marketing system, inadequate value addition, competition from imported honey, poor quality of honey, use of inappropriate bee equipment and rampant use of pesticides as some of the challenges the industry faces.

3. Literature Review

3.1 Theoretical Literature

Theory of production

The study adopted the theory of production to explain the factors that influence beekeeping production in ASAL Kenya. Production theory, originally proposed by the French economist Jean-Baptiste Say in 1803 and explained by Velasco (2011), can be defined as the process of transforming resources or inputs into desired outputs or products. Inputs refer to the various resources that a company utilizes in its manufacturing process to create a product or provide a service. A production function is a mathematical representation that illustrates the maximum output that a corporation can achieve for a given combination of inputs, while maintaining a specific level of technology (Velasco, 2011).

The production function of a company is typically expressed as f(L, K) = Q, where Q represents the total output, L represents labor input, and K represents capital input. This equation assumes a scenario with a single output generated from two key inputs: labor (L) and capital (K). The application of this theory becomes relevant in various contexts, including beekeeping, where the primary objective is to optimize output and, consequently, increase income.

Concept of Agricultural Commercialization

Agricultural commercialization pertains to the extent to which a farming household is integrated into market systems. The transition toward agricultural commercialization signifies a gradual move from subsistence farming to a more profit-driven and modernized approach, emphasizing the optimization of production and the strengthening of vertical connections between input and output markets. When effectively harnessed, commercialization can yield benefits for farmers, including enhanced comparative advantage and increased total factor productivity growth (Johnston & Mellor, 1961). Agricultural commercialization extends beyond the mere marketing of agricultural outputs; it implies that decisions regarding product selection and input utilization are guided by the principle of profit maximization (Yoon-Donn & Yoon, 2009). Commercialization plays a pivotal role in the process of structural transformation. Commercialization fosters a greater investment in input markets, leading to demand for industrial commodities and vital production technologies. The shift toward commercialization results in multiple benefits, including the generation of employment opportunities, heightened labor productivity (Pingali et al., 2019).

3.2 Empirical Literature Review on Honey Production

Technology is an important determinant of honey production, as revealed in several studies. Tarekegn and Ayele (2020) conducted a study in Southern Ethiopia to estimate the impact of improved beehive adoption on honey production efficiency using a multistage sampling technique and a sample of 360 households. The technical efficiency (TE) analysis using the stochastic frontier model showed that

the number of hives, type of beehive used, and proximity to the available forest had significant and positive effects on honey production. Beekeeping experience, education level, cooperative membership, participation in improved beehive technology demonstration, and extension contact had significant positive effects on TE. The result of propensity score matching (PSM) indicates that the adoption of improved beehive technology has a positive and significant effect on production efficiency, as measured by TE. Farmers who adopted improved beehive technology were more technically efficient than those who did not adopt it. Other studies such as Adgaba et al. (2014) and Ahmed et al. (2017) also support the findings of Tarekegn and Ayele (2020). Adgaba et al. (2014) noted that beekeepers owning Langstroth hives produced significantly more honey than beekeepers using other traditional beehive, while Ahmed et al. (2017) found that beekeepers can increase their profit more than double by using box hives instead of traditional hives.

Tadesse et al. (2021) aimed to identify factors that influence honey production and marketing constraints in southwest Ethiopia. The study utilized both qualitative and quantitative data types to illustrate that the use of modern beehives resulted in higher yields compared to traditional beehives. This finding is consistent with the study conducted by Al-Ghamdi et al. (2017), which analyzed the profitability of honey production using traditional hives and box hives and found that the adoption of modern box hives led to better productivity. Additionally, Tadesse et al. (2021) identified several variables that influence honey production, including the price of honey, age of the respondent, marital status, experience, and hives owned.

Tarekegn and Ayele (2020) found that beehive technology affected honey production positively. These results concur with previous studies such as Adgaba et al. (2014) and Ahmed et al (2017). Adgaba et al. (2014) also noted that beekeepers owning Langstroth hives which are more technologically advanced produced significantly more honey than beekeepers using other traditional technologies while Ahmed et al (2017), through a comparative analysis, found out that beekeepers can increase their profit more than double by using box hives instead of traditional hives.

