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Profitability Analysis and Adoption of Improved Box Hive Technology by Small holder Beekeepers: The Case of Bule Hora Woreda, West Guji Zone of Oromia Regional State, Ethiopia

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***Abstract*— *Beekeeping is common and one of the agricultural activities used as good source of off-farm income to farmers in Ethiopia in generally, and particularly in the study area. The objectives of the study are to identify determinant of adoption of improved box hive technology and profitability of smallholder farmers in study area. Multi-stage sampling was employed to identify sample respondents. The sample respondents were stratified into adopters and non-adopters of improved box hive. Out of 148 total sample respondents 30 adopters and 118 non-adopters were identified. The data were collected using structured interview schedule, key informant discussion and observation. Partial budgeting technique and econometric models were employed. Partial budgeting result reveals that the beekeepers get financial benefits by adopting improved box hive. The first hurdle result of adoption decision indicated that beekeeping experience, distance to woreda town, frequency of extension contact, sex, age, education status, access to input were significant factors. Further, the second hurdle result of intensity of adoption revealed that frequency of extension contact, livestock holding, age, sex, access to input, family size and labor force were found to be significant factors. Thus, the woreda office of agriculture and rural developments, NGO's and concerned stockholders should give due attention to these significant variables in the study area to boost improved box hive adoption and its intensity use thereby increase profitability of small holder beekeepers.*

***Keywords*— Adoption, Beekeepers, Improved box hive, Profitability, Traditional hive.**

I. INTRODUCTION

Africa is blessed with numerous types of wild honeybee (Adjare, 1990). Ethiopia is home to some of the most diverse flora and fauna in Africa which provide surplus nectar and pollen to foraging bees (Chala, *etal.*,2012). Suitability of natural environment and climatic condition of Ethiopia, allow the country to sustain large honeybee colonies, which are estimated to be about 10 million (Workeneh, 2007).

Ethiopia is the largest honey producer at 24,000 tons per annum accounting for 24% of the African and2.1 % of the world production, is the leading honey producer in Africa and is one of the ten largest producers in the world (Greiling, 2001). Oromia region produces about 41% of total honey produced by the country, followed by SNNPR and Amhara regions with a respective share of 22% and 21% (SNV, 2005).

Beekeeping is common and one of the agricultural activities used as good source of off-farm income to farmers in Ethiopia. It is eco friendly and does not compete for scarce land resources, (Melaku, 2005). Furthermore it is an important integral part of the economic activity that created job opportunity to more than 2 million people (CSA, 2011). Additionally it supports the national economy through foreign exchange earnings.

Even though the long tradition of beekeeping, high bee density in Ethiopia, the share of the sub-sector in the GDP has never been proportionate with the huge numbers of honeybee colonies and the country's potentiality for beekeeping. Productivity is still low and relatively low export earnings. Improved box hives have been introduced and promoted in the country for the last 50 years. However, there was no adequate study on its adoption determinants. In spite

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of its contribution in the smallholder households' income in particular and nation's economy in general, it is very traditional that the production, productivity and quality of hive produces have been low. It results low contribution of the sub-sector, which harms profits to beekeepers (Belets, 2012). Thus, the beekeepers in particular and the country in general are not benefiting from the sub sector (Nuru, 2002; Beyene and David, 2007).

The study area is one of the potential districts of Oromia region where beekeeping activity practiced by small holder farmers. Majority of beekeepers hang the traditional hive over the long trees which are very difficult for management and harvesting. In earlier, some researches were done to asses honey production and identify the constraints of sub-sector in the study area. However, studies that are aimed to identify the determinants of the technology adoption, socioeconomic and socio psychological factors influencing adoption of beekeeping technology was not exist. Furthermore, there had not been study to assess profitability of improved box hives technology as incentives to generating income for small holder farmers in the study area.

Therefore, the study was very helpful to decision maker and particularly to beekeepers, and extension agents who are responsible to offer technological alternatives appropriate to the goals and resources of the beekeepers in the study area.

The overall objective of this study is to analyze the profitability and determinant of adoption of improved box hive technology with the following specific objectives.

1. To identify the determinants of adoption decision and intensity of use of improved box hive technology by the smallholder beekeepers in the study area.
2. To assess the profitability of improved box hive technology over the traditional beehive in the study area.

II. RESEARCH METHODOLOGY

2.1 Description of the Study Area

Bule Hora *woreda* is one of the ten *woreda* of West Guji zone, Oromia regional states. The *woreda* has thirty five rural kebeles and five urban kebeles. The total area of the *Woreda* is about 420,754 hectares, of which 34,710(8%), 206,385(49%), 43,620(10%) hectares are forest land, cultivated, and grass land respectively. It receives an annual rainfall ranging from750-1500mm and the annual mean temperature ranges between15-25℃. The altitudes of the *Woreda* range between 500 and 2200 meters above sea level.

