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Adopting improved box hive in Atsbi Wemberta district of Eastern Zone, Tigray Region: Determinants and financial benefits

Improving Productivity and Market Success of Ethiopian Farmers

Adopting improved box hive in Atsbi Wemberta district of Eastern Zone, Tigray Region: Determinants and financial benefits

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Abstract

Though beekeeping is a common farming enterprise and income generating activity in Atsbi Wemberta *woreda*, and promotional efforts have been made to improve it, no systematic study has been undertaken to evaluate the promotional efforts and people's response to it. The objectives of this study were to identify determinants of improved box hive adoption by the beekeepers; and to analyse financial benefits from adopting improved box hive technology in Atsbi Wemberta district of Eastern Zone, Tigray Region of Ethiopia. Stratified sampling technique was employed to identify the sample respondents, who were categorized into adopters and non-adopters of improved box hive. Based on probability proportional to size, 45 adopters and 85 non-adopters were selected. The data were collected using structured interview schedule, group discussion, key informant discussion and observation; and were analysed using descriptive statistics, partial budgeting, and logit model. Partial budgeting revealed that the net benefit from improved box hives was more than double that obtained from traditional hive. The logit model revealed that credit, knowledge, education level of household head, perception and visits to demonstrations positively and significantly influenced adoption of improved box hive. Major problems for promoting improved beekeeping practices were identified in the study area. Ranking showed that drought, honeybee pests and diseases, lack of beekeeping materials, death of colony, lack of adequate extension support, marketing problem, shortage of bee forage, lack of adequate beekeeping skill and reduction of honeybee colonies were the major constraints in the beekeeping development in their order of importance. There is a need for actors to come together for concerted and co-ordinated action to address the constraints and problems, as the solutions are not in the domain of any one actor. Women and landless youths can be encouraged to take up this income generating enterprise. Developing the skills of beekeepers and extension agents on bee management and utilization of beeswax through intensive training, enhancing bee forage production and utilization, integrating beekeeping with water harvesting, modifying the improved box hive to include only one super to reduce initial cost, linking honey producers to stable and reliable markets and following a participatory value chain based approach, promoting private entrepreneurs to provide additional services for value addition, promoting farmer-to-farmer knowledge sharing, and encouraging farmer groups to enhance bargaining power and create a learning environment are some initiatives that could go a long way in the sustainable development of this important economic subsector.

1 Introduction

1.1 Beekeeping in Ethiopia

Livestock is an important economic sector in Ethiopia which contributes to economic development. Ethiopia is generally considered to have the largest population of livestock than any country in Africa (Halderman 2004). Livestock contribute upto 20% to Ethiopia's GDP and livelihoods of 60–70% of the population. Apiculture, which is one of the important livestock subsectors, contributes significantly to the improvement of the livelihoods of the nation's population (Aklilu 2002).

There is no well-documented evidence that indicates when and where beekeeping practice started in Ethiopia. According to Ayalew (1978), it had started in the country between 3500–3000 BC. The country has a high potential for beekeeping as the climate is favourable for growing different vegetation and crops, which are a good source of nectar and pollen for honeybees. Due to suitable natural environment of the country a large number of honeybee colonies, estimated at about 10 million, exist in the country (Ayalew 1978).

Ethiopia produces around 23.6% and 2.1% of the total African and world's honey, respectively. It is the leading honey producer in Africa and one of the 10 largest honey-producing countries in the world (Ayalew 1990). It is also one of the four largest beeswax producing countries in the world. In Ethiopia, beeswax is one of the 12 major exportable agricultural products and an estimated one million farmers are engaged in beekeeping (Mammo 1976). The country produces about 28,500 t of honey and 5000 t of beeswax annually (HBRC 2004).

Beekeeping in Ethiopia plays an important role in income generation for beekeeper farmers. An average of Ethiopian birr (ETB)[1] 420 million is obtained annually from the sale of honey, both in local and world markets. Honey production of the country meets beverage requirements of the urban and rural population. It is also demanded for its nutritional and medicinal values. The other hive products such as beeswax, royal jelly, propolis, and bee venom have high demand globally.

In addition, honeybees play a great role in pollinating plants and contribute to increased crop yield. Self-sterile plants (cross pollinated) require pollinating agents to maintain viable seed. According to Crane (1990) honeybees can increase the yield of *Citrus sinensis* by 30%, water melon by 100% and tomatoes by 25%. Admasu et al. (2004) also reported that onion yields increased by 94% due to honeybee pollination.

1. Ethiopian birr (ETB). In April 2008, USD 1 = ETB 9.4916.

The Ethiopian government, realizing the potential of beekeeping subsector of the country, established demonstration stations at Holeta, Nekempt and Jima in 1965. The main objectives of the demonstration stations were to introduce imported improved beekeeping technologies (box hives, casting mold, honey extractor, honey presser, smoker, water sprayer, veil, glove etc.) to the beekeepers and to offer beekeeping training for farmers and experts. According to EBA (2005), formally organized beekeeping extension started in 1978. While the demonstration stations mainly targeted beekeepers located in the vicinity of the station and their coverage was small, formally organized extension has been aiming for a wider coverage. Currently, different private organizations are also engaged in the production of beekeeping equipment.

1.2 Beekeeping in Atsbi Wemberta

Atsbi Wemberta is one of the districts of Tigray Region with a high potential for beekeeping development. The *woreda* (district) has 16,915 honeybee colonies (Atsbi *Woreda* OoARD 2006), making it one of the high potential areas for developing beekeeping in the region as well as in the country. All beekeepers of the district were only using traditional beehives until eight years ago. The traditional beehive is not convenient to undertake internal inspection and feeding, and offers no possibilities of supering (adding an additional box) to differentiate the brood chamber and honey chamber. The annual crude honey yield per traditional beehive is 5–7 kg, while the national average yield of improved box hive is 20–25 kg (HBRC 2004). The quality of honey produced in an improved box hive is also significantly better being free of pollen, beeswax, brood and debris.

