Determinants of the Adoption of Modern Apiculture Among Marginal Households in Baringo and Makueni Counties, Kenya

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Abstract

Apiculture is one of the planet's most widely practiced enterprises, with the potential to generate income. The enterprise has high potential in Kenya, particularly in ASALs. Despite efforts by government agencies, NGOs, and development affiliates to increase the uptake of modernity, the current usage level is still low as the majority of the farmers utilize traditional methods, leading to minimal economic output. To promote the effective adoption of modernity, it is vital to understand and address adoption-influencing issues. Therefore, this study was designed to explore the determinants influencing adoption of modern apiculture among marginal households in Baringo and Makueni Counties of Kenya. Multi-stage sampling technique was used to select 250 respondents with 127 selected from Baringo and 123 from Makueni. Primary data were collected using semi-structured questionnaires and analyzed using multiple linear regression. The findings revealed that gender, marital status, household size, attitude, access to credit, transportation, and climate change had a positive and significant influence on adoption of modern apiculture. Whereas group participation and access to land negatively and significantly influenced adoption of modern apiculture. The study will be a foundation for the formulation of policy regarding the uptake of modern apiculture among beekeepers in Baringo and Makueni Counties.

Keywords: Socio-Economic, Biophysical, Institutional, Multiple Linear Regression

Introduction

Apiculture is one of the most widely practiced economic activities on the planet, with global annual honey output estimated to be over 1.7 million metric tonnes (FAOSTAT, 2021). China is the world's greatest honey producer, producing over 485,960 tonnes annually, followed by Turkey with 96344 tonnes, Iran with 77,152 tonnes, Argentina with 71,318 tonnes, and Ukraine with 68,558 tonnes (FAO, 2021).

Modern apiculture techniques developed way back in the middle of the eighteenth century on the European continent. They began building mobile comb hives to obtain honey without destroying the entire bee population. The advancement of these techniques is credited to the European immigrants who carried on beekeeping in North America. Most African nations still practice honey gathering as well as keeping traditional beehives. Traditional beekeeping has a long tradition and continues to be practiced presently across the African continent (Bunde *et al.*, 2016; Keiyoro *et al.*, 2016).

Many nations have recognized apiculture as a key factor in rural development (Ladino *et al.*, 2023). Beekeeping offers natural health benefits since it provides a food source that is high in nutrients, requires little maintenance, and benefits from a plentiful supply of pollen and nectar from the plants that bees pollinate (UNEP, 2022). Beekeeping has become a particularly beneficial agricultural endeavor for rural populations in developing nations due to the economic advantages that its outputs provide (Infonet-Biovision, 2021).

Kenya produces 140 metric tonnes of bee wax and over 25,000 metric tonnes of honey annually. However, as this represents 20 percent of the total production, around 80 percent of the potential remains unexploited (KIPPRA, 2019; Kiingwa *et al.*, 2020). In Kenya's arid and semi-arid regions (ASALs), beekeeping is an important source of livelihood. 80% of the honey produced is produced by ASALs (KIPPRA, 2019). However, apiculture is also viable in non-arid and semi-arid areas (Mutua *et al*., 2023).

Apiculture has a lot of potential for generating money, reducing poverty, preserving forest resources, and broadening the export base (Narang *et al*., 2022). Boasting a great deal of potential for beekeeping, Baringo County is one of Kenya's leading honey-production regions. Baringo County leads, with 882 metric tonnes worth KES 350 million and a beeswax output of 162.596 metric tonnes, which represents only 10% of the area's potential (Baringo County Government, 2023). This falls below its potential given that the vast majority of the honey produced emanates from traditional Tugen log hives, accounting for 70% of the number of beehives in the Sub-County (Kiprono *et al*., 2021).

Apiculture is a lucrative enterprise in Makueni County since it is among the primary sources of income and has the largest potential for productivity growth. The market price for honey per kilogram ranges between 600 and 1000 shillings (KCSAP, 2021). Makueni County's estimated annual honey output increased from 514 metric tonnes in 2019 to 694 metric tonnes in 2020 (Makueni County Government, 2022).