It consist 25 percent, 60 percent and 15 percent Dega, Weyenadega and Kola agro ecologies, respectively. The total population of the *woreda* is 265877; the male and female accounted for 131,039 (49%) and 134,838 (51%), respectively and 40,209 total household head; 39,026 (97%) and 1,183(3%) male and female household headed respectively (BHWoARD, 2017).

Agriculture is the economic mainstay of the people. Different crop types are cultivated in the *woreda*. Since some kebeles of the *woreda* are semi- pastoralists, livestock population of the area is very high. Beekeeping is an important old traditional agricultural practice in the study area. Traditional beekeeping method are mainly dominates in the study area. Moreover majority of farmers keeping their bees hanging on trees near homestead and their farm and in the forest located at the study area.

2.2 Sampling technique and procedure

For this study purposive multi-stage sampling procedure was used to select sample smallholder beekeepers for the interview. Bule Hora *woreda* was selected purposively based on the honeybee production potential. Out of forty kebeles of *woreda*, beekeeping activities were practiced in thirty-five of them. From those four kebele namely Kuya, Oda Muda, Burka Ebala, and Bule Kagna were randomly selected. Among four selected kebeles, all beekeepers were purposively selected and stratified into adopters and non-adopters of improved box hives sub-groups.

Based on the information's from respective Development Agents list of beekeepers from each kebeles was prepared for the targeted kebeles. Hence, from total 2792 beekeeper's population, 148 samples (118 non-adopters and 30 adopters) were selected randomly based on the probability proportional to size sampling technique from the selected kebeles.

2.3 Data Types, Sources and Method of Data Collection

Qualitative and quantitative data types were utilized for this study. Structured interview schedule was prepared and pre-tested to include all quantitative data on beekeeping system, general view of the respondents on the technology and management practices of their apiary.

Primary and secondary data sources were used for this study. Primary data was obtained from sample respondents through interview method, interviewing key informants and extension workers of the *woreda*. Secondary data was obtained from various sources such as reports of MoA at different levels, CSA, *Woreda* Administrative Office, NGOs, research publications, Internet and books, journals, other published and unpublished materials, which were found to be relevant to the study. For measuring profitability, the data such as price of improved box hive, bees–wax and accessories was collected from the *woreda* ARD office. Honey yield price,

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feed cost, Labor cost and traditional hive cost is taken from sample respondents.

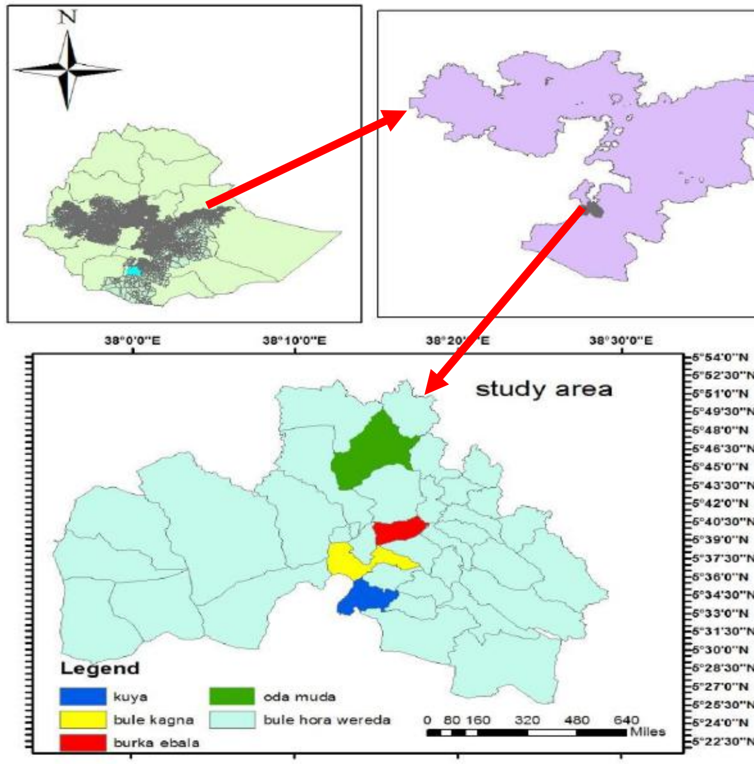

Fig.1: map of the study area

2.4 Method of Data Analysis

2.4.1 Profitability analysis

For the profitability analysis, comparison of the net return gained from traditional hive and improved box hive was prepared in per hive basis. Besides data for different cost items, their cash outlay, service period was collected for each individual that are using the different types of hives to come up for the total cost for the activities. Similarly the yield from traditional and improved box hive was taken in a similar fashion to arrive at the total revenue generated for the activities. Accordingly, partial budgeting was employed to identify profits of adopting improved box hive. To derive the net benefit of the alternative activities the total cost was subtracted from the total benefit. Finally if the net benefit is positive, the activity has economic advantages otherwise, it would be better off to stay using the current situation.

2.4.2 Specification of econometric models

Most adoption studies have used the Tobit model to estimate adoption relationships with limited dependent variables. Adoption and intensity may be different decisions and that estimation of intensity on the basis of factors affecting adoption, as implied by other approaches, may be liable to error (Mignouna, *etal*. 2011). It may be more reasonable to allow the size and nature of the factors that affect the two decisions to be different (Eakins, 2014).

