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Market value chain of honey production in Northern Ethiopia

Filmon Hadaro Hando

Centre for Regional and Local Development Studies, College of Development Studies, Addis Ababa University, Ethiopia.

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Farm commodities that are grown to sell for profit and purchased by parties separate from a farm are seen as cash crops. Coffee, cotton, and honey are produced for sale in South and Western Ethiopia. As honey emerged as a cash commodity, farmers in Northern Ethiopia became involved in honey production as an income source. Studies on honey production have focused on central, south, and western Ethiopia. Northern and eastern Ethiopia are perceived as arid and most degraded, and they are not favorable for beekeeping. This study analyzes the market chain of honey production and questions why farmers engage contrary to the literature and established perceptions. A questionnaire was administered to a total of 1609 honey farmers who were selected randomly from the list of beekeepers in the agricultural office, including desk reviews and key informant interviews. Both descriptive and inferential statistical analyses were conducted. The descriptive data results show that nine out of ten honey products in the market are supplied by smallholders to consumers and retailers. Out of this, six out of seven are supplied directly to consumers. The inferential data results indicate that producers' experience, income, bee colony size, use of modern hives, and the lagged price of honey determine the marketable supply of honey. Both data results confirm that honey production is profitable in Northern Ethiopia. The use of modern beehives enhances productivity and income by 27%. However, shortages of bee forage (due to drought-induced changes), credit, technologies, knowledge, markets, and bee diseases are key problems for beekeepers that require policy intervention.

Key words: Honey value chain, profitability, productivity, market surplus, northern Ethiopia.

INTRODUCTION

Ethiopia has immense potential for honey and beeswax production (Adjare, 1990; Legesse, 2014; Kassa et al., 2017a; Dagnaygebaw and Tariku, 2020; Seble, 2020; Gratzer et al., 2021; Mesele et al., 2022). However, this potential remains untapped due to the practice of traditional beekeeping (Girma, 1998; Meaza, 2010; Gidey and Mekonen, 2010; FAO, 2003; Haftu, 2015; Legesse, 2014; Hailemichael, 2018; Dagnaygebaw and Tariku, 2020; Kassa and Assefa, 2023; Tesfu and Demto, 2021; Benyam et al., 2021; Siyoum, 2022; Zewdu et al., 2022). Beekeeping yields valuable outputs such as honey, beeswax, queen bees, and bee colonies, both for home consumption and marketing (Gidey and Mekonen, 2010; Kassa and Assefa, 2023; Tesfu and Demto, 2021;

E-mail: filmon.hadaro@aau.edu.et; +251 900464412.

Benyam et al., 2021). Ethiopia has the potential to produce 500,000 tons of honey and 50,000 tons of beeswax annually (MoARD and EHBPEA, 2010). However, its annual production does not exceed 45,000 tons of honey and 3,000 tons of beeswax (Kassa et al., 2017b). More recent data indicates that the annual total honey production reached 53,000 tons, which is still about 10% of its potential (Tekeba and Yeshtila, 2018; Gratzer et al., 2021; Siraj and Abdi, 2021). Roughly 80% of the honey produced is consumed locally. However, the per capita honey consumption, considering Ethiopia's population of 120,000,000, stands at 0.53 kg per head (Gratzer et al., 2021; Siraj and Abdi, 2021). According to CSA (2011, 2012), the production and size of beehives vary by region. The central, southern, and western parts of the country produce and supply more than 80% of the honey (Siyoum, 2022; Seble, 2020; Besha, 2023; Dirriba, 2023; Benyam et al., 2021; Gratzer et al., 2021; Siraj and Abdi, 2021). Among the regions, Oromia, Amhara, and the former SNNP regional state supply 46.4, 21.8, and 20.2% of the honey production, respectively. These regions have 55, 19.3, and 15.6% of the bee colonies, respectively (Siraj and Abdi, 202; Besha, 2023; Dirriba, 2023). Tigray and Benshangul-Gumz account for 4.4 and 4.6% of the total bee colonies and 6 and 2.7% of the total honey production, respectively (Seble, 2020; Siyoum, 2022; Benyam et al., 2021). Despite the fact that smallholder farmers supply 80% (Gidey and Mekonen, 2010) and 90% (Seble, 2020; Gratzer et al., 2021; Kassa and Assefa, 2023) of the produce locally, honey production has increased both in quantity and geographic coverage, including traditionally non-honey farming areas (Kassa and Assefa, 2023; Siyoum, 2022; Tesfu and Demto, 2021). As part of the Ethiopian agricultural output markets, characterized by inadequate transport networks, a limited number of traders, inadequate capital facilities, inadequate market information systems, a weak bargaining power of smallholder farmers, and underdeveloped industrial sectors, beekeeping also faces these challenges (Jema, 2008; Oxfam, 2011; Haftu, 2015; Besha, 2023; Tesfu and Demto, 2021; Seble, 2020). The honey production in terms of quantity, quality, and productivity is very low (Legesse, 2014; Haftu, 2015; Zewdu et al. (2022; Besha, 2023; Dirriba, 2023). The marketing system for honey in Ethiopia is poorly developed (Besha, 2023; Benyam et al., 2021; Kassa and Assefa, 2023; Meaton et al., 2021; Biruk et al., 2018). The productivity is low, and the market benefits from this activity are also low, and the market infrastructure is poor (Kassa et al., 2017b; Dirriba (2023; Benyam et al., 2021; Hailemichael, 2018). The honey and beeswax sub-sector significantly improves the poverty status and food security of smallholders in Ethiopia. Despite the constraints facing the sub-sector, the participation of smallholder farmers in honey and beeswax production in Northern Ethiopia is growing and has become an area for academic and policy debate. First, addressing constraints related to the shortage of bee forage, equipment, infrastructure, technology, skill, and policy enabling environment requires evidence-based information. Second, the growing trend of honey production and beekeeping by smallholders in arid areas of Northern Ethiopia, contrary to Ethiopia's traditional honey farming areas, raises scientific curiosity for research. Thus, this study analyzes honey market value chains to inform policy and produce evidence to fill the above policy and research gaps in the context of Northern Ethiopia.

