

Adoption of Jimma Horizontal Modern Beehive: The Case of Jimma and Ilubabor Zone

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Abstract
The main objective of this study is to analyze factors that influence the adoption of Jimma Horizontal Modern beehive (JHMB) and it attempts to fill the existing knowledge gap. The specific objectives are to identify determinants that influencing adoption JHMB in the study area and to quantify the relative importance of the various factors associated with adoption of technology in the study area. Multi-stage sampling technique was employed to identify the sample respondents. The sample respondents were categorized into adopters and non-adopters of JHMB. Based on probability proportional to size 160 adopters and 120 non-adopters were identified. The data were collected using structured interview schedule, group FGD, KII, observation and were analyzed using descriptive statistics, and logit model. The binary logit model reveals that education level of household head, beekeeping experience, extension contact, apiary visit, perception, credit, were positively and significantly influencing adoption of JHMB, whereas age, sex, family size, land holding, livestock holding, market availability, and availability of accessories were not significantly influencing adoption of JHMB. Though different organizations strive to disseminate JHMB, the adopters are not comparable with efforts have been excreted, and this might have different reasons such as institutional, socioeconomic and biophysical. Such information's might be different from according the circumstances in which the farmers are living and working, and still no information has been generated on socioeconomic, institutional and biophysical determinants of adoption of JHMB in study area. The overall finding of the study underlined the importance of institutional support in the areas of availing beekeeping accessories, bee forage and improving beekeepers' perception on the technology to enhance adoption of JHMB. Therefore, agricultural policy and development interventions should be given emphasis to the improvement of such institutional support.
Key terms: adoption, horizontal beehive, logit, honey production
DOI: 10.7176/JESD/13-9-01
Publication date: May 31st 2022

INTRODUCTION

Most of the developing economies are characterized, inter alias, by heavy dependence on agricultural sector, traditional type of farm practices, higher labor to capital ratio, low adoption rate of technology and farm inputs, poor infrastructure facilities including roads, transport, marketing, etc. and low farm productivity.

Similarly, traditional technology, low production and high risk due to adversely changing environmental conditions characterize Ethiopia's agriculture. Its development is limited by institutional, economic and physical factors. Furthermore, imbalance between the population growth rate and agricultural production growth rate is one of the highly pronounced national problems (World Bank, 2011).Many researchers and economic analysts are concerned about the potentials created by new technologies in developing countries and the implications of agricultural development policies and programs in meeting the socio-economic goals of these countries.

For instance, Arnon (1981) noted that subsistence farmers have not yet been able to benefit fully or partly from the fruits of technological innovations because of different factors hindering the adoption of farm technologies. The major challenge facing most of developing countries such as Ethiopia is improving rural as well as urban income and to stimulate underlying income system development. There is an ever-increasing concern that it is becoming more and more difficult to achieve and sustain the needed increase in agricultural production based on intensification, because there are limited opportunities for area expansion.

In Ethiopia, adoption of improved agricultural technologies has been a long-term concern of agricultural experts, policy makers, and agricultural research and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country are very low (Kebede et al., 2004).

The adoption of agricultural innovation in developing countries attracts considerable attention because it can provide the basis for increasing production and income. Small-scale farmers' decisions to adopt or not adopt agricultural technologies depend on their objectives and constraints as well as cost and benefit accruing to it (Million and Belay, 2004). Hence, farmers will adopt only technologies that suit to their needs.

Jimma, Ilubabor and Bunno Bedelle zones are one of the Oromia regional state's zones with high potential of honey and bees wax production and one of the Zones where there was dissemination of Jimma Horizontal Modern Beehives on cash and credit basis from JAERC. However, there is no adequate information on the adoption status and determinant factors such as socioeconomic, economic and socio-psychological factors of the adoption for this technology. Therefore, the socioeconomics, demographic and other technical factors that affect adoption and utilization of this technology has to be identified and this research proposal will initiated for this reason.

With this understanding Jimma Horizontal Modern Beehive was introduced in 2001 to improve farmers' income status in the study area. Currently Jimma Horizontal Modern beehive is distributed to different districts of the zones. However, factors influencing adoption and the impact that has come due to the introduction of the technology was not systematically and empirically studied and documented in the study area. This lacuna has created an information gap.

