Improved beekeeping technology in Southwestern Ethiopia: Focus on beekeepers’ perception, adoption rate, and adoption determinants

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Abstract: Beekeeping is one of the most important sectors that contribute to the improvement of the livelihoods of people in many countries. A cross-sectional study was carried out in southwestern Ethiopia to determine the adoption rate, determinate factors, and community perception of improved beekeeping technologies. A multistage random sampling method was conducted to select study districts. A total of 180 beekeepers were interviewed for this study with a proportional random sampling method from adopters and non-adopters of technologies. From a total of 180 beekeepers, 61 (33.9%) and 119 (66.1%) were adopters and non-adopters, respectively. The majority of respondents stated that high yield, ease for inspection, and quality of honey are the main advantages, while high cost, the need for high skill, and access to technology are the major detriments to the adoption of...
improved beekeeping technology. Multivariable logistic regression analysis identified age (OR = 1.3), an education level (OR = 13.3), awareness of technology (OR = 7.3), visited demonstration site (OR = 21.2), participated in field day (OR = 26.8), marketing problem (OR = 6.2) and access to credit (OR = 4.2) as the determinant factors (P < 0.05) for improved beekeeping technology. Diseases and pests of the honeybee, lack of beekeeping equipment, and credit were the major constraints of improved beekeeping technology that lead bee colony to abscond and reduce honey yield. Hence, it is important to design appropriate control methods for honeybee diseases and pests. Moreover, the beekeepers should get access to beekeeping materials and credit service, and adequate training should be provided to them. Further investigation should be conducted on factors influencing the use of improved beekeeping technology.

**Subjects:** Agriculture; Agriculture and Food; Entomology

**Keywords:** beekeeping; bee hives; honeybee; technology adoption

1. **Introduction**

Beekeeping is one of the most important livestock subsectors that contribute to the improvement of the livelihoods of people in many countries (FAO, 2012). It is also one of the major areas of intervention for poverty alleviation in many developing countries (Amulen et al., 2019). Beekeeping is providing nutritional, income-generating, and ecological security to rural communities at the household level. It also assists to increase crop production through honeybee pollination (Amulen et al., 2019; Tarekegn et al., 2017). Beekeeping is likely to be the most profitable when improved beekeeping technology is used with its full packages (Berhe et al., 2016). However, the traditional beekeeping system which results in low production, poor quality, and marketing efforts has kept beekeeping part of the subsistence sector (Meaza, 2010).

Ethiopia has a potential for beekeeping as the climate is suitable for different vegetation and crops, which are a good source of nectar and pollen for honeybees (Chala et al., 2013; Teklu, 2016). This makes it conducive for the beekeeping business (Adgaba et al., 2001). Although the country has the potential of producing over 500,000 tons of honey per year, the annual production of honey and beeswax is low compared to its potential (Birhan et al., 2015). This is due to the reason that more than 95% of Ethiopian beekeepers use traditional hive management practices that affect yield and quality (CSA, 2017; Gobena, 2017). The traditional production system poses many challenges that reduce the production and productivity of the subsector (Kalayu et al., 2018). Among these, poor management skills, shortage of honeybee forages, disease, and pests are the major ones (Chala et al., 2013; Fikru, 2015). So far efforts have been made to tackle this problem such as modification and dissemination of beekeeping technology that increases production and productivity and maximizes benefit from beekeeping in line with sustainable natural resource conservation (Adgaba et al., 2014). The annual crude honey yield per traditional beehive is 5–7 kg. It is very low in quantity and quality as compared to the national average of ለቁቓቂaka hives and improved box hives, which are 15 kg and 20–30 kg, respectively (Sebho, 2015). Employing improved beekeeping technology with its full packages enables the beekeeper to produce surplus honey (Teklu, 2017).

Different sectors have been striving to disseminate and scale up this technology to improve honey production in Ethiopia (Gebiso, 2015). Despite all these efforts, there has been limited information about factors that influence the adoption of beekeeping technology in the country. Beekeepers have not been able to benefit fully from the technological innovations because of different factors hindering the adoption of beekeeping technology (Berhanu, 2002) and it is difficult to develop a hypothesis that holds true everywhere because of socioeconomic and ecological distinctiveness of the different sites and dynamic nature of most of the determinants (Ehui et al.,
Hence, determining factors that influence the adoption of technology is essential for policy makers, researchers and development practitioners to suitably modifying the approach or technology to improve its uptake by end-users (Adgaba et al., 2014).