LITERATURE REVIEW

Previously, smallholder farming is rain-fed that is dependent on rainwater, deplete the environement, and is conceptualized as sunsistence and survivalist in the context of climate change and dynamic shocks such as rainfall variability and droughts (Abbo et al., 2022). Such farms employ traditional practices and are not considered as business entitites that produce goods and services for profit; such perspectives have changed due to: transformation of traditional farming; introduction of cash crops crops (Achterbosch et al., 2014; Tadesse et al., 2016); marketable farm commodities such as honey (Kansanga et al., 2019; Abbo et al., 2022; Hashmiu et al., 2022). In Ethiopia, traditional honey farming exists analogous to modern farming, and the difference between these systems include use of farm technology, scale of production and productivity, production output and its impact on the environment (Hailemichael, 2018; Benyam et al., 2021; Haftu, 2015). As honey increasingly become marketable farm commodity both for domestic and export markets in Ethiopia, smallholders supply honey to consumers, traders and retailors to maximize profits. In theory, marketing in general and marketable famr commodities comprise three components: the satisfaction of customers, integration of markets and producing and organizing goods and services (Kotler and Keller, 2012; Elgar, 2013; Kansanga et al., 2019; Manida, 2021; Abbo et al., 2022). Supply chain and market chain are synonymously used to describe all participants involved in an economic activity, the transaction of farm inputs and services to enable a product to be made and delivered to a market (FAO, 2005; Lundy et al., 2008; Gratzer et, al., 2021; Siraj and Abdi, 2021; Tekeba and Yeshitela, 2018).

A value chain is differentiated from market and supply chains since participants collaborate toward a shared objective of maximizing benefits (Gratzer et al., 2021). This collaboration aims at achieving goals and minimizes benefits, including response to shocks/risk through the investment of time, effort and other resources in a stress-free work environment (Hobbs et al., 2000; Elgar, 2013; Manida, 2021). Market and value chains are oriented primarily by demand, and thus, supply responds to

consumer needs. In this respect, due to growing demand for consumption and sales, honey production is increasing in Ethiopia, including in traditionally none-honey farming areas of Northern Ethiopia (Seble, 2020). Furthermore, in the context of conducive business environment for actors in the value chain, suppliers and consumers have a high level of confidence in one another that allows greater security in makianf a business and facilitating the development of common goals and objectives for both (Dirriba, 2023; Tesfu and Demto, 2021; Biruk et al., 2018; Hailemichael, 2018; Wezel et al., 2014). Study findings on the determinants of honey production and value chain in Ethiopia include quantity and quality of marketable and marketed surplus, economic factors (product price, provision of consumer goods, production cost and market supply costs), political factors (government intervention modalities and institutional frameworks) (Alemnew, 2010; Awol, 2010; Kassa and Assefa, 2023; Benyam et al., 2021; Bhattarai et al., 2020; Meaton et al., 2021; Biruk et al., 2018; Negash and Greiling, 2017; Drost and van Wijk, 2011; Wezel et al., 2009). Also, the quantity and quality honey production in Ethiopia in general and its environmental impact specicially in Northern Ethiopia include the use of technologies and access to skill training, credit and infrastructure, among others (Dirriba, 2023; Zewdu et al. (2022; Siyoum, 2022; Besha et al., 2022; Tesfu and Demto (2021; Kassa and Assefa, 2023; Meaton et al., 2021; Hailemichael, 2018; Negash and Greiling, 2017; Legesse, 2014).

Honey farmers use two tyes of beehives; traditional and modern beehives (FAO, 2003; IPMS, 2008; GDS, 2009; Dirriba, 2023; Zewdu et al., 2022; Besha et al., 2022; Bhattarai et al., 2020; Kassa and Assefa, 2023; Hailemichael, 2018; Negash and Greiling, 2017). The use of the traditional and modern beehives depends on the socioeconomic and technological status of the smallholders, and the accessibility of the farmers to imporved modern beehives (Besha et al., 2022; Bhattarai et al., 2020; Kassa and Assefa, 2023). In this respect, smallhoders that have the capacity to buy and access skill training use the modern beehives, while those that lack the capacity to buy and access skill training use the traditional beehives (Seble, 2020). In fact, using modern beehives increase honey productivity by more than 32% as compared to the traditional beehives, and the new entrants into honey production in Northern Ethiopia use modern beehives relatively better than those in other parts of the country (Dagnaygebaw and Tariku, 2020; Tesfu and Demto, 2021; Besha et al., 2022; Siyoum, 2022).