Apiculture has the potential to produce large foreign currency while also improving rural living conditions (UNEP, 2022). Kenya is home to various honey-processing enterprises that sell their products to Europe, Japan, and the United States. Kenya's honey sector is mostly focused on exporting. These two countries are the primary destinations for Kenyan honey exports, accounting for approximately 70 percent of total exports (Farmers Trend, 2023; Gok, 2018). For example, in Baringo, beekeepers and other value chain actors stand

to make approximately USD 9 million annually, or more than shillings 1.2 billion, if the potential is increased by 40%. As a result of the County government's investment in the beekeeping value chain, honey production has increased substantially, from an average of 500 metric tonnes to 882 metric tonnes (Baringo County Government,2023).

Promotion of modern apiculture dates back to 1950s, when the Kenya government began training beekeepers on modern apiculture (Kiingwa *et al*., 2020; Silvica, 2019). Most of the honey producing industries were mainly established in Makueni, Baringo, Samburu, and Kitui Counties (Kathila, 2017). These advancements were crucial in the development of the sector through job creation and boosting income of the marginal households.

Many development agency programs, including those by the government and non-governmental organizations (NGOs), have, however, failed to speed up apiculture modernization, notably in Kenya's semi-arid regions (Kipruto, 2016). Better beekeeping technology, such as improved beehives, safety gear, smokers, and honey extractors, are required to increase production and improve income (Kuboja *et al*., 2017).

The sector contributes to environmental conservation and crop productivity through pollination services (ICIPE, 2019). The enterprise may thus play a key role in poverty alleviation, in line with Kenya's long-term plan, Vision 2030. Honey is a vital source of energy, protein, vitamins, minerals, and amino acids, as well as achieving Sustainable Development Goals like Goal 1—reducing poverty and Goal 2—eradicating hunger by establishing food security, feeding the world's growing population via sustainable agriculture, and creating employment opportunities. Despite technological advancements improving rural people's living situations through modern apiculture remains a challenge. Beekeeping, like other agricultural and livestock-farming ventures, did not formerly garner nearly as much attention as it does now (De Castro-Pardo *et al*., 2021).

Several organizations have undertaken efforts to raise awareness of the efficiency and desirability of modern apiculture, yet their efforts have not been extremely effective due to obstacles that hinder farmers from embracing the most modern methods available (Chelagat, 2022). Inefficiencies in production, unskilled labor, restricted access to funding, and lack of extension services are all factors hindering adoption (Muriuki, 2016). The adoption status of modern apiculture and the factors influencing its adoption is not clear in the empirical literature, a gap that necessitated this study.

Research Methodology

Study Areas

This study was conducted in Baringo and Makueni Counties, specifically in Marigat and Kathonzweni wards respectively (figure 1). Marigat Ward is located approximately 260 km north-west of Nairobi and covers an area of 1,514.9 km^2. It is situated between latitude 0.4695°N of equator and longitude 35.9833°E (Survey of Kenya, 2022). The other study site was in Kathonweni Ward in Makueni County which is located between Latitude 1.9131°S and Longitude 37.7317°E (Survey of Kenya, 2022).

According to Kenya National Bureau of Statistics (KNBS, 2019), Marigat Ward had a total of 90,952 inhabitants (45,706 male and 45,246 female) in the 2019 census distributed in 19,854 households. The

population density is low at 63 persons per Km^2. Kathonzweni Ward on the other hand had a total of 79,780 inhabitants (39,335 Males and 40,442 Females) in the 2019 census distributed in 18,365 households. The population density was low at 91 persons per Km^2.

