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Research Article
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Profitability of apiculture and household dietary diversity among rural households in Nigeria

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Abstract: Income diversification plays a critical role in enhancing rural household welfare in developing economies. This study evaluates the profitability of apiculture and examines its association with household dietary diversity among beekeeping households in Lapai Local Government Area of Niger State, Nigeria. Primary data collected in 2019 from 110 households were analysed using farm budgeting techniques and a Poisson generalised linear model for count data. Honey production generated a net farm income of ₦36,900.5 per hive per cycle, with a gross ratio of 0.57, indicating economic viability. Regression results indicate that beekeeping income and meal frequency were positively associated with household dietary diversity at the 5% significance level, whereas household savings were positively associated at the 10% significance level. The findings provide enterprise-level evidence linking apiculture income to household welfare outcomes. Thus, the study recommends that agricultural development strategies should integrate beekeeping into nutrition-sensitive rural programmes, with an emphasis on improved production technologies, capacity building, and enhanced market integration.

Keywords: apiculture, food security, income diversification, Nigeria, poisson regression

1. Introduction

Food security remains a critical development challenge in Sub-Saharan Africa, where structural poverty, climate variability, and weak food systems undermine access to adequate and nutritious food. In 2023, about 733 million people globally experienced hunger, with Africa disproportionately affected (Food and Agriculture Organization, 2024). Beyond caloric deficits, poor diet quality and low dietary diversity continue to drive micronutrient deficiencies among rural households. In Nigeria, over 30.6 million people face acute food insecurity despite significant agricultural potential (World Food Programme, 2025). While agricultural interventions often target production and income, less attention has been given to how specific livelihood activities translate into improved dietary utilisation, commonly measured using the Household Dietary Diversity Score (HDDS) (Sibhatu & Qaim, 2018).

Household dietary diversity is widely recognised as an indicator of household food access and dietary variety rather than a direct measure of nutrient adequacy or nutritional status (Swindale & Bilinsky, 2006). While diet quality refers to the nutritional adequacy of foods consumed and nutritional status reflects an individual's physiological condition, HDDS

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captures the diversity of food groups consumed within the household over 24 hours. Consequently, HDDS provides a useful proxy for assessing household access to a varied diet, particularly in low-income settings.

Apiculture has emerged as a promising nutrition-sensitive livelihood strategy because it requires relatively low capital investment, integrates easily with crop farming, and enhances ecosystem services through pollination, thereby supporting the production of nutrient-rich crops (Khalifa et al., 2021). Evidence suggests that beekeeping contributes to income diversification, poverty reduction, and improved household livelihoods (Amulen et al., 2019; Abro et al., 2022), while broader agricultural commercialisation and livelihood diversification have been associated with improved household dietary diversity (Adjimoti & Kwadzo, 2018). However, existing research has largely concentrated on production performance, technology adoption, profitability, and income effects, with limited empirical attention to the nutritional implications of apiculture, particularly in Nigeria. Furthermore, studies examining the relationship between agricultural income and nutrition often treat farm income as homogeneous, overlooking the possibility that income from specialised enterprises such as apiculture may influence household dietary choices through distinct economic and behavioural pathways. Since income gains alone do not necessarily translate into improved diet quality without complementary financial and behavioural factors (Headey & Alderman, 2019; Ragasa et al., 2019), the relationship between apiculture and household dietary diversity remains insufficiently understood. Addressing this gap is important for establishing whether the benefits of beekeeping extend beyond income generation to improved household nutrition, thereby providing evidence to inform nutrition-sensitive agricultural and rural development policies in Nigeria.

The study contributes to the literature in three ways. First, it provides empirical evidence on the association between apiculture income and household dietary diversity. Second, it incorporates behavioural and financial characteristics into the analysis of household dietary diversity. Third, it applies a Poisson Generalised Linear Model suitable for analysing count-data outcomes. This study will be relevant to policymakers, development practitioners, and agricultural extension agencies seeking to promote apiculture as a nutrition-sensitive and resilience-building livelihood strategy in rural Nigeria and similar contexts.

2. Materials and Methods

2.1 Description of the study area

These characteristics This study was conducted in Lapai Local Government Area (LGA) of Niger State, Nigeria. Niger State lies between latitudes 8°22′N and 11°30′N and longitudes 3°30′E and 7°20′E. It is bordered by Zamfara and Kebbi States to the north and northwest, Kaduna State and the Federal Capital Territory to the northeast and southeast, and Kogi and Kwara States to the south and southwest. The state covers a land area of approximately 74,244 km², representing about 8% of Nigeria's total landmass, making it the largest state in the country.

Lapai Local Government Area was purposively selected for this study based on consultations with key informants from the Niger State Agricultural Development Programme (ADP), who identified it as one of the major beekeeping areas in the state. Agriculture is the dominant livelihood activity in the area, with crop production, livestock rearing, and apiculture serving as important sources of income for rural households. The area lies within the Southern Guinea Savannah vegetation zone and is characterised by abundant natural vegetation and diverse flowering plants that provide forage for honeybees. The climate is characterised by distinct wet and dry seasons, with the major honey harvesting period occurring between November and April. Primary data were collected in November 2019, coinciding with the commencement of the major honey harvesting season. This timing enabled respondents to provide reliable information on honey production, production costs, returns, and household

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food consumption. These characteristics make Lapai LGA an appropriate setting for examining the profitability of apiculture and its association with household dietary diversity.

