Hindawi
Advances in Agriculture
Volume 2021, Article ID 2278396, 10 pages
https://doi.org/10.1155/2021/2278396

Research Article

Beekeeping Production System, Challenges, and Opportunities in Selected Districts of South Wollo Zone, Amhara, Ethiopia

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Received 9 April 2021; Accepted 23 September 2021; Published 1 November 2021

Academic Editor: Innocenzo Muzzalupo

The study was conducted in Tehulederie, Kalu, and Dessie Zuria districts of South Wollo Zone, Amhara, Ethiopia, to assess the current beekeeping production system with available opportunities and challenges facing the beekeeping subsector. The districts were purposively selected based on potential and accessibility and then stratified into lowland, midland, and highland. In total, 135 beekeepers, of which 126 were males and 9 were females, were interviewed using a pretested semistructured questionnaire. The result revealed that beekeeping is actively practiced by the community regardless of age and sex. Three beekeeping production systems, that is, traditional, transitional, and movable frame hive, have been identified, accounting for 80%, 4%, and 16%, respectively. More than 80% of total bee colonies are managed being placed in the backyard. Besides, the study indicated that about 79% of the beekeepers keep bees primarily for income generation and home consumption. According to this study, the average bee colony holding size is 5.13 per a beekeeper. Also, this study identified that the swarm catching method is the major source of bee colony accounting for more than 45% to start beekeeping and 76% to increase existing colony number. Bee colony decline, absconding and swarming, honeybee pests and predators, and lack of training and extension were identified as major beekeeping challenges in the study areas. This study identified the beekeeping production system, opportunities, and challenges of the study areas and has significantly contributed to our knowledge and identified lack of extension and training as intervention areas. Therefore, practical beekeeping training and extension should get primary emphasis to combat the existing challenges.

1. Introduction

Beekeeping is important because it directly contributes to the outputs produced such as honey, beeswax, queen, and bee colonies and other products such as pollen, royal jelly, bee venom, and propolis in cosmetics and medicine [1]. Beekeeping plays a role in providing nutrition, economic, and ecological security as bees are valuable pollinators of both agricultural crops and natural ecosystems [2]. The business almost requires less land and less initial capital, does not take much part of the farmers' time, undertaken by the young and old, men and women, and does not compete with other components of farming systems for resources. It can also be a fascinating hobby, a profitable sideline, or a full-time occupation [3].

Beekeeping is an ancient practice in Ethiopian farming communities [4–6]. The country has substantial potential for beekeeping [7], with an immense diversification of melliferous plants [8] and proper ecological and climatic conditions that favor the existence of numerous bee colonies [9] and honeybee subspecies [10]. Beekeeping can significantly contribute to beekeeper's livelihoods and the country's economy [11]. At different levels, a significant number of people are engaged in trading honey and beeswax and selling local honey wines "Tej". This creates job and self-employment opportunities for a large number of citizens [12]. In Ethiopia, about 1.9 million farm households are involved in beekeeping, and there are about 10 million colonies out of which about 5.92 million are hived [9] and it is estimated that the country has the potential to produce 500,000 tons of honey and 50,000

tons of beeswax per annum [13]. Recent production is estimated at 50,790 tons of honey in 2015/6 CSA [9] and about 5,344 tons of beeswax in 2013 [14].

South Wollo is one of the major potential zones of the Amhara region, endowed with diversified honeybee flora, 186,977 beehives, which accounts for 14.08% of the regional share, of which 183,090 beehives (97.92%) are traditionally made from bamboo, mud, cow dung, and ash mixture [9]. About 1,137,859 kg of honey was produced in 2014/5 with an average productivity of 7.10 kg/hive/annum [15]. However, little research has been conducted on beekeeping production systems and existing challenges and opportunities in the South Wollo zone. Therefore, this study was designed to deliver valuable information on the current beekeeping production system, major challenges of the sector, and the available opportunities in selected districts of South Wollo zone, Amhara region, Ethiopia.

2. Materials and Methods

2.1. Description of the Study Areas. The study was conducted in three districts (Tehulederie, Kalu, and Dessie Zuria) of the South Wollo zone, considering variations in agroecology (mid, low, and highlands). South Wollo zone is one of the 11 zones of the Amhara region, having an area of 17,067.45 km^2, located 10.200–11.71 N and 38.410–40.02 E North of Ethiopia, whose main capital is Dessie, 401 km from Addis Ababa. The area has a long-term mean (1162 mm) rainfall per annum with monthly minimum and maximum temperatures of 12.6 °C and 26.4 °C, respectively.