The constraints, challenges and opportunities of honey production, honey market chain and related issues were studied in Ethiopia and in other countries. Wezell et al. (2009) argued on agrology beyond mainstream crop production and protection dimensions to environmental, social, economic, as well as ethical and development issues that are becoming relevant in current debates. Oxfam (2011) assessed about the importance of collaboration of market actors and its relevance to the creation of enabling environment. Drost and van Wijk (2011) also conducted their research on stakeholders' coordination, the groups engaging and operating it as a platform the coordination and facilitation of social capital formation in the fragmented honey sector. Wezell et al. (2014) rose about the need for new farming practices, more and diverse food in a sustainable way to feed to growing world population, and indicated the importance of agronomic practices in the production of farm commodities. Legesse (2014) assessed the constraints of Ethiopia's beekeepers that use traditional and modern beehives, and related to the productivity and quality of honey produced by smallholder honey farmers. Haftu (2015) documented the scope of honey farmers in Ethiopia. His study shows that about 1.4–1.7 million households engage in beekeeping and produce different types of honey, Alemu et al., (2016), assessed the constraints honey value chain and its impact on the supply chain and incomes of farmers.

Kassa et al. (2017a) conducted a study on the profitability and market performance of honey production in Southern Ethiopia, and identified that honey farmers in average obtained gross profits of 788.70 birr/hive from improved modern hives per year, which is more than 32% as compared to traditional beehives. Negash and Greilling (2017) conducted research on the quality of the apiculture sector value chain in Ethiopia. Kassa et al. (2017b) assessed the potential of honey production in Kaffa, Sheka and Bench Maji zones of Western Ethiopia, including the potential for forest honey farming. Biruk et al. (2018) assessed about the importance of honey value chain for millions of farmers and economy of the country. Hailemichael (2018) assessed about the various bee races and their adaptation and beekeepers' practices to/in different agroecological zones of Ethiopia. Meaton et al. (2021) assessed about the forest honey value chains in Zambia and Ethiopia and linked to livelihood opportunities for farmers and the promotion of forest conservation. Dagnaygebaw and Tariku (2020) assessed about Ethiopia's potential for beekeeping, honey production and its diverse climate and vegetation resources and endowments.

Kassa and Assefa (2023) assessed the impact of the number hives, type of beehive used, and proximity to the available forest on honey production, productivity and quality. Seble (2020) conducted a review of actors and their value adding activities in honey value chain in Ethiopia. The Environment, Forest and Climate Change Commission (2020) assessed the role of trees and forests on honey production and securing profits and the relevance of tree-based landscape restoration in Ethiopia. Bhattarai et al. (2020) conducted value chain analysis of honey bee subsector in Nepal. Gratzer et al. (2021) assessed the importance of honey bees in fruit

and vegetable pollination, honey production and honey branding (natural honey flavours). Benyam et al. (2021) assessed the constraints of beekeeping and honey production in Southwestern Ethiopia. Tesfu et al. (2021) assessed about the importance of environmental conditions for honey production and marketing in Southern Ethiopia. Patel et al. (2021) assessed the context of the reductions in global bee populations and role of bees' in promoting sustainable development goals, and has found that bees potentially and practically contribute towards 15 of the 17 SDGs and, at a minimum, 30 SDG targets. Ahmed et al. (2022) assessed beekeeping and honey production from environmental and sustainable development perspective, and advised land-restoration and water harvesting practices.

Besha et al. (2022) assessed about the determinants of beekeeping experience, training participation, colony number, frequency of extension contacts and types of beehives owned by the smallholder farmers, and have found that these factors significantly affect the volume of the honey produced and marketed as well as income from honey sales. Mesele et al. (2022) assessed about the adoption of different agricultural technologies and identified the role of such practices in poverty reduction in rural regions of Ethiopia. Their findings show that farmers that use modern beehives earn more profits from producvitity gains. Siyoum (2022) assessed about the quantity of honey supplied to the market in Ethiopia (relatively information gathered from all regions) and also indicated determinants of honey production and marketing. A study by Alidu et al. (2022), in Ghana, shows that over 70% of honey farmers practice a rudimentary agriculture and climate change poses a serious threat to smallholder farmers, and has impacts on their income, food security and wellbeing. Zewdu et al. (2022) reviewed the existing literature on beekeeping and honey production, and has acknowledged that beekeeping serves as a livelihood diversification strategy and income source for farmers across the world. Their findings further show that beekeeping enhances income gains for smallholder farmers (between 22 and 44% depending on the use modern and traditional beehives as compared to study results in the past. Dirriba (2023) assessed the honey production andmarketing system and its limitations in Ethiopia. A study by Besha (2023) has found that annual income from honey production is low in Ethiopia due to the lack of value addition activities and poor collaboration between market chain actors. Haftu (2015) assessed about how Ethiopian honey can be competitive, and can address the resource specialties such as shortage of bee forage and practice organic honey and supply to niche markets (domestic and global). They argue that improving the quality, food safety, market information management and cooperation among stakeholders is critical in shaping the competitiveness of Ethiopian honey.

Thus, the theoretical and empirical information reviews in this section is used as an analytical lens to analyze and interpret the data results and discuss its findings.