2.2 Sampling technique and data collection

A multi-stage sampling technique was employed to select the respondents. In the first stage, two districts (Lapai and Birnin Maza) were purposively selected from Lapai Local Government Area based on the prevalence of beekeeping activities, following consultations with local agricultural extension agents. In the second stage, five villages were randomly selected from each district, resulting in a total of ten villages. In the third stage, beekeeping households were identified using snowball sampling because no comprehensive sampling frame of beekeepers existed in the study area. Initial respondents were identified with the assistance of community leaders and extension officers, who subsequently referred other eligible beekeepers within the selected villages. A total of 120 beekeeping households were interviewed using a structured questionnaire. Following data cleaning, 10 questionnaires were excluded because of incomplete information on key study variables, leaving 110 valid questionnaires for analysis, representing a 91.7% usable response rate. The final analytical sample was considered adequate for the statistical analyses undertaken, including profitability analysis and multivariable regression models.

2.3 Analytical techniques

Data were analysed using descriptive statistics, farm budgeting techniques, and econometric modelling.

2.3.1 Descriptive statistics

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarise the socio-economic characteristics of beekeeping households and to describe food consumption patterns and constraints faced by respondents. The severity of constraints faced by beekeeping households was assessed using a five-point Likert scale. Respondents rated each constraint as Very Serious (VS = 5), Serious (S = 4), Moderately Serious (MS = 3), Less Serious (LS = 2), and Not Serious (NS = 1). The weighted mean score for each constraint was computed using the formula in Equation 1, following Parmar et al. (2019).

$$\bar{X} = \sum_{i}^{n} \frac{f_i w_i}{N} \quad (1)$$

Where $\bar{X}$ = weighted mean score, f_i = frequency of responses in category i, w_i = weight assigned to category i, N= total number of respondents, n = number of response categories $\sum$ = Summation. A cut-off mean score of 3.00, representing the midpoint of the five-point scale, was used for decision-making. Constraints with mean scores of 3.00 or above were classified as Serious, while those with mean scores below 3.00 were classified as Not Serious.

2.3.2 Cost and return analysis

Farm budgeting techniques were employed to estimate the profitability of honey production. The gross margin (GM) as in Equation 2, and net farm income (NFI) as in Equation 3 were calculated.using the formular adopted from Akpan et al. (2019).

$$GM = TR - TVC \quad (2)$$
$$NFI = TR - TC \quad (3)$$

where, GM = Gross Margin (₦/hive), NFI = Net Farm Income (₦/hive), TR = Total Revenue

from honey sales (₦), TVC = Total Variable Cost (₦), and TC = Total Cost (₦).

Family labour was valued using the prevailing local wage rate for equivalent hired labour. Depreciation of fixed assets was estimated using the straight-line depreciation method following the approach described by Cui et al. (2025), as presented in Equation 4.

$$\text{Annual depreciation} = \frac{\text{purshase cost} - \text{salvage value}}{\text{useful life}} \tag{4}$$

A zero-salvage value was assumed for all durable beekeeping assets. The depreciable assets included beehives, honey extractors, protective clothing, smokers, hive tools, settling tanks, buckets, storage containers, and wax-processing equipment. Interest paid on production credit was treated as a fixed cost because it did not vary with the level of honey output during the production cycle.

2.3.3 Measurement of household dietary diversity

Household food security was assessed using the Household Dietary Diversity Score (HDDS), which measures the number of different food groups consumed by household members over a 24-hour recall period and is widely used as a proxy indicator of household access to a diverse diet (Swindale & Bilinsky, 2006). The HDDS was determined through a 24-hour dietary recall administered to the household beekeeper, who was asked to recall all foods and beverages consumed by household members during the previous day. The recall was intended to reflect a typical household consumption day rather than an exceptional occasion. Foods consumed both within and outside the home were included in the assessment. Following the FAO guidelines (Swindale & Bilinsky, 2006), twelve food groups were considered: cereals; roots and tubers; vegetables; fruits; meat, poultry and offal; eggs; fish and seafood; pulses, legumes and nuts; milk and milk products; oils and fats; sugar and honey; and other foods. Mixed dishes were disaggregated into their constituent ingredients, with each ingredient assigned to its respective food group. The consumption of any amount of food from a given food group qualified the household for that food group; therefore, no minimum quantity threshold was applied. Each food group consumed was assigned a value of one (1), while food groups not consumed were assigned zero (0). The HDDS for each household was calculated using Equation 5.

$$HDDS_i = \sum_{j=1}^{12} d_{ij} \tag{5}$$

where $d_{ij} = 1$ if food group j was consumed by the household i within the recall period, and 0 otherwise. The HDDS therefore ranges from 0 to 12, with higher values indicating a more diversified diet. For descriptive analysis, households were classified into three dietary diversity categories following the commonly used FAO-based classification: low dietary diversity (HDDS $\leq$ 3 food groups), medium dietary diversity (HDDS = 4–6 food groups), and high dietary diversity (HDDS $\geq$7 food groups).