2.2. Sampling Techniques. A purposive sampling procedure was applied for the study districts according to the beekeeping potential, accessibility, and proximity to honey and beeswax marketing and processing routes. From each district, three kebeles (the lower level of administration in Ethiopia) were selected purposively. From each kebele, 15 beekeepers were randomly selected using a systematic random sampling technique. In total, 135 beekeepers were interviewed using a semistructured questionnaire.

2.3. Method of Data Collection. The study used both primary and secondary sources of data on the beekeeping production system, opportunities, and major challenges of the selected potential areas. Primary data were collected on socioeconomic characteristics (household characteristics, educational status, landholding, and bee colony), beekeeping situation (beekeeping experience, source of bee colony, reasons of engagement in beekeeping, honeybee colony holding size, placement of bee colony, and types of hives), major challenges (colony decline, absconding and swarming, honeybee pests and predators, and training and extension service), and available opportunities. Secondary data were used to select potential localities based on the number of honeybee colonies and honey production considering the three agroecologies acquired from Zonal and district agricultural offices.

2.4. Data Management and Statistical Analysis. All collected data were entered into Microsoft Excel 2007, and descriptive statistics such as percentage, frequency, mean, and standard deviation were used to analyze the data using Statistical Package for Social Science (SPSS) software version 20. Any items that cannot be captured through a quantitative analysis were analyzed qualitatively based upon interviews and group discussion with beekeepers and extension workers.

3. Results and Discussions

3.1. Household Characteristics. Of 135 sample beekeepers interviewed, 93.3% were male-headed and 6.7% were female-headed (Table 1). The very limited number of female participation in beekeeping in the study areas might be due to beekeeping is considered as the work of men [16]. Also, as reported in [17–20], women might not be economically empowered through beekeeping. There is also a report indicating a cultural barrier to women to undertake honey harvesting [1]. Of the total beekeepers interviewed, 92.6% are married, while 3.7%, 3%, and 0.7% are widowed, single, and divorced, respectively (Table 1). Similar results have reported that the majority of beekeepers are married [4, 21–23].

This study found the mean age of respondents to be 43.6 ± 1.2 years, with a range of 20 to 73 years. The majority (91.1%) of respondents were found in economically active age groups of 20–60 years (Table 1), suggesting high potential labor availability for beekeeping (Table 1). Similarly, [22, 24, 25] reported a mean age of 44, 45.05 ± 10.45 and 45.02 ± 13.3 years, respectively, engaged in beekeeping practices in Ethiopia. Age and experience have great implications on identifying local honeybees and their products and behaviors [21]. The family size of the interviewed beekeepers ranges from 1 to 13 with a mean of 5.2, and the majority of the respondents (80.7%) had a family size of >4 (Table 1). Similarly, [26] identified an average family size of beekeepers to be 5.4 ranging from 1 to 10. Large family sizes have a better chance for labor shares in farm activities and hence for beekeeping activities too [26, 27].

3.2. Educational Status of Respondents. The educational level of the beekeepers can have a significant impact in identifying and determining the type of development and extension services that need to be designed for the area [28] and significantly affect the probability of adoption [29]. According to this study, about 29.6% of beekeepers have no educational background, while 31.1% of the respondents received informal education that can only help them to read and write. On the other hand, about 39.3% have formal education with different levels ranging from primary school to secondary school level (Table 2). Therefore, according to this study, the high level of education significantly influenced the effectiveness of improved beekeeping adoption. To this fact, the sample beekeepers with grades 9 to 12 have significantly ($P < 0.05$) higher bee colony holding (11.0) than the beekeepers with lower grade and illiterates (Table 2).

Table 1: Characteristics of the sample beekeeper respondents by districts.

Beekeepers characteristics	Variable	Districts (frequency and percentage)							
		Tehulederie		Kalu		Dessie Zuria		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Sex of beekeeper	Male	39	86.66	43	95.56	44	97.78	126	93.33^{NS}
	Female	6	13.34	2	4.44	1	2.22	9	6.67^{NS}
	Total	45	100	45	100	45	100	135	100
Marital status	Single	2	4.44	1	2.22	1	2.22	4	2.96^{NS}
	Married	39	86.66	43	95.56	43	95.56	125	92.59^{NS}
	Widowed	3	6.66	1	2.22	1	2.22	5	3.7^{NS}
	Divorced	1	2.22	0	0	0	0	1	0.74^{NS}
	Total	45	100	45	100	45	100	135	100
Age of beekeepers	Mean ± SD	44.62 ± 13	44.02 ± 9.8	42.11 ± 13	43.59 ± 12^{NS}				
	Range (min-max)	25–73	20–70	23–72	20–73				
	20–40	22	33.85	18	27.69	25	38.46	65	48.15
	41–60	18	31.03	26	44.83	14	24.14	58	42.96
	61 and above	6	50	1	8.33	5	41.67	12	8.89
Family size	Male	2.44 ± 1.2^{b}		3.02 ± 1.54^{a}		2.18 ± 0.96^{b}		2.55 ± 1.297	
	Female	2.58 ± 1.31		2.76 ± 1.61		2.62 ± 1.11		2.65 ± 1.35^{NS}	
	Total	5.02 ± 2.05^{ab}		5.78 ± 2.38^{a}		4.8 ± 1.56^{b}		5.20 ± 2.055	