In order to improve the quantity and quality of honey yield, the Agricultural and Rural Development (ARD) Office and different non-governmental organizations have introduced improved box hives (Zander type) in Atsbi Wemberta district. Ruttner (1988) noted that the moderate climate of Ethiopia makes it one of the most successful countries in the tropics in box hive utilization.

Improved box hive was introduced into the district in 1998, 30 years after its introduction to the country. Even though the duration of its introduction to the district is short the promotion of the technology is encouraging and currently there are 5716 of such hives in the *woreda*. Improved and traditional beekeeping practices are found to co-exist in the area. Highland areas are used for traditional beekeeping and the mid-lands for improved beekeeping. According to the beekeepers and bee expert of the district, the highland is not suitable for improved box hive as it is too cold and the honeybees cannot resist the cold in the box hive. This results in high rate of absconding of honeybees and low yield.

Traditional hives are mainly engaged in multiplying honeybee colonies and providing them to beekeepers engaged in improved beekeeping management. The current price of a honeybee colony is about ETB 550. A previous study conducted in Atsbi showed that while male beekeeper farmers get about 80% of their stock from fellow farmers, women depend on the forest for 70% of their bee stock (IPMS 2005).

The beekeepers get income from the sale of honey and honeybee colonies. Other hive product, namely beeswax, which can be used for multiple purposes like foundation sheet making, candle making, shoe cream etc. has not been utilized in the study area.

Currently, beekeeping extension is trying to promote both improved and traditional beekeeping practices. It follows a package approach including provision of credit. They provide training on bee management, hive product and colony multiplication. It was observed that the training coverage was very low and as a result, majority of the beekeepers were using indigenous knowledge. IPMS (2005) documented that for most men and women beekeeper farmers the major sources of knowledge and skills was parents and their previous experience. Very few availed trainings organized by World Vision, FAO and Office of ARD. However, the extension workers in the district, especially the DAs, are not conversant with the practical skills or knowledge required to be able to advise the farmers. Generally, the beekeepers get direct technical assistance from the district bee expert, resulting in the knowledge resource being spread very thin. The involvement of DAs in providing technical assistance to the beekeepers is minimal.

In the study area, Dedebit Credit and Saving Institution (DCSI) provides a maximum loan of ETB 5000 for beekeeping activities. The interest rate for loans provided through regular extension service and package was 15 and 9%, respectively, with a repayment period of five years. The interest rate of the regular extension is high due to high transaction costs and high risk of repayment. With regard to package, ARD supports in facilitating credit and its repayment. As a result, its interest rate is lower compared to the regular extension. IPMS (2005) documented that about 60% of the credit accessed by male and female farmers for apiculture was from the Office of ARD. The remaining came from Food Security Desk, REST and World Vision.

There are five beekeeping associations in the *woreda* organized by the district Agricultural and Rural Development office with the assistance of IPMS/ILRI[2] and World Vision. Three of them are constituted by landless youth of Dibab Akorein, Bark Adisebiha

2. IPMS (Improving Productivity and Market Success of Ethiopian farmers) is a project of the MoARD supported by CIDA that contributes to improved agricultural productivity and production through market-oriented agricultural development as a means for achieving improved and sustainable livelihoods for the rural population.

and Hayelom PAs. They have 31, 18 and 10 members, respectively. Each member of the association gets three box hives on credit basis from the IPMS credit fund. The members repay their loan by selling the bee products. Two additional beekeepers associations were organized and financed by World Vision Ethiopia (an NGO). The main objective of these associations is to serve as demonstration site for other beekeepers in the district. The district cooperative office is responsible for the distribution of the hives and management of the credit for all the associations. The district Agricultural and Rural Development Office also provides services of honey extractor and casting mold for beekeepers free of charge. The honey extractor is operated through the Development Agents (DAs) and foundation sheet making is organized at district level.

1.3 Market orientation

Honey is produced mainly for marketing in Atsbi. About 80–90% of the honey produced is sold by rich, middle income and poor households (IPMS 2005). Beekeeper farmers generally supply to markets in nearby towns like Atsbi and Wukro, travelling on foot. The beekeepers sell the honey produced on an individual basis mainly to consumers and private traders twice a year. On average about 10–20 kg of honey is sold per household per annum (IPMS 2005). They are price takers and have no bargaining power. Despite the high honey production in the *woreda* (394 quintal in 2005), there is no ready market attracting beekeepers.

In the study area, the following honey marketing channels are observed.

1. Producer → consumer
2. Producer → honey collector → consumer
3. Producer → honey collector → processing → consumer

There are very few honey collectors in the area that engage solely in honey collection activities. Usually collectors engaged in trading consumer goods, also collect honey as part of their activities. They do not trade in honey in large quantities. The first channel is the dominant in the study area, while the second channel is weak and inefficient. The honey collectors procure honey in small amounts (<200 kg/annum) and store it. They wait for the consumers to come to buy the honey, rather than supplying to the nearby town markets. The third channel is found to be at an initial stage and it is hoped that this will become stronger in due course of time. This optimism stems from the fact that a private company, Dimma Enterprise, which has recently established a processing plant in Adigrat (93 km from Atsbi) started collecting honey from producers in Atsbi *woreda*. This promises to offer a stable and reliable market in the times to come. Dimma Enterprise collected 200 kg of honey from Atsbi during the 2006 production season at prevailing

market price to test the efficiency of its processing plant. They test the honey for moisture content and physical quality (colour, aroma, crystallization etc.) before buying.