2.3.4 Econometric model specification

To examine factors associated with household dietary diversity, a Generalised Linear Model (GLM) with a Poisson distribution and log link function was employed. following Khandoker *et al.* (2022). The Poisson model is appropriate because the dependent variable (HDDS) is a non-negative count variable representing the number of food groups consumed. The model is specified as in Equation 6.

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$$E(HDDS_i \mid X_i) = \exp(X_i\beta) \quad (6)$$

where, $HDDS_i$ is the household dietary diversity score for the household i, $X_i$is a vector of explanatory variables, and β is a vector of parameters to be estimated.

The explanatory variables included in the model are defined as follows:

- Sex of household head (1 = male, 0 = female)
- Household size (number of household members)
- Marital status (1 = married, 0 = otherwise)
- Education (years of formal schooling)
- Age of household head (years)
- Primary occupation (1 = farming, 0 = otherwise)
- Income from beekeeping (₦/year)
- Income from other sources (₦/year)
- Frequency of meals consumed per day
- Monthly savings (₦)
- Goal of beekeeping (1 = sales-oriented, 0 = otherwise)

Marginal effects were computed at the mean of the explanatory variables to facilitate interpretation of the estimated coefficients in terms of their effects on expected household dietary diversity.

2.3.5 Model diagnostics

To assess the suitability of the Poisson specification, model goodness-of-fit was evaluated using the deviance and Pearson chi-square statistics. The ratios of the deviance and Pearson chi-square statistics to their respective degrees of freedom were both 0.52, indicating no evidence of overdispersion and confirming that the Poisson model provided an adequate fit to the data. Although the Household Dietary Diversity Score (HDDS) is bounded between 0 and 12, it is a non-negative count variable, making the Poisson regression model appropriate for the present analysis.

3. Results and Discussion

3.1 Socio-economic characteristics of beekeeping households

The results in Table 1 present the socio-economic characteristics of the surveyed beekeeping households. Apiculture in the study area was predominantly undertaken by men, who accounted for 92.7% of the respondents. This pattern reflects the gendered nature of beekeeping in many rural communities, where participation is often influenced by sociocultural norms and labour requirements (Dingtoumda et al., 2024).

Most respondents (67.3%) were married, and the mean household size was eight persons. Such household sizes may provide family labour for beekeeping and other agricultural activities, although they may also increase household consumption requirements.

The respondents were largely in the economically active age group, with a mean age of 40 years, suggesting that beekeeping is primarily managed by individuals with the physical capacity required for hive management and honey harvesting.

The educational profile indicates that respondents possessed diverse educational backgrounds, comprising formal, non-formal and Quranic education. This diversity suggests varying levels of literacy and access to technical information, which may influence the adoption of improved beekeeping practices. The respondents also had considerable practical experience in apiculture, averaging 17 years, suggesting that many commenced beekeeping in early

adulthood and had accumulated substantial knowledge and skills over time. This finding is consistent with the age distribution, where most respondents were within the economically active age groups (21–50 years).

Table 1. Distribution of beekeepers according to socio-economic characteristics.

Variables	Frequency	Percentage	Mean
Sex			
Male	102	92.7	
Female	8	7.3	
Marital status			
Single	31	28.2	
Married	74	67.3	
Widow	4	3.6	
Separated	1	0.9	
Household size			
1-5	37	33.6	8.0
6-10	50	45.5	
11-15	16	14.6	
16-20	4	3.6	
>20	3	2.7	
Age			
<20	1	0.9	40
21-30	24	21.8	
31-40	34	30.9	
41-50	31	28.2	
>50	20	18.2	
Highest level of education			
Non formal	35	31.8	
Primary	24	21.8	
Secondary	31	28.2	
Tertiary	3	2.7	
Quranic	17	15.5	
Experience in beekeeping			
1-10	33	30.0	17.0
11-20	50	45.5	
21-30	25	22.7	
>30	2	1.8	
Number of Hives			
1-5	86	78.2	2.0
6-10	22	20.0	
>10	2	1.8	

3.2 Income profile of beekeeping households

The distribution of respondents according to their monthly income from their primary occupation and other livelihood activities is presented in Table 2. The average monthly income from the respondents' primary occupation was ₦79,455, while income from other livelihood activities averaged ₦86,727. The primary occupation refers to the respondents' principal source of livelihood and should not be interpreted as income from apiculture. Income from honey production is analysed separately in the profitability analysis (Table 3).

The income distribution indicates that the majority of respondents earned less than ₦100,000 per month from their primary occupation, suggesting relatively modest income levels among the sampled households. However, earnings from other livelihood activities contributed additional income, highlighting the importance of livelihood diversification in supporting

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household livelihoods. For beekeeping households, apiculture represents one of several income-generating activities that may supplement household earnings and strengthen economic resilience.