NS: the mean difference is not significant at 0.05 level; SD: standard deviation; letters in a row with different superscripts denote significant differences at $p < 0.05$.

Table 2: Educational status and mean bee colony holding of the interviewed beekeepers.

Educational status	Respondents		Bee colony holding
	Frequency	Percentage	Mean
Illiterate	40	29.6	4.625^{b}
Basic (read and write)	42	31.1	5.095^{b}
Grades 1–4	22	16.3	4.455^{b}
Grades 5–8	26	19.3	5.423^{b}
Grades 9–12	5	3.7	11.000^{a}
Total	135	100	5.13

Letters in a column with different superscripts denote significant differences at $p < 0.05$.

3.3. Beekeeping Experience of Respondents. The level of beekeepers experience is the number of years that an individual is continuously involved in beekeeping after he/she owns a colony. Differences in beekeeping experience might be responsible to influence the attitude and adoption of new beekeeping technologies [30]. According to this study, 31.85% of the beekeepers have more than 15 years of beekeeping exercises in beekeeping (Table 3). This result agrees with the findings of [22] who reported a considerable proportion (41.1%) of the beekeepers in South Wollo and Wag Himra zones with more than 15 years of experience in beekeeping and [17] 16.5 years for Sekota district beekeepers. Those beekeepers with less than five years of experience accounted only for 23.70% of the total respondents (Table 3). This result was in line with the results of Kebede et al. [23] and Alemu [22]. According to the survey result, as beekeepers acquire the experience, they keep a higher colony number and gain enhanced honey production than the less experienced ones (Table 3).

Table 3: Beekeeping experience of respondents.

Beekeeping experience	Frequency	Percent	Mean colony holding
1–5 years	32	23.70	3.79
5–10 years	34	25.19	6.03
10–15 years	26	19.26	4.50
More than 15 years	43	31.85	4.96

3.4. Source of Bee Colony. The majority (45.2%) of the respondents in the study areas get their starter bee colony from swarm catching (Figure 1), and this agrees with the findings of Alemu [22] and Kebede and Tadesse [19], who reported that 50.3% and 60.3% of the respondents at South Wollo and Wag Himra zone and Hadya zone, respectively. Swarm catching includes the natural swarm from own colonies, bypass bee colony swam baits, and feral bee colonies in the forests. According to this study, the beekeepers prefer and practice swarm catching as major means of obtaining bee colonies since it is cost-free, convenient to keep in traditional beehives, and lacks know-how about artificial means of queen rearing techniques. On the other hand, 17% of the respondents buy colonies and 17% of the respondents get colonies from parents as a gift or inheritance (Figure 1). Newly engaged beekeepers that get their starter colony from their parents have more experience than those started from training or by their motivation, and this might be due to the accumulated experience while assisting their parents [23].

According to this study, more than 94% of the respondents agree that bee colony selling is practiced in the study areas with an average current price of 936.22 ETB. The price of an established traditional colony differs from kebele to kebele or farmer to farmer according to bee colony strength and bargaining power ranging from 300 to 1500

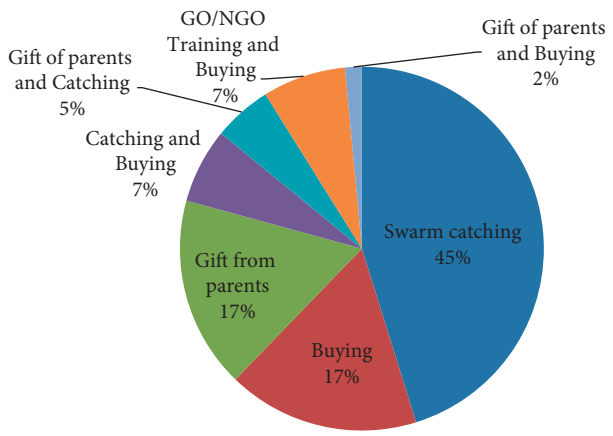

Figure 1: Source of starter bee colony in the study areas.

