frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 23 January 2026
DOI 10.3389/fsufs.2026.1647473

OPEN ACCESS

EDITED BY
Tiziana De Magistris,
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REVIEWED BY
Gunardi Winarno,
University of Lampung, Indonesia
Dara Dimitrov,
University of Waikato, New Zealand

*CORRESPONDENCE
Naftali Kiprono
✉ naftaliruto@gmail.com

RECEIVED 23 July 2025
REVISED 02 January 2026
ACCEPTED 05 January 2026
PUBLISHED 23 January 2026

CITATION
Kiprono N, Gitau R and Chelang'a N (2026) Determinants of beekeepers' honey market outlet choice in Baringo County: a multivariate probit regression analysis. *Front. Sustain. Food Syst.* 10:1647473. doi: 10.3389/fsufs.2026.1647473

Determinants of beekeepers' honey market outlet choice in Baringo County: a multivariate probit regression analysis

Naftali Kiprono*, Raphael Gitau and Naomi Chelang'a

Department of Agricultural Economics and Agribusiness Management, Egerton University, Njoro, Kenya

Introduction: Access to profitable market outlets for beekeepers is a major concern in Baringo County. This paper aims to identify the factors influencing honey producers' choice of market outlets. The study analyzed the market outlets producers chose to determine the most used market channels.

Methods: The study used data collected from 197 randomly selected respondents. The multivariate probit model was used to determine the factors affecting market outlet choice options.

Results and discussion: The results show that of the sampled respondents, 51% sold to wholesalers, 36% to retailers, 34% to middlemen, and 25% to individual consumers. The model results show that gender, education level, access to training and extension services, access to credit, beekeeping experience and honey output are statistically associated with participation in specific market outlets. Education, training, and honey output are positively associated with participation in wholesaler outlets, while beekeeping experience and access to credit are negatively associated with participation in retailer and middlemen outlets, respectively. The estimated correlation structure suggests the presence of both complementary and substitutive relationships among market outlets. The study recommends enhancing access to credit services and strengthening farmer extension and training programs to help beekeepers increase their market participation and income.

KEYWORDS

Baringo County, beekeeper, honey, market outlet, multivariate probit

1 Introduction

Since its independence, the Kenyan government has implemented policies and interventions to increase agricultural productivity, stimulate economic growth, and reduce poverty (Eichsteller et al., 2022). Despite these initiatives, the population still depends mainly on small-scale farming, with most struggling to make a living. Beekeeping is one of the value chains that can turn around the livelihoods of locals, as it thrives in areas where crop farming is limited and the natural vegetation comprises many plant species suitable for bee forage. Honey is mainly produced using traditional approaches based on log hive technology (Mburu et al., 2017). Beekeeping can be carried out successfully in 80% of the country and is especially suitable in arid and semi-arid areas. Beekeeping is an important agricultural enterprise practiced globally for both economic and ecological benefits. It contributes significantly to rural livelihoods, biodiversity, and food security through pollination and the production of honey and other hive products such as beeswax, propolis, and royal jelly. The country's potential for apiculture development is estimated at over 60,000 and 100,000 metric tons of honey and beeswax, respectively (Affognon et al., 2015; Gakenia et al., 2024).

Despite increasing demand for honey and honey products, the number of hives and total honey production have declined sharply in recent years. The decline is attributed to the degradation of bee habitat, inadequate practices, poor beehive quality, pesticide use, access to the market, lack of new entrants to replace those moving out of the value chain, and limited access to formal training, credit, and land, especially for women and young people (Gikunda et al., 2021).

In Kenya, the honey market is liberalized. Marketing of honey is mainly done through community development partners, faith-based organizations, farmer cooperatives and brokers. For example, Honey Care Africa, Church Welfare Service (CWS), African Bee Keepers Limited, and the Hive group. Most of these organizations supply beekeeping equipment to farmers, conduct training, and complete the value chain by purchasing, collecting, and processing bee products and adding value. Honey pricing is mainly based on volume and depends on the farm's location, type of honey (comb honey, processed, semi-processed, crude honey), and source. However, beekeepers also use other market channels existing within their localities (Sagwa, 2021).

Marketing information and facilities are essential as they enable farmers to plan and align production more closely with market demand. Currently, there is poor and inadequate marketing knowledge, which impairs the system. Enhancing the ability of poor smallholder farmers to reach markets and actively engaging them are among the most pressing development challenges (Mutua et al., 2023). Without convenient marketing conditions, the possible increment in output, rural incomes, and foreign exchange resulting from the improved honey technology system could not be adequate. Further, beekeepers still face other challenges, like weak bargaining power, fluctuating prices, and inefficiencies in supply chain linkages (Borena et al., 2023).

The choice of marketing channels, whether direct to individual consumers or indirect through middlemen, retailers, or wholesalers, can significantly influence beekeeping enterprises' income, resilience, and market integration. These decisions are rarely random but are shaped by a multitude of interrelated factors, including individual characteristics, support and financial aspects, marketing environment, and strategic enablers (Mizero et al., 2024). For most farm household heads in rural areas, choosing the appropriate market outlet is a significant consideration in marketing decisions (Mmbando et al., 2015).