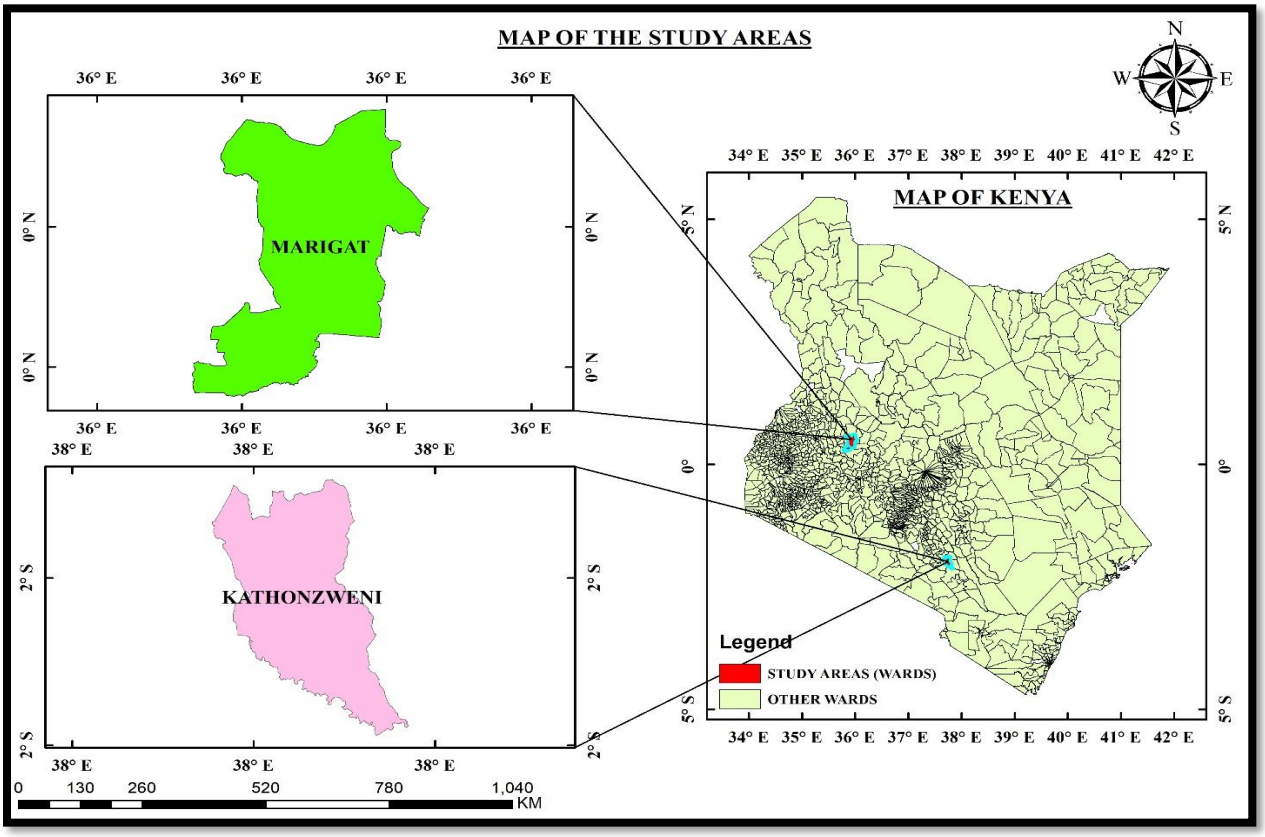

Figure 1: Map of Kenya Showing the Study Areas

Source (Survey of Kenya, 2022)

Research Design

The study adopted descriptive research design to generate statistical data for determinants influencing the adoption of modern apiculture. The design allowed the researcher to collect data, compile, organize, display, and interpret. This design was appropriate since the researcher obtained data and presented it as it was without changing any of the variables (Sileyew, 2019). The researcher was able to arrive at conclusions and draw generalizations on the population of interest.

Target Population

The target population were beekeepers within the study areas.

Sampling Procedure and Sampling Size

The study employed a multi-stage sampling design. Since apiculture was one of the two Counties' 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, farmers were grouped into smaller units. Then, proportionate sampling was used to obtain the total sample size for each stratum, and systematic random sampling was used using a systematic random selection technique to guarantee that the respondents in both research areas were representative. The sampling frame was obtained from the Ministry of Agriculture in both study 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 was the coefficient of variation (25%), and

e the standard error value (0.02)

According to Baringo South Sub County statistics, 688 households in Marigat Ward were engaged in beekeeping, with a sample size of 127, as shown below.

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

$$n = \frac{688x0.0625}{0.0625 + 687x0.0004}$$

$$n = 127$$

In Makueni Sub County, 576 marginal households were accessible in Kathonzweni Ward, with a sample s ize of 123 beekeeping farmers, as shown below.

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

$$n = \frac{576x0.0625}{0.0625 + 575x0.0004}$$

$$n = 123$$

Instruments

The semi-structured questionnaires were the primary tool for gathering primary data. The questionnaire comprised both closed and open-ended questions. Questionnaires were presented by trained enumerators after the instruments had been thoroughly pre-tested to ensure that it was adequate and dependable in obtaining high-quality data.