Therefore, this study will proposed to analyze factors that influence the adoption of Jimma Horizontal Modern beehive and it attempts to fill the existing knowledge gap.

Objectives

- To identify determinants that influencing adoption Jimma horizontal modern beehive in the study area.
- To quantify the relative importance of the various factors associated with adoption of Jimma horizontal modern beehive in the study area
- To assess the impacts of horizontal beehive adoption on income level of farmers.

METHODOLOGY

Description of Study Areas

The Mettu district lies in the south-western part of Oromia regional state occupying an area of 24,389 square m^2kilometers (km^2). The region falls within the equatorial monsoon belt, which is characterized by two main seasons, wet and dry. The wet season is associated with a double maxima rainfall regime from June to September (mean annual rainfall = 1,270 mm) and January toApril (mean annual rainfall = 1,778 mm). The district is well endowed with rivers and wet land. Rain-fed agriculture is predominantly practiced, and is associated with the cultivation of major staples such as maize, Teff, Coffee, Fruit and Vegetables.

Gera district is one of the woredas in the Oromia Region. It is part of the Jimma Zone, Gera is bordered on the south by the Gojeb River which separates it from the SNNPR, on the northwest by Sigmo, on the north by Setema, on the northeast by Gomma, and on the east by Seka Chekorsa. The administrative center of this woreda is Chira; other towns in Gera include Cheriko and Dusta.

The altitude of this woreda ranges from 1390 to 2980 meters above sea level, A survey of the land in this woreda shows that 26.5% is arable or cultivable (23.4% was under annual crops), 7.0% pasture, 56.6% forest, and the remaining 9.9% is considered degraded, built-up or otherwise unusable. Spices, corn and Teff are important cash crops. Coffee is an important cash crop of this woreda. Over 50 square kilometers are planted with this crop. Gera has 41 kilometers of dry-weather and 50 of all-weather road, for an average road density of 62.7 kilometers per 1,000 square kilometers. About 20.4% of the urban and 17.2% of the rural population has access to drinking water.

The total population of Gera woreda has about 112,395, of whom 56,488 were men and 55,907 were women; 4,746 or 4.22% of its population were urban dwellers. The majority of the inhabitants were Moslem, with 85.64% of the population reporting they observed this belief, while 11.9% of the population said they practiced Ethiopian Orthodox Christianity, and 2.36% were Protestant (CSA,2007).

Seka Chekorsa is one of the woredas in the Oromia Regional state. It is Part of the Jimma Zone, Seka Chekorsa is bordered on the south by the Gojeb River which separates it from the SNNPR, on the west by Gera, on the northwest by Gomma, on the north by Mana.

The altitude of this woreda ranges from 1580 to 2560 meters above sea level; A survey of the land in this woreda shows that 45.3% is arable or cultivable (44.9% was under annual crops), 6.1% pasture, 25.8% forest, and the remaining 22.8% is considered swampy, degraded or otherwise unusable. Khat, peppers, fruits and Teff are important cash crops. Coffee is another important cash crop for this woreda; over 50 square kilometers are planted with this crop.

Total population for this woreda of 208,096, of whom 104,758 were men and 103,338 were women; 7,029 or 3.38% of its population were urban dwellers. The majority of the inhabitants were Moslem, with 86.66% of the population reporting they observed this belief, while 10.93% of the population said they practised and 2.27% were Protestant.

Dedo is one of the woredas in the Oromia Region state. it is Part of the Jimma Zone, Dedo is bordered on the south by the Gojeb River which separates it from the SNNPR on the west by Gera, on the north by Kersa, and on the east by Omo Nada.