As a result generalizations to the Tobit model have been developed. One generalization which is popular in the literature is the double hurdle model, originally formulated by Cragg (1971), assumes that households make two decisions with regard to purchasing an item, each of which is determined by a different set of explanatory variables. In order to observe a positive level of expenditure, two separate hurdles must be passed. Later, a lot of studies has been extensively applied this econometric model. For instance Hassen (2014), who employed double hurdle in studying factors affecting the adoption and intensity of use of improved forages in North East Highlands of Ethiopia, and Kiyingi, *etal.* (2016),Martey,*etal.* (2014) were among those who have been extensively employed this double hurdle econometric model.

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The double-hurdle model is a parametric generalization of the Tobit model, in which two separate stochastic processes determine the decision to adopt and the level of adoption of technology. The double-hurdle model has an adoption (D) equation:

$$D = \alpha Z_i + U_i \qquad (1)$$

Where *Di* is a dummy variable that takes the value 1 if the farmer adopts improved box hive and zero otherwise, Z is a vector of household characteristics and α is a vector of parameters. The level of adoption (Y) has an equation of the following:

$$Y_i^* = \beta X_i + V_i$$
$$Y_i = Y_i^* \, if \, Y_i^* > 0 \, \& D_i > 0$$
$$Y_i = 0, \, otherwise \qquad (2)$$

Where Yi is the observed variable to be the proportion of improved box hive, X is a vector of the individual's characteristics and β is a vector of parameters. The error terms, Ui and Vi are distributed as follows:

$$\begin{Bmatrix} U_i \sim N(0,1) \\ V_i \sim N(0,\sigma^2) \end{Bmatrix} \qquad (3)$$

Finally, the observed variable Yi in the double-hurdle model is determined by;

$$Y_i = D_i Y_I^* \qquad (4)$$

The log-likelihood function for the double-hurdle model is:

$$Log\ L = \sum_0 \ell n \left[1 - \Phi(\alpha Z_i^{`}) \left(\frac{\beta X_i^{`}}{\sigma}\right)\right] + \sum_+ \ell n \left[\Phi(\alpha Z_i^{`}) \frac{1}{\sigma} \phi \left(\frac{Y_i - \beta X_i^{`}}{\sigma}\right)\right] \qquad (5)$$

Where "0" indicates summation over the zero observations in the sample, while "+" indicates summation over positive observations, and Φ (.) and ϕ (.) are the standard normal cumulative

distribution functions and probability distribution functions, respectively.

Under the assumption of independence between the error terms Vi and Ui, the model (as originally proposed by (Cragg, 1971) is equivalent to a combination of a truncated regression

model and a univariate Probit model. The Tobit model, as presented above, arises if:

$$\lambda = \frac{\beta}{\sigma} \text{ And X = Z.} \qquad (6)$$

A simple test for the double-hurdle model against the Tobit model can be used. Therefore, one simply has to estimate the truncated regression model; the Tobit model and the probit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using (Green, 2000):

$$\Gamma = -2\left[\ln L_T - (\ln L_p + \ln L_{\mathrm{TR}})\right] \sim X_k^2 \qquad (7)$$

Where LT - likelihood for the tobit model; LP - likelihood for the probit model; LTR – likelihood for the truncated regression model, and k is the number of independent variables in the equations. If the test hypothesis is written as H0: $\lambda = \frac{\beta}{\sigma}$ and H1: $\lambda \neq \frac{\beta}{\sigma}$. H0 will be rejected on a pre-specified significance level, if $\Gamma > X_k^2$.

2.5 Hypothesis and Definition of Variables in the Model

2.5.1 Definition of dependent variables

The dependent variables were defined as proportion of improved box hive for tobit model. Whereas adoption decision of improved box hive, taking the value 1 if households adopted and 0 otherwise for the probit(first hurdle); and proportion of improved box hives (the intensity use of box hive) truncated (second hurdle), respectively.

2.5.2. Definition of independent variables

1. Sex of household head (SEX): is dummy variable taking the value 1 for male and 0 otherwise. Male household heads are more likely to adopt than female because they have more access to information. Belets (2012) found that being male household head has positive effect on improved box hive technology adoption. Therefore, it was hypothesized that sex (being male) of household heads has a positive influence on the adoption decision and intensity of use.

2. Age of household head (AGE): is continuous variable that is measured in years. Older farmers have more experience and acquire indigenous knowledge than younger farmers as a result of age based knowledge gained and probably experiences accumulated over years' differences. Hence, have a higher probability of adopting the practice. Benedict (2015) found that age had a positive influence on adoption of beehive technology. Therefore, it was hypothesized to have a positive effect on adoption of improved box hive technology.