Data Analysis

Before data processing, each survey was verified for completeness. To make the study organized and comprehensive, qualitative data was coded. Data was analyzed using SPSS (version 24). A multiple linear regression model was used to determine factors influencing adoption of modern apiculture in the study areas. Before data analysis, the independent variables were subjected to heteroscedasticity using a white test, and the variance inflation factor was also used to determine multicollinearity for all continuous variables. Variance Inflation Factor (VIF) and contingency coefficient were used to evaluate both the continuous and categorical variables. The study had two continuous variables and 13 categorical variables to determine the influence of these variables on adoption of modern apiculture among marginal households in the two sites.

Afterward, the actual data analysis was conducted using an econometric model, multiple linear regression.

Results and Discussion

This section details the results of the econometric model was used in determinization of adoption of modern apiculture among marginal households. Diagnostic tests were done on all the independent variables to determine hitches of multicollinearity and heteroscedasticity before analysis.

Diagnostic Test of Variables

Multicollinearity is where independent variables causes inter-`association and inter-correlations which results to incorrect estimates and conclusions (Salmeron *et al*., 2018; Thomson *et al*., 2017). The VIF for the two variables presented in Table 1 (age and household size) were found minimal whereby the VIF values were less than 10. This indicates that the data did not have major multicollinearity problem (Swaumu *et al*., 2022). The results of this research align with those of Kiprono *et al*. (2022) whose findings revealed that, given that the VIF values were lower than 10, there existed insufficient linear association across the variables that were subject to examination.

Table 1: VIF for continuous variables

Variable	VIF	I/VIF
Age	1.31	0.7645
Household size	1.31	0.7645

Results in (Table 2) below indicate that there is no problem of heteroskedasticity in the variables since the p-value was greater than 5%. The result concurs with outcomes reported by Nyamamba *et al*. (2022) whose p-value was greater than 5%. The white test was preferred to the Breusch-Pagan test since it accounts for both the magnitude and direction of change (Farbmacher & Kogel, 2017).

Table 2: Test For Heteroskedasticity

Source	Chi2	Df	P
Heteroskedasticity	128.5	118	0.2397
Skewness	67.97	15	0.0000
Kurtosis	21.25	1	0.0000
Total	217.72	134	0.0000

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According to the findings presented in Table 3 below, Gender of the respondent had a positive and was significant at 5% significance level. This indicates that majority of the apiculture farmers were female who influenced positively adoption of modern apiculture in the two study areas. This is because the modern systems (backyard systems) have integrated women in apiculture by helping their husbands in the activities thus influencing them to start their own apiaries. Similarly, modern apiculture allows women to place their hives at waist height thus could comfortably harvest and conduct other routine activities. This study is a contrast to that of Gikunda *et al*. (2021) who argued that women and youth lacked interest in bee keeping since women feared bee stings, believed that the enterprise was only meant for men and equally are unable to construct bee hives. Also, Soh *et al*. (2021) discussed that, male beekeepers are likely to adopt modern apiculture since it involves carpentry activities dominated by men than women thus limiting women in modern apiculture.

Multiple Linear Regression Results on adoption of Modern Apiculture

Variable	Coefficient	Std. Error
Socio-Economic Factors		
Age (continuous)	0.0086	0.0435
Gender (categorical)	0.1974**	0.0853
Marital status (categorical)	0.1028**	0.0465
Level Education (categorical)	0.0332	0.0373
Household size (continuous)	-0.0392**	0.0162
Attitudes (categorical)	0.1702**	0.0775
Institutional Factors		
Extension Services (binary)	-0.0003	0.0390
Group Membership (binary)	-0.2972***	0.0780
Access to Credit (binary)	0.1072*	0.0642
Access to Land (binary)	-0.1450**	0.0702

Access to Markets (binary)	-0.1980	0.1258
Transportation (binary)	0.2403***	0.0804
Biophysical Factors		
Destruction of woody vegetation (binary)	-0.0403	0.0743
Drought and Famine (binary)	-0.0681	0.0816
Climate Change (binary)	0.2069**	0.0852
Cons	0.3187	0.3152

, ** and * denote 10%, 5% and 1% statistical significance levels.*

In the study (Table 3), marital status was significant at 5% and had a positive influence on the adoption of modern apiculture. This shows that honey producers who are married are more likely to adopt modern bee technologies than those who are single honey producers. The result reflects observations made by Mwangi and Bula (2021) who revealed that most women involved in the enterprise were married and viewed it as an economically feasible activity that their families could support and adopt. The study however, contrasts to that of Yohana and Saria (2020) who indicated that women who practiced bee keeping were those who were divorced, separated and widowed since they were the breadwinners for the family. Equally, Tadesse *et al*. (2021) argued that single honey producers were technically efficient than producers who are married.