Table 2. Distribution of respondents according to monthly income from primary and other livelihood activities**.**

Variables	Frequency	Percentage	Mean(₦/Month)
Monthly income from primary occupation			
<50,000	30	27.3	₦79,455.
51,000-100,000	52	47.3	
101,000-150,000	19	17.3	
151,000-200,000	7	6.4	
>200,000	2	1.8	
Monthly income from other livelihood activities			
<50,000	29	26.4	86,727.27
51,000-100,000	46	41.8	
101,000-150,000	22	20.0	
151,000-200,000	5	4.6	
>200,000	2	1.8	

3.3 Household food consumption and dietary diversity

Meal frequency is an important indicator of household food access and utilisation and has been associated with dietary diversity. Figure 1 shows that 49.0% of households consumed three meals per day, while 25.5% consumed one meal per day and another 25.5% consumed two meals per day. Although more frequent meal consumption may provide greater opportunities to consume a wider variety of food groups, meal frequency and dietary diversity measure different dimensions of household food security. Meal frequency reflects the regularity of food consumption, whereas the Household Dietary Diversity Score (HDDS) measures the variety of food groups consumed within a 24-hour recall period. Previous studies have similarly reported a positive association between meal frequency and dietary diversity (Headey & Alderman, 2019; Mekonnen et al., 2021).

Figure 2 shows that 59.1% of households were classified as having high dietary diversity, while 36.4% and 4.5% were classified as having medium and low dietary diversity, respectively. Based on the FAO Household Dietary Diversity Score (HDDS) classification, households were categorised as having low dietary diversity (HDDS ≤ 3), medium dietary diversity (HDDS = 4–6), and high dietary diversity (HDDS ≥ 7). The predominance of households in the high dietary diversity category suggests that many sampled households consumed foods from a wide range of food groups during the 24-hour reference period. Although income from apiculture and other livelihood activities may contribute to more diversified diets, the present findings describe dietary diversity among sampled beekeeping households and should not be interpreted as evidence that apiculture alone improved household dietary diversity. Nevertheless, the presence of households with medium and low dietary diversity indicates that income alone may not guarantee optimal dietary outcomes, highlighting the need for complementary interventions such as nutrition education and improved access to diverse foods.

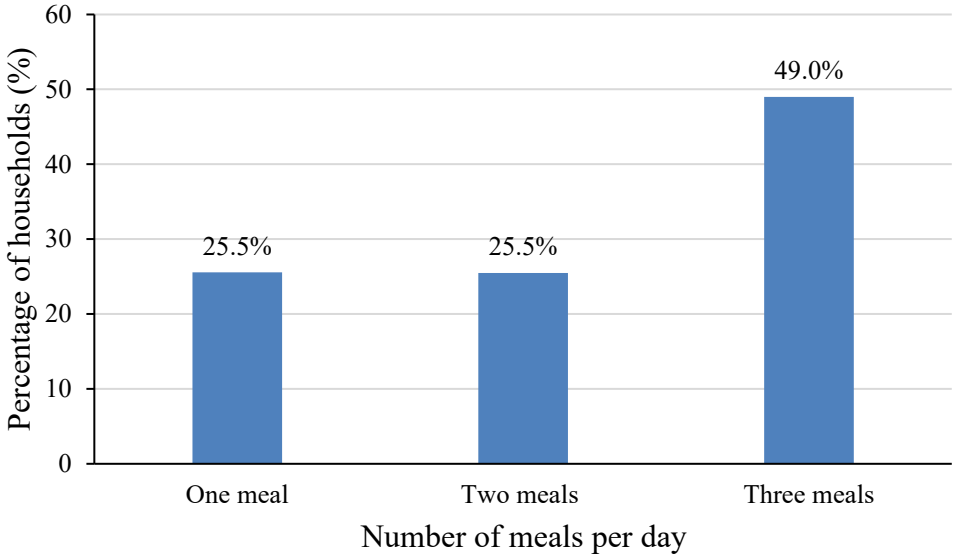

Figure 1. Distribution of beekeeping households by daily meal frequency (n = 110).

