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Contribution of Beekeeping to Household Food Security among Small-Scale Farmers in Eastern Cape Province, South Africa

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Ordered Probit Regression Model, Food Security, Beekeeping, Rural Households.

Beekeeping has increasingly been recognized as a livelihood diversification strategy with the potential to improve the welfare of rural households. However, empirical evidence on its contribution to household food security remains limited, particularly in rural South Africa. This study examines the contribution of beekeeping to household food security among small-scale farmers in the Eastern Cape Province of South Africa. Primary data were collected from 240 households using a purposive stratified sampling procedure across five district municipalities. Household food security status was assessed using the Household Food Insecurity Access Scale (HFIAS). The results indicate that 42% of households were moderately food insecure, 30% were severely food insecure, and only 28% were food secure. An ordered probit regression model was employed to analyse the determinants of household food security. The findings show that household size ($p = 0.031$), employment status ($p = 0.045$), total household income ($p < 0.001$), participation in beekeeping ($p = 0.001$), access to extension services ($p = 0.050$), and production output ($p = 0.006$) significantly influence household food security status. Participation in beekeeping positively contributes to improving household food security. The study recommends strengthening support for rural households through improved access to extension services, beekeeping resources, and training programmes that enhance livelihood diversification and food security.

1. Introduction

Agriculture is central to rural livelihoods in developing nations, yet many households continue to face nutritional deficiencies. Food security is widely defined as having physical, social and economic access to sufficient, safe, nutritious food to meet dietary needs for an active and health life (FAO, 2021). Achieving food security is still a challenge in both developing and developed countries, with poverty being a key driver of food insecurity in rural societies (WFP, 2022). Despite the importance of agriculture for rural livelihoods, empirical evidence on the role of specific livelihood strategies such as beekeeping in improving household food security remains limited, particularly in South Africa.

In recent years, the emphasis on food security discussions has shifted to the household level, where individual access to food is now regarded as imperative. Food security at the household level means the ability of food providers to secure adequate food at all times to meet the dietary requirements and cultural preferences of their household members (Becker & Fanzo, 2023). Achieving all other rights, including the right to education and good health, relies on having access to enough food at household level. Consequently, achieving food security is crucial for the

rural households. A right to enough food, water and social security is stated in the Bill of Rights (Chapter 2 of the Constitution of the Republic of South Africa). Nevertheless, the issue of food insecurity is still a huge problem in most rural communities (Department of Agriculture, 2022).

Rural communities continue to show higher poverty than urban areas, contributing directly to food insecurity (Rusere et al., 2024). According to Statistics South Africa (2021), over 10 million people live in poverty, with rural women being disproportionately affected. In addition, Statistics South Africa (2017) illuminates that approximately 77% of people in 2011 lived in poverty, while in 2015, the poverty level increased to 81.3%. This upsurge in poverty amplified the gap between rural and urban societies from 35.6 to 40.7 %. This indicates that rural populations have higher rates of poverty than those residing in urban societies. This suggests that poverty puts pressure, particularly in rural areas, to survive on natural resources and indigenous knowledge. Sustainable income-generating activities like beekeeping could help bridge this gap by improving household income and food security (Hecklé et al., 2018).

Beekeeping has been increasingly recognized as a sustainable livelihood strategy, particularly for its role in enhancing the sustainable conservation of the natural environment (Alebachew & Eshetie, 2020; Patel et al., 2020). Bee colonies could increase food security by better crop pollination and generating more cash for households from sales of bee products (Gratzer et al., 2019). Furthermore, Jeil et al. (2020) supported that beekeeping has a significant role in enhancing livelihood diversification. Beekeeping promotes the standard of living of most households that are engaging in it (Schouten, 2020). However, there is currently a lack of significant evidence proving the influence of beekeeping to the attainment of food security (Nega & Eshete, 2018). This gap is particularly relevant in the Eastern Cape Province of South Africa, where rural poverty and food insecurity remain widespread despite the potential for apiculture development. The Eastern Cape Province was selected for this study because it is characterised by high levels of rural poverty, limited livelihood opportunities, and strong dependence on natural resources for household survival. At the same time, the province has favourable environmental conditions for beekeeping, making it a suitable context for examining the contribution of apiculture to household food security.

1.1. Conceptual Framework on the Effect of Beekeeping Towards Food Security

This section outlines the conceptual framework guiding the analysis of the relationship between beekeeping and household food security. It presents a structured approach to understanding the various factors influencing beekeeping participation and household food security, ranging from socioeconomic variables, livelihood assets, and institutional support. The framework highlights the relationship between these factors and their potential impact on the adoption of beekeeping and its contribution to household food security. By mapping out these interconnected elements, the framework aims to provide a better understanding of the determinants influencing household livelihood strategies and food security outcomes.

Maxwell, Coates, & Vaitla (2013) explain that people achieve food security when they have access to sufficient food that is also acceptable in terms of cultural and societal backgrounds. Indigenous knowledge, poverty alleviation, food availability, accessibility, and utilization are interconnected, as beekeeping contributes to food production, preservation, and conservation of natural resources, thus ensuring food sustainability. It becomes evident that apiculture has prospects to alleviate poverty (Thomas & Tounkara, 2020).

Households have different levels of access to food and resources, influenced by power dynamics within the family. These factors influence the allocation of labour and other resources, shaping their ability to generate income or grow food, thereby ensuring food security. Understanding the intra-household dynamics related to asset ownership and income generation is essential for understanding food security at the household level. Expanding household income is one of the primary strategies for mitigating food insecurity.