1.4 Focus of the study

This study looked at adoption of improved box hives at the individual farm household level. Individual adoption refers to the farmer's decisions to incorporate a new technology into the production process (Feder et al. 1985). According to Dasgupta (1989), the term adoption implies the continued use of a recommended idea or practice by individuals or groups over a reasonably long period. Adoption is a complex process, which is governed by many socio-economic factors including: farmers' socio-psychological system; their degree of readiness and exposure to improved practices and ideas, i.e. changes like the awareness and attitude of farmers towards improved agricultural technologies; institutional factors which act as incentives/disincentives to agricultural practices; and farmers' resource endowment like land holding size and labour are some of the factors of considerable importance in bringing about the technological change in agriculture (Salim 1986). The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, economical and social factors. Adoption or rejection of an innovation is a decision to be made by an individual.

Adoption is viewed as a variable representing behavioural changes that farmers undergo in accepting new ideas and innovations in agriculture. The term behavioural change refers to desirable change in knowledge, understanding and ability to apply technological information, changes in feeling behaviour such as changes in interest, attitudes, aspirations, values and the like; and changes in overt abilities and skills (Ray 2001).

Identification of the factors that influence the adoption of a technology, positively or negatively, are important for policymakers, researchers and organizations involved in beekeeping development programs to get insights into the adoption of improved box hive, which in turn would help them to suitably modify the strategies for improved uptake.

Kerealem (2005) showed that adoption rate of improved box hives is low in the country and highlighted the importance of investigating factors influencing the adoption of improved box hives. There is no information currently available on the determinants of the technology adoption, and the financial benefit of adopting the box hive technology. To fill this knowledge gap, this study was designed with the specific objectives of:

- identifying the determinants of improved box hive adoption by the beekeepers, and
- analysing the financial benefits from adopting improved box hive technology.

2 Research process

2.1 Study area

Atsbi Wemberta district is located in Eastern zone of Tigray Region at about 65 km northeast of Mekele, the regional capital city. It has an altitude, which ranges from 2400–3000 metres above sea level (masl) called *dega* (highland); and an altitude ranging from 1800–2400 masl called *weinadega* (midland). The district has a total area of about 1223 km^2, with 70 and 30% *dega* and *weinadega*, respectively. The average temperature of the area is 18ºC. Rainfall is usually intense and short in duration, with an annual average of about 667.8 mm.

Atsbi Wemberta has a total human population of 112,639, of which 55,359 (49.15%) and 57,280 (50.85%) are male and female, respectively. The urban and rural population is 9609 and 103,030, respectively (District Agricultural and Rural Development Office 2006).

2.2 Sampling techniques

Purposive sampling was employed to identify peasant associations in which improved box hive was promoted. Based upon the number of beekeepers and honeybee colony population, four peasant associations (Hayelom, Dibab-Akorein, Barka-Adisabiha and Michael Emba) with high beehive population were selected purposively (Figure 1). In the selected peasant associations, the beekeepers were stratified into adopters and non-adopters[1] of improved box hives. The total sample size for the study was 130 beekeepers among which 8 are women and 122 are men. There were no women that adopted box hives in the sample respondents. Based on the probability proportional to size principle, 45 adopters and 85 non-adopters were selected for the study through systematic sampling method.

2.3 Data collection and analysis

A full understanding of the complexities involved in the adoption of technologies and the impacts they have can only be achieved by mixing methods, such as quantitative surveys, qualitative interviews, focus group discussions etc. (Dick et al. 2004). The required data were collected from beekeepers and extension workers of the district.

1. Adopters are those beekeepers who used improved box hive for at least two years and non-adopters are beekeepers who did not use improved box hives during the study period.