The altitude of this woreda ranges from 880 to 2400 meters above sea level. A survey of the land in this woreda shows that 63.1% is arable or cultivable (38.4% was under annual crops), 13.6% pasture, 9.3% forest, and the remaining 14% is considered swampy, degraded or otherwise unusable. Teff, corn and vegetables are important cash crops. Coffee is also an important cash crop for this woreda; over 50 square kilometers are planted with this crop. Total population for this woreda of 288,457, of whom 143,935 were men and 144,522 were women; 5,755 or 2% of its population were urban dwellers. The majority of the inhabitants were Moslem, with 92.98% of the population reporting they observed this belief, while 5.42% of the population said they practised Orthodox and 1.47% was Protestant

Gechi is one of the woredas in the Oromia Region State. Part of the Illubabor Bunno Bedelle Zone, Gechi is bordered on the south by Didessa, on the east by the Jimma Zone, on the north by Bedele, and on the east by the Didessa River which separates it from the Jimma Zone. Gechi is the major town in Gechi. Borecha woreda was part of Gechi. Coffee is an important cash crop of this woreda. Between 20 and 50 square kilometers are planted with this crop.

Total population for this woreda of 70,478, of whom 35,307 were men and 35,171 were women; 5,442 or 7.72% of its population were urban dwellers. The majority of the inhabitants were Moslem, with 87.7% of the population reporting they observed this belief, while 10.58% of the population said they practiced Orthodox Christianity, and 1.66% was Protestan

Bedele woreda is one of the woredas in the Oromia Region state. Part of the Bunno Bedelle Zone, Bedele is bordered on the south by Gechi, on the southwest by Chora, on the west by Dega, on the north by the southern exclave of the Benishangul-Gumuz Region, on the northeast by the Didessa River which separates it from the west Welega Zone, and on the southeast by Gechi. The total population for this woreda of 77,687, of whom 38,654 were men and 39,033 were women; none of its population was urban dwellers. The majority of the inhabitants were Moslem, with 53.8% of the population reporting they observed this belief, while 28.37 of the population said they practiced Orthodox Christianity, and 17.69% were Protestant

Sampling Technique and Sample Size

Sampled beekeepers were selected by multi-stage sampling procedure for the interview. Gera, Dedo and Seka districts from Jimma zone; Gechi and Bedelle districts from Bunno Bedelle zone and Mettu district from Ilubabor zone were selected purposivelybased on their potentiality honey production and improved Jimma horizontal modern hive promotion. Secondly, kebeles based on honey production, in each district was grouped into medium and high producer. Thirdly, one from medium and high honey producing kebeles of each district was selected randomly. The households were stratified into honey producers and non-producers and listed in selected kebeles. Finally, from the honey producers group, 45 households were selected randomly with total sample size of 270.

In the second stage, based on the proportion of the number of peasant associations in the selected districts, a total of 12 peasant associations (2 PAs from each district were randomly selected. In the final stage, a total of 280 households (160 technology adaptors and 120 non- adopters) were selected randomly using probability proportional to size sampling technique.

In addition to this, farmers differ in their experience practice horizontal beehive. Hence, in this study, considering those farmers practice horizontal beehive for two and more years as adopters and those not practice horizontal beehive currently as non-adopters.

Sources and Methods of Data Collection

Formal sample survey method was used to collect primary data for this study. More specifically,a structured questionnaire was administered to collect primary data from selected sample households. The questionnaire was first pre-tested on selected respondents and on the basis of the results of the pre-test necessary modifications was made before the execution of the survey.

Method of Data Analysis

Descriptive Statistics

Mean, standard deviation, percentages and frequency are of the descriptive statistics used to examine the demographic, socioeconomic and institutional characteristics of sample respondents. Furthermore, mean differences of both discrete and continuous variables amongadopters and non-adopters were computed using chi square and t-tests, respectively**.**

Econometric Analysis

Numerous econometric models have been applied to analyze the determinants oftechnology adoption. However, the econometric specification largely depends on the purpose of the study and the type of data available. One of the most used methods for modeling technology adoption behavior is the censored regression model, also called the tobit model. The key underlying assumption for the model specification is that farmers demandingimproved technology it's have unconstrained by access (Wooldridge, 2010). In line with this, tobit model specification has no mechanism to distinguish households with a constrained positive demand for the new technology from those with unconstrained positive demand, and assumes that a household not adopting the technology is making a rational decision. Hence, for access constraints to technology, tobit model yields inconsistent parameter estimates (Bingxin et al., 2011).