The amount of assets a household has directly influences how secure their access to food is, while also having an indirect influence on the actions and results of their means of subsistence. Greater livelihood opportunities and security can be translated from the availability of household assets. However, how effectively a household can use its resources to pursue its various sources of income depends on how vulnerable it is. The impact of household challenges or shocks on food allocation can also vary depending on the household member. The social framework in which a household lives must be taken into account in shaping intra-household dynamics, including income generation, food consumption and food access. While there are notable geographical patterns, the nature and intensity of social norms differ across various contexts (Becker & Fanzo, 2023; Lufuke et al., 2023).

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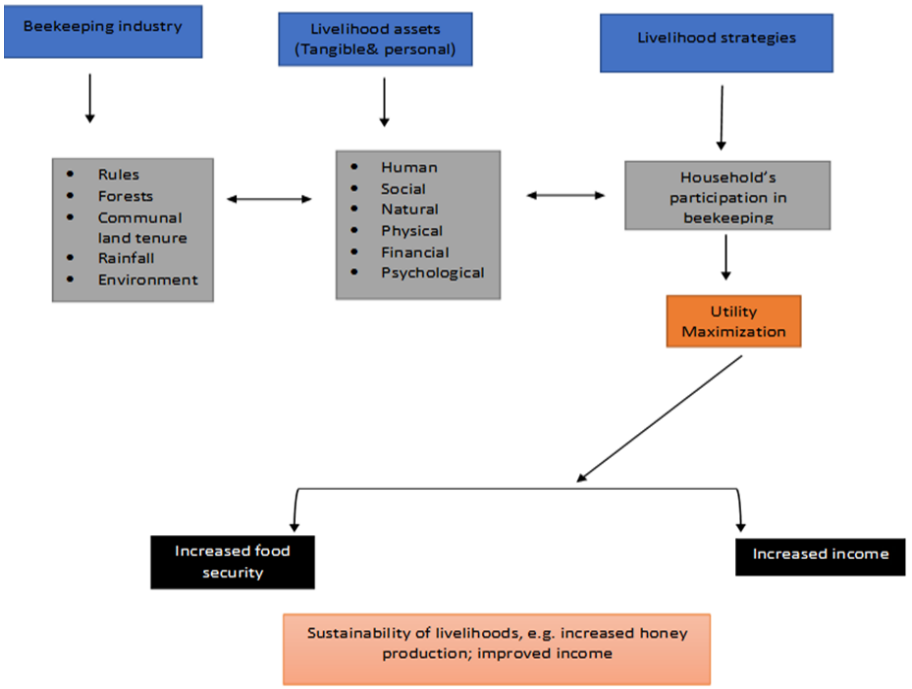

Figure 1: Conceptual Framework on Beekeeping as a Livelihood Strategy to Rural Societies.
Source: Ashley & Carney (1999); DFID (1999)

2. Methods and Materials

2.1. Study Area Description

This study was conducted in the Eastern Cape (EC) Province, which is the South Africa's second largest province in terms of land size, covering 13.9% of the country's total land. The province is divided into six district municipalities, and the metropolitan areas with Bisho serving as a provincial capital (Department of Water Affairs and Forestry, 2007). See Figure 2.