Atsbi wereda peasant association

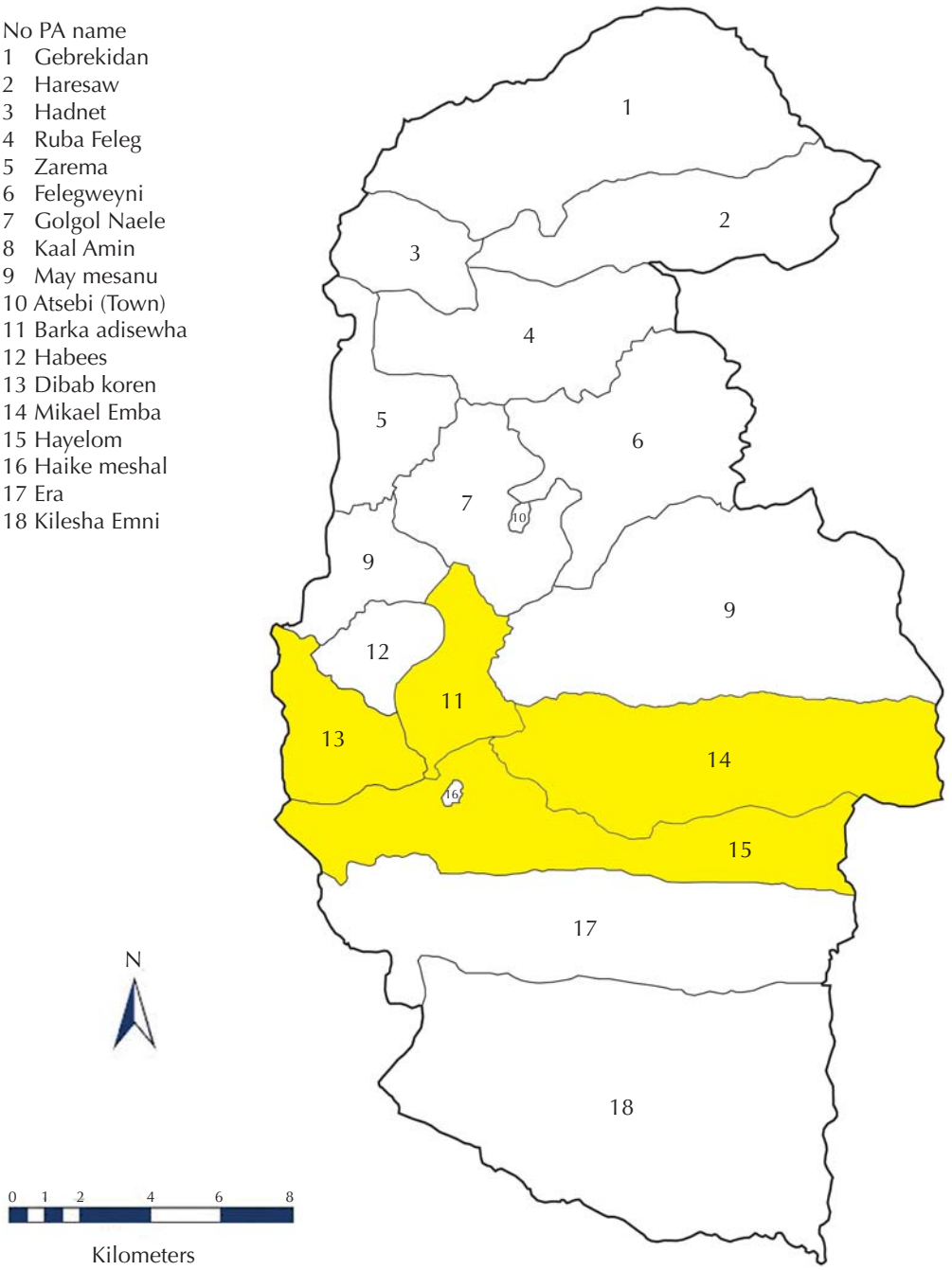


Figure 1. *Map of Atsbi* woreda *with sampled PAs.*

Structured interview schedule was prepared and pre-tested to include all quantitative data pertaining to the proposed study. For obtaining the relevant information, personal observations, focus group discussions and personal interviews were conducted with beekeepers, extension workers and bee experts.

Enumerators who have know-how on beekeeping were recruited and trained to collect data using the interview schedule, under the supervision of the researcher. The researcher monitored the enumerators during data collection. Secondary data were collected from different sources such as books, research publications, journals, office reports, internet etc.

The required data for partial budgeting, such as prices of improved box hive, pure beeswax and accessories were collected from the District ARD office. Honey yield, price, feed cost, labour cost and traditional hive cost were collected from respondents.

2.4 Data analysis

Tools used for data analysis and presentation were descriptive statistics such as percentages, frequencies, mean and standard deviations; t-test and χ^2 were employed to test the significance of continuous and discrete variables, respectively. SPSS version 12 was used to analyse the quantitative data. Any data/information that could not be captured through quantitative analysis were analysed qualitatively based upon interview and group discussion with extension workers and beekeepers. For assessing financial benefit of improved box hive, partial budgeting[2] was employed.

Many models used in adoption studies fail to meet the statistical assumption necessary to validate the conclusions based on the hypothesis tested and they recommend the use of qualitative response models (Feder et al. 1985). Logit and probit models are mainly used in adoption studies. However, the output of probit and logit models is usually similar (Aldrich and Nelson 1984). Even though their outputs are similar, the logit model is easier to estimate. A binary logit model was used to identify the determinants of improved box hive adoption in this study. Following Gujarati (1988) the model is specified as:

$$\text{Ln } (Pi/(1-Pi) = b0 + b1x1 + \text{---} + b16x16 + e$$

The dependent variable is the natural log of the probability of adopting improved box hive (P), divided by the probability of adopting (1–P). The model was estimated using the

2. A partial budget is a technique for assessing the benefits and costs of a practice relative to not using the practices. It takes into account only those changes in costs and returns that result directly from using a new practice.

maximum likelihood method. The variables presented below were used in the model hypothesized to influence the adoption of improved box hive positively are denoted by (+), and negatively by (–).

X1 = AGE (age of household head in years (–)
X2 = AMLSIZ (number of family members (+)
X3 = EDUCATI (years of formal schooling of household head (+)
X4 = CREDIT (borrowing habit of household head, dummy variable (+)
X5 = EXTCONTA (extension contact, dummy variable (+)
X6 = VISTDEM (visiting demonstrations, dummy variable (+)
X7 = MKTAVIL (availability of market, dummy variable (+)
X8 = BKTRAIN (attending beekeeping training, dummy variable (+)
X9 = PERCEPTION (perception of household head, in five point scale (+)
X10 = KNOWLGE (knowledge of household head that helps in addressing practical questions (+)
e = error term

3 Adopting improved box hives for beekeeping in Atsbi Wemberta

3.1 Demographic and socio-economic characteristics of sample respondents

Table 1 summarizes demographic and socio-economic characteristics of sample respondents. The mean age of household head for adopters and non-adopters is 42.2 and 47.2 years, respectively, with a significant mean difference at $P<0.01$. It implies that beekeepers are generally reluctant to experiment with new technology as they get older. Yohannis (1992) and Shiferaw and Holden (1998) in their study of adoption of soil and water conservation in Ethiopia also indicated that age of the household head negatively influenced adoption. The mean family size is 6.6 and 5.9 for adopters and non-adopters, respectively, again significantly different at $P<0.05$. This indicates that beekeepers with large family size opt for improved technologies to improve productivity and incomes. Adopting improved box hives also demands additional labour and therefore, households with larger family size are more able to meet these demands. IPMS (2005) documented that highest labour is involved in watching and during swarming times, beehive construction, honey extraction and colony multiplication.