Double hurdle is the model introduced as a more flexible and alternative to tobit model (Cragg, 1971). The modeling approach assumes a two-step decision process based on the assumption that household makes two separate decisions; the first step involves the decision whether to adopt certain technology or not and secondly the intensity of adoption. The model estimation involves a probit regression to identify factors affecting the decision to adopt improved beehive technology by using all sample households in the first stage, and in thesecond stage, the intensity of the adoption was analyzed by truncated regression model.

Heckman two-stage model has been used extensively to correct for bias arising from sample selection (Heckman, 1979). In this model, the decision to adopt is sequential two-stagedecision making process. In the first-stage, farmers make a discrete decision whether to adopt or not. In the second-stage, conditional on their decision to adopt the technology, farmers make continuous decision on how much to use. One problem with the two equations is that the two stage decision making processes are not separable due to unmeasured variables determining both the discrete and continuous decision thereby leading to the correlation between the errors of the equations. If the two errors are correlated, the estimated parameter values on the variables determining the intensity is biased (Woodridge, 2010). Besides, there were many zeros in the dependent variable of second stage, OLS estimation was biased because of duplications of many zero's which results no variability. To capture the above problems, the double hurdle procedure with probit and truncation regressions were used separately. The model is a parametric generalization of the tobit and Hackman model, in which two separate stochastic processes determine the decision to adoptand the level of adoption (Bingxin et al., 2011). In addition, using double hurdle model provides consistent and asymptotically efficient estimates for all the parameters. Thus, double hurdle model was used analyze decision to adopt and intensity of adoption, the with tobit model result for comparison.

Specification of Double Hurdle Model

The model involves two-step estimation procedure. In the first stage, probit regression was used to identify factors affecting adoption decision. The model takes a value 1 and 0 that are assigned to represent the choice whether a producer decides to adopt or not. The standard probit model that assesses the household adoption decision is described as follows:

$$Di = \alpha Zi + Vi \; (adoption\ decision\ equation) \qquad 1$$

$$Di = 1, if\ Di* > 0\ and\ 0\ if\ Di* \leq 0$$

Where, $Di$is a dummy variable that takes the value 1 if the producer adopts improved Jimma Horizontal Modern Hive and 0 otherwise, Z is a vector of independent variables hypothesized to influence adoption decision and α is a vector of parameter to be estimated and error term.

In the second stage, truncated regression that excludes part of sampled observation based on the value of the dependent variable was used (Wooldridge, 2010). The regression considers the observations that take 1 for adoption decision or only that adopts improved Jimma horizontal modern hive technology. Therefore, the second hurdle represents the actual level of adoption, expressed by the number of improved beehives owned. Thus, the truncated regression model with the lower left truncation equal to 0 was used to determine factors affecting the intensity of adoption.

$$yi = \beta ixi + \mu \lambda i + \eta i$$

$$\hat{y}i = \beta' xi + Ui \quad (equation\ for\ intensity\ of\ adoption)$$

$$yi = y'i\ if\ y' > 0\ and\ D'i > 0$$

$$yi = 0\ otherwise$$

Where, $\hat{y}i$and y' are latent and the observed intensity of adoption respectively, xi is a vector of variables influencing intensity of adoption and β is a vector of parameters to be estimated. The error terms are assumed to be independently and normally distributed as both decisions made by the individual honey producer independently which is as:

$$Vi \sim N(0,1)\ \ and\ Ui \sim N(0, \sigma^2)$$

The log-likelihood function for the double-hurdle model that nests probit model and a truncated regression model is given following Christoph and Peter (2014) as:

$$\log L = \sum \ln\left[1 - \phi(Z'i\alpha)\left(\frac{xi}{\sigma}\right)\right] + \sum_{+} \ln\left[\phi(Z'i\alpha)\frac{1}{\sigma}\emptyset(\frac{yi - x'i\beta}{\sigma}\right]$$