Most studies have focused on marketing outlet choices for food crops, neglecting the beekeeping value chain. Similarly, global studies on the determinants of honey producers' market outlet choices yield varied results due to differences in methods and locations. Such results cannot be accepted universally. Identifying these critical factors is crucial for identifying potential areas of intervention that can help honey producers optimize the benefits of their honey production and marketing activities. By addressing this gap, the study aims to analyse the determinants of marketing outlet choices among beekeepers in Baringo County.

2 Literature review

In a study to determine market outlet choice for honey producers in Ethiopia, Tarekegn et al. (2017) sampled 154 households using a simple random sampling method. The study used a multivariate probit model and found that the quantity of honey sold, frequency of extension contact, beekeeping experience, distance to the nearest market, market information about each outlet, cooperative membership, and trust in buyers positively affected the choice of marketing channel. However, education level, household size, and income were not significant. The authors suggested increasing participation across various outlets, expanding equal access to infrastructure, establishing honey collection centers in potential production areas, increasing the frequency of extension contact, and organizing additional beekeepers into honey cooperatives. In a similar study, Tadesse et al. (2021) found that 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 among the leading factors influencing marketing of honey.

Kaygisiz (2023) conducted a study in Turkey to examine the determinants influencing beekeepers' choice of marketing channels for strained honey. The study used primary data collected from 162 respondents. The findings revealed that several factors significantly affected marketing channel selection, including the beekeeper's education level, income, access to government or institutional support, preferred payment method, satisfaction with existing marketing channels, pricing strategies, sources of market information, and credit usage. Furthermore, a comparative analysis between those using direct marketing channels and those relying on indirect channels (retailers, wholesalers, and middlemen) highlighted notable differences based on age, the proportion of income derived from beekeeping, the number of hives owned, the contribution of strained honey to total beekeeping income, and honey price. The study recommended that enhancing beekeeper training, improving access to market information, strengthening infrastructure, and promoting cooperative membership could be vital to enhancing beekeepers' marketing outcomes and overall income.

Adgo and Seyoum (2018) conducted a study in Ethiopia to understand the determinants of honey marketing in the domestic market channel. The study utilized data from 125 randomly selected beekeepers. The results revealed that 69.6% of sample households chose collector market channel, 9.6% chose cooperative market channel, and 20.8% chose consumer market channel to sell their honey. Further, findings from the multivariate probit model showed that experience of beekeeping, membership to a cooperative, transport facility, and time spent selling honey products significantly affected honey producers' choice of market outlet. The study stressed the need to improve transport networks for farmers' cooperatives and assist beekeepers in identifying promising market channels.

In a study to determine factors influencing choice for honey market outlets in Ethiopia, Borena et al. (2023) surveyed 150 honey-producer households. The study used a multivariate probit model and found that household head educational level, agroecology, market distance, frequency of extension contact, market information, and volume of honey marketed significantly affected the willingness to choose honey market outlets. The study recommended that government and support service

provider interventions are required to improve the production of marketed honey.

2.1 Theoretical framework

The study used the random utility maximization theory framework, which is particularly relevant for understanding how beekeepers choose specific market outlets, considering the inherent uncertainty in how beekeepers perceive these outlets. The fundamental assumption is that beekeepers select a particular outlet/outlets based on its utility or benefit. Following this theory, the decision to choose an outlet/outlets is determined by random factors (McFadden, 1973).

Unlike the standard discrete choice setting that assumes mutually exclusive alternatives, this study conceptualizes market outlet engagement as a set of non-mutually exclusive participation decisions. Beekeepers may sell honey through more than one outlet within a production period, implying that the decision to participate in one outlet does not impede participation in others.

The latent utility that beekeeper i derives from participating in market outlet j is specified as:

$$U_{ij} = \beta_j^{'} X_i + \varepsilon_{ij} \quad (1)$$

where U_{ij} represents the unobserved net utility associated with participation in outlet j; X_i is a vector of beekeeper-specific, institutional, and market-related characteristics; $\beta_j{}'$ is a vector of outlet-specific parameters; and ε_{ij} is a stochastic error term capturing unobserved factors affecting participation (Green, 2012).

The observed participation decision is linked to this latent utility through a binary indicator defined as:

$$Y_{ij} = \begin{cases} 1 \; if \; U_{ij} > 0 \\ 0 \; otherwise \end{cases} \quad (2)$$

where $Y_{ij} = 1$ denotes participation by beekeeper i in outlet j, and $Y_{ij} = 0$ indicates non-participation. This formulation implies that participation occurs when the perceived net utility from engaging in a specific outlet is positive, independent of participation decisions in other outlets.

3 Methodology

3.1 Study area

The study was conducted in Baringo County, one of the 47 Counties in Kenya, in the Rift Valley region. The County lies between longitudes $35^0 30'$ and $36^0 30'$ East and latitudes $0^0 10'$South and $1^0 40'$ It borders Turkana and Samburu Counties to the North, Uasin Gishu to the South West, Laikipia to the East, Nakuru to the South, and Elgeyo-Marakwet and West Pokot to the West. The main crops grown in the County are maize, pigeon peas, beans, Irish potatoes, sweet potatoes, sorghum, cassava, and finger millet. In contrast, the cash crops are coffee, cotton, macadamia, and pyrethrum. Livestock products include honey, beef, mutton, hides, and skin. However, little value addition is done to these products (Safari and Wambua, 2024). Baringo South Sub-County was chosen because of its significance in honey production, with an area of $1678Km^2$ out of which $215Km^2$ constitutes arable land (Baringo County Government, 2018). The area's estimated population is 89,210; furthermore, the area has four administrative wards: Marigat, Ilchamus, Mochongoi and Mukutani (KNBS, 2019). Figure 1 represents a map of the study.