3. Educational status of household head (EDUC): This variable was measured by formal years of schooling attended by the respondents. Improved box hive technology utilization involves technical applicability; Bayissa (2014) found that educational status of the household head has a positive relationship with the probability of adoption decision of improved *teff* technologies. Therefore, educational status was hypothesized to have a positive effect on both adoption and intensity of adoption of improved box hive technology.

4. Family size of household (FAMSIZE): It is continuous variable measured in total number of household members. Bunde (2015) found that family size has significant effects on adoption of modern bee keeping technologies. Thus, it

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was expected that family size positively affect adoption of improved box hive technology.

5. Labor force of household (LABOR): is a continuous variable measured in the total number of productive members in a household. Agriculture needs labor as an input in order to perform activities. Tadele (2016) found that Labor availability has positive influence on adoption of improved box hive. Hence, it expected to affect adoption of improved box hive positively.

6. Beekeeping experience (EXP): is continuous variable measured in the number of years respondents engaged in beekeeping activity. Experience helps beekeepers to acquire endogenous knowledge as a result beekeepers are able to recognize the advantage and disadvantage of different beekeeping practices. Endrias (2003) and Bayissa (2014) found that experience has a positive effect on adoption of new technology. Therefore, it was hypothesized that beekeeping experience positively affects adoption decision of improved box hive technology.

7. Farm size (FARSIZE): It is a continuous variable measured in hectares. The study by Bunde (2015) shows no significant relationship on land holding and adoption of modern bee keeping. Thus, it was hypothesized that farm size positively/negatively influenced probability and intensity of adoption of improved box hive technology.

8. Total livestock holding (TLU): It is a continuous variable and refers to the total number of livestock the household own in terms of TLU. It is assumed that household with larger TLU can have a better economic strength and financial position to invest in new technologies than those household with less number of TLU. Jebessa (2008) and Bayissa (2014) confirmed that livestock holding has positive influence on adoption in their respective studies. Therefore, is hypothesized as it may positively influence adoption and intensity use of improved box hive technology.

9. Leadership participation of household head (LEADPT): It is a dummy variable taking a value 1 if the farmer was in a leadership position during the study year, and 0 otherwise. Jebessa (2008) found that leadership position of the household head influences adoption decision positively. Therefore, leadership position was expected to influence adoption and intensity of adoption of improved box hive positively.

10. Frequency of extension contact (FRECONT): is continuous variable refers to the number of contacts with extension agents that the sample farmer made in month. Farmers who have a frequent contact with extension agents are expected to accept and practice new ideas faster than those farmers who made few contacts. Tadele (2016) and Melaku (2005) found that extension contact has a positive effect on adoption of new technologies by exposing farmers to new information and technical skills. It is therefore, hypothesized that frequency of extension contact may positively influence adoption and intensity use of improved box hive.

11. Access to credit service (CRDSERV): is continuous variable measured in amount of credit received and applied for the purpose of beekeeping activities. Use of credit can solve problem of capital shortage for the investment and is expected to enhance adoption of the improved box hive. Belets (2012) found that access to credit positively influence the intensity use of improved box hive. Therefore, it was expected that receiving credit has positive influence on adoption and intensity of use of the improved box hive technology.

12. Other off-farm activity involvement (OFFACT): is dummy variable that takes a value1 for participant of off-farm activities other than beekeeping and 0 otherwise. Participating in off-farm activities enables to earn additional income and more likely to purchase improved inputs. Awotide, *etal*(2014)showed that involvement on off-farm activities positively affected the decision to adopt new agricultural technology. Therefore, thus, household's participation in off-farm activities were expected to affect improved box hive technology adoption positively.

13. Input access (INPACS): It is dummy variable and takes 1 if the accessories are available and 0, otherwise. The availability of the necessary inputs at the right time and place and in the right quantity and quality should be ensured (Ehui *et al.* (2004). Therefore, it was hypothesized that availability of input accessories in the area facilitates adoption of the new technology.

14. Distance from FTC (DISTFTC): is continuous variable measured in kilometer. Thus, as residences of beekeepers are far from FTC, a probability that the visit of extension contact decrease. This would limits beekeepers to gain technical assistance and training offered at FTC. Therefore, it was hypothesized as distance from FTC negatively influence adoption of improved box hive technology.

15. Distance from all-weather roads (DISTROAD): is continuous variable measured in kilometer. This may be due to the fact that as residences of beekeepers are far from all whether roads, there is a probability that the vicinities densely covered by different vegetation's that are sources of honeybee feed. Belets (2012) found that distance to all weather roads positively affect the intensity of use of improved box hive technology. Therefore, distance from all-weather roads expected to positively affect adoption and intensity of use of improved box hive technology.

16. Distance from the *woreda* town (DISTWRT): is continuous variable measured in kilometer. Proximity to the woreda town offers opportunities of low transportation cost for beekeepers to contact with woreda experts. Bayissa (2014) showed that the distance of farmers' residence from the town was negatively associated with improved box hive adoption decision. Therefore, it is expected to influence adoption and intensity use of improved box hive negatively.