In relation to beekeeping experience, there is no statistically significant difference between adopters and non-adopters. The average years of beekeeping experience of both categories is nearly equal. The education level of adopters of improved box hive is significantly higher than non-adopters of the technology, implying the influence of the variable in making adoption decisions. The average farm size of adopters and non-adopters is 0.55 ha and 0.59 ha, respectively (both below the national average land holding of 1.5 ha). This difference was not statistically significant, implying that farm size does not affect adoption of improved box hive in the study area.

Apiary is the place where honeybee colonies are kept on the farm/homestead. The apiary size ranges from 6 m^2 to 100 m^2 with the mean of 26.8 m^2 and 19.01 m^2 for adopters and non-adopters, respectively. The difference which is not significant indicates that beekeeping activity does not require large or fertile pieces of land. Uncultivated land can also be used. Even landless farmers with small plots of land around homesteads can engage in this activity.

The mean livestock holding, taken as a proxy for wealth status, is 4.4 and 3.9 for adopters and non-adopters, respectively. There is no significant difference in the wealth status of both categories measured by livestock holding, implying that the improved box hive technology is not necessarily suitable only for resource rich households.

Table 1. *Demographic and socio-economic characteristic of sample respondents (n=130)*

Variable	Standard deviation	Adopters	Non-adopters	T-test
Age	Mean	42.2	47.2	2.621***
Family size	"	6.6	5.9	2.043**
Beekeeping experience	"	10.7	9.5	0.941Ns
Farm size	"	0.55	0.59	0.465Ns
Education	"	2.7	1.1	4.239***
Apiary size	"	26.8	19.01	1.388Ns
Livestock	"	4.4	3.9	0.615Ns
Bee colony	"	3.2	2.4	1.590Ns
Perception	"	16.4	13.8	4.008***
Knowledge	"	4.7	3.3	6.054***
Beekeeping training	Yes	(75.6)	(5.9)	χ^2
	No	(24.4)	(94.1)	
Extension	Yes	(84.4)	(42.4)	68.014***
	No	(15.6)	(57.6)	21.259***
Credit	Yes	(88.9)	(27.1)	
	No	(11.1)	(72.9)	45.036***
Apiary visit	Yes	(71.1)	(29.4)	
	No	(28.9)	(70.6)	20.780***
Market	Yes	(75.6)	(21.2)	
	No	(24.4)	(78.8)	36.253***

*** Significant at P<0.01, ** Significant at P<0.05, NS- Non- significant.
Figures in parentheses indicate percentages.

The average honeybee colony holding was 3.2 and 2.4 honeybee colonies for adopters and non-adopters, respectively. Having more or less number of colonies did not affect the use of improved box hive, as farming households which decided to use the technology could start by purchasing the colonies. Among the respondents, 29.4 and 71.1% of non-adopters and adopters respectively, had got an opportunity to visit an apiary, through extension activities. It is significantly different at P<0.01, showing that farmer-to-farmer exchange of experience and knowledge sharing influences adoption positively.

The difference in positive perception about the technology was also significantly different among adopters and non-adopters. Higher yields and better quality, ease of inspection and, ease of product harvesting are the major relative advantages of improved box hive identified by the majority of beekeepers. On the other hand, high cost, high skill

requirement need of accessories, and unavailability of the box hives are the main relative disadvantages of improved box hive as noted by the respondents.

3.2 Gender roles in different beekeeping activities

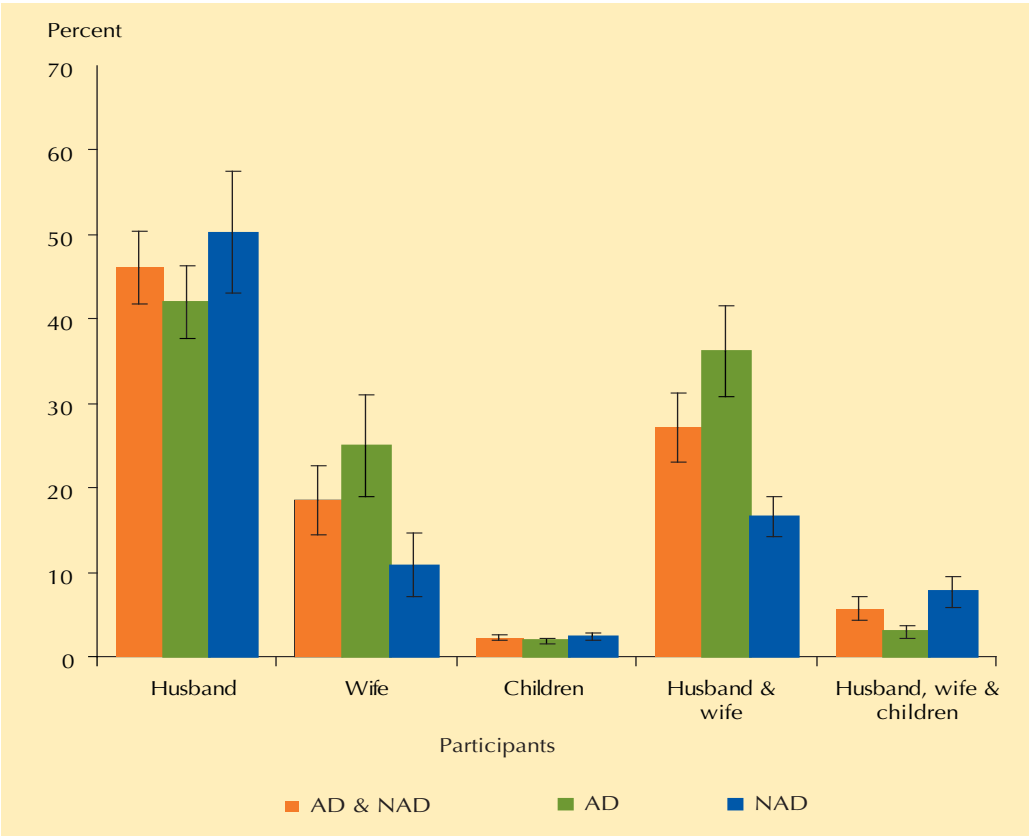
As noted by Robinson (1980), among the relative advantages of beekeeping is that the whole family can be involved in beekeeping activities. There are different activities involved in beekeeping such as swarm catching, transferring, hive inspection, honeybee feeding, honey harvesting, honey extraction and marketing. Figure 2 depicts the involvement of the household members in different beekeeping activities. Husband alone undertook 46% of beekeeping activities and wife alone 18.5%. Transferring of honeybees from traditional to improved box hive, swarm catching, honey harvesting and extracting are mainly done by men whereas, external hive inspection, honeybee feeding, and honey selling are the main activities of women. Honey extractor is an improved equipment that is increasingly being used for honey extraction. It is owned by District Agricultural and Rural Development office and managed by Development Agents (DA) at the peasant association level, to popularize its use. The beekeepers were using the equipment free of charge, when this study was conducted.