METHODOLOGY

Both quantitative and qualitative primary data was collected from 1609 honey producers, traders, and consumers in the honey marketing chain that were selected by two-stage stratified random sampling. Secondary data were also collected from empirical studies, policy reports and unpublished documents. Both descriptive and econometric analysis were employed, and the data was summarized using STATA 11 Software. The descriptive analysis used percentages, ratios, mean values and standard deviations while the profitability analysis was conducted by calculating total cost (fixed and variable cost) per hive based against total revenue. The formula used was:

$$\text{total profit} = TR - TC = PQ - \Sigma P_i X_i \ (TR=PQ) \quad (1)$$

Where TR = total revenue i.e., value of the product (PQ), TC = Total cost of production ($\Sigma P_i X_i$), P = price of produce, Q = Total production per/hive, P_i = price of input I and X_i = quantity of input i.

Multiple linear regression econometric models were used to analyse the determinants of honey value chain. This model was preferred and applied since the beekeepers were participants of the honey market and the dependent variable is continuous. The model's specification is are follows;

$$Y = \alpha + \beta' X + U \quad (2)$$

Where: Y = quantity of honey supplied to the market, α = Intercept, β '= vector of estimated coefficient of the explanatory variables; X = vector of explanatory variables, and U = disturbance term.

The parameter estimates of the above model may not be Best Linear Unbiased Estimators (BLUE) when some of the assumptions of the Classical Linear Regression (CLR) models are violated. Hence it is important to run diagnostic tests. The tests for the presence of multi-collinearity and heteroskedasticity among the variables that were assumed to affect supply of honey in the area were run. Two measures (tests) that were often suggested to test the existence of multi-collinearity; i.e., Variance Inflation Factor (VIF) for association among the continuous explanatory variables and Contingency Coefficients (CC) for dummy variables were used in this study. The variance inflation factor (VIF) was defined and computed as:

$$VIF(x_j) = \left(\frac{1}{1 - \mathbf{R_j^2}}\right) \quad (3)$$

Where, VIF = variance inflation factor, x_j = the j^{th} quantitative explanatory variable regressed on the other quantitative explanatory variables. $\mathbf{R_j^2}$ = the coefficient of determination when the variable and x_j is regressed on the remaining explanatory variables.

As a rule of thumb, if the VIF of a variable exceeds 10, that variable is said to be highly collinear (Gujarati, 2004; Wooldridge, 2016)). The result of the VIF is less than 10, and therefore, there is no indication of multi-collinearity a among variables. To test multi-collinearity among qualitative variables, contingency coefficient was computed for each pair of dummy variables.

The contingency coefficients are defined and computed as:

Table 1. Summary of explanatory variable and hypothesis.

Variable	Explanation	Category	Value	Expected sign
FAMSIZE	Family Size	Continuous	Number	(+/-)
EDU	Educational Level	Dummy	0=Illiterate, 1=Literate	(+)
EXPR	Experience in beekeeping	Continuous	Years	(+)
INCOME	Gross annual income	Continuous	Birr	(+/-)
NBCOL	Size of bee colony owned	Continuous	Number	(+)
OWMHIVE	Ownership of modern hive	Dummy	0= No	(+)
APRTVTY	Average productivity of honey	Continuous	kg	(+)
LAPRICE	Lagged price of honey (current)	Continuous	Birr	(+)
DSTNMKT	Distance to the nearest market	Continuous	Kilometer	(-)
ACEXSE	Access to extension service	Dummy	0= No, 1= yes	(+)
ACMKTINF	Access to market information	Dummy	0= No	(+)
ACCREDIT	Access to credit	Dummy	0= No	(+/-)

$$C = \sqrt{\frac{\chi^2}{n + \chi^2}} \quad (4)$$

Where: C = coefficient of contingency, χ^2 =Chi-square random variable and n = total sample size. Test for heteroskedasticity was employed to detect the presence of heteroskedasticity. Ordinary least squares (OLS) estimates were used and such estimates, according to Gujarati (2004) and Wooldridge (2016) argued and proven to be unbiased. Thus, OLS tests of significance are advised to generate scores that enable the study to conduct correct inferences (Gujarati, 2004; Wooldridge, 2016). Gujurati suggest of other test statistics for detecting heteroskedasticity. Among them are Park, Breusch-Pagan, White's tests, and Koenker-Bassett (KB) test of heteroskedasticity. However, according to Gujarati (2004) and Wooldridge (2016), there is no ground to say that one test statistics of heteroskedasticity is better than the other test statistics. In this study the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity was used to check the presence of heteroskedasticity.The Explanatory variables in this model were X_1 = Family size, X_2 = Educational level, X_3 = Gross annual income, X_4 = Experience in beekeeping, X_5 = Size of bee colony owned, X_6 = Ownership of modern hive, X_7 = Average productivity of honey, X_8 = Lagged price of honey (current price), X_9 = Distance to the nearest market, X_{10} = Access to extension service, X_{11}= Access to market information and X_{12} = Access to credit. The assumptions of the explanatory variables above are summarized as follows (Table 1).