III. RESULT AND DISCUTION

3.1. Descriptive Results of the Study

From total of 148 smallholder beekeepers interviewed, 20.27% (30) and 79.7(118) % were adopters and non-adopters, respectively. The entire adopter category owned both traditional and improved box hives. Information sources evidences that remote kebeles have good potential of beekeeping as they do have dense natural forest which contains many species of flora. The mean proportion of improved box hive was 0.2673 and 0.0542 for adopters and entire sample respondents respectively. Whereas the mean number of improved box hives of adopters and entire sample were 4.9 and 0.993 hives respectively. Survey result indicated that number of box hive owned by sampled adopters is 147 with minimum 2 and maximum of 12 box hives.

The survey result shown that total number of beehives owned by entire sample respondents was 4748 (147 improved box and 4601 traditional) hives. Out of the total hive 3002 (111 improved box and2891 traditional) hive is with bee colonies. The mean distribution of beehives with bee colonies for the total respondents was 20.28 (21.711non adopters and 14.667 adopters). The mean difference of beehive with bee colonies holding among two groups was found to be statistically not significant.

In the study area, there is a forest which contains variety of flowering plants considered as sources of bee forage. Particularly, the study area is blessed with *croton macrostachyus (locally, mokkoniisaa)* and *vernonia amygdalina* (locally called *Ebichaa*), coffee tree bee floras, which is essential and main source of nectar and pollen for honey production. Regarding the nature and extent of vegetation coverage of the study area 18.2% of sample beekeepers replied that it was nil. Whereas, 46% and 35.8% were respond that extent of vegetation coverage of the area is moderate and dense respectively.

Honey is harvested in the study area starting from mid-July to half of September each year (the peak period) and harvested from February to beginning of March. In the last year it ranged from one to a maximum of three times. About 83.1% of the beekeepers reported having harvested honey at twice with only 3.38% harvesting three times. Remaining 13.51% of sample beekeepers harvested only one times within a year which depended on the availability of bee forages.

Beekeeping is among the effervescent agricultural enterprises used as source of income for smallholder farmer. Although size of hive holding per household differs, the per hive basis computation between traditional and improved box hive has shown that the users of the improved box hive enjoy relatively better yield. Besides, 70% of adopters acquired honey yield between 101upto 250 in kilograms. The remaining 30% of them were obtained 51 up to 100 kilograms. From no- adopters only 25.4% were harvested between 101 up to 250 kilograms of honey yield. Whereas half of non –adopters harvested honey yield between 51 up to 100 kilogram. The rest 24.57% of them enjoyed 50 kilogram and below. The result realized that even though number of hive make difference, adoption of improved box hive guarantees beekeepers to enjoy better yield.

Further, the result show that majority 55.4% of sample respondent earned less than 5000ETB, 24.324% of them were earn between 5001- 10000ETB, 12.84% of the sample beekeepers earned between 10001-15000ETB, while the remaining 7.43% of respondents earned 15001-20000ETB. This was an indication that beekeeping is an important source of income for the community in the study area. Regarding adopters 80% of them earned more than 5000ETB. Whereas only 35.6% of non- adopters earned above 5000ETB. This result justified that the high revenue made possible for the adopters of improved box hive.

Effective bee colony management requires use of appropriate accessories. It was found that in the study area except the known basic hive tools many of the materials are either non-existent or kept at farmer training center. Relatively improved box hive demands further input accessories than traditional beehive. These includes smoker, bee veil, high boots, glove, overalls, bee brush, water sprayer, queen catcher, decamping knife, honey presser, honey extractor, casting mold and uncapping fork. But most of the interviewed respondents were lacking these accessories.

Lack of this equipment has been a big hindrance to the adoption of improved box hive technology. For traditional method, beekeepers were able to acquire the basic

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accessories to undertake activity which made from local materials. Whereas improved box hive technology, beekeepers needed a modern hive tool which is expensive and rarely exist. In addition it was difficult for beekeepers to prepare them from locally available materials. The evidence from respondents realized that lack beekeeping accessories highly affect adoption of improved box hive technology in the study area.

3.2. Partial budgeting results

The partial budget excludes the fixed costs such as land, bee colony, labor (unskilled) requirement because it is unchanging across practices. Instead it includes the costs that vary across the two practices. All benefits and costs should be calculated using the nearest market prices and input costs. That is, the actual price which the farmer pays for the inputs or receives for the products in 209/10 at the nearby marketplace. Opportunity cost was considered for activities undertaking by beekeepers. Hence, the average honey yield and beeswax, and average selling prices throughout 2009/10 were taken for this study. The same was done for inputs costs and requirements.

Input requirements and their cost were shown in Table 1 below. Bee wax was acquired to prepare combs for improved box hive which requires skilled labor, but bee themselves prepared combs for traditional bee hive. Improved box hive requires improved accessories and skilled labor during honey harvesting but traditional bee hives doesn't. Such difference in input requirements of the two hives resulted in cost difference. As it shown below partial budget contain two columns, representing the two practices. The total costs that vary for both improved and traditional honey production were estimated to be 477.05 Birr/hive and 76.895Birr/hive, respectively.