3.2 Research design

The study used a cross-sectional research design, which is helpful because much information is obtained quickly. It allows data collection from different groups of respondents at one point in time. Moreover, this design also collects data, enabling measurement of the prevalence of all factors under investigation (Kumar, 2014).

3.3 Sampling procedure

A multi-stage sampling procedure was used to select the sample for the study. First, Baringo County was chosen because beekeeping is a priority value chain in its annual strategic plan. Baringo South Sub-County was also selected purposively since it is the leading Sub-County in honey production. Marigat, Ilchamus, Mochongoi, and Mukutani wards in the Sub-County were all selected because they have the highest concentration of beehives. Respondents were selected using simple random sampling.

3.4 Sample size determination

The target population comprises beekeepers in Baringo South Sub-County. According to data from the Sub-County Agricultural Office, there are 5,416 registered beekeepers in the four wards. As Yamane (1967) suggested, since the population size is known with certainty, the following formula is appropriate to determine the sample size.

$$n = \frac{N}{1 + N(e^2)} \quad (3)$$

Kothari (2004) accepts an error of less than 10 percent thus, this study used an error of 0.07, which is precise, hence a smaller sample size that could fit the budget.

$$n = \frac{5416}{1 + 5416(0.07^2)} = 196.67 \approx 197 \quad (4)$$

Where:

n = Sample size,

N = Total population of interest,

e = The allowable margin of error ranges from 0.05 to 0.1.

3.5 Analytical framework

When confronted with several potential marketing outlets, beekeepers may sell through multiple outlets to maximize profits.

10.3389/fsufs.2026.1647473

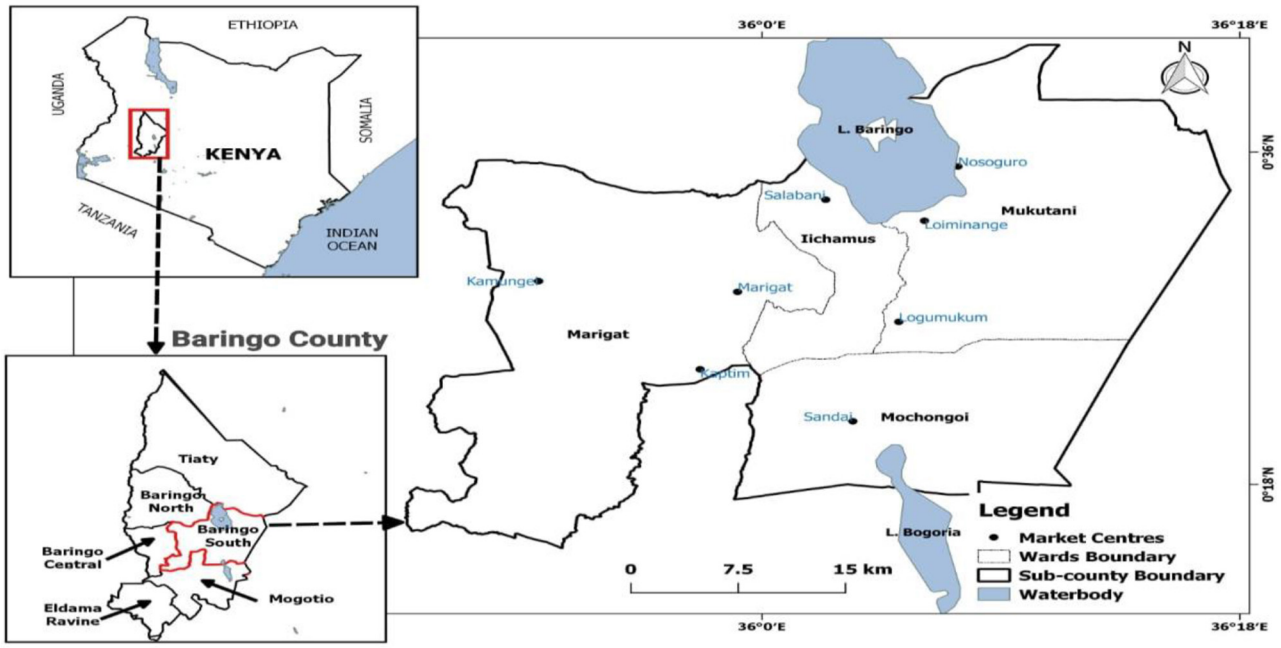

FIGURE 1
Baringo south sub-county map. Source: egerton university, department of geography (2020).

Therefore, in conjunction with using a specific market outlet, a beekeeper can select other outlets. The decision might have been informed by prior use of a particular outlet, which could help inform future decisions.