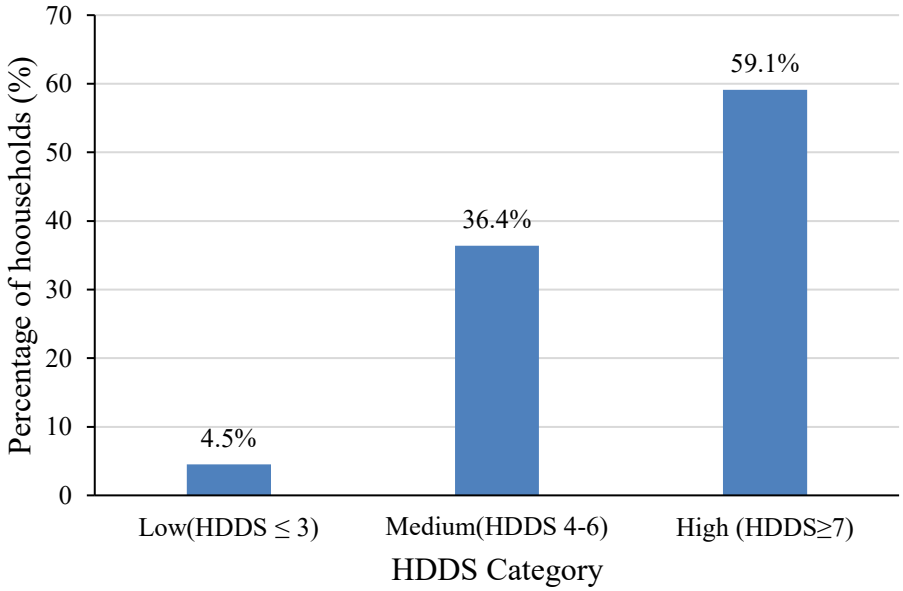

Figure 2. Distribution of beekeeping households according to Household Dietary Diversity Score (HDDS) categories (n = 110).

3.4 Cost and return analysis of honey production

The cost and return analysis in Table 3 shows that honey production is economically viable in the study area. Each hive produced 34.0 litres of honey per production cycle, generating revenue of ₦85,000 (USD 276.95) at an average price of ₦2,500 (USD 8.15) per litre. Average net farm income was ₦36,900.5 (USD 120.23) per hive per cycle. The gross ratio of 0.57 indicates that production costs accounted for 57% of revenue, and the benefit–cost ratio of 1.77 shows that every ₦1 invested generated ₦1.77 in gross revenue, a return of ₦0.77 per naira invested. The positive net income suggests that investment in beekeeping equipment and management can generate returns over time.

Fixed costs (including depreciation) made up 76.9% of total costs. This reflects the capital-intensive but low-running-cost nature of beekeeping: households buy hives, protective clothing,

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smokers, harvesting tools and containers once and use them over several cycles, while recurrent costs are small because bees forage freely and need few purchased inputs. Similar structures have been reported. In Yewa North, Nigeria, fixed costs were 91.5% of total costs, with the hive alone accounting for 44.5% (Abere & Lameed, 2012), and in Tanzania the main fixed items were protective gear, containers, binding wire and hives, while transport, labour and processing costs were small (Peter and Said, 2026). Because the fixed outlay is spread over few hives and limited output, it weighs heavily on total costs. Profitability therefore depends on using equipment over many cycles and on increasing colony numbers, consistent with increasing returns to scale in honey production in Oyo State (Ayodeji et al., 2018).

This cost structure suggests that high initial equipment costs may act as an entry barrier for resource-poor households, which often lack the savings or credit to meet a large upfront outlay. In Tanzania, the upfront costs of improved hives were an entry barrier that slowed adoption among smallholders, who preferred cheaper traditional hives (Peter and Said, 2026), and in Ikwuano, Nigeria, beekeepers raised their own capital and identified inadequate capital as the major constraint (Okpokiri et al., 2015). Access to credit and lower-cost, locally made hives could ease entry, although this study did not test the barrier directly, so the interpretation is tentative. Given the modest scale of production, apiculture is best viewed as a complementary livelihood strategy rather than a primary income source, consistent with beekeepers combining honey production with other jobs (Okpokiri et al., 2015). Its contribution to dietary diversity is therefore likely to come through incremental income gains and greater financial stability. These estimates reflect prices and costs during the survey period and may change with market conditions.

Table 3. Average cost and return of honey production per hive per production cycle.

Cost items	**Value ₦/hive/production cycle**	**% of total cost**
Variable cost		
Hired labour	7,734.5	16.1
Family labour	318.2	0.7
Cost of transportation	3,042.7	6.3
Total variable cost	11,095.4	23.1
Fixed cost		
Depreciation	30,725.7	63.9
Interest on credit	6,278.2	13.1
Total fixed cost	37,004.1	76.9
Total cost	48,099.0	100.0
Revenue items	**Value ₦/hive/production cycle**	
Average honey yield (litres/hive/production **cycle)**	34.0	
Average selling price (₦/litre)	2500 (USD 8.15)	
Total revenue (₦/hive/production cycle)	85,000 (USD 276.95)	
Gross margin = TR - TVC	73,904.6 (USD 240.79)	
Net farm income	36,900.5 (USD 120.23)	
Gross Ratio **(TC/TR)**	0.57	
Benefit- Cost ratio **(TR/TC)**	1.77	
Return per naira invested **(NFI/TC)**	0.77	

Note: USD equivalents were calculated using the average official exchange rate for 2019 (US$1 = ₦306.92).

3.5 Determinants of household dietary diversity

The results of the Generalised Linear Model (GLM) with a Poisson distribution and log link function are presented in Table 4. Model diagnostics indicate a good fit to the data, as both the deviance and Pearson chi-square statistics divided by their respective degrees of freedom were

0.52, indicating no evidence of overdispersion. This confirms the suitability of the Poisson model for analysing the determinants of household dietary diversity.