Table 1: Average input requirements and costs of both traditional and improved production practice.

Activity	Traditional bee hive	Improved box hive
Labor for combs preparation (MD hive-1)	-	1
Wage rate for comb preparation (Birr)	-	60
Labor cost for combs preparation (Birr) (A)	-	60
Labor for harvesting (MD hive-1)	1.5	2
Wage rate for harvesting (Birr)	40	60
Labor cost for harvesting (Birr) (B)	60	120
Labor cost (ETB) (A+B)	60	180
Beeswax for comb making (kg hive-1)	-	1
Beeswax price (Birr)	-	60
Beeswax cost (Birr)(C)	-	60
Feed (kg hive-1)	-	2
Feed price (Birr)	-	32
Feed cost (Birr)(D)	-	64

Source: own survey output, 2018

The higher the yield obtained from the introduced technology encourages the farmers to adopt that technology. Accordingly, the result shown that the traditional hive yields on average 10.997kg /hive /year with its average selling price of 83.97birr/kg, whereas improved box hive yields on average 24.167kg/hive/year with its average selling price 98.167birr/kg. The results shows average yield and honey price of improved box hive is greater than that of traditional hive.

The net benefit from the traditional and improved box hive was 905.925Birr/hive, 1913.45 Birr/hive respectively. It revealed that adoption of improved box hive result in additional income to the extent of 1007.525 Birr in the study area. The income being more than two times that obtained from the traditional hive. Belets (2012) using partial budgeting analysis concluded that the net benefit of box hive was more than two times higher than that of traditional beehives.

However, net benefits are not the same thing as profit, because the partial budget excludes the fixed costs which are not relevant to this particular decision. Looking for higher net benefits beekeepers would choose to adopt improved box hive. But the choice is not obvious, because farmers will also want to consider the increase in costs. Therefore, marginal analysis is required to compare those two practices.

Table 2: Partial budget for improved box hive and traditional hive

Items	Traditional bee hive	Improved box hive
Incomes		
Average honey yield (kg hive-1)	10.997	24.167
Average honey selling price (Birr kg-1)	83.97	98.167
Average beeswax yield (kg hive-1)	0.99	0.3
Average beeswax price (Birr kg-1)	60	60
Gross benefit (Birr hive-1) (E)	982.82	2390.5
Input cost		
Labor cost (Birr hive-1)	60	180
Feed cost (Birr hive-1)	-	64
Beeswax cost (Birr hive-1)	-	60
Accessories charged (Birr hive-1)	-	18
Transport cost (Birr hive-1)	-	10
Interest on variable costs (Birr hive-1)	4.5	24.9
Interest on fixed costs (Birr hive-1)	4.133	66.75
Depreciation of beehive	8.26	53.4
Total costs that vary (Birr hive-1) (F)	76.895	477.05
Net benefit (Birr hive-1) (E-F)	905.925	1913.45
Marginal benefit (Birr)	1007.525	
Marginal cost (Birr)l	400.155	
Marginal rate of return MRR	2.518	

Source: own survey output, 2018

If the small farmers were to adopt box hive, it would require an extra investment of (400.15birr), which is the cost difference between two practices (477.05birr-76.89birr). This difference can then be compared to the gain in net benefits, which is1007.53birr/hive (1913.45-905.93) birr. In changing from traditional bee hive practice to improved box hive the small farmers must make an extra investment of 400.15birr.
Furthermore, the marginal analysis for the alternative practices is calculated using the marginal rates of return as marginal benefit divided by marginal cost to decide which practice is suitable to beekeepers. Accordingly, the marginal rate of return is 2.518birr (251.8%). Therefore, for each 1 Birr/hive on average invested in improved box hive, beekeepers recover their 1 Birr, plus an extra 2.518birr in net benefits. This implies that adoption of improved box hive makes higher marginal benefit than traditional beehive.

3.3. Results of the Econometric Model

A simple test for the double hurdle model against the Tobit model can be used. Based on the log-likelihood values of the two models estimated, the LR-test results suggest the rejection of the tobit model. That is, the test statistic Γ = exceeds the critical value of the χ2distribution (Table 3). Rejection of the tobit model implies the observation of zero level of adoption can no longer be considered as corner solution and one can proceed to probit and truncation model.

Table 3: Test of double-hurdle model versus tobit model

Indicator	Tobit, 0≤Y≤1	Probit, D	Truncated Regression, (Y>0)
LOG-L	2.22	-16.46	47.8
Number of observation (N)	148	148	30
Double-hurdle versus Tobit test statistic: $\Gamma = 58.24 > \boldsymbol{X^2_{0.01,16}} = 30.58$			

Source: model log-L calculations 2018.

The parameter estimates of the Probit and truncated regression models are presented in Table (4). The probit and truncated regression model fits the data reasonably well. The probit Wald chi2 (15) = 64.73, Prob. > chi2 = 0.0000, and for

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truncated regression Wald chi2 (15) = 193.49, Prob. > chi2 = 0.0000 is highly significant at the 1% level, show that the model has good explanatory power. This indicates the explanatory power of the factors included in the model is satisfactory.