The participation of women in the beekeeping activities was high in adopter category and the difference is significant at $P<0.1$, showing that adoption of improved box hive increases the labour share of women. But this also indicates that improved beekeeping activities are convenient for participating women. Traditional hives have to be hanged on a tree or under the roof, which makes it difficult for women to operate. The perception of the farmers was also that improved beekeeping activities do not necessarily overload the women as the activities in which they are mainly involved like honey extraction, harvesting and, transferring are carried out during their free time and are not done on a daily basis. For instance, transferring is done once a year, unless additional hives are introduced or absconded colonies have to be replaced. Honey extraction is done twice a year in the study area. Group discussions revealed that in most cases honey is sold by women. However, previous studies show that the income from sale of honey is mainly controlled by men (IPMS 2005).

3.3 Factors influencing the adoption of improved box hive

As indicated in Table 2, 90% of the total variation for the adoption of improved box hive is explained by binary logit model. The χ^2 result shows that the parameters are significantly different from zero at $P<0.01$ for the adoption of improved box hive. The model correctly predicted sample size of 84.4% and 92.9% for adopters and non-

adopters, respectively. Among, the explanatory variables, credit, knowledge, education level of household head, perception and visiting demonstration were found to be significant as hypothesized. Age, family size, extension contact, market availability and beekeeping training were insignificant compared to other explanatory variables in the regression. Probably, the lower influence of variables such as beekeeping training, extension contact and availability of market is due to the fact that the high cost of improved box hive and honeybee colony dominates all other factors. Even though extension services and training are provided, it cannot enhance adoption of the technology if the user cannot afford the technology. Market availability seems to be a common constraint for all honey producers, whether they adopt modern box hives or not. This argument was confirmed by group discussion with the farmers.



AD- Adopter, NAD- non-adopter. Bars indicate ±SE (n = 73 to 129 individuals).

Figure 2. *Household member participation in beekeeping activities.*

The explanatory variables that were significantly influencing adoption of improved box hive are discussed here:

Table 2. *Logistic regression for factors influencing improved box hive adoption*

Variables	B	S.E.	Wald	Sig.	Exp(B)
AGE	–0.017	0.045	0.150	0.699	0.983
FAMLSIZ	0.382	0.257	2.211	0.137	1.466
EDUCATION	0.446	0.172	6.729	0.009***	1.562
PERCEPTION	0.252	0.134	3.523	0.061*	1.287
CREDIT	2.607	0.968	7.251	0.007***	13.555
EXTCONTA	0.805	0.628	1.643	0.200	2.237
VISTDEM	2.262	0.905	6.247	0.012**	9.598
KNOWLED	1.656	0.603	7.549	0.006***	5.239
MKTAVAIL	1.257	0.789	2.538	0.111	3.515
BKTRAIN	0.144	0.413	0.122	0.727	1.155
Constant	–15.465	4.362	12.570	000	000

–2 log likelihood 59.852
χ^2 107.857***
Predicted adopter 84.4 %
Non-adopter 92.9%
Overall 90%
*, **, *** significant at p<0.1, p<0.05, and p<0.01

Credit — In the study area, improved box hive was perceived as being costly by the beekeepers. Under such circumstances, credit plays a significant role in enhancing the technology promotion. As anticipated, credit affects adoption positively and significantly at P<0.01, the odds in favour of adopting improved box hive increased by a factor of 13.6 for beekeepers who had received credit. This result is supported by Lelisa (1998) who studied determinants of fertilizer adoption, intensity and probability of its use and found that access to credit is one determinant of fertilizer adoption and intensity of its use. Doss et al. (2003), Feder et al. (1985), and Cramb (2003) also concluded that credit is correlated with the use of improved inputs.

Knowledge — Improved beekeeping technology requires knowledge on the practical aspects. The odds in favour of adopting improved box hive increased by a factor of 5.24 for beekeepers who acquired better skills on improved beekeeping practices. The result is in line with Yadav (1992) who found that adoption of improved paddy cultivation practices has a highly significant and positive correlation with knowledge of farmers. Degnet and Belay (2001) also showed that farmers' knowledge of fertilizer use and its application rate positively influenced adoption of high yielding maize varieties.

Education — Education increases the access to information and thereby possible knowledge of beekeepers regarding improved box hive. It also increases the understanding of the technology and facilitates its application. As hypothesized, education influences adoption of improved box hive positively and significantly at

P<0.01%. The odds in favour of adopting improved box hive increased by a factor of 1.56 for beekeepers who had higher education level. The result is also supported by earlier studies of Voh (1982) that dealt with factors associated with the adoption of recommended farm practices in a Nigerian village; Feder et al. (1985) which focuses on adoption of agricultural innovation in developing countries; and Cramb (2003) that identified factors affecting the successful adoption of new technologies by smallholders.