Southwestern Ethiopia has the potential for beekeeping. This area is endowed with natural tropical rain forests with suitable climates that favor high honeybee population density and forest beekeeping is widely practiced (Adgaba, 2007; Shenkute et al., 2012). A large volume of honey is produced from these areas annually (CSA, 2017). In this area the majority of households keep honeybees as a source of income from honey sell and beekeeping is an integral part of the farming communities of the area (Adgaba, 2007). There have been efforts by different organizations to increase honey production using improved beekeeping in the areas. Some of the technologies are transitional beehive, modern beehive, honey presser, honey extractor, veil, management of honeybee pests, and improved bee forages (Tarekegn et al., 2018). Despite efforts made to introduce improved beekeeping technology in the area, there are not many adapters of these technologies (Shenkute et al., 2012). Even though improved beekeeping technology has been introduced in this area, honey production is still traditional which is practiced mainly by hanging traditional hives on tall trees in the dense forest (Tarekegn et al., 2018). Nevertheless, the utilization of improved beekeeping technology is influenced by different factors. Hence, the objective of this study was to assess community perception of improved beekeeping technology and to determine the adoption rate, identify determinant factors of improved technology.

2. Materials and methods

2.1. Study areas
The study was conducted in the Bench-Sheko and Sheka zones of southwestern Ethiopia (Figure 1). Bench-Sheko and Sheka zone are located in the southwest of Addis Ababa, the capital city of Ethiopia at 561 and 694 km, respectively. The altitude of Bench-Sheko ranges from 850 to 3000 m. a.s.l. and that of Sheka is 1200 to 3000 m.a.s.l. The annual average temperature of Bench-Sheko ranges from 20°C to 40°C and the annual rainfall ranges from 1200 to 2000 mm. The annual average temperature of Sheka ranges from 15.1–27.5°C and annual mean rainfall ranges from 1201–1800 mm. The major crops which support beekeeping in the areas include Pisum sativum L., Sorghum bcteror L., Carthamus tinctarius L., Vicia faba and Zea mays L. Farmers both in Bench-Sheko and Sheka zones practiced mixed crop-livestock production systems.

2.2. Study design, sample size and sampling method
A cross-sectional study was conducted from June 2017 to June 2018 in Bench-Sheko and Sheka zones. A multistage purposive random sampling method was employed to select the study zones based on the potential of beekeeping and introduced beekeeping technologies. Study populations were all beekeepers in selected districts of the study zones. Four districts were selected randomly from the two selected zones, namely Guraferda, Sheko, Masha, and Anderacha. Then, a total of 14 peasant associations were randomly selected from selected districts. Upon discussion with agricultural experts/extension agents in each district, a total of 180 beekeepers were randomly selected from selected peasant associations. Beekeepers were stratified into adopters and non-adopters of improved beekeeping technologies among selected peasant associations. The selected beekeepers were interviewed. During the interview socio-demographic data of the respondents, their perceptions about modern beekeeping technologies, constraints of modern beekeeping technologies, honeybee pests and predators were asked.

2.3. Method of data collection
The data of all variables hypothesized to influence beekeeping technology adoption and respondent’s views on the technologies were collected. The sample respondents were interviewed with the help of structured and semi-structured (closed and open-ended questions) questionnaire. A semi-structured questionnaire was designed, pre-tested, and refined to collect data. For this study, adoption is defined as a decision of beekeeper to use recommended ideas, practices, or technology over a reasonably long period (Adgaba et al., 2014).
2.4. Hypothesized variables

Adoption is viewed as a variable representing behavioral changes that beekeepers undergo in accepting new ideas and innovations. The term behavioral change refers to a desirable change in knowledge, understanding, and ability to apply technological information, change in motivation such as a change in interest, attitudes, aspirations, value, and change in ability and skills (Tarekegn et al., 2018). Based on literature review variables hypothesized to influence beekeeping technology adoption and respondent’s views on the technologies are shown in Table 1.