ETB. The study indicated that there is an increasing trend of bee colony price from time to time due to the increasing demand of bee colony and the decreasing trend of a bee colony in the study areas (Table 4). To increase their bee colony, the majority (75.6%) of the respondent beekeepers acquire through catching swarm bees and the rest through buying, splitting, overcrowding, and/or the combination of them (Figure 2).

3.5. Reasons of Engagement in Beekeeping. According to the study result, 52.99% and 30.60% of the respondents keep bees primarily for income generation and home consumption, respectively, whereas 69.77% of the respondents rank home consumption as a secondary preference (Table 5). This result is in line with [22], which investigated 94.8% of the beekeepers produce attractive comb honey for both sale and home consumption at South Wollo and Wag Himra zone. However, [24] reported 59.4% of the beekeepers in the Tigray region keep their bee colonies for selling honeybee colony as honeybee colony marketing in the region is common at central market places and individual apiaries (Table 5).

3.6. Honeybee Colony Holdings. The average honeybee colony holding of the sample respondents is 5.1 (Table 6), demonstrating that the area is suitable for beekeeping development. More specifically, beekeepers own on average more traditional hives (4.1) than moveable frame hives (0.8) and top bar hive (0.2) (Table 6). Accordingly, out of 693 bee colonies in the study area, 79.94%, 4.04%, and 16.02% of the honeybee colonies were hived in traditional, transitional, and frame hives, respectively (Table 6). The product volume and quality of the product are low for traditional hives [4, 31]. However, beekeepers preferred traditional hives for their low input price and operation cost [31], availability [23], convenience to construct, more quantity of wax produced and less dependency on external inputs, and convenience to be used as a bait hive [4].

The majority (76.30%) of the farmers who participated in the study have a colony number below six (Figure 3), suggesting smallholder beekeeping system is prevailing in

Table 4: Reasons of colony decline.

Reason for colony decline	Frequency	%	Order of importance
Chemical application	85	62.96	1
Lack of management	63	47.41	2
Predators	62	45.93	3
Pests	39	28.89	4
Drought	31	22.96	5
Absconding	22	16.30	6
Swarming	19	14.07	7
Unknown reason	17	13.33	8
Lack of bee forages	14	10.37	9
Lack of water	9	6.67	10
Others (theft, climate change)	4	2.96	11
Diseases	0	0.00	

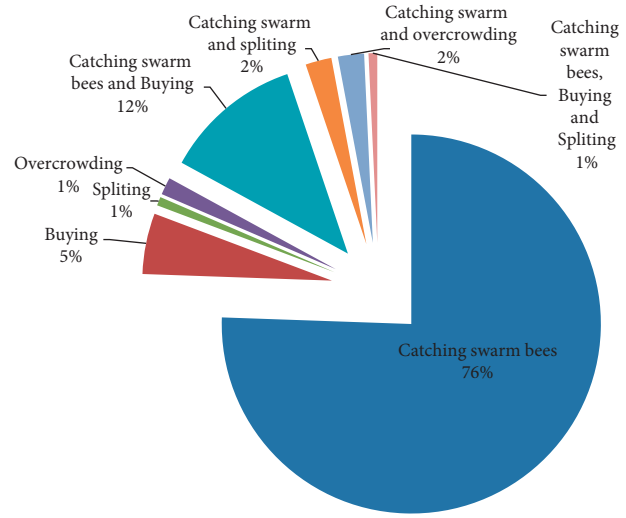

Figure 2: Methods of increasing bee colony in the study areas.

the study areas. The result was very comparable with the results from Kilte Awlaelo, Sekota, and Burie districts that are reported as 5.79, 5.9, and 6.48 colonies per beekeeper, respectively [4, 17, 32].

3.7. Beehive Placement. In the study areas, 80.38% of the total colony and 73.88% of traditional colonies are placed at backyards indicating that backyard beekeeping is a common practice of honey production in the study areas, and this agrees with the findings of [19, 22, 33] that establish more proportion of beekeeping at backyards. Backyards are easier for frequent inspection and other hive managements (including swarm prevention, pest and predator control, and quality honey production) compared with free apiaries [20]. The share of traditional colonies kept at the backyard is higher in Tehulederie 86.03% than Kalu (69.76%) and Dessie Zuria (69.55%). There is no single beekeeper that puts his beehives inside the house and hangs on trees in forests (Table 7). Reference [22] also confirmed that all the traditional beehives from the South Wollo zone and Wag-Khimra Zone are kept at the backyard and under the eaves of the house.

Table 5: Rank index for reasons of engaging in beekeeping.