Carroll and Kinsella (2013) examined the potential of beekeeping, as an appropriate livelihood strategy for smallholder farm households using the sustainable livelihoods framework emphasized on the need to build human capital for beekeeping rather than just promoting modern beehives. Building human capital for beekeeping through investment in the knowledge, skills, and experience of beekeepers to be achieved.

Membership in cooperatives or farmer groups has been found to positively affect the adoption of agricultural practices due to increased access to information and social capital. Serra and Davidson (2021) investigated the economic benefits of cooperative membership among female honey producers in Ethiopia. The study finds that cooperative membership significantly increases production quantity. Membership in cooperatives has a significant impact on honey production as it plays a crucial role in capacity building by providing training on bee colony management and apiculture development, which enhances honey productivity.

However, the effectiveness of cooperatives in promoting honey production depends on several other factors such as leadership and management capacity, access to working capital, government support, and infrastructure facilities.

Extension support service is a crucial component in any agricultural economic activity. However, when it comes to beekeeping, this seems to be in contrast. Carroll and Kinsella (2013) found out that even though extension services are perceived as useful, extension support did not translate into increased honey production and revenue per hive attributed to inappropriate extension messages and methods which were linked to very limited research. There was no statistically significant association between the extent of extension visits received and revenue per hive, suggesting that extension was not effective. The study found that revenue per hive was higher for older and more experienced beekeepers, an indication that there is an important pool of knowledge at the community level that could be used to support and promote beekeeping in Kenya.

3.3 Empirical Literature Review on Honey Commercialization

Tarekegn et al. (2017) investigated the factors affecting the market supply of honey in the Chena district, Kaffa zone, Southern Ethiopia. The study found that beekeeping experience, hive types used, number of beehives owned, number of extensions in contact, and cooperative membership positively affected honey market supply, with the distance from the nearest market negatively affecting honey supply. Beekeeping experience was found to be positive and significant because the more a farmer has experience in beekeeping the more honey they can contribute to the market. The type of hive used has a positive relationship with honey market supply because modern hives are more efficient at honey production and by extension the marketed supply of honey. These results is consistent with those of Affognon et al. (2015), who found a positive relationship between the use of modern hives and the quantity of honey produced. Tarekegn et al. (2017) also found out cooperative membership to positively affect the market supply, a result similar to that of Serra and Davidson, (2021) findings that cooperative membership increases the market prices and encourages more honey produced to be sold. Cooperatives also provide beekeepers with access to markets, value-addition opportunities, and lower transaction costs. n, (Berem, 2015) (Musinguzi et al., 2018).

Tadesse et al. (2021) examined factors influencing organic honey production level and marketing using a multiple linear regression model. Poor market linkage, lack of market information, poor infrastructure, low price of product, weak bargaining power of farmers, long-distance to market, shortage of packing and storage materials, presence of illegal traders and absence of branding were found to have a significant impact on the marketing of honey in the study area. Poor market linkage and lack of market information hinder the ability of honey producers to connect with potential buyers and access market opportunities. Lack of infrastructure, such as transportation and storage facilities, further complicates the marketing process. The low price of the product and the weak bargaining

power of farmers contribute to their limited ability to negotiate favorable prices for their honey. The long distance to the market and shortage of packing and storage materials poses logistical challenges for honey producers. The presence of illegal traders further disrupts the market through practices such as adulteration. The absence of branding limits the ability to differentiate and promote their honey products effectively.

4. Methodology

4.1 Theoretical Framework

The study is grounded on production theory, which states that the output of a production process is a function of the inputs used.

$$Y = F(A,K,L)$$

Where Y is the output (quantity of honey produced), A is technology. K is capital and L is labor.