2.5. Data analysis

Data obtained from this study was recorded and stored in Microsoft Excel and transferred to SPSS version 20. The collected data were analyzed and presented using tables and figures. The adoption rate was calculated as the number of beekeepers who adopted the technology divided by the total number of respondents. Association between adoption and determinant factors was analyzed using the logistic regression model. The variables with p-value less than or equal to 0.25 in
Table 1. Description of variables used in the regression analysis of factors influencing beekeepers’ knowledge and perception of beekeeping technology

| Variable                              | Variable type | Units                          |
|---------------------------------------|---------------|--------------------------------|
| Adoption decision of improved technology | Dummy         | Adopter = 0, Non-adopter = 1 |
| Gender of respondents                  | Dummy         | Male = 0, Female = 1           |
| Age of respondents                     | Categorical   | 18–35 years = 1, 36–63 years = 2, >64 years = 3 |
| Education level of respondents         | Categorical   | Secondary school and above (9–12 = 1, Elementary (1–8) = 2, Read and write = 3, Illiterate = 4 |
| Awareness of technology                | Dummy         | Yes = 0, No = 1                |
| Visited demonstration site             | Dummy         | Yes = 0, No = 1                |
| Supplementary feeding                  | Dummy         | Yes = 0, No = 1                |
| Participated in workshop               | Dummy         | Yes = 0, No = 1                |
| Marketing problem                      | Dummy         | Yes = 0, No = 1                |
| Access to credit                       | Dummy         | Yes = 0, No = 1                |
| Beekeeping experience                  | Continuous    | Year                           |
| Family size                            | Categorical   | 1–5 = 1, 6–10 = 2, 11–15 = 3   |
| Marital status                         | Categorical   | Single = 1, Married = 2, Divorced = 3 |
| Districts                              | Categorical   | Masha = 1, Anderacha = 2, Guraferda = 3, Sheko = 4 |

univariable logistic regression, after checking for multicollinearity using collinear matrix index and interaction effect using cross-product terms were taken forward for multivariable modeling. The model fit was observed using the Hosmer-Lemeshow test. For all statistical analysis, 95% confidence intervals and a critical value of 0.05 was used.

3. Results and discussion

3.1. Socio-demographic characteristic of beekeepers
The present study showed that the majority of adopter is a younger age group. The age of beekeepers was statistically associated with the use of improved technology (p < 0.05), which indicates older beekeepers are less aware or not adopt new technology (Table 2). Wodajo (2011) and Abejew et al. (2011) also reported that the age of beekeeper negatively influenced the adoption of beekeeping technology, which is similar to this result. The majority of adopters (95.1%) and non-adopters (97.5%) were males. This result also showed a significant association between gender and adoption of improved beekeeping technology (p < 0.05) which indicates that beekeeping is a male-dominated activity in the study area as in common with other parts of the country (Berhe et al., 2016; Chala et al., 2013; Olana & Demrew, 2018; Shenkute et al., 2012; Tarekegn et al., 2017) and most African countries (Mburu et al., 2017).

This result also indicated that the family size of adopters is higher than non-adopters with a statistically significant difference (p < 0.05) suggesting that beekeeper with large family size may opt more for technology adoption. Moreover, technology adoption increases hive products which contribute to satisfying the need of their family through monetary gains. The mean year of the respondent’s experience in the beekeeping of adopters and non-adopters was 12.1 and 14.0 years, respectively (Table 2). This result showed the mean years of beekeeping experience of adopters were less than non-adopter. The experience of beekeepers was associated with the uses of improved technology (p < 0.05), which corroborate earlier findings of Adgabo (2007) and Abejew and Zeleke (2017). While beekeeping experience helps the beekeeper to get more understanding of management practices of the beekeeping activities, beekeeping experience alone cannot influence the beekeeper to adopt the technology (Table 2).
Table 2. Socio-economic characteristics of beekeepers in southwestern Ethiopia