Table 4: Econometric model results for the probability of adoption and intensity of use improved box hive technology

Variables	Independent Double Hurdle Model				
	Probit model result			Truncated regression result	
	Coefficient	Robust Std. Err.	Marginal effect	Coefficient	Robust Std. Err.
SEX	-1.631376**	.7563794	-.1066562	-.2263372***	.0669754
AGE	.1656101**	.0642536	.0108273	-.0071247**	.0032006
EDUC	.8751047***	.2276296	.0572127	-.0082576	.0212793
LEADP	.0524049	.3958261	.0034261	.0020936	.026923
FAMSZE	.1267598	.0926221	.0082873	.0155514*	.0086956
OFFRACT	.172809	.3818061	.0112979	-.0218083	.0287823
LABFORC	-.5157303	.3297863	-.0337175	.1010104***	.0361978
FARMSZE	-.1506449	.111545	-.0098489	.0188329	.0159808
TLU	.060589	.0601451	.0039612	.0080611***	.0030116
BEKPEXP	-.1504107**	.0723624	-.0098336	.005036	.0033094
INPUTACS	1.175198*	.6872856	.0768322	.1057464***	.0325044
DISTTWN	-.6067825***	.1854652	-.0396703	-.0022117	.0052725
DISTWRD	-.4819801	.4024766	-.0315109	-.0058919	.0168866
EXCONT	1.357737***	.4537768	.0887662	.0724374***	.0186629
DISTFTC	.0569326	.3105	.0037221	-.0195621	.018586
_cons	-1.37634	2.011902		.6226365	.1547071
/sigma				.0494248	.0062512
Number of obs. = 148 Log- L = -16.457541 Wald chi2 (15) = 64.73 Prob. > chi2 = 0.0000 Pseudo R2 = 0.7794				Number of obs = 30 Log- L = 47.794441 Wald chi2 (15) = 193.49 Prob. > chi2 = 0.0000 Limit: lower = 0, upper = +inf	

Significant *at 10%, ** at 5% and *** at 1% probability level

Results of the analyses indicate adoption and intensity of use of improved box hive were influenced by different factors at different levels of significance. Sex of household head is found to be one of the factors influencing adoption of improved box hive technologies and its intensity use negatively at 5% and 1% probability level, respectively. The result show that being female household head increase adoption of improved box hive by 10.6%, ceteris paribus. Adoption of improved box hive is higher among female headed than their counter parts. Thus, it rationalize that traditional way of beekeeping, especially by hanging hive over the long tree practiced in the study area is very difficult for management and harvesting. This is not convenient for female headed farmers. These propel female headed beekeepers to adopt improved box hive technology.

For intensity use the obtained result suggests that, being female headed household are more likely to intensify improved box hive than their counter parts and it increase intensity by 0.22, ceteris paribus. The difficulties of traditional beekeeping are relatively susceptible to the female headed household. As a result female headed household use improved box hive as a preeminent alternative. The result of this study is in agreement with finding of (Awotide, *etal*. 2014) who has reported negative sign of sex with adoption of agricultural technology in south-eastern Nigeria.

Age of the farmer household head was passes both hurdles and positively affected the decision to adopt at 5% significant level, but negatively affected intensity of use of improved box hive at 5% significant level. The result indicates as the age of the household increases by one year, the probability of adoption of improved box hive increases by 1.08 percent.

The justification is that as age increase the beekeepers expand their awareness and understand the benefits of modern beekeeping method. The result is consistent with the findings of (Hassen, 2014).

However, age is negatively significant in the intensity use of improved box hive at 5 % significant level. As age increase by one year intensity of use of improved box hive decrease by 0.0071 ceteris paribus. This indicates that aged farmers are most likely to have a lower level of improved box hive because of risk averting nature of older farmers were more conservative than the younger farmers. The result is consistent with the findings of (Asmiro,*etal*. 2017).

Educational status of household head has a positive effect at 1%probability level with the adoption of improved box hive. The result indicated that, other variable being constant, an increase in years of schooling increases the probability of adoption by 5.72%. This suggests that farmers with higher educational background would have better opportunity to access information and can easily understand the benefit of improved box hive and apply the technologies as per the recommendation. This result supports the findings of (Workineh, *etal.*2008)

The estimated coefficient result for beekeeping experience was found to be significant with unexpected negative sign in adoption decision at 5% probability level. As beekeeping experience increase by one year adoption decision decrease by 0.98%, ceteris paribus. Experience beekeepers' acquired is mostly traditional. Thus, more experienced beekeepers in traditional method might be reluctant to accept new ideas and adopt new technologies than less traditionally experienced beekeepers. This result is in agreement with the findings of (Belets, 2012).