The analytical framework used in the study was based on the production function. The regression analysis was used to determine the relationship between household socioeconomic characteristics and honey production. A Cobb-Douglas production function was used to determine factors that influence honey production among households in the ASALs. The general form of a multiple linear regression model is given by:

$$Y_i=\beta_o+\beta X_1+\beta X_2+...+\beta_n X_n+\varepsilon \quad (1)$$

Where Y is a continuous dependent variable representing the quantity of honey produced by the household and is measured in Kilograms, β are parameters to be estimated, whereas $X_1...X_n$ are the independent variables and is ε the error term.

In Equation 4 the model for analyzing the factors influencing honey production is specified as.

$Y_i=\beta_o+\beta_1$ (modern beehive ownership)$+\beta_2$ (Traditional beehive ownership)$+\beta_3$ (household size)$+\beta_4$ (credit amount)$+\beta_5$ (Membership to cooperatives)$+\beta_6$ (pesticide usage)$+\beta_8$ (education level)$+\beta_9$ (age of household head)$+\beta_{10}$ (gender of household head)$+\varepsilon$ (4)

Table 3.1: Classification of Independent Variables of the Honey Production Function

Production Function Independent Variables	Type of factor of production
Education level of the household head	Human capital
Access to credit	Financial capital
Modern beehive	Physical Capital Input
Traditional beehive	Physical Capital Input
Membership to cooperatives	Technology
Household size	Labour input
Pesticide Usage	Indirect
Gender	Control
Marital Status	Control

To achieve the second objective of investigating the factors influencing honey commercialization and its intensity, a censored Tobit model was used. The model is adopted due to its suitability to use all observations both those zero observations, that is those who did not commercialize and the above-zero observations, that is, those who commercialized. For this study, honey commercialization is censored at zero. The outcome function for choosing to commercialize is given by:

$$Y^*=X\beta + \varepsilon \quad (5)$$

where Y* represents the latent variable (unobserved), X is a matrix of independent variables, β represents the coefficients to be estimated, and ε is the error term which is assumed to follow a normal distribution. The unobserved variable Y* is assumed to follow a linear relationship with the independent variables. Y* is the target of estimation in the model, and since it cannot be observed fully, the observed component is constructed by taking the maximum of Y* and zero.

The observed dependent variables (Y) are defined as:

$$Y = \max (Y^*,0) \quad (6)$$

The censoring in the Tobit Model will imply that for the values of Y* below the threshold, the observed values Y will be zero and for the values of Y* above the threshold, the observed values Y will be equal to Y*.

The specific form of the Tobit model for investigating factors influencing the commercialization of honey will be.

$HCI=\beta_0 + \beta_1$ internet$+\beta_2$ cooperative membership$+ \beta_3$ access to market$+\beta_4$ credit$+\beta_5$ gender$+\beta_6$ age$+ \beta_7$ education$+\varepsilon$ (7)

Where commercialization is measured as:

HCI=(The Quantity of honeysold\/the Quantity of honey harvested)*100 (8)

4.2 Description of the Variables Used in the Study

4.2.1 Data sources

The study examines household-level data from the Kenya Integrated Household Budget Survey (KIHBS) 2015/16, conducted by the Kenya National Bureau of Statistics. The KIHBS 2015/16 used the National Sample Survey and Evaluation Program (NASSEP V) master frame, which was developed based on the 2009 Population and Housing Census (KPHC) conducted in Kenya. The survey's sampling methodology involves a two-stage stratified probability sampling process, which first selects clusters (enumeration areas) in proportion to their size and then systematically chooses households within these clusters.

4.2.2 Variables definition and their measurement

Table 3.2 presents the list of variables used in the study as well as their measurement.