Apiary visit — Apiary is the place where the honeybee colonies are kept, in the farms of model farmers. Visiting the apiary helps the beekeeper to learn more about the technology. It also motivates the beekeepers towards adopting the technology. The odds in favour of adopting improved box hive increased by a factor of 9.6 for beekeepers who had an opportunity of visiting apiary. Beekeepers who get an opportunity of visiting the apiary and exchanging knowledge and experience with fellow farmers, seem to become more favourable to adopting the technology. Beekeepers trust information from each other more than they do with the outsiders. Hence, apiary visit is an important mechanism to introduce beekeeping technology and induce adoption. The result coincides with Melaku (2005), who explained that there is significant association between adoption and apiary visit by farmers.

Perception — Positive perception of beekeepers about the technology favourably influences adoption decision. The odds in favour of adopting improved box hive increased by a factor of 1.28 for beekeepers who perceived the technology positively. The finding is supported by Shiferaw and Holden (1998) who found that perception influences adoption positively. The result is also in agreement with study of Million and Belay (2004) on factors influencing adoption of soil conservation measures in Gununo area of south Ethiopia, which found that the perception about soil conservation problem influenced adoption of soil conservation technology positively. Farmer to farmer experience sharing visits also contributes towards developing positive perception towards an innovation or a new technology.

3.4 Financial benefits of adopting improved box hive

Yield is an important determinant factor in adopting the technology. The higher the yield obtained from the introduced technology, the easier it is to convince the farmers to adopt the technology. In the study area the minimum and maximum honey yield per annum for improved box hive is 8 and 64 kg, respectively. The mean annual honey yield is 27 kg. It is above the national honey yield average, which is about 20–25 kg/hive per annum. The price of one kg pure honey was ETB 35 at farm gate and ETB 50 at nearby regional town. Hence, a beekeeper could get ETB 945–1350 gross benefit per hive/annum.

The partial budgeting reveals that adoption of improved box hive does result in additional income to the extent of ETB 489.11 in the study area (Table 3), the income being almost three times what one would get from the traditional hive. Melaku (2005) using partial budgeting analysis also concluded that both the homemade and institutionally made Kenya Top Bar Hive (KTBH) were beneficial and remunerative. As noted by the author, movable top bar hives result in higher net return per colony compared with traditional hives. The national average of KTBH is 10–15 kg crude honey/hive per annum, which is below the national average of improved box hive (20–25 kg pure honey/annum). Comparison of KTBH with improved box hive was not included in this analysis, as the KTBH were not used in the study area.

Table 3. *Partial budget for improved box hive and traditional hive (n = 45)*

Additional cost (ETB)*	Improved box hive	Traditional hive	Additional return (ETB)	Improved box hive	Traditional hive
Transport	12.55	–	Honey yield	945	250
Accessories service charge					
Interest on loan	19	–	Total return	945	250
Feed cost	23.65	0.26			
Pure beeswax	26.5	8.70			
Labour cost	123.15	—			
Total cost	15	5			
	219.85	13.96			

Net income from improved box hive (945 – 219.85) = ETB 725.15.
Net income from traditional hive (250 – 13.96) = ETB 236.04.
Incremental net benefit per improved box hive (net income of improved minus net income of traditional = 725.15 – 236.04) = ETB 489.11.
* Ethiopian birr (ETB). In April 2008, USD 1 = ETB 9.4916.

Observation and discussions with beekeeper farmers revealed that they were using only one super, while they received two supers. Hence, there is an opportunity to reduce the price of the hive if the beekeepers are provided with one super instead of two supers. Currently, the hive stand of box hive is made up of metal, which also increases the cost of the hive. This can also be made from locally available materials. With the reduction in cost of these two items, the price of the hive can be reduced.

3.5 Major constraints of beekeeping in the study area

Group discussions were held with representative respondents including adopters and non-adopters as a part of the study, with the objective of identifying the existing

constraints limiting development of beekeeping subsector. The participants identified and prioritized 10 major constraints (Table 4).

Table 4. *Ranking of beekeeping constraints in the study area*

Constraints	Frequency	Rank
Drought	41	1
Absconding of honeybees	39	2
Diseases and pests	15	3
Lack of beekeeping material	10	4
Death of colony	6	5
Lack of adequate extension support	5	6
Marketing problem	4	7
Shortage of bee forage	3	8
Lack of adequate beekeeping skill	2	9
Reduction of honeybee colony	1	10

Drought is considered to be the primary constraint in beekeeping in the study area. It affects the feed sources (bee forage and water) adversely. IPMS (2005) documented that the major source of feed is from the natural forest (about 70% of the requirement) and the rest is from home prepared pulse flour and sugar. Another problem mentioned is that of 'imodia' (rust) which affects the flower, as a result of which the honeybee cannot get nectar and pollen. As a consequence, the honeybee colony absconds to areas where resources are available for their survival. The prevalence of diseases and pests (ant and wax moth) also forces the colonies to abscond.

In order to enable safety, protective materials such as veil, glove and smoker are essential for the beekeepers. In the study area, though the dissemination of improved hives was encouraging, in most cases they were not accompanied by these protective materials.

Death of colonies was reported from Michael-Emba peasant association. As confirmed during group discussion, this was due to the draining of chemicals used in the animal health centre of the peasant association into the water source of the area, from which honeybees consume the water.