Reason	Priority frequency (%)			Total	Index value	Overall rank
	1st	2nd	3rd			
Income	71(52.99)	2(4.65)	—	73(39.89)	0.44	1
Home consumption	41(30.60)	30(69.77)	—	71(38.80)	0.37	2
Hobby	14(10.45)	8(18.60)	6(100)	28(15.30)	0.13	3
Others (training)	8(5.97)	3(6.98)	—	11(6.01)	0.06	4
Total	134	43	6	283	1	

Index = sum of (3*ranked 1st + 2* ranked 2nd + 1* ranked 3rd) for individual reason divided by the sum of (3*ranked 1st + 2* ranked 2nd + 1* ranked 3rd) for over all reasons.

Table 6: Honeybee colony holdings and share of colony holding.

Parameters	Hive type	Tehulederie		Kalu		Dessie Zuria		Overall	
		Total	Mean ± SD	Total	Mean ± SD	Total	Mean ± SD	Total	Mean ± SD
Number of beehives	Traditional	159	3.53 ± 1.92	203	4.51 ± 5.51	192	4.27 ± 6.79	554	4.10 ± 2.60^{NS}
	Transitional	2	0.04 ± 1.95	5	0.11 ± 2.83	21	0.47 ± 2.86	28	0.21 ± 1.82^{NS}
	Frame	18	0.40 ± 0.21	40	0.89 ± 0.38	53	1.18 ± 3.13	111	0.81 ± 4.13^{NS}
	Total	179	3.98 ± 1.92	248	5.51 ± 5.51	266	5.91 ± 6.79	693	5.13 ± 5.20^{NS}
Share of colony holding	Hive type	Tehulederie		Kalu		Dessie Zuria		Over all	
		Total	%	Total	%	Total	%	Total	%
	Traditional	159	88.83	203	81.85	192	72.18	554	79.94
	Transitional	2	1.12	5	2.02	21	7.89	28	4.04
	Frame	18	10.06	40	16.13	53	19.92	111	16.02
	Total hives	179	100	248	100	266	100	693	100

SD: standard deviation; NS: the mean difference is not significant at 0.05 level; traditional: hives made of locally available materials like bamboo and tree branches and coated by mud and ash; transitional: Kenyan TBH; frame: Langstroth frame hives.

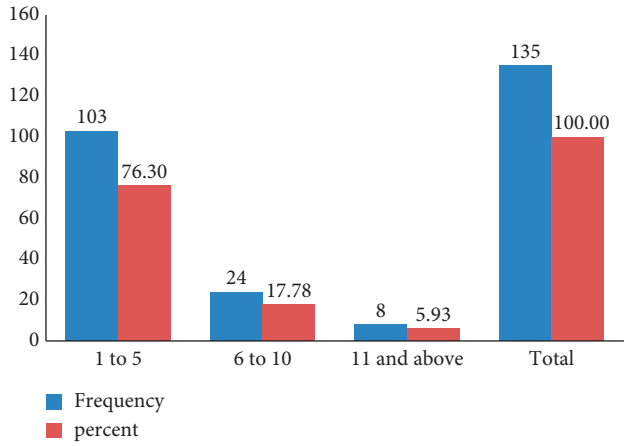

Figure 3: Frequency and percentage of bee colony ownership in the study areas.

3.8. Honeybee Colony Decline. Despite the potential of the study areas for beekeeping, in recent years, there has been a decreasing trend of honeybee colony populations. According to this study, 96.3% of the respondents agreed on the decreasing trend of bee colonies due to different threatening factors on bees and their products. Based on this fact, 60.74%, 46.67%, 45.93%, 27.41%, and 22.22% of the respondents put pesticide and herbicide application on crops, lack of management, predators, pests, and drought, respectively, as major reasons for the colony decline in the study areas. No honeybee disease was reported as a threatening factor for colony decline in the study areas (Table 4), and this might not reflect the absence of bee disease in the study area but might reflect lack of close observation and/or lack of skill in identifying pathogens among beekeepers. Owing to multiple factors, Alemu [22]; Kebede et al. [23]; Belie [4]; and Alemu [5] have reported bee colony decline trend in Wag Himra and South Wollo zones, Amhara Region, Bure, and Sekota, respectively.

Unwise application of agrochemicals was the major issue reported by beekeepers and accounted for 62.96% of the factors (Table 4) that caused the significant effect on bee colony decline in the study areas [22], and its damage has been acknowledged at regional and country levels [34]. According to this study, the intensity of chemical application is higher in Kalu district in the irrigable areas in July to November to control and/or treat animal and crop pests and diseases. The chemical application time in the study areas is set by Knapsack sprayer owners or renters as also reported by [34]. A threat from wider agrochemical brands application is a challenge from nonbeekeepers [34]. It has been also reported that more than 82.4% of the respondent beekeepers in the South Wollo and Wag Himra zone [22] and 54% in Mecha, Dangla, and Guangua districts [34] are using agrochemicals in their localities.