Table 3 2: Variables definition and measurement

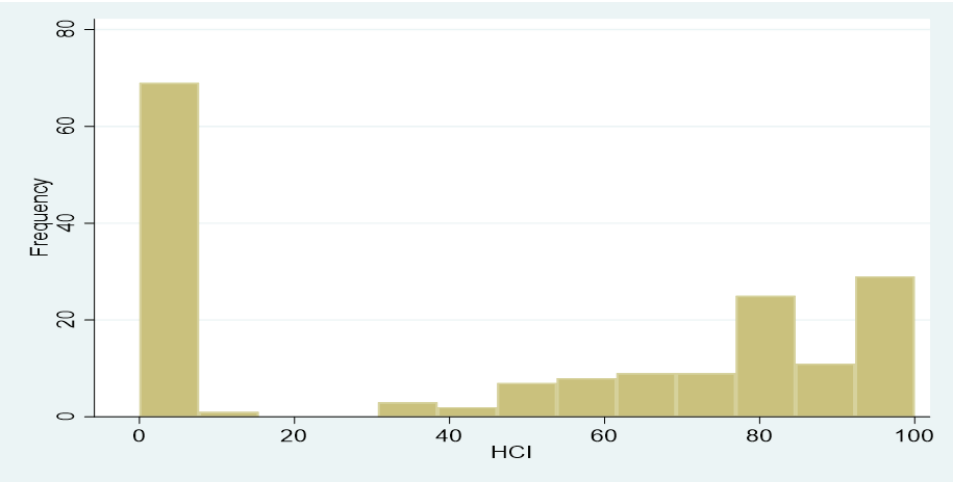
Variable	Description	Measurement
Honey produced (Kgs)	Quantity of Honey Produced	Kilograms
Honey Commercialization Index	Ratio of quantity sold to total honey produced	Ratio of quantity sold to total honey produced as a percentage
Beehive type (Technology)	Beehive used	Dummy (1=Modern,0= Traditional)
Household Size (Labour)	No of individuals in a Household Hold	Continuous
Amount of Credit borrowed (Capital)	The amount of credit borrowed	Kenyan Shillings
Membership to Cooperatives	Membership in cooperatives/saccos	Dummy (1=Yes, 0=No)
Pesticides (Indirect factor)	The value of pesticides/ herbicides	Kenyan Shillings
Education of the Household Head	The highest level of education for the household head	Categorical 1=No formal,2=Primary, 3=Secondary, 4=Tertiary
Age of the Household Head	Age of the Household head	Years
Access to Markets	Household's access to market	1=access, 0 no access
Gender of the Household Head	Gender of the Household Head	Male 1, Female 0
Access to Internet	Access to internet connection to the household	Access 1, no access 0

Dependent Variables

The Honey Commercialization Index measures the level of honey commercialization by a household, indicating what proportion of the honey produced is sold in kilograms. It is expressed as a percentage. The HCI is a continuous variable, calculated as the quantity of honey sold divided by the total quantity of honey produced, multiplied by 100. This means HCI ranges from zero (0) per cent (no

honey sold) to 100 per cent (all honey produced is sold). Figure 3.1 presents a histogram of HCI.

Figure 3.1: Histogram of Honey Commercialization Intensity (HCI)



Honey commercialization has a high frequency of observations concentrated at zero.

Quantity of honey produced: The quantity of honey produced is a continuous variable measured in kilograms. The quantity of honey produced is a dependent variable in the first objective.

Independent variables

Market Access: This is a dummy variable and is measured which takes the value of 1 if the household sold honey to honey processors, traders, and cooperatives and 0 if they didn't sell any.

Education level of the household head: This is a continuous variable and refers to the years of formal schooling of a household head. Households with formal education determine the readiness to accept new ideas and innovations, and easy to get supply, demand, and price information and this enhances farmers' willingness to produce more and increase the volume of sales.

Access to credit: Access to credit is measured as a dummy variable taking a value of one if the household has access to credit and zero otherwise. Among other things, credit access is assumed to have a positive significance to the quantity of honey produced, because a farmer who has access to credit service can purchase improved box beehives and hence increase the production and marketable supply of honey at the county level.

Traditional beehive: A traditional beehive is a dummy variable taking a value of one if the household uses a traditional beehive and zero if the household does

not use a traditional beehive. The expected relationship between the quantity produced and traditional beehives is negative.