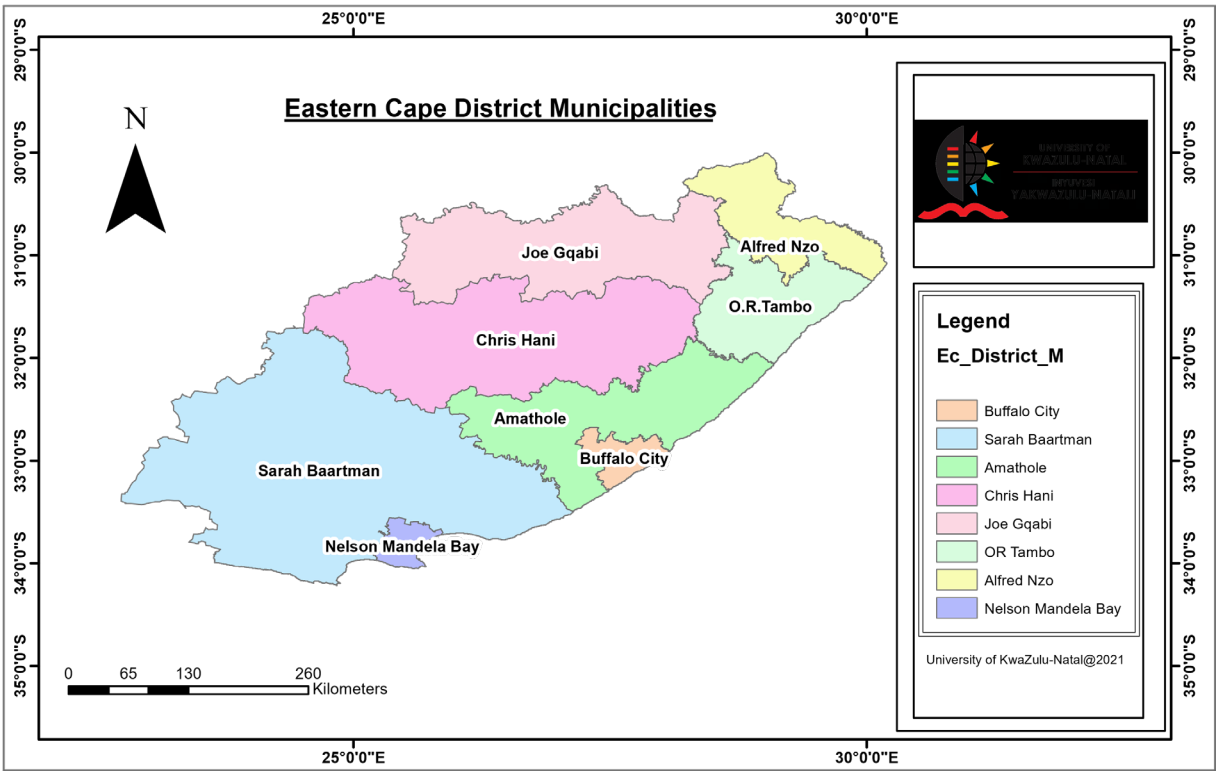

Figure 2: Map showing Districts in Eastern Cape Province.
Source: https://travelinsa.wordpress.com/eastern-cape/

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Rural areas dominate the Eastern Cape (EC) Province, with approximately 65% of the population residing in rural communities characterized by high levels of unemployment and poverty (Statistics South Africa, 2013). Agriculture remains a critical livelihood strategy and contributes significantly to the provincial economy (Eastern Cape Department of Economic Development and Environmental Affairs, 2011). However, in recent years, agricultural activity in the EC has declined and remains largely underutilized. Consequently, many rural households rely heavily on alternative sources of income, such as wages, salaries, and social grants.

Rural households use different livelihood strategies to survive, such as welfare social grants, but it`s not enough for households to meet their basic requirements, like education and food. Policymakers and province officials have implemented numerous development projects and strategies to improve and address food insecurity and unemployment by introducing skills, education, and provision of service delivery.

Climate patterns such as rainfall in summer in the EC province allow its ecological zones to be favourable for apiculture (beekeeping). Also, its forested biomes and farmsteads of approximately 2.2 million hectares favour apiculture (Eastern Cape Department of Economic Development and Environmental Affairs, 2011). Households that run beekeeping enterprises can improve their food security status through income and other downstream economic activities (Dawud et al., 2020; Srivani Maddala, 2020). This means that EC province has a great opportunity to grow and develop the beekeeping industry. Also, the abundance of forage and plantations raises a great opportunity for pollination services by bees to have great potential in the EC beekeeping industry. The emerging interest for honey in the EC markets has encouraged participation in the beekeeping industry.

2.2. Research Design and Approach

This study adopted a cross-sectional research design within a quantitative methodological framework. A cross-sectional design involves collecting data from a population at a single point in time, enabling the examination of prevailing conditions, characteristics, or relationships among variables. This design is widely applied in empirical research to assess the distribution of phenomena and to analyse associations between key variables. Its primary advantage lies in its efficiency, as it allows for the collection of data from a relatively large sample within a limited time frame and at a lower cost, without requiring longitudinal follow-up. The quantitative research approach emphasises the use of numerical data to systematically measure variables, test hypotheses, and identify statistical relationships (Lim, 2025). This approach enhances objectivity and analytical precision by relying on formal statistical techniques and empirical measurement. Collectively, the use of a cross-sectional design and quantitative approach enables the generation of generalisable findings based on observations made at a specific point in time, while facilitating robust and systematic data analysis.

2.3. Sampling Procedure and Sample Size

The sample size was determined on the traits of the population (Sim & Wright, 2005). The sample size for beekeepers was calculated using Yamane's (1967) formula for finite populations:

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

Where n = sample size; N = population size, 115 in this case e = confidence level (95%).

$$n = \frac{115}{1+115\,(0.05)^2}$$

$$n = 89$$

Due to time, financial, and logistical constraints, a full census was not feasible; however, the selected sample was deemed adequate to capture variability within the population. To allow for comparative analysis, 151 non-beekeeping households were also included. A multistage sampling procedure was used for non-beekeepers: two district municipalities (OR Tambo and Alfred Nzo) were randomly selected; local municipalities were stratified, and rural wards were purposively chosen based on agricultural potential. Households were then randomly selected from each ward in proportion to their population size.

2.4. Data Collection

Primary data were collected using a structured questionnaire administered to sampled households through face-to-face interviews. The questionnaire comprised both closed- and open-ended questions designed to capture household demographics, socio-economic characteristics, perceptions of beekeeping, and participation in beekeeping activities. To ensure clarity and relevance, the structured questionnaire was pre-tested with fifteen households who were not part

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of the main sample. This pre-test aimed to identify ambiguous questions, improve the flow of questions, and assess the appropriateness of the language used. Based on the feedback, necessary adjustments were made before the final administration. Trained enumerators fluent in the local Xhosa language facilitated the data collection process to ensure cultural sensitivity and accurate interpretation of responses. Reliability was ensured through standardized training of enumerators and consistent administration of the questionnaire, while validity was enhanced through expert input and alignment of the questionnaire with study objectives and relevant literature.

2.5. Data Analysis

Following data collection, responses were coded and entered into a computer database using a predefined coding framework. Initial data screening was conducted to assess internal consistency and logical coherence among related variables, such as household size and the number of income earners. Data completeness was evaluated by identifying missing values and incomplete responses, with records containing substantial omissions or implausible patterns flagged for verification or excluded where correction was not possible. The data cleaning process involved checking for duplicate entries, correcting data entry errors, and standardising variable formats to ensure consistency across categorical variables, including gender and education level. Continuous variables were examined for extreme values, and identified outliers were reviewed to confirm their accuracy and validity. To further ensure data quality, a subset of the dataset was randomly selected and cross-validated against the original questionnaires to verify accurate data capture. Once the dataset was finalised, statistical analyses were conducted using SPSS Version 28. These procedures ensured that the dataset was reliable and suitable for subsequent econometric and descriptive analyses.