Income from beekeeping was positively associated with household dietary diversity and was statistically significant at the 5% level ($\beta = 1.59 \times 10^{-6}$, $p = 0.039$). Although the estimated coefficient is numerically small because income was measured in naira, its practical implication is meaningful. Specifically, the average marginal effect (AME = 0.0000103) indicates that a ₦10,000 increase in beekeeping income is associated with an increase of approximately 0.10 in the expected Household Dietary Diversity Score (HDDS), holding other variables constant. Although this increase appears modest, incremental improvements in HDDS are meaningful because the score ranges from 0 to 12, and even small increases reflect the consumption of additional food groups. This finding suggests that additional income generated from apiculture may enhance households' ability to purchase a wider variety of foods. Similar positive associations between agricultural income diversification and dietary quality have been reported by Adjimoti and Kwadzo (2018), Ragasa et al. (2019), and Amulen et al. (2019).

Meal frequency was also positively associated with household dietary diversity at the 5% significance level ($\beta = 0.107$, $p = 0.042$). Households with higher meal frequency were more likely to have higher dietary diversity scores. Although meal frequency and dietary diversity measure different dimensions of household food security, the positive association observed suggests that households with better access to food were also more likely to consume a wider variety of food groups. This finding is consistent with previous studies reporting positive associations between meal frequency and dietary quality (Headey & Alderman, 2019; Mekonnen et al., 2021).

Savings exhibited a positive association with household dietary diversity but was only marginally significant at the 10% level ($\beta = 1.32 \times 10^{-6}$, $p = 0.065$). This association should therefore be interpreted with caution because it was statistically significant only at the 10% level. Nevertheless, it suggests that households with financial reserves may be better able to maintain dietary diversity during periods of income fluctuations or food price increases.

Commercial orientation in beekeeping (Goal of beekeeping = 1) was negatively associated with household dietary diversity, although the association was only marginally significant ($\beta = -0.162$, $p = 0.072$). Holding other factors constant, commercially oriented households had an expected dietary diversity score about 15% lower than other households (IRR = 0.85), equivalent to roughly one fewer food group (AME = -1.05, SE = 0.585). The negative sign is notable because income from beekeeping, which is controlled for in the model, was positively associated with dietary diversity ($p = 0.039$). The result therefore does not indicate that earning from bees' harms diets. It suggests that, at a given income, a commercial orientation is associated with a less diverse diet. Four explanations are plausible.

First, commercially oriented households are likely to sell a larger share of their honey, so less is available for household consumption, and its direct contribution to dietary variety is lost. Second, specialisation in a market-oriented enterprise may draw labour, time and land away from producing other foods such as vegetables, legumes or poultry, narrowing the range of foods available at home. This is consistent with differences in livelihood strategies reported by Ogutu et al. (2020). Third, income from commercial beekeeping is seasonal and arrives at harvest, so uneven cash flow may limit regular purchases of diverse foods during the rest of the year, even when annual income is the same. Fourth, unobserved factors such as market access, remoteness, wealth or food preferences may influence both the decision to commercialise and household diet, and the model does not capture them. The result may also partly reflect reverse causality, since households with constrained food access may be more likely to pursue commercial activities. Overall, the findings indicate that beekeeping income and meal frequency were positively associated with household dietary diversity, while savings and the primary goal of beekeeping showed weaker, marginal associations. These findings suggest that

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income generated from apiculture, as part of a diversified livelihood portfolio, may contribute to improved household food access and more diversified diets. However, because this study was based on cross-sectional data collected from beekeeping households only, the observed relationships should be interpreted as associations rather than evidence of causal effects.

Table 4. Determinants of household dietary diversity.

Variables	Coefficient	S. E	p-value	AME	AME S. E
Sex	-0.225	0.177	0.205	-1.455	1.150
Household Size	-0.001	0.008	0.868	-0.008	0.050
Marital status	-0.071	0.106	0.506	-0.458	0.689
Education	0.0003	0.008	0.970	0.002	0.054
Age	0.0003	0.005	0.946	0.002	0.030
Primary Occupation	0.078	0.098	0.430	0.502	0.636
Income from beekeeping	1.59e-06**	7.66e-07	0.039	0.0000103	0.0000050
Other incomes	-1.50e-07	7.11e-07	0.832	-0.00000097	0.0000046
Frequency of eating	0.107**	0.053	0.042	0.694	0.342
Savings	1.32e-06 *	7.12e-07	0.065	0.0000085	0.0000046
Goal of beekeeping	-0.162*	0.090	0.072	-1.051	0.585
Constant	1.708	0.301	0.000	—	—

Model Statistics: Log- likelihood = -227.326, AIC = 4.351, Deviance/df = 0.52, Pearson/df = 0.52, poisson model with log link, and no evidence of overdispersion.