Technology: Technology is a dummy variable taking a value of one if the household uses a modern beehive and zero if the household uses a traditional beehive. The variable represents the adoption of technology in honey production and the expected relationship between the quantity of honey produced and the beehive technology is positive.

Membership to cooperatives: Membership to cooperatives is a dummy variable that indicates whether a household is a member of a honey cooperative. A value of 1 indicates that the household is a member of a cooperative, and a value of 0 indicates that the household is not a member of a cooperative. Membership of cooperatives is expected to have a positive relationship with honey production and commercialization intensity since cooperatives can provide several benefits to their members, including access to training and technical assistance, access to expanded markets as well as markets with higher prices and collective bargaining power.

Pesticide Usage: Pesticide usage is a continuous variable measured in Kenyan shillings to reflect the value of pesticides used. The more pesticides used the more the negative impact it has on honey production. This is because the bees do not extract the nectar from the crops/plants treated with pesticides.

Internet Access: Internet access is measured as a dummy variable which takes a value of 1 if the household has access to the Internet and 0 if the household does not have internet access. Access to the internet helps with commercialization in terms of providing a digital market for the household.

Household size: Household size is a continuous variable that measures the number of individuals in a household. Household size is expected to have a positive relationship with honey production. This is because larger households have more labour available to produce and sell honey. Also, larger households may be more likely to have members with beekeeping experience, knowledge, and social networks.

Control Variables

Gender of the household head: This is a dummy variable that takes a value of one if the household head is male and zero otherwise.

Age of the household head: Age is a demographic variable and is measured in years. Age is expected to have a positive effect on both the quantity produced and the intensity of commercialization. The age of the household head is taken as a proxy measure of the farming experience of the household. The older the household, the more they are skilled in beekeeping, hence expected to produce much and sell more to the market.

Descriptive Statistics

Table 4.3 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Honey produced (Kgs)	173	93.45	949.76	1	12500
Honey Commercialization Index	173	47	41.11	0	100
Technology	173	0.20	0.40	0	1
Household Size	173	4.3	2.66	1	14
Amount of Credit borrowed	173	26062.72	22162.94	1000	50000
Membership to Cooperatives	173	0.22	0.41	0	1
Pesticides/Herbicides	173	1232.42	1341.08	100	6000
Access to Internet	173	0.15	0.35	0	1
Education of the Household Head	173	2.96	1.34	1	5
Age of the Household Head	173	29.47	16.72	18	91
Gender of the Household Head	173	0.66	0.48	0	1

Source: Author

Honey produced measured in kilograms is the dependent variable for the first objective. According to the descriptive statistics, on average, the households produced approximately 93.45 Kg of honey. However, there is a wide variation in honey production, as indicated by the high standard deviation and the large range between the minimum and maximum values. The Honey Commercialization Index, which is the dependent variable measuring honey sold relative to the quantity produced showed that on average 47 per cent of households have commercialized among the households. The results also show that 20.30 per cent of households uses modern beehive technology in their honey production activities. The average number of members in the household is 2 members, while the average amount of credit borrowed stands at Ksh. 26,062.72, with a substantial standard deviation. About 22 per cent of households are members of cooperatives and Pesticide/ herbicide expenditure averaged at Ksh. 1,232.42, but this, too, displays significant variability. Household heads are, on average, 29.47 years old, with ages ranging from 18 to 91 years. 65.9 per cent of households were male-headed and lastly, only about 14.5 per cent of households have access to the internet.

5. Findings and Discussion

This section presents the findings of the study in line with the two research objectives.

Factors influencing honey production.

Table 4.1 presents the regression results on factors influencing honey production.