Household size had a negative significance level on adoption of modern apiculture in both women and youth. It had a significance level of 5%. This signifies that the more the family dependents, the less the respondents are likely to transition their apiculture activities to modern. The finding is consistent to that of Andaregie *et al*. (2021) who found household size negative and greatly significant on adoption of modern apiculture. Equally, Mulatu *et al*. (2021) found that majority of apiculture farmers with larger families are non-adopters of technology. However, Bojago (2023) found a positive influence stating that larger families are more likely to use modern technologies in order to meet their daily needs. Correspondingly, Andaregie *et al.* (2022) reported that those households with large family size are likely to produce more honey and adopt new technologies since there is availability of more labour to look after the enterprise.

In respect to attitudes, it had a positive significance level of 5% on the adoption of modern apiculture. The results indicate that, individual attitudes towards modern technologies influenced strongly the adoption of modern apiculture. Positive attitudes influenced bee keepers to desire to adopt modern technology. This finding is in line with that of Tulu *et al*. (2020) who argued that individual perceptions on a technology's characteristic such as its relative merit and concerns about disadvantages influenced a farmer's desire to embrace the new technology. Due to their focus on making quick money, youths see beekeeping as a less viable business, this is corroborated by Gikunda *et al*. (2021) who found out that young people's social backgrounds are influenced by societal customs and assumptions, which define how they feel about the venture.

The coefficient of group membership had a negative influence on the adoption of modern apiculture. It had a significance of 1% indicating that, being a group member does not enhance women and youth to adopt modern apiculture in the two study areas. The possible reason could be of dependency on farmer group decisions limiting independence of the farmer's decision making. If the group agreement does not support individual's preferences, it discourages them from adopting modern apiculture. This finding is line with of Vaughan *et al*. (2019) who discussed that in a larger group there is limited individual attention and support during training and mentorships affecting the ability to grasp an idea, practice and adopt modern practices.

Access to credit was significant at 10% and a positive influence on adoption of modern apiculture among women and youth in the study area. This signifies that beekeepers that have access to finances are able to procure or purchase modern equipments increasing the adoption rate of modern apiculture technology. The result is consistent to that of Andaregie *et al*. (2021) and Mulatu *et al*. (2021) found that access to financing helps beekeepers to purchase equipments, adopt modern beekeeping techniques and expanding their businesses improving their livelihoods. Similarly, Bojago (2023) stated that bee farmers with access to financing are capable of purchasing modern equipments needed in the enterprise at a relatively lower cost than those without access. Equally, Tulu *et al*. (2020) found that a credit service helps beekeepers to adopt new innovative and improved apiculture technologies by minimizing their financial problems.

Access to land by beekeepers in the study areas had a negative influence on the adoption of modern apiculture. It had a significance level of 5% justifying that landholding had a negative influence on adoption of modern apiculture. This projects that land and adoption to technology are inversely related. Beekeepers could venture into apiculture enterprises by just owning an apiary site. Equally, farmers with vast tracts of land are not interested in bee keeping technologies. This is because producers with large tracts of land prefer other livestock enterprises over apiculture. This study is in line with that of Mulatu *et al*. (2021) and Tekle (2018) who argued that this enterprise contributes greatly to household income without needing to own land. However, Jemase and Chesikaw (2021) argued that inaccessibility to land prevented women and youth starting an apiculture business because land was primarily owned by older men.

Transportation's coefficient was positive and significant at 1% significance level on adoption of modern apiculture by women and youth. Distance to the nearest marketplace from households influenced positively on the adoption on modern apiculture by women and youth. The finding implies that households situated far away from markets and input providers are likely to adopt modern apiculture. This is because the transaction costs involved during transportation encourages beekeepers to intensify their enterprise in order to get much income after deducting transportation costs. Equally, the study areas are ASAL's region, bee keeping is among the economic activities carried out in the study areas, and hence bee keeping is a cheap alternative as compared to other enterprises. Thus, embracing new technologies attracts higher returns in the households. This was a contrast to Andaregie *et al*. (2022) who reported that rural households located far away from marketplace get limited information and have difficulties in accessing inputs for apiculture.