| Variables          | Categories                      | Adopter N = 61 | Non-adopter N = 119 | Combined N = 180 | P-value |
|--------------------|---------------------------------|----------------|---------------------|------------------|---------|
| Sex                | Male                            | 58 (95.1)      | 116 (97.5)          | 174 (96.7)       |         |
|                    | Female                          | 3 (4.9)        | 3 (2.5)             | 6 (3.3)          | 0.040   |
| Marital status     | Single                          | 8 (13.1)       | 13 (10.9)           | 21 (12.0)        |         |
|                    | Married                         | 52 (85.2)      | 105 (88.2)          | 157 (86.7)       | 0.807   |
|                    | Divorced                        | 1 (1.5)        | 0 (0)               | 2 (1.2)          |         |
| Age                | 18–35 years                     | 31 (50.8)      | 76 (63.9)           | 107 (59.4)       |         |
|                    | 36–63 years                     | 28 (45.9)      | 38 (31.9)           | 66 (36.7)        | 0.026   |
|                    | >64 years                       | 1 (1.7)        | 4 (3.4)             | 6 (3.3)          |         |
| Family size        | 1–5                             | 28 (45.9)      | 68 (57.1)           | 96 (53.3)        |         |
|                    | 6–10                            | 28 (45.9)      | 47 (37.8)           | 75 (42.7)        | 0.037   |
|                    | 11–15                           | 5 (8.2)        | 4 (3.0)             | 5 (5)            |         |
| Educational level  | Illiterate                      | 2 (3.3)        | 18 (15.1)           | 20 (11.1)        |         |
|                    | Read and write                  | 10 (16.4)      | 17 (14.3)           | 27 (15.0)        | 0.005   |
|                    | Elementary (1–8)                 | 29 (47.5)      | 61 (51.3)           | 90 (50.0)        |         |
|                    | Secondary school and above (9–12)| 20 (32.8)     | 22 (18.5)           | 42 (23.3)        |         |
| Beekeeping experience |                             | 12.1 ± 1.0     | 14.63 ± 1.6         | 13.36 ± 0.9      | 0.027   |

N = Number of respondents; values in parentheses are percentages; a: value given as mean ± SD.

3.2. Place of honeybee hives
The majority of beekeepers (64%) in the study areas reported that they placed their honeybee colonies in the forest followed by the backyard/homestead (30%) as described in Figure 2. This result is in line with the finding of Serda et al. (2015) and Atersaw and Anja (2018).

3.3. Beekeepers’ perception of improved beekeeping technology
It is very important to identify perceived relative merit of improved beekeeping technology and its relative detriment to determine the perception of beekeepers about improved technology and for appropriate interventions. The majority of the adopter and non-adopter respondents reported that high yield (10%), ease of inspection (8.9%), ease of harvesting of products (7.8%), and quality honey (7.2%) are the main advantages of improved beekeeping technology. On the other hand, the respondents indicated high cost (12.2%), the need of high skill (11.7%), the need for accessories (8.3%) and unavailability of the technology (5.6%) as the major relative detriment of improved beekeeping technology (Table 3). This indicates that beekeepers had positively perceived improved beekeeping technology which is a good opportunity for beekeeping extension intervention. This result is in line with the findings of Yehuala et al. (2013) and Affognon et al. (2015) who found that perception influences the adoption of beekeeping technology.

3.4. Major constraints to beekeeping production
The major problems affecting beekeeping development in the study areas include honeybee disease, pest and predators (27.2%), lack of beekeeping materials (26.7%), high cost of modern hive and accessories (22.2%), lack of credit facility (7.2%) and lack of beekeeping skill (6.1%) as described in Table 4. These constraints were the most important factors affecting the use of improved beekeeping technology. This can be alleviated by offering training to the beekeepers about improved beekeeping technology, and disease and pest
detection and prevention methods. Result of this study is line with the findings of Abebe et al. (2011), Gidey et al. (2012), Tesfa et al. (2013), Nebiyu and Messele (2013), and Kebede and Tadesse (2014) who reported disease, pest and predators, lack and high cost of beekeeping materials as major constraints of using of improved beekeeping technology.

Figure 2. Place where beekeepers kept honeybee colony.

Table 3. Beekeepers’ perception of improved beekeeping technologies in southwestern Ethiopia

| Advantage of using technology | Adopter N = 61 | Non-adopter N = 119 | Combined N = 180 |
|------------------------------|----------------|---------------------|-----------------|
| High yield                   | 15 (24.6)      | 3 (2.5)             | 18 (10.0)       |
| Easy for inspecting          | 11 (18.0)      | 5 (4.2)             | 16 (8.9)        |
| Easy for harvesting          | 10 (16.4)      | 3 (2.5)             | 14 (7.8)        |
| Produce quality honey        | 9 (14.8)       | 4 (3.4)             | 13 (7.2)        |
| Can be used for queen rearing| 9 (14.8)       | 3 (2.5)             | 12 (6.7)        |
| Managing colony/add/reduce volume | 8 (13.1) | 2 (1.7)             | 10 (5.6)        |