Table 4 1: Factors influencing honey production

Log of Quantity Produced	**Non-Asal**	**Semi-Arid**	**Arid**
	Coefficient	Coefficient	Coefficient
Technology	0.143	1.464**	0.778**
	(0.942)	(0.611)	(0.366)
Log of Household Size	-1.759	-0.283	0.423
	(1.261)	(0.145)	(0.329)
Log of Credit (Amount)	-0.463*	0.043	0.146*
	(0.232)	(0.098)	(0.074)
Membership to cooperatives	-0.639	-0.002	-0.130
	(0.896)	(0.258)	(0.320)
Log of Pesticide amount used	-0.431**	-0.057*	0.126***
	(0.160)	(0.042)	(0.042)
Education level of the household head	0.501	-0.087	-0.066
	(0.286)	(0.115)	(0.132)
Age of the household head	0.149*	-0.003	-0.005
	(0.025)	(0.017)	(0.016)
Gender of the household head	4.597*	-0.136	-0.286
	(0.078)	(0.571)	(0.688)
Constant	1.371	2.628**	0.478
	(5.634)	(1.201)	(1.754)
No. of Observations	49	75	49

Source: Author

Note: Standards errors in parentheses

Type of Beehive used

Ownership of a modern beehive is positively related to honey production in all arid, semi-arid and non-arid areas; however, the relationship is significant only in semi-arid and arid areas. The positive relationship can be explained by the fact that with the use modern hives harvesting of honey is efficient, ease of management and less susceptibility to harsh hive conditions. In contrast use of traditional beehives presents challenges during harvesting, where the harvested honey contains impurities such as brood and wax. The beekeepers are forced to discard the impure honey therefore losing part of the harvested honey. These results concur with those of Al-Ghamdi et.al (2017) who found that the productivity of box hives was 72 per cent higher than the productivity of traditional hives, and consequently the incomes of beekeepers using box hives than those using traditional hives.

Credit

The results of the study reveal a statistically significant and positive relationship between credit access and the quantity of honey produced in ASAL counties. Beekeeping households that have a higher amount of credit tend to produce a higher quantity of honey compared to those with access to a lower amount of credit. Credit plays a crucial role in supporting beekeeping activities. Beekeepers often face substantial upfront costs, such as the acquisition of modern beehives, the acquisition of protective gear, training, and compliance with quality standards for honey production such as testing services. The availability of credit alleviates these financial burdens, enabling beekeepers to invest in the necessary resources and infrastructure for successful honey production. Access to credit can enhance beekeepers' ability to scale up operations and increase honey production.

Pesticide Usage

The coefficient for pesticide usage is negative and statistically significant, which means that increasing pesticide and herbicide usage is associated with a decrease in honey production. Pesticides and herbicides can kill bees directly, weaken bees and make them more susceptible to diseases and parasites. Bayer et al. (2009) found out that pesticide usage can reduce bee colony size by up to 40 per cent. Herbicides and pesticides also contaminate nectar and pollen, which can reduce the quality of honey and make it less nutritious for bees.

Labour (Household size)

There is a negative and statistically significant relationship between household size and the quantity of honey produced in non-arid and semi-arid regions. This means that households with larger household sizes produced less honey than households with smaller household sizes. This finding is consistent with the fact that beekeeping is not as labor-intensive as compared to other agricultural

practices. However, the results are not in line with the findings of Ojo et al. (2016), who found a positive and statistically significant relationship between household size and honey yield. In arid regions, the relationship is positive but not statistically significant.

5.2 Factors driving commercialization

Several factors drive honey commercialization in arid and semi-arid areas. Access to the internet, membership in cooperatives, access to the market, and credit amount, are included in the analysis. Gender of the household head, age of the household head, and education level of the household head are included as the control variables.