RESULTS

Descriptive and qualitative data analysis

According to data results in Table 2, 94.3% of sample respondents were males whereas 5.7% were females. The data results imply new trend in the participants in this sub sector. Honey production. Traditionally, is a male-domain in Ethiopia, and the data above shows that female begun participating in honey production, though the participation rate is small (5.7%). However, more work is neeed to ensure gender equality and inclusion in future policy supports to the sub sector. About 91.7% are in the age category between 18 and 54 whereas the rest are above 54. About 95.9% of the sampled respondents were married, and 4.1% are not married. The family size of 84.6% of the respondents is between 1 and 7, whereas 15.4% have above 7 persons in the household. Out of the sample respondents, about 82.2% are illiterate (who do not read and write) whereas the remaining 17.8% are literate, mostly, as observed from the interview results, attended some level of primary schooling.

The survey questions were desined based on the review information in section 2 above. The questions were categorized into demographic, socio-economic, environmental, market and institutional categories, Household heads were interviewed by trained enumerators, and the items translated into the local language. The items were pre-tested before administration with sample respondents, The striking finding from this study is that the beekeeping and honey marketing value chain is almost controlled by males (94.3%) and females consisted only 5.7% Such gender inequality in this growingly productive market value chain and production needs policy attention in Northern Ethiopia.

The data results in Table 3 show the type of hive (modern or traditional), size of bee colonies owned, bee-hives with bee-colonies, and average honey production and productivity data. Accordingly, the mean honey production is 56.23 KG, and the mean honey productivity per hive is 21.73 KG. Out of the smallholders that participated in the study, 63.2% possess modern bee-hives while the rest 36.8% own traditional bee-hives. In average, the surveyed smallholders own 2.7 beehives; out of which 1.5 is modern and 1.2 is a traditional beehive. The total bee colonies owned by the selected farmers are that out of the beehives owned, 220 have 1 to 3 bee colonies, 184 have 4 to 6 bee colonies and 45 have 7 to 10 bee colonies. The data sets in Table 4 also indicate that price ranges, current and the predicted values, vary from Birr 40 to 100 and 45 to 120

Table 2. Demographic and socio-economic characteristics of sampled farmers.

Variable	Respondent socio-demography	Frequency (N=1609) and percentages
Sex	Female	88 (5.7%)
	Male	1521 (94.3%)
Age	18-54	1475 (91.7%)
	>54	134 (8.3%)
Marital status	Single	66 (4.1%)
	Married	1543 (95.9%)
Family size	1-7	1361 (84.6%)
	>7	248 (15.4%)
Educational Level	Literate	286 (17.8%)
	Illiterate	1323 (82.2%)

Table 3. Responses on honey production and productivity by sampled farmers.

Variable	Frequency (N=1609) and percentages	Average productivity in kg
Types of hives owned		
Modern hive	1017 (63.2%)	32.53
Local hive	592 (36.8%)	10.92
Mean production in KG by respondents	56.23	21.73
Size of bee colony owned	**Number of beehives with bee-colonies**	**Average bee-hives ownership**
1-3	220	Overall average (2.7)
4-6	184	Modern beehives (1.5)
7-10	45	Traditional beehives (1.2)

Table 4. Responses on factors affecting honey production and marketing.

Variable	Responses	Frequency (N=1609) and percentages
Experience in beekeeping	2-10	92 (59.8)
	>10	68 (40.2)
Previous honey price range	40-100	121 (71.6)
	100-135	48 (28.4)
Current honey price range	45-120	117 (69.2)
	121-150	52 (30.8)
Income category in birr	5,000-10,000	57 (33.7)
	>10,000	112 (66.3)
Distance in kilometres from nearest market	5-19	84 (49.7)
	>20	85 (50.3)

Table 5. Producers access to services.

Explanatory variable		Frequency (N=1609) and percentages
Access to market services	Credit accessed	66 (39.1)
	Extension contacts	113 (68.9)
	Market information (nearest)	118 (69.8)
	Market information (Broader)	17 (10.1)
Source of market information	Village market	133 (78.7)
	District cooperative	36 (21.3)

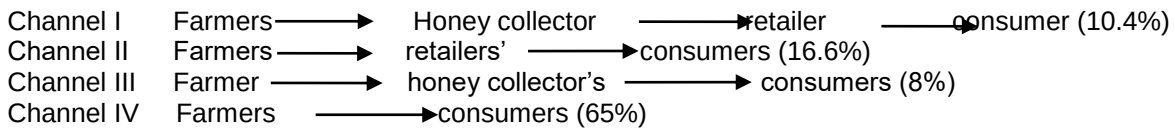

Figure 1. Four marketing channels.

respectively. This indicates that the price gains for honey producers increased by Birr 5 in village market to Birr 20 in bigger market.

Market information on prices of honey in the previous year enhances the ability of the smallholder farmers to decide on the volume of production and extension and related services that enhance the productivity of honey. The average lagged price of honey/kg in in the previous year was sold by the sampled respondents was birr 187.5 while the average current price of honey/kg sold by the respondents was birr 218.0. Thus, there is a birr 30.5 increase in price per kg from the previous year. Because of the increase in prices, the annual income increased by birr 5,000 to 10,000 for 33.7% of beekeepers and above birr 10,000 for 66.3% of beekeepers. The distance in kilometer from nearest market is 5 to 19 km for 49.4% and above 20 km for 50.3% of the beekeepers observed by the study. According to the interview data summary, the price increase was attributed to access road, and beekeepers were able to sell the honey in distant markets.