| Disadvantage of using technology | Adopter N = 61 | Non-adopter N = 119 | Combined N = 180 |
|----------------------------------|----------------|---------------------|-----------------|
| High cost                        | 15 (24.6)      | 7 (5.9)             | 22 (12.2)       |
| Needs high skill                 | 14 (22.9)      | 5 (4.2)             | 21 (11.7)       |
| Needs accessories                 | 13 (21.3)      | 2 (1.7)             | 15 (8.3)        |
| Unavailable                      | 7 (11.5)       | 3 (2.5)             | 10 (5.6)        |
| Abscending of bees               | 5 (8.2)        | 2 (1.7)             | 7 (3.9)         |
| Easily exposed to pest/disease   | 4 (6.6)        | 4 (3.4)             | 8 (4.4)         |
| Needs seasonal management        | 3 (4.9)        | 3 (2.5)             | 6 (3.3)         |

N = Number of respondents; values in parentheses are percentages.
3.4.1. Honeybee pests
The presence of honeybee pests can hinder the adoption of improved beekeeping technology as they attack honeybees and hive products. This does not mean that traditional beekeeping techniques are not affected by pests. About 80.3% of adopters and 71.4% of non-adopters reported about the existence of pests in the apiary site. The main honeybee pests in the study areas were identified by the respondents based on the damage they cause on honeybees and hive products. The majority of the beekeepers (24.4%) reported ants as a serious problem in the areas, followed by a honey badger (18.9%) and wax moth (11.7%). About 8.9% and 6.11% of the respondent indicated that spider and hive beetle as the most important pests that affect hive products, respectively. The lizard was the least problem, mentioned by only 2.2% of the respondents (Figure 3). This result is supported by FAO (2009), Monga and Manocha (2011), Gidey et al. (2012), Dabessa and Belay (2015), and Kiros and Tsegay (2017).

Some of the respondents indicated different methods to manage pest problems such as frequent cleaning of the apiaries, using ash, and control of predators, which corroborate the previous report of Tesfaye et al. (2017).

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**Table 4. The major constraints to beekeeping in southwestern Ethiopia**

| Constraints                           | Adopter N = 61 | Non-adopter N = 119 | Combined N = 180 |
|---------------------------------------|----------------|--------------------|------------------|
| Diseases, pests and predators         | 14 (22.9)      | 35 (29.4)          | 49 (27.2)        |
| Lack of beekeeping materials         | 23 (37.7)      | 25 (21.0)          | 48 (26.7)        |
| High cost of beekeeping materials    | 13 (21.3)      | 27 (22.7)          | 40 (22.2)        |
| Lack of credit facility              | 4 (6.6)        | 9 (7.6)            | 13 (7.2)         |
| Lack of beekeeping skill             | 3 (4.9)        | 8 (6.7)            | 11 (6.1)         |
| Absconding of bees                   | 2 (3.3)        | 4 (3.4)            | 6 (3.3)          |
| Indiscriminate application of agrochemicals | 1 (1.6)    | 3 (2.5)            | 4 (2.2)          |
| Low quality of beekeeping materials  | 1 (1.6)        | 2 (1.7)            | 3 (1.7)          |

N = Number of respondents; values in parentheses are percentages.
3.5. Adoption rate and determinant factors of improved beekeeping technology

The overall adoption rate of improved beekeeping technology in the study areas was 33.9%. The highest (54.5%) and lowest (4.1%) adoption rate of improved beekeeping technology was recorded in Masha and Guraferda district, respectively (Table 5). According to the respondents, this low adoption rate of improved beekeeping technology was due to the high-cost needed for the technology, the need for accessories, and lack of knowledge about the technology. Moreover, the lack of training and extension supports were also mentioned as factors for a low adoption rate. A similar level of adoption rate was reported by Yehuala et al. (2013) and Albore et al. (2019) in Ethiopia, and Adgaba et al. (2014) in Saudi Arabia. However, this result is higher than the finding of Gebiso (2015), who reported an adoption rate of 22% in the Arsi zone, Ethiopia. There was a statistically significant difference in the adoption of improved beekeeping technologies among districts (p < 0.05). This may be due to the difference in the educational level of beekeepers, credit, and extension services, which influence the adoption of improved beekeeping technologies among the districts.