Table 4 2: Factors Driving Commercialization

Log of Honey Commercialization Index	**Non-Arid**	**Semi-Arid**	**Arid**
	Coefficient	Coefficient	Coefficient
Access to Internet	0.037	-0.070	0.09
	(0.047)	(0.147)	(0.140)
Membership to Cooperatives	-0.009	-0.105	-0.110
	(0.071)	(0.106)	(0.144)
Access to Market	5.407***	6.160***	5.725***
	(0.121)	(0.356)	(0.221)
Log of Credit Amount	0.018	0.031	0.078**
	(0.466)	(0.027)	(0.033)
Gender of the Household Head	-0.134	0.650***	0.263
	(0.254)	(0.208)	(0.224)
Log of the age of the Household Head	-0.239	0.458	0.234
	(0.239)	(0.163)	(0.206)
Education level of Household Head	0.065***	-0.103	-0.003
	(0.021)	(0.032)	(0.033)
Constant	-0.640	-4.027***	-3.053***
	(0.915)	(0.942)	(0.895)
No. of Observations			

Source: Author

Access to Market is significant and positively related to honey commercialization in all three regions, suggesting that market access is a key factor affecting honey commercialization. Beekeepers who have easier access to markets are more likely to be able to sell their honey at a good price, which can lead to increased commercialization. Beekeepers face various challenges in their efforts to access the markets with a wider range of buyers. Beekeepers in remote rural areas travel long distances to reach markets, which can increase their costs and reduce their profits. Beekeepers who live close to major cities have a clear advantage as they can transport their honey to market more easily and efficiently, with access to a wider range of buyers. Reliable market information is important to inform beekeepers' decisions about selling their honey. Without this information, beekeepers may be more likely to sell their honey at a low price. small-scale beekeepers who may not have the resources to transport and access market information to enable them to market their honey effectively.

Credit is significant in the arid region, suggesting that it is more important for honey commercialization in this region than in the non-arid or semi-arid regions. This may be because beekeepers in the arid region are more likely to face financial constraints. Therefore, enabling access to credit by beekeepers in arid counties helps them to invest in equipment and other honey production supplies which significantly increase production and improve quality. These results concur with those of Tarekegn, Haji, and Tegegne (2017) found that beekeepers with credit access in arid regions of Ethiopia were more likely to supply honey to cooperatives. Tadesse et al. (2021), found that poor market linkage, lack of market information, and poor infrastructure were significant barriers to honey marketing in arid regions and credit play a crucial role to overcome these barriers by allowing them to invest in equipment, supplies, and training.

6.1 Conclusion and Recommendations

6.1 Conclusions

Honey production was found to be significantly influenced by the type of beehive used, access to credit, and pesticide usage in arid and semi-arid areas. Beekeepers who use modern beehives produce more honey than those who use traditional beehives, probably because traditional beehives are associated with both more difficulty in honey harvesting and highly likelihood of honey contamination. Beekeepers with access to credit can invest in necessary resources and infrastructure, such as modern beehives and training, which leads to higher honey production. Pesticide usage is associated with lower honey production, as it can kill bees directly, weaken them, and contaminate nectar and pollen.

Honey commercialization is a key factor in improving the livelihoods of honey-producing households. However, beekeepers often face challenges in accessing credit and markets, which can limit their ability to expand and grow their production and effectively market the output. The results indicate that credit access and market access are significant factors in honey commercialization, especially in the arid region suggesting that beekeepers in the arid region are more likely to benefit from credit access than beekeepers in other regions.

6.2 Recommendations

Recommended interventions towards enhancing honey production and its commercialization are:

- Policymakers can tailor beekeeping support programs to the specific needs of each region. For instance, prioritizing credit access in regions where it is beneficial for honey commercialization and creating accessible credit programs tailored to beekeepers' needs in a specific region.
- Policymakers can support beekeepers in arid and semi-arid areas by providing them with access to credit. Providing beekeepers with access to credit can help them invest in necessary resources and infrastructure, such as modern beehives and training. This can lead to higher honey production and income for beekeepers.
- Promote sustainable beekeeping practices. Sustainable beekeeping practices, such as avoiding the use of pesticides and planting bee-friendly plants, can help to protect bees and increase honey production. Policymakers and development practitioners can promote these practices through education and training programs. This will also help the households to access international markets as controlling the use of pesticides will enhance the quality of honey produced.
- Establish linkages between buyers and sellers to help enhance market access for households that want to venture into honey commercialization. This can be done through supporting the regional bodies that buy honey from the farmers to be able to access both domestic and international markets.

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