2.5.1. Model Choice and Specification

T- test was used analyse the socio-economic characteristics of beekeepers and non-beekeepers. Descriptive statistics was used to analyse sources of income as part of the aspect that play significant role towards food security of the household. To evaluate household food security status, this study used the Household Food Insecurity Access Scale (HFIAS) method. To establish how much beekeeping contributes to household food security, the study also utilized an ordered regression model.

2.5.1.1. Household Food Insecurity Access Scale

Coates, Swindale, & Bilinsky (2007) state that the Food and Nutrition Technical Assistance (FANTA) organization employs the HFIAS quick survey method to assess household food access issues over the past 30 days. This method includes nine questions that explore dietary, or food consumption adjustments households make due to limited resources for acquiring food. To establish if the household falls into one of the three categories of household food access, the final results are evaluated using a scoring methodology. These are the categories: Low food insecurity access (HFIAS = 0-9), moderate food insecurity access (HFIAP = 10–18), or higher food insecurity access (HFIAS = 19–27) are all possible.

2.5.1.2. Ordered Probit Regression Model

The study employed an ordered probit regression model to analyse the determinants of household food security. This model is appropriate when the dependent variable is ordinal, containing categories with a natural order but unknown or unequal distances between them. In this study, household food security was measured using the Household Food Insecurity Access Scale (HFIAS) and classified into three ordered categories: low food insecurity (HFIAS = 0–9), moderate food insecurity (HFIAS = 10–18), and high food insecurity (HFIAS = 19–27).

The ordered probit model belongs to the generalized linear model (GLM) family, in which a linear combination of explanatory variables is linked to the probability of each outcome category through a non-linear link function. Maximum Likelihood Estimation (MLE) is used to estimate the model parameters (Amelia, Indahwati, & Erfiani, 2022; Greene, 2012; Meyer et al., 2022).

The model is specified as follows:

$$y_i^* = x_i^* \beta + u_i, u_i | X_i \sim \text{normal}\,(0, 1) \quad (1)$$

Where y_i*, is a latent (unobserved) variable representing household food security, i represent categories, x_i* is a vector of explanatory variables including beekeeping participation and socioeconomic factors, β is a vector of coefficients, and u_i is a normally distributed error term. Threshold parameters ($a_1 < a_2 < a_3$) define the boundaries between the observed categories of food

security. The probability of a household falling into each food security category is determined by these thresholds.

Ordered probit was preferred over ordered logit because it assumes normally distributed errors, which better fits our data. It is widely used in empirical research for ordinal outcomes with three to seven categories (Davidson & MacKinnon, 2004) and reduces to a standard probit model when the dependent variable has only two categories.

2.5.2. Dependent and Independent Variables

Table 1 shows various independent variables used in the regression model.

Rural household engagement in livelihood strategies such as beekeeping plays a vital role in improving food security. It allows household to have a better purchasing power which directly influences food security status of households. Participation in beekeeping as a variable was coded as a dummy, 0 no and 1 = yes. Hence, a positive relationship between food security status and participation in beekeeping was expected.

Gender is also considered as one of the important factors that affects household food security. The literature indicated that beekeeping industry is mostly dominated by men. Women still face barriers that hinder participation including cultural norms and lack of access to resources. This variable was coded as a dummy, 0 = male and 1 = female. The relationship between gender and food security may be positive or negative.

Table 1: Description of Independent Variables Stated in the Ordered Regression Model and Anticipated Symbols.

Variables	Variable Description	Anticipated Symbol
Participation	0= no; 1= yes	+
Gender	0= male; 1= female	±
Age	Number	+
Employment status	0 = no; 1= yes	+
Household size	Number of household members	+
Education level	0= informal; 1= primary; 2= secondary; 3= tertiary	+
Household income	Number (South African Rands)	+
Access to extension services	0= no access; 1= access	+
Access to markets	0= no access; 1= access	+
Access to credit	0= no access; 1= access	+
Membership to CBOs	0= non-membership to CBO; 1= Membership to CBO	+
Production out	Amount harvested (kgs)	+
Market Place	0 = home, 1 = town, 2 = roadsides	+
Access to infrastructure	0= no access; 1= access	+
Land tenure system	Total farm size owned by the household in hectares	+-
Note: CBOS (Community-Based Organization)		

The independent variables included in the ordered probit model were selected based on prior literature and their expected influence on household food security (Table 1). Participation in beekeeping (0 = no, 1 = yes) is expected to positively influence household food security, as beekeeping generates income and improves access to nutritious food. Gender of the household head (0 = male, 1 = female) may influence food security through decision-making and resource allocation, with effects potentially positive or negative depending on context. The age of a household head influences food security through experience, knowledge, and resource management. Literature notes that younger households are more active in beekeeping and may take advantage of opportunities such as lucrative markets, which directly influence food security. This variable is coded as a continuous variable (number of years), with a positive association expected.