Multinomial Probit model could be used however, it assumes that decision-makers select a single option from a set of mutually exclusive alternatives, implying a ranked preference structure across choices. In contrast, the Multivariate Probit (MVP) model estimates a system of correlated binary participation decisions, allowing producers to engage in multiple market outlets simultaneously (Shah and Alharthi, 2024; Wang et al., 2023). In the context of honey marketing, beekeepers often sell through more than one outlet within a production period, making outlet participation non-mutually exclusive. The MVP framework is therefore appropriate, as it captures both the determinants of participation in each outlet and the potential correlation across outlet decisions arising from unobserved factors.

Therefore, the study adopted a multivariate probit (MVP) econometric model, which evaluates the influence of the set of explanatory variables on each market outlet while allowing unobserved components to be flexibly linked. The source of correlation might be positive and negative correlations between different market outlet options (Mengstu et al., 2023). In this study, the dependent variables are four dummy variables —Wholesalers, retailers, individual consumers, and middlemen —that equal 1 if the beekeeper chooses the outlet option and 0 otherwise. The model can be defined empirically as shown in Equation 5:

$$Y_{ik}^{*} = \beta_k X_{ik} + \varepsilon_k \; Where \; (k = 1, \ldots\ldots.., m)$$
$$Y_{ik} = 1 \; if \; Y_{ik}^{*} > 0 \; and \; 0 \; otherwise \tag{5}$$

Where Y_{ik}^{*} denotes a latent variable that captures the observed and unobserved characteristics associated with k^{th} market outlet, while Y_{ik} is the binary dependent variable and $(k = 1, \ldots, m)$ denotes the different market outlets beekeepers use. The ability of beekeepers to use a market outlet option to take value 1 and 0 otherwise, X_{ik} is a vector of independent variables that represent household demographic characteristics and institutional factors. β_k and ε_k represent the parameter to be estimated and the error term, respectively. A positive correlation among market outlets indicates complementarity, whereas a negative correlation indicates substitutability. The error term follows a multivariate normal distribution, with zero mean, variance normalized to unity and a $n \times n$ covariance matrix. The covariance matrix is shown in Equation 6;

$$II = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} & \cdots & \rho_{1m} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} & \cdots & \rho_{2m} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} & \cdots & \rho_{3m} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 & \cdots & \rho_{4m} \\ \vdots & \vdots & \vdots & \vdots & 1 & \vdots \\ \rho_{m1} & \rho_{m2} & \rho_{m3} & \rho_{m4} & \cdots & 1 \end{bmatrix} \tag{6}$$

Parts $(\rho_{21},\ \rho_{12},\ \rho_{31},\ \rho_{13},\ \rho_{41}\ and\ \rho_{14})$ in the variance-covariance matrix represent the correlation between the stochastic components of different market outlets. Equation 7 provides a multivariate probit model that jointly depicts decisions to select a particular market outlet under the premise of the unobserved correlation between the stochastic component of the $k^{th}$and m^{th} outlet options. Correlation between the error terms of several latent equations, which represent unobserved qualities that influence the

TABLE 1 Model variables hypothesized to influence the choice of market channel.

Variable	Description	Measurement
Dependent variables		
wholesaler retailer middleman individual consumer	Participation in wholesale outlet participation in retailer outlet participation in middleman outlet participation in individual consumer outlet	1 = yes, 0 = no 1 = yes, 0 = no 1 = yes, 0 = no 1 = yes, 0 = no
Independent variables		
Age	Age of the household head	Years
Household size	Number of household members	Count
Gender	Sex of the household head	1 = male, 0 = female
Education level	Formal education of household head	Years of schooling
Credit access	Access to credit	1 = yes, 0 = no
Income	Total off-farm income	Kenyan shillings
Group membership	Beekeeper group membership	1 = yes, 0 = no
Extension access	Access to extension services	1 = yes, 0 = no
Off-farm income	Access to off-farm income	1=yes, 0=no
Distance	Distance to the honey market	Kms
Honey harvested	Amount of honey harvested	Kgs
Training	Honey marketing training	1 = yes, 0 = no
Experience	Years engaged in beekeeping	Years

choice of different adaptation strategies, is made possible by this specification's non-zero off-diagonal elements.

The explanatory variables used in this study (Table 1) were obtained from past studies on the choice of honey market outlets (Adgo and Seyoum, 2018; Borena et al., 2023; Kaygisiz, 2023; Tadesse et al., 2021; Tarekegn et al., 2017).

4 Results and discussions

The descriptive statistics presented in Table 2 illustrate the mean differences in key continuous variables across different market outlets, the associated standard deviations, and t-statistics.

The average household size of beekeepers was approximately five members, with minimal variation across different market outlet participation. Beekeepers who sold to wholesalers had slightly larger household sizes (5.28) compared to those selling to retailers (4.89), although the difference was not statistically significant. Larger household sizes may indicate greater labor availability within the household, which can influence marketing activities, and decision-making (Mizero et al., 2024).

The mean age of respondents was approximately 41 years, indicating that most participants are middle-aged, a demographic often associated with greater experience, and risk management capacity. The mean age of beekeepers who sold through wholesale market outlets was 45.01 years, which is significantly higher than the overall mean at the 1% level. This suggests that older beekeepers are more likely to engage in wholesale marketing, possibly due to their well-established social networks and accumulated market experience (Mwembe et al., 2021).