To identify determinant factors of improved beekeeping technology, the variables with no significant interactions and multicollinearity were entered into a multivariable logistic regression model. A Hosmer-Lemeshow goodness-of-fit value (p = 0.74), indicated that the model was fit the data well. The multivariable logistic regression analysis revealed that age, educational level, a supplement of feed during dearth period, awareness of technology, visit the demonstration site, participated in the workshop, marketing problem and access to credit were independently associated (p < 0.05) with the adoption of improved beekeeping technology in the areas (Table 6).

A statistically significant difference (p < 0.05) was observed in adopting improved technology among the educational level of beekeepers. The odds in favor of adopting improved beekeeping technology increased by a factor of 13.3 for beekeepers who had attained relatively higher levels of education. Education increases the knowledge of beekeepers on improved technologies as education provides them more access to information on improved technology. Moreover, it increases the understanding of the technology which in turn helps to easily apply the technology. The present result is in line with the findings of Wodajo (2011), Yehuala et al. (2013), Adgaba et al. (2014), and Affognon et al. (2015).

Improved beekeeping technology requires knowledge of their practical activities. It is statistically significant (p < 0.05) with 7.3 times more odds of adopting improved beekeeping technology in beekeepers that had a better knowledge of improved beekeeping practices. Studies have confirmed that farmer’s awareness about beekeeping technology was positively influenced the adoption of improved beekeeping technologies (Albore et al., 2019; Njuguna et al., 2017; Tarekegn et al., 2018).

The present study also showed that beekeepers that had no marketing problem were 6.2 times more likely to adopt improved beekeeping technologies than that had marketing problems for their products. This may be due to the availability of the market for the hive products that might increase the adoption of improved beekeeping technologies. This is mainly due to honey produced in improved box hive has high quality and as a result, it has a high demand. This finding agrees

| Table 5. Adoption rate of improved beekeeping technologies in southwestern Ethiopia |
|---------------------------------|--------|--------|--------|--------|--------|
| **Districts**                   | **Total samples** | **Adopter** | **Non-adopter** | **Exp(B) (95% CI)** | **P-value** |
| Masha                           | 44     | 24 (54.5) | 20 (45.5) | 1.81 (1.77–4.01) | 0.019 |
| Andarecha                      | 47     | 19 (40.4) | 28 (59.6) | 1.81 (1.76–4.29) | 0.014 |
| Sheko                          | 40     | 16 (40.0) | 24 (60.0) | 1.81 (1.75–4.29) | 0.014 |
| Guraferda                      | 49     | 2 (4.1)   | 47 (95.6) | 8.2 (6.18–13.82) | 0.0001 |
| Overall                        | 180    | 61 (33.9) | 119 (66.1) | 8.2 (6.18–13.82) | 0.0001 |

CI: Confidence Interval, Exp (B): Exponential function of the regression coefficient.
with the reports of Belie (2009), Manga and Manocha (2011), Legesse (2014), and Shibu et al. (2016) who stated that marketing is an important factor for honey production.

The odds of in favor of adopting improved beekeeping technology increased by a factor of 1.3 for beekeepers who are young people. Age had a significant influence \((p < 0.05)\) in the adoption of improved beekeeping technologies. This may be as beekeepers get older they lose production or other benefits of new technologies and become none adopters of technologies (Motamed & Singh, 2003). Moreover, older beekeepers are less likely to know about an emerging technology or less skillful to adopt technology. This result is supported by the previous results of Adgaba et al. (2014).

Participation of beekeepers in demonstration and workshop of improved beekeeping technologies were significantly associated with the adoption of the technology. The odds in favor of adopting improved beekeeping technology increased by factors 21.2 and 26.8 for beekeepers who participating in demonstration and workshop of improved beekeeping technology, respectively. This may be due to the fact that beekeepers who participated in demonstration and field day of improved beekeeping technology had a chance to exchange knowledge and experience with experts, researchers, and other beekeepers. This motivates the beekeeper to adopt improved technology. The present finding concurs with previous results (Affognon et al., 2015; Albore et al., 2019; Tamrat, 2015; Tarekgn et al., 2018; Wodajo, 2011; Yishak & Punjabi, 2011).