Employment status (0 = no, 1 = yes) is anticipated to improve food security, as employed households have higher income. Household size plays a significant role in influencing food security; larger households require more food, which may increase the risk of food insecurity, but they may also provide more labor for agricultural activities. This variable was measured as a continuous variable representing the number of household members, with a positive association expected (Gundersen & Ziliak, 2015). Education level (0 = informal, 1 = primary, 2 = secondary, 3 = tertiary) enhances decision-making, resource management, and access to information, positively impacting food security. Educated households are better equipped to adopt improved beekeeping practices (Amare & Simane, 2017), and a positive association is expected. Household income, measured as a continuous variable in Rands, is expected to positively influence food

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security by enabling households to purchase sufficient and nutritious food. Access to extension services (0 = no, 1 = yes) can improve beekeeping productivity and household food security, while access to markets (0 = no, 1 = yes) allows households to sell products at better prices, generating income for food. Access to credit (0 = no, 1 = yes) enables households to invest in productive assets and inputs, enhancing food security.

Membership in community-based organizations (CBOs) (0 = non-member, 1 = member) facilitates resource sharing, training, and market opportunities, positively influencing food security. Production output, measured in kilograms, directly increases food availability or income from sales, improving household food security. The marketplace (0 = home, 1 = town, 2 = roadsides) affects household income and food access, with sales in town or roadside markets expected to have a positive effect. Access to infrastructure (0 = no, 1 = yes) improves market participation and food security through better roads, storage, and electricity. Finally, land tenure system, measured as total farm size in hectares, influences production capacity and resource security, with effects potentially positive or negative depending on household resource management.

3. Results and Discussion

3.1. Socio-economic Characteristics of Farmers

This section presents the descriptive results of the demographic and farm characteristics of small-scale farmers in the study area.

Table 2 presents the t-test analysis between beekeepers and non-beekeepers. The gender variable shows mean scores of 0.27 and 0.73 among beekeepers and non-beekeepers, respectively. The t-test p-value of 0.000 indicates a statistically significant difference in gender distribution between the two groups. This suggests that most beekeepers were male. The finding implies that male-headed households are more likely to engage in beekeeping activities, potentially due to gendered roles in rural livelihood strategies, where men may have greater access to productive resources or be more willing to take on physically demanding tasks such as hive management.

The age variable has a lower mean score of 45.74 among beekeepers compared to 53.07 among non-beekeepers. The t-test p-value of 0.002 indicates a statistically significant difference in age between the two groups. This finding implies that younger individuals are more likely to engage in beekeeping. It may reflect that younger household heads are more innovative, open to adopting new income-generating activities, or physically better suited to manage beekeeping operations, thus increasing their livelihood resilience.

The household size shows a lower mean of 4.88 among beekeepers compared to 6.25 among non-beekeepers. The t-test p-value of 0.002 confirms a statistically significant difference in household size. This finding suggests that smaller households are more inclined to participate in beekeeping. This may be because smaller households are more agile in decision-making and can more easily allocate limited resources to specialized enterprises like beekeeping, potentially enhancing their income diversification.

Household occupation also revealed a significant difference, with a lower mean of 0.12 for beekeepers compared to 0.38 for non-beekeepers. The t-test p-value of 0.000 shows a statistically significant variation in household occupation between the two groups. This indicates that beekeepers are more likely to be full-time farmers. Full-time engagement in agriculture may offer the time and commitment necessary for managing beekeeping operations, suggesting that integrating beekeeping into routine farming enhances livelihood outcomes.

Employment status shows mean scores of 0.61 among beekeepers and 0.83 among non-beekeepers. The t-test p-value of 0.003 indicates a statistically significant difference. This suggests that beekeepers are more likely to be unemployed or self-employed compared to non-beekeepers. The result implies that beekeeping may be adopted as a self-reliant livelihood strategy, particularly by those not formally employed, to fill income gaps and improve household welfare.

Regarding income sources, crop sales show a lower mean of R115.56 for beekeepers versus R216.43 for non-beekeepers. The t-test p-value of 0.019 indicates a statistically significant difference. Similarly, livestock sales show a mean of R1,245.97 for beekeepers and R2,317.48 for non-beekeepers, with a t-test p-value of 0.001. These findings suggest that beekeepers earn less from traditional farming sources than non-beekeepers. This may indicate that households earning less from conventional agricultural activities diversify into beekeeping to supplement their incomes. Bee product sales show a considerably higher mean of R2,433.58

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among beekeepers compared to R0.00 among non-beekeepers, with a t-test p-value of 0.000. This finding validates the economic value of beekeeping as an income-generating activity. Households engaged in beekeeping benefit directly from the sale of honey and related products, reinforcing beekeeping's role in enhancing rural livelihoods and improving household resilience to economic shocks.

Table 2: Socio-economic Characteristics of Farmers. (N=240).

Variable	Beekeepers, Avg (SD)	Non-Beekeepers, Avg (SD)	Pooled, Avg	t-test (p-value)
Gender (Male=0; Female=1)	0.27 (0.446)	0.73 (0.446)	0.50	0.000***
Age (years)	45.74 (7.366)	53.07 (10.530)	49.96	0.000***
Marital status	0.65 (0.479)	0.57 (0.497)	0.61	0.215
Education level (years)	1.70 (1.005)	1.51 (1.142)	1.61	0.184
Household size	4.88 (2.189)	6.25 (2.283)	5.42	0.000***
Household occupation	0.12 (0.331)	0.38 (0.597)	0.25	0.000***
Employment status	0.61 (0.633)	0.83 (0.671)	0.72	0.003***
Crop sales (ZAR)	115.56 (298.507)	216.43 (568.405)	165.13	0.042**
Livestock sales (ZAR)	1245.97 (2485.684)	2317.48 (3584.202)	1781.73	0.011**
Bee product sales (ZAR)	2433.58 (3527.518)	0.00 (0.000)	1432.04	0.000***

3.2. Beekeeping Products Produced

This section focuses on the specific bee products produced by beekeepers as illustrated in Figure 3. The results reveal that four main bee products are produced including honey (100%), propolis (30%), royal jelly (28%), and beeswax (34%. Honey emerged as the primary product, reflecting its widespread demand and marketability. These results align with the results of Oyerinde & Omara-Achong (2021), who discovered that practicing beekeeping involves producing different bee products with honey as a primary product produced. These results suggest that while honey production dominates, other bee products have substantial economic potential. This diversification of bee production allows households to benefit from various streams, contributing to food security and livelihoods.