The overall mean off-farm income of beekeepers was Ksh 13,550.76. Although beekeepers selling to wholesalers, and individual consumers reported relatively higher off-farm incomes, the variations were not statistically significant. This finding is consistent with Aklilu et al. (2025), who observed that off-farm income may not directly influence market participation but can enhance liquidity for meeting marketing-related costs.

The average education level of beekeepers was 10.4 years, indicating that most respondents had attained at least secondary education. Beekeepers who sold to middlemen had a slightly lower mean education level (9.44 years), which was significantly different from the overall mean at the 10% level. Education enhances farmers' ability to acquire, process, and utilize market information effectively, thereby improving decision-making (Chebura et al., 2025). The relatively lower education level among middlemen may therefore suggest a greater reliance on experiential rather than formal knowledge in their marketing activities.

The average landholding size of beekeepers was 4.37 acres, with those selling to wholesalers owning significantly larger parcels (5.32 acres) compared to other market participants ($p < 0.05$). Land size often determines production capacity, and the level of marketable surplus, thereby influencing participation in more lucrative market outlets (Legesse et al., 2024).

The average distance of beekeepers to the market was 4.00 km, with significant differences observed between those selling to wholesalers, and retailers at the 5% level. Beekeepers who sold to wholesalers were located farther from the market (4.71 km) compared to those selling to retailers (3.53 km). This suggests that distance plays an important role in determining the choice of market outlet, consistent with the findings of Ketema and Lika (2023).

The average beekeeping experience was 9.17 years, though those who sold to individual consumers reported having more years of beekeeping experience. Experience influences marketing efficiency by improving negotiation skills, and network building (Mengistu and Meressa, 2023). This suggests that individuals with longer experience are better positioned when selecting a market outlet.

The mean quantity of honey harvested was 73.36 kilograms. Beekeepers who sold to middlemen, and individual consumers harvested 94.70 kg, and 113.87 kg, respectively, reporting significantly higher harvest volumes than the overall mean. This indicates that higher production levels increase the likelihood of selling to middlemen, and individual consumers. These findings align with Tarekegn et al. (2017), who noted that production volume is a key determinant of market outlet choice.

The results in Table 3 present descriptive statistics for categorical variables that influence beekeepers' market outlet choice.

TABLE 2 Summary statistics for the continuous variables.

Variable	Mean (All)	Retailers	Wholesalers	Middlemen	Individual consumer
Household size	4.944	4.891 (1.939) (0.345)	5.282 (2.581) (-1.615)	4.889 (2.136) (0.140)	5.733 (2.052) (-1.442)
Age (years)	40.995	40.129 (12.458) (0.980)	45.014 (11.955) (-3.416***)	41.148 (16.145) (-0.067)	40.4 (13.282) (0.188)
Off-farm income	13550.76	12,751.49 (12,877.38) (0.832)	15,273.24 (15,076.64) (-1.3163)	11,592.59 (13,841.16) (0.792)	17,000 (16,299.65) (-1.006)
Education level	10.401	10.495 (2.958) (-0.432)	10.451 (3.097) (-0.1669)	9.444 (4.209) (1.718*)	10.267 (4.415) (0.173)
Land size	4.372	4.235 (3.693) (0.492)	5.317 (4.423) (-2.531**)	4.778 (3.745) (-0.568)	4.3 (3.673) (0.072)
Distance	4.003	3.531 (2.978) (2.253**)	4.709 (3.133) (-2.474**)	4.407 (2.557) (-0.742)	3.707 2.092) (0.391)
Experience (years)	9.173	8.178 (6.966) (1.787*)	11.042 (8.261) (-2.477**)	11.111 (11.284) (-1.349)	12.867 (11.789) (-1.859*)
Honey harvested	73.360	78.188 (112.072) (-0.733)	90.845 (132.903) (-1.959*)	94.704 (191.176) (-1.262)	113.867 (65.542) (-1.732*)

***, **, * denotes statistical significance at 1%, 5% and 10% significance levels, respectively. The values in parentheses are the standard deviation and *t*-values, respectively, associated with the market outlets.

TABLE 3 Summary statistics for categorical variables.

Variable	Category	% (All)	Retailers	Wholesalers	Middlemen	Individual consumer
Gender	Male	78.17	80.20 (0.498)	78.87 (0.0319)	62.96 (4.241**)	80.00 (0.032)
	Female	21.83	19.80	21.13	37.04	20.00
Extension access	Yes	40.10	42.57 (0.528)	56.34 (12.183***)	25.93 (2.618)	40.00 (0.000)
	No	59.90	57.43	43.66	74.07	60.00
Training	Yes	47.21	47.52 (0.008)	64.79 (13.767***)	40.74 (0.525)	46.67 (0.002)
	No	52.79	52.48	35.21	59.26	53.33
Group membership	Yes	58.38	60.40 (0.348)	71.83 (8.271***)	44.44 (2.499)	60.00 (0.018)
	No	41.62	39.60	28.17	55.56	40.00
Credit access	Yes	22.84	17.82 (2.965*)	32.39 (5.746**)	11.11 (2.443)	20.00 (0.074)
	No	77.16	82.18	67.61	88.89	80.00

***, **, * denotes statistical significance at 1%, 5% and 10% significance levels, respectively. The values in parentheses are the chi-square values associated with the market outlets.