Where, $\boldsymbol{\phi}$ and $\emptyset$ refer to the standard normal probability and density functions respectively, and represent independent variables for the Probit model and the Truncated model respectively,$\boldsymbol{\alpha}$,$\boldsymbol{\sigma}$, and $\boldsymbol{\beta}$ are parameters to be estimated for each model. The result of double-hurdle model was also compared with the alternative tobit model separately. Tobit model supposes that there is a latent unobservable variable yi* which depends linearly$\boldsymbol{xi}$on via a parameter vector$\boldsymbol{\beta}$. In addition, there is a normally distributed error termUi to capture random influence on this relationship. The observable variable$\boldsymbol{yi}$is defined as being equal to the latent variable whenever the latent variable is above zero and tobe equal to zero otherwise. According to Tobin (1958), tobit model is expressed as:

$$yi = \begin{cases} yi' if\ yi' > 0 \\ 0\ if\ yi\ \leq 0\ and \\ yi' = \beta xi + Ui, UiN(0, \sigma^2) \end{cases}$$

Where yi' islatent variable, ß is a vector of unknown coefficients and X is a vector of independent variables. The log-likelihood functions verify the equality of the coefficients in the adoption decision equation with the level of adoption equation is given as:

$$LnLT = \sum_{yi=yi'} -\frac{1}{2}[\ln(2\pi) + ln\sigma^2] + \frac{yi - xi\beta}{\sigma^2}) + \sum_{yi=0} ln\left[1 - \phi(\frac{x\beta}{\sigma})\right]$$

A test for the tobit model against the double-hurdle model comes from the fact that the hurdle model log likelihood can always be written as the sum of the log likelihoods of the two separate models: a probit and a truncated model (Hailemariam et al., 2006). As such the hurdlemodel likelihood function can always be maximized, without loss of information, bymaximizing the two components separately (Alemu, 2010). Therefore, whether a tobit or a double hurdle model is more appropriate can be determined by estimating the Tobitand the double hurdle models (the truncated regression model and the probit model) separately. After estimation, conducting a likelihood ratio test that compares the tobit with the sum of thelog likelihood functions of the probit and truncated regression models (Genanew &Alemu, 2010). The likelihood ratio test statistics G can be computed (Greene 2012) as:

$$\rho = -2\lfloor lnLtobit - \lfloor LnLprobit + Ln\ trunsacted)\rfloor\rfloor \sim Xk^2$$

Where, $\boldsymbol{\rho}$ is likelihood ratio statistic, $\boldsymbol{ln}$ is natural logarithm, $\mathbf{L_{Tobit}}$,is likelihood values for Tobit, L_{Probit} is likelihood values for Probit is $T_{runcated}$ is likelihood values for Truncated regression, $\boldsymbol{x^2}$ is chi-square and k is the number of independent variables in the equations. The null hypothesis is rejected when the likelihood ratio statistic ($\boldsymbol{\rho}$) exceeds the value of the chi-square statistic ($\boldsymbol{x^2}k$). For good measure, Akakie's Information Criterion (AIC) is alsoincluded as a model selection criterion. According to Akaike (1974), AIC serving as a measure of goodness of fit for individual models by:

$$AIC = 2K - 2Ln\ (L)$$

Where, k is number of parameters in the model, Lis the likelihood function. The AIC method helps to know that the specified model best explains the data and the preferred model is the one with the lowest AIC value, compared to its alternative model (Hailemariam et al., 2006; Adam, 2010).

Hypotheses of Variables

Adoption is viewed as a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations. The term behavioral change refers to desirable change in knowledge, understanding and ability to apply technological information, changes in feeling behavior such as changes in interest, attitudes, aspirations, values and changes in overt abilities and skills (Rogers, 2003). The term improved beehives in this study refers to Jimma horizontal modern beehive. Based on theory and previous study the following variables were hypothesized.

Table 1. Summary Of Variables Hypothesized For Econometric Analysis.