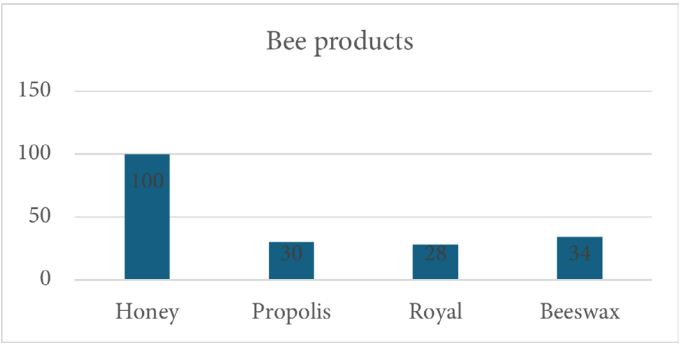

Figure 3: Produced Beekeeping Products.

3.3. Share of Various Sources of Income to Household Income

Figure 4 shows the results of the share of household income generated from various activities in the study area. The results indicate that wages and salaries constitute the largest share household income (39%), followed by livestock sales (21,2%), this suggests the critical role of livestock farming in the study area, not only as a traditional asset but also as a significant contributor to household income. Social welfare grants (14,3%), beekeeping activities, specifically bee product sales, contribute (8%) to household income, old age pension (6,3%), other (unspecified) (4,7%), domestic worker (2,4%), remittances (2%), crop sales (1,9%) and hawking (0,50%).

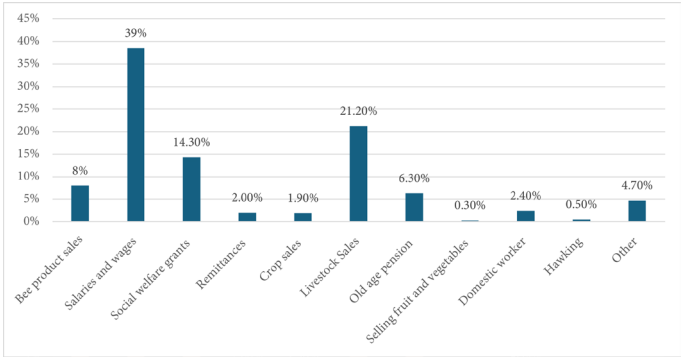

Figure 4: Share of Various Sources of Income to Household Income.

While the contribution of bee product sales is relatively modest at 8%, it reflects the potential for beekeeping to enhance household income. Beekeepers in the study area reported harvesting between 80kg and 4 915kg of bee products per season, depending on scale, hive type and management practices. Despite the current low contributions, regression results (table 5.2) indicate that the amount of honey harvested is a statistically significant and positive determinant of household income ($p< 0.01$). The fact that beekeeping contributes at all in the presence of other income streams, suggests that it is a viable livelihood strategy, though not yet fully explored or optimized in the study area. These results align with those of Yusuf, Cishe, & Skenjana (2018) and Abro et al.

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(2022), who found that beekeeping plays a crucial role in supplementing household income through the sale of bee products.

3.5. The Impact of Beekeeping to Household Food Security

3.5.1. Household Food Security Status

This section evaluates household food security status. Descriptive results from Figure 5 indicate that 42% of households were moderately food insecure, while 30% were more food insecure. Only 28% of households were classified as less food insecure. These results suggest that the majority of households face moderate to severe food insecurity. The lack of access to employment and education significantly contributes to their vulnerability. These results are consistent with those reported by Selepe, Mtyingizane, & Masuku (2015).