About 78% of the beekeepers reported were male, while 22% were female. Gender was not significantly associated with participation in most market outlets, except for sales to middlemen, where the proportions of male (62.96%) and female (37.04%) participants differed at the 5% level. This finding aligns with Okoye et al. (2021), who found that gender disparities affect farmers' access to profitable markets.

Access to extension services showed a statistically significant difference, particularly for those selling to wholesalers ($p < 0.01$). More than half (56.34%) of the beekeepers with extension contact and 43.66% without sold to wholesalers. This indicates that extension services enhance farmers' awareness of market requirements. Consistent with Anthony et al. (2021), extension contact strengthens farmers' market participation by improving their technical and marketing knowledge.

Beekeeping training showed a statistical difference at the 1% level for wholesalers' market outlet choice, with 64.79% of participants receiving training. This underscores the role of honey marketing training provided by non-governmental organizations in promoting participation in structured markets. Similar findings by Mizero et al. (2024) emphasize that training improves farmers' marketing skills.

Approximately 58% of the beekeepers in the sample reported being members of farmer groups, while 42% did not belong to any group. A significantly higher proportion of beekeepers who were members of groups (71.83%) sold through wholesaler market outlets compared to 28.17% among non-members, with the difference statistically significant at the 5% level. This finding aligns with Methamontri et al. (2022), who found that group membership positively influences participation in higher-value markets.

About 77% of beekeepers accessed credit. A significant proportion of beekeepers who did not access credit (82.18%) sold through retail market outlets compared to 17.82% who accessed credit, with the difference statistically significant at the 10% level. Furthermore, a significant proportion of beekeepers who did not access credit (82.18%) sold through wholesalers' market outlets, compared to 17.82% who accessed credit, with the difference statistically significant at the 5% level. This finding is consistent with Ketema and Lika (2023), who reported that access to finance enhances farmers' ability to exploit better market opportunities.

The results in Table 4 present the observed frequencies of participation in different honey market outlets. Retailers were the most commonly used outlet, with 51.27% of honey producers reporting sales through retail channels.

Wholesalers and middlemen were also widely used, accounting for 36.04% and 34.52% of producers, respectively. Participation in direct sales to individual consumers was comparatively lower, with 25.89% of producers engaging in this outlet.

10.3389/fsufs.2026.1647473

TABLE 4 Descriptive statistics of honey market outlets.

Markets	Frequency	%
Retailers	101	51.27
Wholesalers	71	36.04
Middlemen	68	34.52
Individual consumers	51	25.89

TABLE 5 Multicollinearity test for explanatory variables.

Variables	VIF	1/VIF
Age	2.356	0.424
Years of experience	2.081	0.481
Education level	1.797	0.556
Land size	1.763	0.567
amount of credit	1.681	0.595
Household size	1.677	0.596
Training access	1.639	0.61
Extension access	1.629	0.614
Off-farm income	1.556	0.643
Group membership	1.398	0.716
Amount of honey harvested	1.199	0.834
Distance	1.147	0.872
Gender	1.053	0.949
Mean VIF	1.617	

TABLE 6 Heteroscedasticity test.

Source	Chi-square	Df	*P*
Heteroscedasticity	89.1	86	0.3881
Skewness	23.85	12	0.0213
Kurtosis	0.16	1	0.6865
Total	113.12	99	0.1572
chi2(86) = 89.10			
Prob > chi2 = 0.3881			

x^2 = chi-square; df = degrees of freedom; *p*-value = significance level.

4.1 Diagnostic tests

Based on the variance inflation factor (VIF) results in Table 5, there is no evidence of multicollinearity among the explanatory variables used in the MVP model. All VIF values are below the commonly accepted threshold of 5, indicating that the regression coefficient estimates are stable and reliable.

Table 6 presents the results of the heteroscedasticity using White's test.

Heteroscedasticity is one of the violations of the linear regression model, in which the variance across observations is not constant (Green, 2012). The Breusch-Pagan test is specifically designed to assess the linear form of Heteroscedasticity. In contrast, the White test allows the independent variable to have a nonlinear and interactive effect on the error variance. The white test is more potent than Breusch Pagan since it can detect a more general form of Heteroscedasticity (Wooldridge, 2004). The results showed that there was no major problem with Heteroscedasticity, as the *p*-value for the chi-square test was 0.3881, which is greater than 0.05; therefore, we failed to reject the null hypothesis.

Table 7 presents the overall fit statistics, predicted probabilities, joint probabilities, and the estimated correlation matrix of market outlet participation based on the Multivariate Probit (MVP) model. The predicted probabilities indicate that participation is most likely in the individual consumer outlet, with an estimated probability of 0.733. This is followed by middlemen (0.430), wholesalers (0.403), and retailers (0.066). These results imply that, conditional on observed characteristics, beekeepers have a higher likelihood of participating in individual consumer markets, while participation in retail outlets is comparatively less likely.

The joint probabilities of success (all outlets chosen simultaneously) and failure (no outlet chosen) are both 0.0203. These low values imply that the simultaneous choice of all market outlets is uncommon, highlighting the distinctiveness of each outlet.