Climate change was positive with a significance of 5% on adoption of modern apiculture amongst the women and youth in the study areas. Changes in climate conditions have impact on quantity of honey produced; survival of bee species, pollen produced thus lowering the nutritional quality. Persistent of weather conditions forced women and youth in the two study areas to adopt modern technologies such as supplementing feed to the bees, hive shading and tree planting to reduce the extremes of weather on the enterprise. This result is in line with that of Rai and Ravuiwasa (2019) that stated that climate related stress endangered bee species, water resources, new disease development and plant environment thus encouraging beekeepers to adopt modern apiculture methods. Similarly, Yohana (2021) argued that due to current climate changes and variabilities, beekeepers have opted for new production systems as a way of coping with the adverse effects of climate change.

Efforts to contribute to better natural resources management and utilization of ASAL areas demands for proper assessment of the above factors that influence adoption of modern apiculture among marginal households and the challenges involved during adoption.

Conclusion

The study intended to determine the factors that influence modern apiculture uptake. The data demonstrated that socio-economic factors, institutional factors, and biophysical factors all significantly influence modern apiculture adoption. Gender, marital status, family size, attitude, access to credit, transportation, and climate change had a positive and significantly influenced adoption, whereas group participation and access to land negatively and significantly influenced adoption of modern apiculture as determined by the multiple linear regression model. Based on the conclusion, the research recommends increased access to training programs to help farmers increase their technical skills and knowledge in modern beekeeping, market integration, and value addition. Credit-granting organizations to offer low-interest loans and grants to cover the initial expenses for beekeeping accessories. In addition, gender mainstreaming at all levels and particular policies are required to counter the norms of inequality between men and women in all domains and dimensions. Additional research is needed to determine how apiculture's productivity influences marginal households' welfare.

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Disclosure of conflict of interest

There is no conflict of interest declared by the authors in regard to the findings of this research.

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Appendix: Household questionnaire

Introduction

My name is Nyamira Enock Nyamorambo. I am pursuing a Master's degree in Natural Resources Management at Egerton University. I am carrying on research on ***'Determinants of the adoption of modern apiculture among marginal households in Baringo and Makueni counties, Kenya".*** I would like to ask you some questions about the study. The information provided will be kept confidential and used solely to conduct research into potential answers to the current problem. The results will guide policymakers and other community-based entities to identify areas where intervention is needed to achieve the desired improvement in modern apiculture uptake.

Section A: SOCIO-ECONOMIC FACTORS

1. Ward …….
2. Location
3. Age 1- (18-26) 2- (26- 35) 3- (36-45) 4- (46 and above)
4. Marital status; Single ( ) Married ( ) Widow(er) ( ) Divorced ( )
5. Education background/Years of schooling?

None ( ) Primary ( ) Secondary ( ) Tertiary /College ( )

6. Gender; Male ( ) Female ( )
7. Number of dependents in your family….
8. Do you have any other sources of income besides beekeeping? Yes ( ) No ( )
9. How many hives do you have in total?
10. Number of traditional hives?
11. Number of modern hives?
12. Are there social-cultural beliefs that hinder women and youth from practicing beekeeping?

Yes ( ) No ( )

B: INSTITUTIONAL FACTORS

1. Are you in any Beekeeping group? Yes ( ) No ( )
2. If yes, how long have you been in the group

3. What are the benefits? Training ( ) Market ( ) Loans ( )
4. Are the training and extension services sufficient? Yes ( ) No ( )
5. Are there accessible markets for your bee products? Yes ( ) No ( )
6. What is the distance in minutes to the market?
7. What are the types of road networks used to access the market?
8. Do you access loans to boost your apiculture enterprise? Yes ( ) No ( )

C) BIOPHYSICAL FACTORS

1. Has the destruction of woody vegetation reduced bee flora? Yes ( ) No ( )
2. Due to the climate change effect, has honey production reduced? Yes ( ) No ( )
3. Hive production reduces during drought and famine. Yes ( ) No ( )
4. When environmental temperatures are high, do bee colonies flee away? Yes ( ) No ( )

D) CHALLENGES FACING MODERN APICULTURE

Which of the following challenges for adoption do you experience?

1. Inadequate capital	
2. Cultural hindrances	
3. Inadequate knowledge and skills	
4. Inadequate access to market	
5. Inadequate equipment and materials	
6. Persistent drought and famine	
7. Land access	
8. Destruction of woody vegetation	