Variables	Type	Measurement	Expected sign
Adoption decision of improved JHMB technology	Continuous	Adopter=1, Non-adopter=0	
Number of improved JHMB owned	Continuous	Number	
Sex of household head	Dummy	Male=1, Female=0	+
Educational level of household head	Continuous	Grade	+
Household size	Continuous	Man equivalent	+
Number of local beehive owned		Number	-
Participation demonstration of improved JHMB	Continuous	1= Yes, 0=No	+
Total income in 1000	Continuous	Birr	+
Beekeeping experience	Continuous	Year	
Perception towards price of improved JHMB beehives	Categorical	1=High, 2=Medium, 3=Low	-
Frequency of extension contact per year	Continuous	Number	+
Distance from FTC	Continuous	Km	+
Cooperative membership	Dummy	Yes=1, No=0	+
Credit utilization	Dummy	1=User 0=Non-user	+

Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.13, No.9, 2022

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Jimma Horizontal Modern Beehive Adopters and Non-Adopters

The summary statistics of the socioeconomic characteristics of adopters and non-adopters of Jimma horizontal modern beehive are given in table 2. It is evident that honey productionis male-dominated with the percentage of males generally high in the study areas. There is a small but significant difference in the years of schooling of household heads among adopters and non-adopters, with the former being more educated. So while the age and gender of adopters and non-adopters do not differ significantly, adopters were, on average, better educated.

The household demographics show that the mean household size of adopters is significantly lower than that of non-adopters. There is also a trend towards higher numbers of males, and lower numbers of females, in adopter Households, but these differences were not significant. The dependency ratio of non-adopters is higher and significantly different at 10 percentfrom that of adopters. This implies that the ratio of non-working members to working members is higher in non-adopter households. Therefore, labor availability is lower in these households than in adopter households. About half of all farmers in the study area belong to farmers' associations, and had similar limited access to credit, irrespective of whether they were adopter or non-adopter households. The mean difference in number of extension visits per year is 2.24 and it is significant at 1 percent.

Land tenure patterns are similar for both adopters and non-adopters. Inheritance and rent are the most common tenure arrangement. About 28.85 percent and 35.71 percent obtained their land by inheritance among adopters and non-adopters, respectively. Rents in cash or on crop share basis represent tenure arrangements for 65.38 percent of adopters and 57.14 percent of non-adopters. Those who purchased their land represented 5.77 percent of adopters and 3.56 percent of non-adopters. Others obtained land on mortgage.

Table 2.Characteristics of Adopters and Non-Adopters ofJimma horizontal modern beehive

Characteristics	Adopters	Non-adopters	% Difference	Chi-square value/t-test
Age of household head	41.38	43.32	4.68	1.041
Gender of household head-male (%)	94.23	98.21	3.98	+1.200
Years of schooling of household head	10.63	9.30	12.51	1.801*
Household size	5.97	6.78	13.56	1.693*
Adult male above 15 years	2.14	1.98	7.48	$^{+}$1.042
Adult female above 15 years	2.12	2.21	4.25	$^{+}$0.358
Dependency ratio	0.67	0.77	14.93	1.810*
Number of beehive	0.66	0.58	1.12	1.440
Member of association (%)	48.07	55.35	7.28	$^{+}$0.572
Number of extension visits per year	4.31	2.07	51.97	2.456***
Access to credit (%)	5.76	1.78	3.98	$^{+}$1.091

***significant at 1%; *significant at 10%; $^{+}$ chi-square values

Awareness and Rationale for Adoption and Stopping the Use of the Jimma horizontal modern beehive

Level of awareness: The sources of information and sources of purchase of Jimma horizontal modern beehive by survey respondents varied (figure 2). The major sources of information onJimma horizontal modern beehive to farmers were information dissemination by other farmers (35%), Ministry of Food and Agriculture (MoFA) extension agents (24%) and research center field demonstrations (22%). research center including different non-organizationfield demonstrations accounted for more than half (56%) of the Jimma horizontal modern beehive sales outlet; MoFA sales agents accounted for 32 percent while the manufacturers (local artisans) sold only 2 percent of the technology directly to farmers. These results confirm the active roles of reach center and agricultural office in facilitating the diffusion of Jimma horizontal modern beehive among farmers in the study areas. These findings suggest that Jimma horizontal modern beehive manufacturers have little influence in the sale of their products.

Rationale for Jimma horizontal modern beehive adoption and non-adoption

For all the adopters, 65 percent claimed reduction in aggregate labor use for honey production as the reason for Jimma horizontal modern beehive adoption, while 49 percent mentioned time savings in traditional beehive as the reason for Jimma horizontal modern beehive adoption.