| Factors                        | Adopter | Non-adopter | Exp(B) (95% CI) | P-value |
|-------------------------------|---------|-------------|-----------------|---------|
| Age                           |         |             |                 |         |
| 18–35 years                   | 31      | 76          | 1.3 (0.06–21.12) | 0.044   |
| 36–63 years                   | 28      | 39          | 0.4 (0.02–7.01) | 0.936   |
| > 64 years                    | 1       | 4           |                 | 0.51    |
| Education level               |         |             |                 |         |
| Secondary school and above    | 2       | 18          | 13.3 (1.83–26.08) | 0.011   |
| Elementary                    | 29      | 62          | 4.9 (1.71–14.00) | 0.003   |
| Read and write                | 10      | 17          | 3.3 (0.88–12.18) | 0.076   |
| Illiterate                    | 20      | 22          |                 |         |
| Awareness of technology       |         |             |                 |         |
| Yes                           | 55      | 70          | 7.3 (2.32–23.06) | 0.001   |
| No                            | 6       | 49          |                 |         |
| Visited demonstration site    |         |             |                 |         |
| Yes                           | 17      | 22          | 21.2 (1.92–35.09) | 0.013   |
| No                            | 44      | 97          |                 |         |
| Supplement of feed            |         |             |                 |         |
| Yes                           | 33      | 107         | 8.1 (3.06–21.66) | 0.001   |
| No                            | 28      | 12          |                 |         |
| Participated in workshop      |         |             |                 | 0.019   |
| Yes                           | 16      | 13          | 26.8 (2.37–102.81) | 0.008   |
| No                            | 45      | 106         |                 |         |
| Marketing problem             |         |             |                 |         |
| Yes                           | 41      | 43          |                 |         |
| No                            | 20      | 76          | 6.2 (2.55–15.45) | 0.001   |
| Access to credit              |         |             |                 |         |
| Yes                           | 4       | 15          | 4.2 (1.85–10.78) | 0.007   |
| No                            | 57      | 104         |                 |         |
Feeding supplementary feed to honeybee colony during the dearth period was significantly associated (p < 0.05) with the adoption of improved beekeeping technology. The odds in favor of adopting improved beekeeping technology increased by a factor 8.1 for beekeepers who fed their colonies during the dearth period. Supplementary feed is important for honeybee colonies to develop the colony with an optimum population during nectar flows and prevents the colony from being attacked by different diseases and pests easily. This result is in line with the reports of Tesfa et al. (2013).

Credit service is significantly associated (p < 0.05) with the adoption of improved beekeeping technologies. The beekeeper with access to credit service was 4.2 times more likely to adopt improved beekeeping technology compared to that of none access to credit service. A credit service may help them to minimize the financial problem of beekeepers that enable them to adopt improved beekeeping technologies. Moreover, credit service may enable beekeepers to purchase inputs or acquire physical capital, needed for technology adoption. This suggested that access to credit is capable of increasing the rate of adoption of improved beekeeping technology. Hence, the accessibility of credit service for technology adoption is important (Monga & Manocha, 2011). This result corroborates the findings of Mujuni et al. (2012), Yehuala et al. (2013), and Albore et al. (2019).

4. Conclusion and recommendations
The present study showed a low adoption rate of improved beekeeping technology in the study areas. High yield, ease for inspection, and quality honey are the main advantages of improved beekeeping technology reported by the beekeepers, whereas high cost, need for high skill, and accessories of technology were mentioned as the major relative detriment. The beekeepers have positively perceived improved beekeeping technology, which is a good opportunity for beekeeping extension intervention. Ages, education level, awareness of technology, visited demonstration site, participated in field day; marketing problem and access to credit are the determinant factors for improved beekeeping technologies. Disease, pest and predators, lack of bee equipment and credit are the major constraints of improved beekeeping technologies reported by the beekeepers. Based on the above conclusions the following recommendations were forwarded:

- Appropriate prevention and control methods of honeybee pests should be studied.
- Beekeeping equipment and accessories have to be accessible to the beekeepers and great attention has to be given which can increase productivity and appropriate management practices of modern beehives. This can positively affect beekeepers’ probability of adoption and use of modern beehive.
- Provision of credit service which enables the farmers to solve their financial constraints and beekeepers can use the money to buy modern beehives and access to modern beekeeping equipment.
- Adequate training has to be provided for beekeepers both practically and theoretically.

5. Ethical Considerations
All procedures were conducted according to the experiment practice and standards approved by the research ethics committee of the Ethiopian Institute of Agricultural Research. As well, verbal consent was obtained from the beekeepers. Full cooperation and voluntary participation of all participants was obtained by assuring them of the confidentiality of their involvement.

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