3.6 Constraints to beekeeping

The constraints faced by beekeeping households are presented in Table 5. The severity of each constraint was assessed using a five-point Likert scale and ranked using weighted mean scores. High cost of modern hives and accessories emerged as the most serious constraint, followed by hive absconding, pests and predators, and diseases. These findings suggest that both financial and technical challenges continue to limit the productivity and expansion of beekeeping in the study area. Limited access to credit and lack of modern equipment further indicate that inadequate investment and institutional support constrain the adoption of improved beekeeping practices. In contrast, high production costs, poor management, exposure to pesticide and herbicide applications, lack of water, and adverse weather conditions were perceived as less serious constraints. Overall, improving access to affordable beekeeping equipment, credit facilities, and extension services could enhance the productivity, profitability, and sustainability of apiculture among rural households.

Table 5. Constraints faced by beekeepers.

Constraints	VS	S	MS	LS	NS	Sum	Mean	Rank	Decision
High cost of modern hives and accessories	64 (58.2)	27 (24.6)	11 (10.0)	6 (5.5)	2 (1.8)	472	4.29	1st	Serious
Absconding	31 (28.2)	24 (21.8)	23 (20.9)	29 (26.4)	3 (2.7)	381	3.46	2nd	Serious
Pests and predators	25 (22.7)	23 (20.9)	26(23.6)	35 (31.8)	1 (0.9)	366	3.32	3rd	Serious
Shortage of bee forage	16 (14.6)	18 (16.4)	49 (44.6)	24 (21.8)	3 (2.7)	350	3.18	6th	Serious
Diseases	25 (22.7)	26 (23.6)	25 (22.7)	26 (23.6)	8 (7.3)	364	3.31	4th	Serious
Death of the colony	18 (16.4)	32 (29.1)	27 (24.6)	24 (21.8)	9 (8.2)	356	3.23	5th	Serious
High production cost	20 (18.2)	19 (17.3)	20 (18.2)	41 (37.3)	10 (9.1)	328	2.98	9th	Not serious
Lack of access to credit	22 (20.0)	20 (18.2)	24 (21.8)	28 (25.5)	16 (14.6)	334	3.03	7th	Serious
Poor management	20 (18.2)	20 (18.2)	23 (20.9)	31 (28.2)	16 (14.6)	327	2.97	10th	Not serious
Lack of modern equipment	25 (22.7)	13 (11.8)	27 (24.6)	29 (26.4)	16 (14.6)	332	3.02	8th	Serious
Exposure to pesticides and herbicides application	12 (10.9)	17 (15.5)	26 (23.6)	35 (31.8)	20 (18.2)	296	2.69	12th	Not serious
Lack of water	15 (13.6)	17 (15.5)	26 (23.6)	34 (30.9)	18 (16.4)	307	2.79	11th	Not serious
Bad weather	11 (10.0)	12 (10.9)	24 (21.8)	41 (37.3)	22 (20.0)	296	2.54	13th	Not serious

Sources: Field survey (2019)

Note: VS=Very serious, S=Serious, MS=Moderately Serious, LS= Less Serious, NS= Not serious.
Figures outside parentheses indicate frequencies, while figures in parentheses indicate percentages

4. Conclusion

This study examined the profitability of apiculture and its association with household dietary diversity among beekeeping households in Lapai Local Government Area of Niger State, Nigeria. The findings showed that honey production was economically viable, generating positive net farm income and a favourable benefit–cost ratio. Household dietary diversity was generally high, although some households continued to experience limited dietary diversity. The regression results indicated that income from beekeeping and meal frequency were positively and significantly associated with household dietary diversity, while savings and the commercial orientation of beekeeping showed weaker associations. The major constraints identified included the high cost of modern hives and accessories, hive absconding, pests and predators, and bee diseases.

The findings highlight the economic potential of apiculture as a complementary livelihood enterprise and its relevance to household food access and dietary diversity. However, the observed associations do not establish a direct causal relationship between beekeeping income and household dietary diversity. Enhancing the contribution of apiculture to rural livelihoods requires improved access to affordable beekeeping equipment, credit facilities, technical extension services and reliable markets. Integrating beekeeping support with nutrition education and other nutrition-sensitive agricultural interventions could further strengthen its contribution to household welfare. Future research could employ longitudinal data and include non-beekeeping households to provide further evidence on the relationship between apiculture and household dietary diversity.

Data Availability

The datasets generated and analysed during this study are available upon reasonable request.

Author Contributions

Oseghale Agatha Itohan: Conceptualisation, Methodology, writing original draft, Supervision. **Shehu Shittu Mohammed:** Data curation, visualisation, Writing- Original draft preparation. **Ogaji Abu:** Data Analysis. **Jirgi Abigail John:** Writing- Reviewing and Editing.

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Conflicts of Interest

The authors hereby declare that there is no conflict of interests.

Ethics Statement

The purpose of the study was explained to all participants, and verbal informed consent was obtained before data collection. Participation was voluntary, and respondents' anonymity and confidentiality were maintained throughout the study.

References

Abere, S. A., & Lameed, G. A. (2012). Production and profitability of honey in Yewa North, Nigeria. Mediterranean Journal of Social Sciences, 3(15), 182–187.