Access to extension services as policy support encourages the production and productivity of honey and the supply it to the market. Access to diverse extension services improves production and productivity of farmers. In this study, as indicated in Table 5, access to credit, extension expert contact and market information determine both the production and productivity, as well as prince gains from its marketing. In this respect, from the observed smallholder beekeepers, 39.1% accessed credit, 68.9% had extension expert contact, 69.8 and 10.1% got market information about the prices in the nearest and distant markets. Regarding the sources of information, 78.7% got from the village market while 21.3% of the beekeepers got from cooperatives. As observed in the field, the honey value chain passes through four marketing channels as shown in Figure 1.

Regarding the practices and costs of beekeeping and honey production, the inputs and outputs, considering the honey production and marketing as smallholder homestead business, was assessed as well. In terms of the practices (management of the business), as indicated by the interview data results, most smallholder interviewed visit their bee colonies daily and clean the area to avoid ants, insects and small rodents that climb the boxes and harm the bees, as well as forage on the honey from the hives. Though there are traditional beehives, none of the respondents keep their bee colonies in the forest, rather rear in their homesteads. However, the beekeepers raised the need for training and experience sharing to further improve their beekeeping business.

Regarding the cost of production, in average, the beekeepers observed expend birr 2,067 per hive. The cost is needed for buying hives, queen lauder, wax, gloves, smokers, bee colony, knife, boots, water sprayer, honey container, and bee veils. The profitability is also assessed by reviewing the cost and revenue per hive, and multiplying the net income by the amount of hives with functioning bee colonies. In this respect, as indicated in Table 6. the average productivity of sampled producers for the production year had 18.8 kg/hive and the average selling price of honey in the previous year was birr 187.5. Since there were two types of hives (modern and traditional), the profitability analysis was calculated for each type of hives owned by the farmer.

As the figures in Table 6 indicate, cost and profitability analysis of honey production by using the modern hives was encouraging regarding its profitability. This shows that a farmer with 32.53 average production of honey per

Table 6. Profitability analysis for honey farmers.

Modern hives owners	Average cost birr/hive
Initial investment and working capital cost	2,662
Average price/kg in birr	111
Average productivity/modern hive	32.53
Average value/hive (revenue/hive)	3610.83
Profit/hive	948.83
Traditional Hives Owners (New Entrants)	**Average cost birr/hive**
Initial investment and working capital cost	1,622
Average price/kg in birr	76.6
Average productivity/local hive	10.92
Average value/hive (revenue/hive)	836.47
Profit/loss	-785.53
Traditional Hives Owners (Experienced Farmers)	**Average cost birr/hive**
Total operational costs	668
Average price/kg	76.6
Average productivity/local hive	10.92
Average value/hive (revenue/hive)	836.47
Profit/hive	168.47

Table 7. Problems of honey farmers.

Key beekeeping constraints (multiple response)	Frequency (N=1609) and percentages
Bee disease and forage pests	1525 (94.8%)
Shortage of beekeeping equipment and inadequate skills	1481 (92.1%)
Shortage of bee forage (due drought and deforestation)	1430 (88.8%)
Shortage of honey bee colony	1312 (81.5%)
Shortage of transport and timely market information	1165 (72.4%)
Shortage of credit and distance of big markets	1063 (66.1%)

beehive with an average market price of honey 111 Birr would generate annual profit of birr 948.83/beehive. Thus, the annual profit of birr 1,897.7 was generated for the modern beekeeper. Except for new entrant, the traditional beekeeper also gains a profit of birr 168.47/hive in a year.

From the interview data results, the constraints beekeepers face includes shortage of bee forage (due to drought and deforestation, and lack of provision of bee forage plants by existing extension services), reduction in honeybee colonies (due to shortage of forage, bee predators, lack of skills in managing and migration of sub-colonies), lack of injection capital (due to lack of credit) and shortage (increase in price) of beekeeping equipment. In terms of specific shortages faced by beekeepers observed, the Table 7 presents the summary of the multiple responses of the sample respondents in the field.

Accordingly, in terms of chronology constraints, the bee disease and forage pests (94.8%) emerged as the first problem for beekeepers in the study area. The next in flow of the challenges are shortage of – beekeeping equipment and inadequate skills (92.1%), bee forage (due drought and deforestation) (88.8%), reduction of honey bee colony (81.5%), transport and timely market information (72.4%) and credit and distance of big markets (66.1%) respectively.

OLS estimation results and discussion of results and findings

Prior to the estimation of the model parameters, model diagnostic test was conducted both for multi-collinearity (using tolerance and variance inflation factors (VIFs) and heteroskedasticity (using *Breusch-pagan (Cook-Weisberg))*. The multi-collinearity test indicated none of the VIFs exceed 10 and none of the discrete explanatory variables exceeded the contingency coefficient of 0.75, which is the cutoff point. The *Breusch-pagan (Cook-*

Table 8. Report on OLS estimation results.