3.9. Absconding. Honeybee colonies abandon their hive at any season of the year for different reasons [35]. Absconding is a common phenomenon, especially in the case of ill management as a response to disturbance [36]. This study revealed that absconding is very serious and 98.52% of the respondents in the study areas agreed on the prevalence of

Table 7: Placement of beehives in the study areas.

Placement of hives	Hive type	Districts							
		Tehulederie		Kalu		Dessie Zuria		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Backyard	Traditional	154	86.03	173	69.76	185	69.55	512	73.88
	Transitional	2	1.12	2	0.81	0	0.00	4	0.58
	Frame	18	10.06	16	6.45	7	2.63	41	5.92
Apiary site	Traditional	0	0.00	22	8.87	4	1.50	26	3.75
	Transitional	0	0.00	3	1.21	21	7.89	24	3.46
	Frame	0	0.00	23	9.27	45	16.92	68	9.81
Under the eaves of the house	Traditional	5	2.79	7	2.82	3	1.13	15	2.16
	Transitional	0	0.00	0	0.00	0	0.00	0	0.00
	Frame	0	0.00	0	0.00	1	0.38	1	0.14
Inside the house	Traditional	0	0.00	0	0.00	0	0.00	0	0.00
	Transitional	0	0.00	0	0.00	0	0.00	0	0.00
	Frame	0	0.00	0	0.00	0	0.00	0	0.00
Hanging on trees near homestead	Traditional	0	0.00	1	0.40	0	0.00	1	0.14
	Transitional	0	0.00	0	0.00	0	0.00	0	0.00
	Frame	0	0.00	1	0.40	0	0.00	1	0.14
Hanging on trees in forests	Traditional	0	0.00	0	0.00	0	0.00	0	0.00
	Transitional	0	0.00	0	0.00	0	0.00	0	0.00
	Frame	0	0.00	0	0.00	0	0.00	0	0.00
Total	179		248		266		693		

bee colony absconding in their site/locality. Attacks from pest, drought, and management problems are taking the share of 29%, 17.9%, and 15%, respectively. It is also reported that 20% of the respondent beekeepers do not know the reason for absconding (Table 8). Pest attack, mainly wax moth, is prominently a serious problem triggering bee colony to abscond. This study showed that bee colony absconding prevails during the dearth period especially from April to June, and this agrees with the result of [22] as prolonged dearth periods cause bee forage scarcity. The mean number of bee colony absconded in the sample respondents was 2.23 per beekeeper within the last three years (Table 8). This figure agrees with the result of [4], which reported 2.6 mean bee colonies absconded per beekeeper at the Burie district.

From the total of absconded colonies, 81.2% were from traditional hives due to the reasons of inconveniency for management and being easily attacked by pests (Table 8). The absconded bees from frame hives were only 9%, and this might be due to skill development made on frame hives concerning its seasonal management and pest control to minimize absconding. Beekeepers within the study area tried to regulate absconding through frequent inspection (21.80%), feeding and watering (17.59%), pest control (11.09%), cleaning sites (10.90%), and other options. Also, 19.5% of respondent beekeepers are not applying any options to control the absconding of bee colonies (Table 8).

3.10. Reproductive Swarming. Reproductive swarming is the natural way in which honeybee colonies reproduce. That means some workers move from the colony with virgin or mated queens to a new place and cooperate to build their new nest. Swarming behavior gives an extension to the life of honeybee colonies where the mother colony can live for a long time and multiple swarms can result from it [37]. In this study, 93.3% of the respondents appreciated the existence of swarming (Table 9). Although there exists a small portion of swarming in frame hives (5.56%), the most frequent swarming was observed in traditional hives (91.27%). This might be due to the small size of traditional beehives that induce overcrowding so that the bee colonies are forced to issue swarm. The effect of temperature and the quality of the traditional beehives from which it is constructed are listed to have an impact (Table 9). In contrast to absconding, swarming is more prominent from September to October, and this is in line with [38] that established swarming is frequent in September and in April in the Supé and Bonga of southern Ethiopia, respectively.

According to the discussion, beekeepers kill the successive swarms after catching the first one to three strong swarms. This may be because the construction of a new nest with wax requires a sufficient amount of food and a larger number of bees [37]. According to this study, if conditions are favorable, the frequency of swarming is every year (70%) and once in two years (15.4%) (Table 9).