Abro, Z., Kassie, M., Tiku, H. A., Taye, B., Ayele, Z. A., & Ayalew, W. (2022). The impact of beekeeping on household income: Evidence from north-western Ethiopia. Heliyon, 8(5), e09492. https://doi.org/10.1016/j.heliyon.2022.e09492

Adjimoti, G. O., & Kwadzo, G. T. M. (2018). Crop diversification and household food security status: Evidence from rural Benin. Agriculture & Food Security, 7, 82. https://doi.org/10.1186/s40066-018-0233-x

Akpan, S. B., Udo, U. J., & Akpan, P. J. (2019). Analysis of the gross margins and commercialization of manure and fertilizer based waterleaf (*Talinum triangulare*) farmers in Nigeria. Agricultural and Resource Economics: International Scientific E-Journal, 5(4), 5–31. https://doi.org/10.51599/are.2019.05.04.01

Amulen, D. R., D'Haese, M., D'Haene, E., Acai, J. O., Agea, J. G., Smagghe, G., & Cross, P. (2019). Estimating the potential of beekeeping to alleviate household poverty in rural Uganda. PLOS ONE, 14(3), e0214113. https://doi.org/10.1371/journal.pone.0214113

Ayodeji, B. T., Dontsop Nguezet, P. M., Olalekan, O. S., & Roland, O. (2018). Assessing beekeeping potential in Oyo State, Nigeria. International Journal of Applied Business and Economic Research, 16(4), 887–898.

Cui, C. M., Harrison, J. A., Ng, F., & Rouse, P. (2025). Accounting choices in data envelopment analysis. Journal of Productivity Analysis, 63, 219–237. https://doi.org/10.1007/s11123-024-00749-9

Dingtoumda, O. G., Yamkoulga, M., Sawadogo, S., Kam, K. W., & Ilboudo, Z. (2024). Peasant perception of beekeeping constraints and practices in large honey production areas in Burkina Faso. Journal of Ethnobiology and Ethnomedicine, 20, 67. https://doi.org/10.1186/s13002-024-00690-z

Food and Agriculture Organization (FAO) (2024). The state of food security and nutrition in the world 2024: Financing to end hunger, food insecurity and malnutrition in all its forms. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cd1254en

Headey, D. D., & Alderman, H. (2019). The relative caloric prices of healthy and unhealthy foods differ systematically across income levels and continents. The Journal of Nutrition, 149(11), 2020–2033. https://doi.org/10.1093/jn/nxz158

Khandoker, S., Singh, A., & Srivastava, S. K. (2022). Leveraging farm production diversity for dietary diversity: Evidence from national level panel data. Agricultural and Food Economics, 10, 15. https://doi.org/10.1186/s40100-022-00221-y

Khalifa, S. A. M., Elshafiey, E. H., Shetaia, A. A., El-Wahed, A. A. A., Algethami, A. F., Musharraf, S. G., AlAjmi, M. F., Zhao, C., Masry, S. H. D., Abdel-Daim, M. M., Halabi, M. F., Kai, G., Al Naggar, Y., Bishr, M., Diab, M. A. M., & El-Seedi, H. R. (2021). Overview of bee pollination and its economic value for crop production. Insects, 12(8), 688. https://doi.org/10.3390/insects12080688

Mekonnen, D. A., Akerele, D., Achterbosch, T., de Lange, T., & Talsma, E. F. (2021). Affordability of healthy and sustainable diets in Nigeria. Frontiers in Sustainable Food Systems, 5, 726773. https://doi.org/10.3389/fsufs.2021.726773

Ogutu, S. O., Gödecke, T., & Qaim, M. (2020). Agricultural commercialisation and nutrition in smallholder farm households. Journal of Agricultural Economics, 71(2), 534–555. https://doi.org/10.1111/1477-9552.12359

Okpokiri, C. I., Nwachukwu, I. N., & Onwusiribe, C. N. (2015). Determinants and profitability of honey production in Ikwuano Local Government Area, Abia State, Nigeria. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 15(3), 211–216.

Parmar, I. S., Soni, P., Kuwornu, J. K. M., & Salin, K. R. (2019). Evaluating farmers' access to agricultural information: Evidence from semi-arid region of Rajasthan State, India. Agriculture, 9(3), 60. https://doi.org/10.3390/agriculture9030060

Peter, K. H., & Said, M. K. (2026). Economic viability of beekeeping practices on income generation among smallholder beekeepers in Sikonge District, Tanzania. Ghana Journal of Geography, 18(1), 14–20. https://doi.org/10.4314/gjg.v18i1.3

Ragasa, C., Aberman, N.-L., & Mingote, C. A. (2019). Does providing agricultural and nutrition information to both men and women improve household food security? Evidence from Malawi. Global Food Security, 20, 45–59. https://doi.org/10.1016/j.gfs.2018.12.007

Sibhatu, K. T., & Qaim, M. (2018). Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. Food Policy, 77, 1–18. https://doi.org/10.1016/j.foodpol.2018.04.013

Swindale, A., & Bilinsky, P. (2006). Household dietary diversity score (HDDS) for measurement of household food access: Indicator guide (Version 2). Food and Nutrition Technical Assistance Project, Academy for Educational Development.

World Food Programme (2025). Nigeria country brief. https://docs.wfp.org