Variables	Coefficient	Std. Err.	t-value	P-value
FAMSIZE	0.8584089	0.4590155	1.50	0.137
EDU	3.717537	2.345996	1.58	0.115
EXPR	2.069425	0.2453582	8.43***	0.000
INCOME	0.0001737	0.0000924	1.88*	0.062
NBCOL	5.474616	1.06483	5.14***	0.000
OWMHIVE	2.190288	1.221792	1.79*	0.075
APRTVTY	0.8569744	0.1580971	5.42***	0.000
LAPRICE	0.1501706	0.0457584	3.28***	0.001
DSTNMKT	0.0945377	0.0646567	1.46	0.146
ACEXSE	1.411707	1.665289	0.85	0.398
ACMKTINF	1.738847	1.681008	1.03	0.303
ACCREDIT	2.290224	2.322875	0.99	0.326
CONSTANT	-30.14783	2.924608	-10.31	0.000
F (12, 137) = 229.79	Prob > F = 0.0000		R-squared = 0.9514	

Statistically significance: *** and * at 1 and 10% level respectively.

Weisberg) heteroskedasticity test also no concern, and therefore, it is possible to run a robust regression. Besides, the *Shapiro-swilk* test result showed the normal distribution of residuals implying there was no problem of normality. Thus, study conducted a robust OLS regression analysis using all the 7 continuous and 5 dummy explanatory variables. In total, 12 explanatory variables were assumed to influence volume of honey supply to the market, leading to increase/decline in prices and profits, as well as decrease/increase in honey productivity per hive in the study area. The results in Table 8 show the OLS estimation results.

The significant variables were interpreted below. The OLS results show that experience in beekeeping, annual income, number of bee colonies owned, ownership of modern beehive, output of honey and lagged price of honey were significant in determining the supply of honey to the market. The experience of honey producers was significant. As farmer's experience in beekeeping increased by one year, the amount of honey supplied to market increased by 2.069 kg. Also, annual income also positively affects the volume of honey supplied to market and found to be significant at 10% significance level. The model predicts that as the income of the respondent increased by one birr the volume of honey supplied to market also increased by 0.00017 kg. The model output in this respect predicts that a unit increase in bee colony size results in an increase in volume of marketable supply of honey by 5.47 kg.

DISCUSSION

From the interview results, it is evident that respondents who are illiterate and those above the age of 54 face challenges in accessing information, extension services, modern technologies, and transporting their produce to distant markets. These findings are consistent with existing literature, which suggests that advanced age and low education levels can constrain smallholder farmers from accessing extension services, adopting new technologies, and embracing new farming practices (Gidey and Mekonen, 2010).

Studies indicate that the use of improved modern beehives constitutes the adoption of modern technology, including farm practices and facilities/equipment, and it has a positive impact on both honey production and productivity. The use of modern technology is also related to the experiences of smallholder beekeepers. As indicated in Table 4, 54.4% of producers have beekeeping experience between 2 and 10 years, while 45.6% have more than 10 years of experience. Existing studies by Worku et al. (2011), MoARD and EHBPEA (2010), Kotler and Keller (2012), IPMS (2010), Gidey and Mekonen (2010), CSA (2011, 2012), Awol (2010), and Alemnew (2010) all show that years of experience improve individuals' access to relevant market information, extension services, and enhance their adaptability to risks and shocks, thereby improving individual-level beekeeping activity and productivity. The findings of these studies and policy reports are supported by the interview data obtained from smallholder beekeepers in Northern Ethiopia.

According to Mendoza (1995), a marketing channel is the sequence through which produce passes from farmers (producers) to consumers, including through traders and retailers. The analysis of the marketing channel aims to provide systematic knowledge of the flow of goods and services from their origin (producer) to the final destination (consumer) (Kotler, 2003; Kotler and

Keller, 2012). The study findings mentioned above confirm the honey market channel identified in this study. The OLS estimation results of this study are consistent with the findings of Alemnew (2010) and also support this result. Annual income positively affects the volume of honey supplied to the market and increases household incomes. This finding is also consistent with a study by Woldemichael (2008). The number of bee colonies owned by the producer also affects honey supply to the market. The model output in this study predicts that a unit increase in bee colony size results in an increase in the volume of marketable supply.

A study finding by Kindie (2007) also supports this result, suggesting that an increase in honey productivity is related to the use of technology, farming practices, and equipment. A unit increase in the use of technology, farming practices, and modern equipment (such as modern beehives) leads to higher productivity.

The findings of studies conducted by Worku et al. (2011), Rehima (2006), Kindie (2007), and Bosena (2008) are also consistent with the findings of this study. Accordingly, a one-birr price increase in the honey market implies a rise in yearly honey sales. Also, according to Worku et al. (2011) and Meaza (2010), the determinants of marketable honey supply are significantly and positively linked to the lagged price and volume of supply.

Conclusion

Besides the constraints in honey production and market chains, there are immense opportunities and potential for beekeeping in Ethiopia, including in arid areas of Northern Ethiopia (Skan, 2023). Existing constraints in the sub-sector include limited policy support in land provision, collaboration among development actors supporting this value chain, such as SNV-Netherlands, and extension services. Additionally, support for integrating the sub-sector with sustainable land restoration and water harvesting is almost non-existent. On the other hand, the increase in honey prices and the growing demand for honey are notable. If this sub-sector is modernized, it can enhance the poverty reduction and environmental conservation efforts of the government and incentivize smallholder farmers to practice sustainable agriculture.