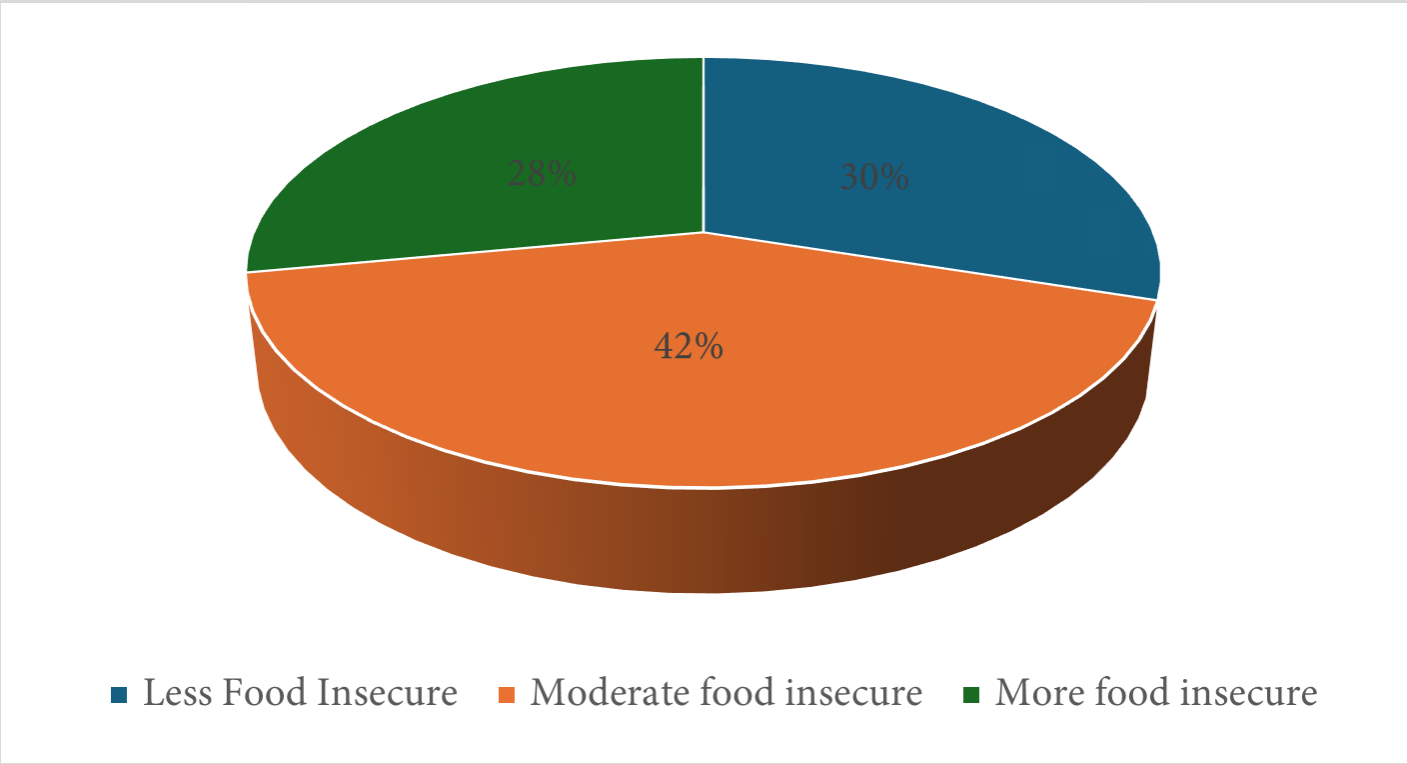

Figure 5: Household Food Insecurity Status.

3.5.2. Determinants of Household's Food Insecurity Status

Determinants of a household's food insecurity status are estimated using the ordered probit model. The model results are shown in this section in Table 3. Estimated household food insecurity status categories were regressed against several explanatory variables. The model's results indicate a low log-likelihood of -118.28869 and significant at $p<0.01$. The estimated cut-off points (μ) is also presented by the model results. The first cut-off point (Y=0 for the less food insecure category) was utilized as a mark for comparison purposes. Based on the summarized model results, statistically significant independent variables were further discussed in this section.

The results show that household size is significant at the 5% level, with a positive coefficient. This indicate that as the number of household members increases, the likelihood of being more food insecure also increases. The marginal effects indicate that a larger household size increases the probability of falling into the "more food insecure" category by 2.23% and decreases the probability of being less food insecure by 0.98%. This may be due to the fact that a larger household size means more members need to be supported with the household's limited resources. This could also reflect a higher dependency ratio, where fewer working members support a larger number of dependants. These results are consistent with results of Amare & Simane (2017) and Dube, Haji, & Zemedu (2018), who observed that households with a more members had a negative correlation to the less food insecure household category.

The coefficient employment status is positive and significant at the 10% level. This suggests that employment is associated with a high likelihood of food insecurity.

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This may be contradicting with most literature but can be explained by the nature and quality of employment in rural areas. Many of the employed individuals in the societies may be engaged in informal, seasonal and low paying jobs that do not provide adequate income to meet the basic household needs. This implies that employment, in this context, does not necessarily adequate to food security. These results align with the results of Devereux & Tavener-Smith (2019).

Table 3: Ordered Probit Results with Marginal Effects.

Household Food Security										
Marginal Effects										
Variables	Coefficients	Std. Err.	Z	P-value	Less food Insecure (dy/dx)	P-value	Moderate food Insecure (dy/dx)	P-value	More food Insecure (dy/dx)	P-value
Gender	0.1544151	0.2209963	0.70	0.485	-0.0134207	0.490	-0.0173215	0.478	0.0307422	0.482
Age	0.016961	0.0133059	1.27	0.202	-0.0014741	0.197	-0.0019026	0.211	0.0033767	0.201
Marital status	-0.0507783	0.1781343	-0.29	0.776	0.0044133	0.775	0.0056961	0.777	-0.0101093	0.776
Educational	-0.1500931	0.1239336	-1.21	0.226	0.013045	0.224	0.0168367	0.231	-0.0298817	0.224
Household Size	0.1122507	0.0518979	2.16	0.031*	-0.009756	0.033	-0.0125917	0.027	0.0223477	0.026
Employment status	0.3380035	0.1683225	2.01	0.045*	-0.0293769	0.041	-0.0379155	0.057	0.0672924	0.045
Total household Income	-0.000257	0.0000313	-8.22	0.000***	0.0000223	0.000	0.0000288	0.000	-0.0000512	0.000
Participation in beekeeping	-0.8181806	0.2563107	-3.19	0.001**	0841236	0.002**	.0796463	0.001**	-0.16377	0.001**
Access to credit	1.818868	1.555402	1.17	0.242	-0.1580831	0.235	-0.2040314	0.254	0.3621145	0.242
Access to Extension services	0.4438839	0.2261562	1.96	0.050*	-0.0385792	0.055	-0.0497926	0.045	0.0883719	0.045
Access to markets	-0.1370037	0.2344734	-0.58	0.559	0.0119074	0.560	0.0153684	0.558	-0.0272758	0.558
Market place	-0.0129494	0.1145979	-0.11	0.910	0.0011255	0.910	0.0014526	0.910	-0.0025781	0.910
Member of community association	-0.0772305	0.3799482	-0.20	0.839	0.0067123	0.839	0.0086633	0.839	-0.0153756	0.839
Output	-0.0204115	0.0073793	-2.77	0.006**	0.001774	0.006	0.0022897	0.007	-0.0040637	0.004
Access to infrastructure	-0.310713	0.248935	-1.25	0.212	0.027005	0.218	0.0348542	0.200	-0.0618592	0.204
Land tenure system	6.505232	167.9104	0.04	0.969	-0.5653887	0.969	-0.7297238	0.969	1.295112	0.969
/cut1	-2.077735	0.691549								
/cut2	0.7353181	0.6593847								
LR chi2(16) = 267.61; Prob > chi2 = 0.0000; Log likelihood= -118.28869; Pseudo R2 = 0.5308										
Note: ***, ** and * indicate significance at 1%, 5% and 10% probability levels, respectively. The average marginal effects are also reported. SPSS was utilized.										