As expected, access to inputs positively influenced adoption and intensity of use of improved box hive at 10% and 1% probability level. As the beekeepers come to be access input, adoption of improved box hive increased by 7.68%. The result realized that availability of input is a necessary condition for the adoption of improved box hive. Moreover, access to inputs increase intensity use of improved box hive by 0.1057%. Our possible explanation is that availability of input in the local area eases the households to purchase and use improved box hive in their field. This result supports the findings of researches on technology adoption by (Raju, *etal*. 2015).

Frequency of extension contact shows significant effect with expected positive sign in adoption decision and intensity use of improved box hive at 1% probability level for both first and second hurdle. The result indicates that increase a visit of farmer's contact with extension agents per month increase the probability of adoption by 8.87%, intensity of use of improved box hive by 0.0724, ceteris paribus, underlining the importance of extension contact in operation of new technology. This result is well-matched with the findings of Endrias (2003);Melaku (2005).

Livestock holding has positive and significant influence on intensity of use of improved box hive at 1% probability level. As the farmer increases livestock holding by one TLU the intensity use of improved box hive increased by 0.008%, being other variable constant. The results justify that farmer hold high TLU can earn more cash-income that might enable them to intensify improved box hive. This finding is in agreement with findings of Wongelu (2014).

The distance of beekeepers residence from woreda town has a negative influence on the intensity of use of improved box hive at 1 % probability level. The result indicates as the farmers' residence from the woreda town far by one kilometer, intensity of use of improved box hive decreased by 0.0396, ceteris paribus. This implies farmers who are far from woreda town did not easily contact with woreda bee experts to access technical support and modern inputs. This may turns to reduce farmers' intensity of use of box hive. The result is consistent with the findings of Shiyani *etal*. (2000);Hassen (2014).

The variable labor force availability has a positive effect on the intensity of use of improved box hive at 1%probability level. As labor availability increase by one man equivalent unit, intensity of use of improved box hive increase by 0.101%, ceteris paribus. These indicates that household with high labor availability are more likely to intensify use of improved box hive. This result is in agreement with findings of Abreham, *et al*. (2012). Family size variable also positively affects the intensity of use of improved box hive technology at 10% probability level. The obtained results suggest that large family size households are more likely to reduce family labor cost and used as labor source. The result is consistent with the findings ofMignouna, *etal.* (2011).

IV. CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study the following points are considered by Governmental and Non-governmental Organizations as essential areas of intervention to utilize the technology effectively and efficiently. Concerning profitability analysis, as partial budgeting result revealed that improved box hive is profitable over traditional beehive; attention should be given for every smallholder farmer to adopt and intensify improved box hive technology, and thereby improve their livelihood.

The findings of this study indicated that frequency of extension contact was the most significant institutional service affects adoption and increased the use of improved box hives. The positive effect of this factor is an indication that frequent follow-up by the extension agents should be given to reach the technology to every smallholder beekeeper and to increase the number of improved box hive by adopters. Accordingly, it is crucial to offer in-service training on improved beekeeping practices to DAs which, in turn, help them to develop practical knowledge of the technology. The other means of popularizing the technology is use field days to be organized on the farmers' field to increase the awareness level of the beekeepers along with practical knowledge of improved beekeeping technology. This, in turn, helps the beekeepers to develop positive view of the technology.

Education status of households head was found to be positively influenced adoption decision of improved box hive. The educated beekeepers can easily understand the basic management practices of beekeeping and they also know the advantage that is obtained from improved beekeeping by comparing with traditional. Thus, it is appropriate for research, DA's and NGOs to target them during improved box hive technology promotion as they can easily understand about the technology which, in turn, helps for convincing the others to adopt the technology.

The result indicates age of the household head was positively affect adoption of improved box hive technology. However, it was found that negative effect on intensity use of improved box hive. The result realized that the assumption of risk aversion behavior of aged farmers, it is uncertain for aged farmers to increase the intensity of use of improved box hive. Thus, targeting young farmers for intervention of improved box hive intensification is probably advisable.

Furthermore, beekeeping experience negatively affected adoption decision of farmers. This made older beekeepers less responsive to the technology adoption. Thus, more attention must be given to less traditionally experienced beekeepers for rapid adoption decision of improved box hive and great effort should be made by the concerned bodies to traditionally experienced beekeepers to utilize new ideas during experience sharing sessions with young beekeepers.

The result shows that access to input significantly and positively influenced both adoption decision and intensity use of improved box hive. Lack of input accessories makes operating the improved box hive difficult. Hence, availing these accessories or training the beekeepers on how to make these accessories should get attention while promoting the improved box hive technology. Accordingly, collaboration among the OoARD of woreda and extension agents was recommended to make channel between beekeepers and input provisionary.

As the livestock holding was considered as a proxy for farmers' wealth status, wealthy status farmers can earn more cash-income that might enable them to intensify improved box hive technology. Hence, efforts should be made to improve apiculture sub-sector through promoting livestock sub-sector. Further, the result suggested that distance from *woreda* town was negatively influenced adoption improved box hive technology. In fact, as farmer residents far from woreda town, transportation cost would be increased. Therefore, strengthening good rural-urban road network, and developing infrastructure and transportation availability is recommended.

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