There is also an increasing trend of involvement of smallholder honey farmers as business entities (household farm organizations). This trend has the potential to lead to the emergence of the private sector, enhancing the possibility of producing modern beehives, commercial honey production, and increased availability of equipment and facilities, as well as an increase in traders and retailers in the market channel. Such a trend will enhance the maximization of the immense potential of beekeeping and honey marketing in Ethiopia in general, and in specific regions and local economies in particular.

Ethiopia has a rich tradition and culture of beekeeping and honey marketing. The honey production sub-sector is male-dominated. According to the current research, only about 5.7% of honey farmers are females in Northern Ethiopia. This indicates that there is a possibility to scale up the experiences of these female farmers as role models for other regions. Besides, the demand for honey, locally and for export, as well as the increase in price gains, is evident from the results of this study. However, the constraints in honey production and marketing require policy attention.

Honey production is thus a lucrative income-generating economic activity (Skan, 2023), and honey marketing is increasingly becoming a means of income and business opportunities for all actors in the market chain, including smallholder farmers in Northern Ethiopia.

The availability of institutional credit strongly influences the adoption of improved beehives. However, the high cost of improved hives and bee colonies remains a challenge, including their lack of accessibility. Credit is available, but not all smallholder farmers can access it due to high transaction costs. The price and productivity gains of using modern beehives are high. However, most smallholders use traditional beehives due to their poverty, which results from inadequate income and a lack of credit to purchase modern beehives.

The study concluded that the traditional honey production system was not economically profitable, but it is still practiced by a significant number of smallholders in Northern Ethiopia. The traditional honey production system is characterized by a low input-output ratio and is economically inefficient in terms of productivity and profit gains. On the contrary, the modern beehive is more profitable because of the productivity gains and the quality of the honey.

Recommendations

For smallholder beekeepers and honey farmers, in order to increase honey supply in the market, the government and stakeholders working in the areas of apiculture should collaborate and ensure the following:

1. Ensure an adequate supply of modern beehives, tailored extension services, credit, market information, training, technical assistance, and research and innovation support to encourage the sector.
2. Address infrastructure, market information, and channel-related constraints in the supply of honey, especially in a tailored manner that accounts for the regional and climatic contexts of the country.
3. Collaborate on the establishment of beekeepers' associations and cooperatives to enhance the timely flow of market information and increase their negotiating

strength in the market.
4. Work towards enhancing social inclusion, including the participation of female honey farmers, traders, and retailers across the market chain, and ensure that they benefit, including by enforcing guidelines.
5. Provide policy support and incentives to promote the integration of beekeeping, honey farming, land restoration, and water harvesting, ensuring the sustainability of the sub-sector and enhancing its contributions towards the Sustainable Development Goals (SDGs) and the achievement of the respective SDG targets.

Areas of future research

Studies on beekeeping, honey production, and the honey market, as well as the value chain, have mostly focused on specific cases, often at the district or regional level. Although studies at the regional level could serve as a foundation for a holistic national-level study of this sub-sector, currently, there are no reports or policy information available for such a nationwide comprehensive study. Therefore, conducting a nationwide sample study is a potential topic for future research.

Research is also needed to assess the impact of the national greening and tree planting efforts of the country over the last three years. There is an expectation that the billion trees, both edible and non-edible, planted by the green movement will enhance bee forage and contribute to the quality and flavor of honey. Reports from organizations like AGRITECH by the Jerusalem Institute for Policy Research (2020) and FAO, IZSLT, Apimondia, and CAAS (2021) suggest that integrating beekeeping with fruit farming can improve honey quality, provide natural flavors from specific fruits, and enhance pollination, resulting in higher fruit productivity.

Studies conducted by Zocchi et al. (2020), Topal et al. (2021), and Manida (2021) indicate that creating an enabling environment and fostering collaboration and coherence among stakeholders are critical for the apiculture sector. Additionally, an impact study of national-level policies and institutional support for the sector by the government, NGOs, and the private sectors, which are currently fragmented and not coherent, is needed to develop policy information that can promote collaboration and create platforms for organized honey farming in Ethiopia. For example, World Vision Ethiopia has been implementing catchment-based land restoration programs in arid areas of Oromia and Tigray regions, using a field-based approach to build farmers' capacity for biodiversity regeneration while securing their incomes. The impact of incentive-based land restoration, income-generating employment (such as beekeeping, fruit and vegetable production, indigenous tree planting, and water harvesting in ponds), has not been thoroughly studied, especially in the context of linking beekeeping, biodiversity, water resources, and household welfare. Such practices also align with the conceptual foundations of transforming rural smallholder farming towards the practices of the emerging circular rural economy. Studies by Picknoll et al. (2021) and Gebru et al. (2016) highlight the relevance of sustainable apiculture and environmental restoration. In this regard, the arid areas of Northern Ethiopia hold potential for honey farming (beekeeping) as an emerging and important income-generating, land-restoration, and household welfare-improving agricultural activity. Collecting evidence on both best practices and challenges in these arid areas of the Northeast, East, and Southeast regions of the country is also a potential thesis topic for further study. Furthermore, exploring the integration of beekeeping, land restoration, water harvesting, income-generating farm employment, carbon financing, and marketing as part of building the foundations for a rural circular economy could be another area for future research.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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