This variable is highly significant at the 1% level, with a negative coefficient. The negative sign indicates that higher household income significantly reduces food insecurity. The marginal effects show that increasing household income decreases the likelihood of falling into the "more food insecure" category by 0.0051% and increases the probability of being less food insecure by 0.0022%. Higher household income significantly reduces the likelihood of food insecurity. As household income increases, families have better access to food, leading to improved food security. This result suggests that policies aimed at income generation, such as micro-enterprise development or improving market access for rural farmers, could play a vital role in reducing food insecurity among vulnerable households. Even small increases in income seem to make a meaningful difference in food access. These results are consistent with the results of Mabuza et al. (2016).

Participation in beekeeping is significant at the 1% level, with a negative coefficient. This indicates that households involved in beekeeping are less likely to be food insecure. The marginal effects reveal that beekeeping participation decreases the probability of being more food insecure by 16.38% and increases the likelihood of being less food insecure by 8.41%. Households that participate in beekeeping are significantly less likely to be food insecure. This suggests that beekeeping contributes to improving household food security, possibly by providing both food (through honey production) and income (from selling honey and bee products). It also aligns with the idea that diversified income sources, especially in rural areas, can reduce reliance on uncertain agricultural income and improve overall livelihood stability. Comparable results were shared by Gratzer et al. (2019), Jeil et al. (2020), Patel et al. (2020), and Hinton et al. (2020).

The coefficient for access to extension services is positive (0.443) and statistically significant at 10% level. This suggests that access to extension services are more likely to experience food insecurity. Even though this may seem unexpected, it suggests that extension services currently available in the study area might not be effectively addressing food security needs. It is possible that extension officers focus less on strategies to directly improve food security and more on technical aspects of farming. Also, this can be drawn from the fact that the services may be insufficient in coverage or frequency. These results are inconsistent with the results of Sigei (2014) and Maoba (2016).

Output is significant at the 1% level, with a negative coefficient. This implies that higher agricultural output

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reduces the likelihood of food insecurity. The marginal effects suggest that increased output reduces the probability of being more food insecure by 0.40% and increases the likelihood of being less food insecure by 0.17%. Higher agricultural output is associated with lower food insecurity. This result indicates that households producing more food through their agricultural activities are better able to meet their food needs. Increased production not only ensures sufficient food for household consumption but also allows for surplus sales, generating additional income. An increase in output reflects improved household well-being and income, which promotes rural households to improve their household food insecurity status through available food for consumption and income generated from sales. These results correspond with results of Statistics South Africa (2018) and FAO (2021).

4. Conclusion and Recommendations

This study estimated the contribution of beekeeping to household food security in the Eastern Cape Province. The findings indicate that most rural households experience food insecurity, with larger households being particularly vulnerable. Participation in beekeeping, higher household income, and increased production output were associated with improved household food security, highlighting the potential of beekeeping as a livelihood diversification strategy. Some unexpected results, such as the positive association between employment and food insecurity, suggest that low-paying or informal jobs may not sufficiently alleviate food insecurity in rural areas.

The study has important policy implications. Development agencies and the government should promote family planning, provide targeted extension services, and support beekeeping programs by offering training, skills development, equipment, and access to markets. Improving the quality of rural employment and enhancing household income opportunities are also critical for strengthening food security. For future research, longitudinal studies could assess the long-term effects of beekeeping on household food security, while broader regional analyses could explore variations across different provinces or socio-economic contexts. Such studies would provide more robust evidence to guide policy interventions and support rural livelihoods effectively.

Conflict of Interest

The authors declare that they have no competing financial or personal interests that could have influenced the work reported in this study.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contribution

Nontu Yanga conceptualised the study, designed the methodology, conducted data collection and analysis, and drafted the manuscript. Maxwell Mudhara provided academic supervision, contributed to the interpretation of results, and reviewed and revised the manuscript. Both authors read and approved the final version of the manuscript.

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Ethical Clearance

Ethical approval for this study was obtained from the relevant institutional ethics committee prior to data collection. The study was conducted in accordance with established ethical standards for research involving human participants.

Informed Consent

Informed consent was obtained from all participants prior to their participation in the study. Respondents were informed about the purpose of the study, their voluntary participation, and their right to withdraw at any stage without penalty.

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