3.11. Swarm Control. Swarm control is important to minimize the risk of honeybee colony working force loss. Beekeepers in the study areas use different means of bee colony swarm control so that the issued swarm bee colonies remain under their control. Queen cell removal before the queen hatch out (25.8%), reuniting swarm back to mother colony by killing the queen (20.3%), and honey comb harvest (19.4%) (Table 10) are among techniques practiced by the beekeeper to control the swarm. This result agrees with Belie's [4] result that established that about, 85.80% of the

Table 8: Absconding of honeybee colonies in the study areas.

	Hive types	Freq.	%
Type of hives absconded	Traditional	108	81.20
	Transitional	0	0.00
	Frame	12	9.02
	All types	13	9.77
Reason of absconding	Response	%	Rank
Pest attacks (wax moth, ants)	178	28.99	1
Unknown reason	123	20.03	2
Drought	110	17.92	3
Management problem	92	14.98	4
Chemical application	26	4.23	5
Feed shortage	24	3.91	6
Traditional belief (not inspecting at full moon set)	24	3.91	7
Absence of forage	16	2.61	8
Water shortage	12	1.95	9
Predators	9	1.47	10
Control measure of absconding	Response	%	Rank
Frequent inspection	114	21.80	1
No control	102	19.50	2
Feeding and watering	92	17.59	3
Pest control	58	11.09	4
Cleaning site	57	10.90	5
Cut old combs	24	4.59	6
Ash dusting	21	4.02	7
Intensive management	18	3.44	8
Timing of inspection (traditional belief)	16	3.06	9
Smoking	10	1.91	10
Leave honey on harvest	6	1.15	11
Plastering hive with cow dung	5	0.96	12

Table 9: Beekeepers response to reproductive swarming of honeybees in the study areas.

Parameter	Response	Frequency	Percent	Cumulative (%)
Is there swarming?	No	9	6.7	6.7
	Yes	126	93.3	100.0
From which type of hive?	Traditional	115	91.27	91.27
	Frame	7	5.56	96.83
	All	4	3.17	100.00
Frequency of swarming	Every year	91	70.00	70.00
	Once in two years	20	15.38	85.38
	Not known	9	6.92	92.31
	Every three years	4	3.08	95.38
	Two to three years	2	1.54	96.92
	Two to four years	2	1.54	98.46
	Four or five years	1	0.77	99.23
	Three to five years	1	0.77	100.00

sample respondents have experience of catching incidental swarms that can be transferred to other hives (70.3%), return to the original hive (34.2%), and offer for selling (4.4%).

3.12. Honeybee Pests and Predators. The beekeeping production system of the study areas reported to face a multitude of challenges and pests and predators are recognized as major ones. Pests endanger honeybee life and their product and lead the colonies to abscond or die (Table 9). Many research findings also confirmed pests and predators as major threatening factors for honeybees and beekeeping business [6, 22, 25, 39]. The results from this survey study have identified birds, ants, wax moths (*Galleria mellonella*), lizards, honey badgers (*Mellivora capensis*), spiders, wasps, beetles, bee lice (*Braula coeca*), and termites as the major honeybee pests and predators in order of their decreasing importance (Table 11).

Also, the cross-sectional studies conducted at South Wollo zone and Wag Himra zone have identified ants, wax moths, bee-eating birds, varroa mites, wasps, lizards, spiders, bee lice, death head hawks moth, and honey badger as major pests and predators in order of importance [22]. A similar study conducted in the selected district of the Tigray region recognized ants, birds, spiders, mites, wax moths, beetle, bee mice, honey badger, cat worm, and lizards as major

Table 10: Method of swarm control.

Parameter	Response	Frequency	Percent	Rank
Method of swarm control	Removal of queen cells	84	25.85	1
	Harvest honey comb	63	19.38	3
	Return back to mother colony	66	20.31	2
	Supering	20	6.15	6
	Use large volume hive	27	8.31	5
	Smoking the hive with *Boswellia papyrifera*	40	12.31	4
	Cut brood combs	4	1.23	9
	Cut old combs	4	1.23	9
	Regular inspection	6	1.85	7
	Attach queen excluder at entrance	2	0.62	11
	Smoking with camel dung	2	0.62	11
	Smoking with mule bone	5	1.54	8
	Smoking with bamboo root	1	0.31	13
	Smoking with *Hayginia abissinica* flower	1	0.31	13

Table 11: Honeybee pests and predators of in the study areas.