4 Conclusion and recommendations

In Atsbi Wemberta *woreda*, there are about 16,915 honeybee colonies and 5716 improved box hives. Improved box hive coverage is 33.8%, which is way above the national improved box hive coverage of about 1%. The price of one honeybee colony is ETB 550 in the study area. Pure and crude honey costs ETB 35 and 25 per kg, respectively. The logit model revealed that use of credit, knowledge, educational level of household head, positive perception and apiary visit positively and significantly influenced the adoption of improved box hive in the study area. On the other hand, age, family size, extension contact, beekeeping training and market availability did not significantly influence adoption of improved box hive.

Partial budgeting analysis revealed that the beekeepers benefit from additional income by adopting improved box hive. The net benefit from improved box hives exceeds the benefit from traditional hive by more than double. Improved beekeeping practice is profitable for beekeepers in all areas and needs more popularization of the technology. It is, however, important to note that training in improved beekeeping to develop required skills is very essential to capture these potential benefits.

Major problems of beekeeping identified and prioritized in the study area were: drought, pests and diseases of honeybees, lack of beekeeping materials, death of colony, lack of adequate extension support, marketing problem, shortage of bee forage, lack of adequate beekeeping skill and reduction of honeybee colonies.

Both economic and non-economic factors affect the adoption of improved box hive. Hence, for effective utilization of the technology, both factors need equal consideration by policymakers and organizations involved in beekeeping development. In other words, providing the necessary exposure and skills; and institutional support in the form of credit, technology and, market linkages need to be addressed simultaneously.

Participatory value chain based approach: All the problems faced by beekeepers cannot be addressed by a single organization. Various actors (including research, extension, decision-makers, input suppliers, credit agencies and those along the value chain) need to collaborate in search of appropriate solutions and implement them. Following a participatory value chain based approach would go a long way in the efficient development of the subsector. Formation of formal or informal actor-alliances with a specific objective will be a useful mechanism to do this. The extension service should take the lead in creating necessary linkages and forming such alliances.

Utilization of beeswax: Currently, the beekeepers in the study area are using only honey and honeybee colonies for income generation. However, other hive products particularly beeswax which is important for foundation sheet making is not yet utilized in the area. Therefore, beekeeping extension, NGOs and private sectors can make efforts to promote the utilization of the beeswax produced through provision of training on collection of the crude beeswax and extraction. This will enhance the income from the enterprise.

Management strategies: Absconding of colonies is the common problem faced by beekeepers in the area, mainly caused due to feed scarcity, honeybee enemies attacking honeybees as well as the products, and indiscriminate agrochemical application. Beekeeping extension, NGOs and private sector should focus efforts on skills development in managing bee colonies including improved feeding practice and growing more bee forage. Particularly, promoting ant protection methods using cone shaped metal sheet, cone shaped used inner tube of rubber and used engine oil is urgently required to overcome the existing ant problems in the study area.

Availability of institutional credit strongly influences the adoption of improved box hives, due to the high cost of the box hive and the colony. Even though credit was available, non-adopters resisted taking any loans due to the high prevalence of honeybees absconding. There is an urgent need to develop the skill of beekeepers on the management of absconding through organizing practical and hands-on beekeeping training, which will facilitate developing confidence in the technology.

The research and development organizations should identify and document the existing indigenous technical knowledge of beekeepers to integrate it optimally into improved beekeeping practices.

Promoting private entrepreneurs to provide additional services for value addition: Provision of foundation sheet at the same time for the base and super of the hive decreases the acceptance of the hive by the honeybees. Hence, foundation sheet should be made for super while adding a box (supering). Casting mold management at district level is not an efficient way to provide fresh foundation sheet to the beekeepers. The District Agricultural and Rural Development Office has to decentralize its management at PAs level. ARD can organize landless youths into groups in each PA and they can provide foundation sheet and honey extraction service at reasonable price to beekeepers. In this way, the landless youths can generate income for themselves, while providing essential services to the beekeeper farmers. The group can also engage in honey and crude wax collection. Credit institutions should be motivated to provide loans to these groups towards initial working capital and equipment.

Integrating with water harvesting: Drought is one of the major problems in beekeeping development of the area. To overcome the problem, it is crucial to integrate beekeeping activities with water harvesting to secure their livelihood. The research organizations should select moisture stress tolerant perennial bee forage suitable to the area and promote them widely in collaboration with beekeeping extension, NGOs, and the private sector. Similarly, the existing indigenous bee forages such as in 'gribiya' (*Hypostus ariculata*) and 'tebeb' (*Basium clandiforbium*) etc., which flower even in the summer season should be promoted and also grown in area enclosures.

Modifying box-hives to reduce costs: Farmers were using only one super, while two are generally provided. Reducing the number to one will significantly reduce the initial cost and make it more affordable and therefore attractive to the beekeeper farmers. The possibilities of substituting the metallic hive stand with one made from locally available materials can also be explored in order to reduce the cost. If this accelerates adoption, the quality and yield of honey will improve and there will be enough volume to supply the newly developing market through the private processing company.

Promoting farmer-to-farmer knowledge sharing: Opportunities to visit other farmers' apiaries were found to significantly influence adoption of improved box hive through developing a positive perception and trust in the technology. This is an effective extension method, but requiring additional resources. Extension strategies need to be rethought to design ways of incorporating such effective methods (including field days) while efficiently utilizing available resources. This requires development agents who are competent, knowledgeable and who understand the significance of farmer-to-farmer exchange. In addition to the farmers, DAs also need in-service training on improved beekeeping practices to develop practical knowledge of the technology.

Farmer groups to create learning environment: Cooperative office of the district ARD and NGOs need to come together to strengthen the existing beekeepers cooperative as they can provide a good learning environment for similar areas. Organizing them to operate in enclosure areas has multiple advantages, i.e. apiary can be established in the area and they can also protect and conserve it by planting different bee forages.

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