The estimated correlation matrix reveals important relationships between the unobserved factors influencing these market outlet choices. Notably, there is a significant negative correlation between retailers and wholesalers (-0.495) and between retailers and middlemen (-0.189), both statistically significant at the 1% level. This indicates that factors increasing the likelihood of choosing retailers tend to decrease the likelihood of selecting wholesalers or middlemen, and vice versa. The correlation between middlemen and individual consumers is positive and significant at the 5% level (0.156), suggesting some shared unobserved influences. Other correlations, such as between wholesalers, middlemen, wholesalers, and individual consumers, were not statistically significant.

The likelihood ratio test strongly rejects the null hypothesis that all correlation coefficients are zero ($\chi^2(6) = 73.64$, $p < 0.001$), confirming that accounting for correlations among the choices significantly improves the model fit. This justifies the use of the MVP approach over separate univariate models. Furthermore, the Wald test statistic ($X^2(56) = 140.77$, $p < 0.001$) and the log-likelihood value of−438.95 indicate that the model fits the data well. The analysis is based on 197 observations, and five simulation draws were used for estimation.

Age was positively and statistically associated with participation in the wholesale market outlet at the 5% (Table 8), indicating that older beekeepers are more likely to engage in bulk selling. This could be due to greater experience, trust networks, and risk tolerance when dealing with larger transactions. Similar trends were observed by Mwembe et al. (2021), who reported that older farmers often have more market knowledge and contacts, which enable them to negotiate better terms.

Gender was negatively and statistically associated with participation in individual consumer and middlemen market outlets at the 10% significance level. This implies that Male beekeepers were less likely to sell through these channels than

TABLE 7 Overall fitness, probabilities, and correlation matrix of the market outlets from the MVP.

Variable	Retailer	Wholesaler	Middlemen	Individual consumer
Predicted probability	0.066	0.403	0.430	0.733
Joint probability (success)	0.0203			
Joint probability (Failure)	0.0203			
Estimated correlation matrix				
	ρ^1	ρ^2	ρ^3	ρ^4
ρ^1	1			
ρ^2	−0.495***	1		
ρ^3	−0.189***	−0.100	1	
ρ^4	−0.003	−0.009	0.156**	1
Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: $X^2(6) = 73.64$ Prob > $X^2 = 0.0000$				
Number of draws (#)	5			
Number of observations	197			
Log-likelihood	−438.95212			
Wald [$X^2(56)$]	140.77			
Prob > X^2	0.0000***			

***, ** denotes statistical significance at 1% and 5% significance levels, respectively.

TABLE 8 MVP estimates of factors influencing the choice of honey market outlet.

Variables	Retailers		Wholesalers		Middlemen		Individual consumers	
	Coeff.	Std. err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err
Household size	−0.031	0.055	0.071	0.057	0.018	0.054	0.030	0.066
Age	0.007	0.011	0.024**	0.012	0.014	0.011	−0.005	0.013
Gender	0.189	0.223	0.082	0.227	−0.916***	0.220	−1.324***	0.242
Off-farm income	−0.000	0.000	−0.000	0.000	−0.000	0.000	0.000	0.000
Education level	−0.007	0.040	0.101**	0.047	0.011	0.040	−0.026	0.044
Land size	0.016	0.029	−0.012	0.033	−0.046	0.032	−0.031	0.037
Extension access	0.438*	0.252	0.255	0.250	−0.762***	0.256	−0.057	0.279
Training	−0.172	0.253	0.489**	0.238	0.418*	0.246	−0.108	0.273
Group	0.339	0.225	0.211	0.224	0.158	0.224	−0.183	0.255
Credit access	−0.818***	0.288	0.241	0.320	−0.702**	0.310	0.324	0.352
Distance	−0.061*	0.033	0.058*	0.033	0.007	0.035	−0.014	0.039
Experience	−0.028*	0.017	0.012	0.018	0.014	0.016	0.011	0.018
Honey harvested	0.001	0.001	0.020*	0.001	−0.000	0.001	0.001	0.001
_cons	0.143	0.711	−3.545**	0.834	−0.077	0.702	0.687	0.774

***, **, * denotes statistical significance at 1%, 5% and 10% significance levels, respectively.

female beekeepers. This could reflect gender-based roles in marketing activities, where women are often more involved in informal and local market transactions. From a behavioral perspective, this association may also relate to substitutability between informal channels and more formal market options, with male beekeepers potentially substituting away from individual consumer and middlemen outlets toward alternative channels. However, Arumugam et al. (2022) report that male farmers are more likely than their female counterparts to participate in middlemen and wholesaler outlets, which they associate with differences in bargaining capacity, negotiation practices, and contract enforcement.

The education level of respondents was positively and statistically associated with participation in the wholesale market outlet at the 5% significance level. The findings imply that educated beekeepers were much more aware of the profitability of selling

at higher returns market outlets. The finding aligns with Anthony et al. (2021), who found that higher education levels increase the chance of farm product producers integrating into high-value chain markets.

Access to extension services was positively and statistically associated with participation in the retailer outlet at the 1% significance level. This association may reflect greater exposure to market information, quality requirements, and marketing practices among beekeepers with extension contact, which is often linked to engagement with more structured market channels. Similar associations between extension access and market participation are reported by Ermias (2021) and Ozkan et al. (2022). In contrast, access to extension services was negatively associated with participation in the middlemen outlet at the 10% significance level. This pattern may indicate that beekeepers with extension support are less likely to rely on informal intermediaries and instead engage with alternative outlets or collective marketing arrangements. This finding differs from Chelanga et al. (2021), who report a positive association between extension access and middlemen participation.