Honeybee pest and predators	Relative degree of importance							Score	Index	Rank
	1st	2nd	3rd	4th	5th	6th	7th			
Birds	40	54	22	7	—	—	—	742	0.260	1
Ants	53	19	31	11	2	—	—	690	0.242	2
Wax moth	13	20	24	14	4	5	—	409	0.144	3
Lizard	13	21	15	17	5	2	1	380	0.133	4
Honey badger	7	6	12	20	4	3	—	243	0.085	5
Spiders	—	6	13	5	8	2	3	152	0.053	6
Wasps	3	5	7	—	5	1	2	105	0.037	7
Beetles	—	1	4	9	6	1	—	82	0.029	8
Bee lice	—	2	3	—	3	—	1	37	0.013	9
Termite	—	1	—	1	—	—	—	10	0.004	10

Index = sum of (7*ranked 1st + 6* ranked 2nd + 5* ranked 3rd + 4* ranked 4th + 3* ranked 5th + 2* ranked 6th + 1* ranked 7th) for individual reasons divided by the sum of (7*ranked 1st + 6* ranked 2nd + 5* ranked 3rd + 4* ranked 4th + 3* ranked 5th + 2* ranked 6th + 1* ranked 7th) for over all reasons.

Table 12: Beekeeping extension and training in the study areas.

Parameters	Variable	Frequency	Response (%)
Did you get beekeeping extension service?	Yes	24	17.78
	No	111	82.22
Do you take beekeeping training?	Yes	52	38.52
	No	83	61.48

honeybee pests and predators [24, 40]. Likewise, in the Amhara region [23], ants, wax moths, bee-eater birds, spiders, bee lice, honey badger, termite, small hive beetles, and snake were the most harmful pests in order of importance. Moreover, [39] also identified ants, honey badgers, beetles, birds, wax moths, spiders, mites, lizards, bee lice, and toads as the most threatening pests and predators in Sidama and Gedeo zones of Southern Ethiopia.

3.13. Extension and Training. Extension and training packages are crucial for the government sectors for improved technology interventions as well as policy and regulations disseminations. Beekeeping training develops the beekeepers' self-confidence in using technology and increases the productivity of the beekeepers. According to this study, only 17.8% of the beekeepers received beekeeping extension service on improved beekeeping technologies from the district development agents. However, the majority of the respondents (82.2%) did not get any beekeeping extension service (Table 12). This result is in line with the result of [23] who reported that only 33.2% of the sample respondents had the chance of getting extension service delivery in the Amhara region. Lower beekeeping extension services influence the adoption of improved beekeeping technologies [41]. The extension services delivered to the study area beekeepers were just provision of inputs like smokers, frame beehives, beeswax, honey extractor, casting mold, beekeepers suit, starter colony, and money along with training on basic seasonal bee management and honey harvesting. Besides, newly engaged farmers are encouraged to buy frame beehives after training.

4. Conclusions and Recommendations

Beekeepers in South Wollo keep bees primarily to generate income and also partly use bee products for home consumption. Beekeeping in the area is largely practiced by men and the involvement of women is culturally impaired. Beekeepers within the ranges of active age groups (20–60 years) are largely involved in beekeeping practices. Although most of the beekeepers have 15 and more years of beekeeping experience, still traditional beekeeping is prevailing and the bee colony holding of an individual is small. Due to a lack of improved skills and knowledge on artificial queen rearing, still, bee colony swarm catch by hanging bait hives on long trees is a major means of colony obtaining. Unwise use of agrochemicals, seasonal shortage of bee forage, bee pests and undesirable characteristics of the bees (absconding, swarming), and lack of adequate and appropriate extension services are identified as major challenges of beekeeping development in the areas. Great emphasis should be given to training and extension programs for the beekeepers focusing on the practical aspects of general beekeeping and more specifically on honeybee management, pest and predator prevention, and/or control methods.

This study identified beekeeping production, challenges, and opportunities in the South Wollo zone. Furthermore, the study generated more quantitative data that can fill the information gap on the general aspects of beekeeping in the study areas and boldly showed intervention areas to the policymakers and development practitioners.

Data Availability

The data that support the findings of this study are available from the corresponding author, Bihonegn, upon reasonable request.

Disclosure

This manuscript is part of the thesis work entitled "Assessment of Beeswax Production, Quality and Market Chains in Selected Districts of South Wollo Zone, Amhara Region, Ethiopia."

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors would like to thank all study areas' District Office of Agriculture and their respective experts for facilitating and providing all necessary information. Besides, the authors would like to thank the Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) project for its financial support. Finally, the authors would like to express gratitude to Sekota Dryland Agricultural Research Center and its staff for their assistance to conduct this study. The authors also would like to thank CGIAR, https://cgspace.cgiar.org/, for uploading the thesis.

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