Training was positively and statistically associated with participation in both wholesaler and middlemen market outlets, at the 5% and 1% significance levels, respectively. This association could be indicative of the greater range of skills and information that is generally delivered in training programs, such as that of honey production, handling, quality control, packaging and the basic marketing procedures. From a behavioral perspective, training may be associated with complementary engagement in formal and informal channels, where trained beekeepers meet observable requirements for bulk buyers such as wholesalers while retaining flexibility to transact with middlemen when transaction costs, liquidity needs, or market conditions make informal channels more suitable. These results are in line with those of Mizero et al. (2024), who show positive relationships between training and participation in honey market outlets.

Access to credit was negatively and statistically associated with participation in both retailer and middlemen outlets at the 1% significance level. This pattern may reflect substitutability between these outlets and alternative market channels, whereby beekeepers with access to credit are less reliant on outlets that prioritize immediacy of payment or minimal quality and packaging requirements. Credit access may be associated with greater flexibility in covering harvesting, packaging, and transport costs, enabling engagement with other market outlets. This finding is similar to that of Mwembe et al. (2021), who concluded that producers are more likely to opt for high-value market outlets with higher prices rather than sell at farm-gate prices.

Distance to market was negatively and statistically associated with participation in the retailer outlet at the 1% significance level and positively associated with participation in the wholesaler outlet at the 10% significance level. This pattern may reflect substitutability between retailer and wholesaler channels in the presence of spatial transaction costs. Beekeepers located farther from markets may be more frequently observed engaging with wholesalers, who are better positioned to accommodate bulk transactions and transportation logistics, while proximity to markets is more compatible with retailer participation. The finding is consistent with Ngeno et al. (2024), who found that distance played an important role in determining carrot farmers' choice of market outlet.

Beekeeping experience was negatively and statistically associated with participation in the retailer outlet at the 1% significance level. This association may reflect differences in marketing orientation between more and less experienced producers, with more experienced beekeepers potentially engaging in alternative outlets that better align with their scale of operation or accumulated market relationships. The study corroborates Tarekegn et al. (2017), who found that farming experience significantly influenced honey producers' market outlet choices.

The quantity of honey produced was positively and statistically associated with participation in the wholesaler outlet at the 1% significance level. This association is consistent with the volume requirements typically associated with wholesaler transactions, as beekeepers with higher output levels are more likely to be able to supply honey in bulk quantities. The finding corroborates Borena et al. (2023), who found that the amount of honey produced affected the market outlet choice.

5 Conclusions and recommendations

The study highlights the importance of heterogeneous beekeeper attributes, institutional facilitation, financial access, strategic facilitators and marketing environment indicators in influencing the selection of honey market outlets. Empirical evidence demonstrates that there is a strong association between gender, education, training, extension services, access to credit, beekeeping experience and honey yield with the participation in certain market channels. Beekeepers whose education is higher and who can access training have higher chances of selling via the wholesalers, as access to credit and extension services is linked to less dependency on middlemen. Conversely, beekeepers with all-encompassing experiences connected to the work are less likely to involve themselves in retail outlets, implying that they prefer more lucrative outlets. Moreover, increased honey production creates a probability of involvement in wholesaler outlets.

These findings suggest that policy interventions to improve market access for beekeepers should focus on enhancing farmer training, strengthening extension systems, facilitating access to affordable credit and promoting productivity. Additionally, understanding how socio-demographic factors such as gender and education shape market behavior is crucial for designing inclusive marketing strategies and support programs that ensure fair participation across all categories of beekeepers.

5.1 Limitations and future research

This study had a number of limitations, which were taken into account when interpreting the results. First, the cross-sectional observations used to conduct the analysis mean that the analysis cannot be used to make causal inferences. The estimated relationships represent statistical correlations of explanatory variables and participation in market outlets as opposed to causal influences.

Second, the empirical model has numerous equations and explanatory variables that are approximated at a comparably small scale of 197 observations. Although the Multivariate Probit model is highly appropriate in dealing with interdependent decisions,

model complexity and sample size can restrict the statistical power and accuracy of specific coefficient estimates.

Third, the Multivariate Probit model is based on excellent distributional assumptions that involve joint normality of error terms across equations. Although this framework is widely used in studies of multiple discrete choices, violations of these assumptions may affect the robustness of the estimates.

Lastly, the analysis fails to consider data on output prices, transaction costs and contractual issues related to various market outlets. These factors are expected to have a significant role in influencing the decisions of market participation, however this information could not be reliably collected because most honey transactions in the study area are informal, with prices negotiated individually and contracts rarely standardized.

Future studies can overcome these shortcomings by using panel data or experimental designs with greater causal identification. The gathering of detailed price, contract and transaction cost data would also provide a more comprehensive analysis of the honey market outlet selection. Also, future research may investigate the dynamic nature of outlet participation and investigate how market decisions change over time with the adaptation to changes in production conditions, institutions and policy environments.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

NK: Data curation, Formal analysis, Resources, Visualization, Writing – original draft, Writing – review & editing. RG: Supervision, Writing – review & editing. NC: Conceptualization, Data curation, Project administration, Resources, Writing – original draft.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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