Other important reasons that accountedfor Jimma horizontal modern beehive adoption are increased honey production (31%), non-requirement of high initial capital (29%) and the affordability of the Jimma horizontal modern beehive (8%). The results thus indicate that the most important reasons forJimma horizontal modern beehiveadoption are reduction in labor use for honey production and time-saving. The most-cited reasons for not adopting Jimma horizontal modern beehiveare that they were considered unaffordable by many(58%) and a problem as they required at least two workers to carrying at one time (31%). Other reasons that made Jimma horizontal modern beehive less attractive were a lack of suitability for it have short duration (19%), lack of awareness (14%) and, to a small extent, lack of a reliable accessories (4%).

Factors that influence stopping the use of the Jimma horizontal modern beehive, our survey revealed that about 21 percent of all adopters had subsequently stopped using the Jimma horizontal modern beehive.

As shown in table below, the reasons given by the respondents for stopping the use of the Jimma horizontal modern beehiveincluded: bought modern beehive, Jimma horizontal modern beehive had broken down, unsuitable for bees extents of honey production and unreliable honey production.

Factors that Influence Jimma horizontal modern beehive Adoption

Explanatory variables and summary statistics used in the adoption model are presented in table below. Diagnostic statistics (table) showed that the model had a good fit to these variables with log likelihood scores that are significant at 1 percent and with the signs of the variables agreeing with a priori expectations, except the variable for age of household head. Three of the variables were statistically significant at 5 percent. These were the dependency ratio, number of extension visitsper year. Dependency ratio has a negative relationship with the probability of adoption and is significant at 1 percent. Increase in the number of nonworking household members as compared to those working infers lower labor availability for productive economic activities.

This apparently discouraged Jimma horizontal modern beehive adoption, which requires supply sources. Also, increase in the number of dependents in the family may reduce the household income available for investments, thusdiscouraging adoption. The number of extensionvisits per year is positive and significant at 5percent showing that the higher the frequency of visits the higher the probability of Jimma horizontal modern beehive adoption

Table Summary statistics of the explanatory variables for the adoption model

variables		Mean	Std. dev.
Age of householdhead in years	Age of the household member responsible for final decisions onfarm operations and investments	42.30	1.80
Year of schooling	Number of years of formal education of household head	9.94	3.89
Household* size	Total number of members of the household	6.30	0.19
Household membersabove 15 years	Total number of household members above 15 yearsrepresenting the adult workers in the household	4.23	2.26
Dependency ratio	Ratio of non-income-earning members of the household toincome-earning members of the household	0.72	0.01
Number of technology	Number of MB under honey production before adoption	0.59	0.41
Technology users	Dummy variable for membership of technology user; 1 for users, 0 for non-users		
Number of extension visits	Number of visits from MoFA and RC per year	3.10	1.83
Gender	Dummy variable for gender; 1 for male, 0 for female		
Accessibility to credit	Dummy variable for accessibility of credit from formal and/or informal sources; 1 for accessibility and 0 otherwise		

Table Factors that influence the adoption of the Jimma horizontal modern beehive using the Heckman two-step procedure

Variable	**Coefficient**	**Standard error**	**Z**	**P-value**
Constant	-0.261	0.724	0.361	0.717
Age	0.009	0.016	0.567	0.571
Years of schooling	0.050	0.041	1.211	0.226
Household size	-0.025	0.055	-0.464	0.642
Dependency ratio	-0.808***	0.280	-2.880	0.004
Number of JHMB	0.248	0.363	0.683	0.495
Number of extension visits per year	0.067***	0.336	1.999	0.045
Log-likelihood	-60.572			
Chi-square	28.428			
Probability of chi-square	0.0081			
N	263			

*** Significant at 1%; ** Significant at 5%.

This study shows that the age of household head, years of schooling, number of JHMB have positive relationships with the probability of adoption, but are not significant. Similarly, household sizes have negative relationships with the probability of adoption but are not significant.

Due to data constraints, the number of JHMB is used as a proxy for wealth status in this study. The variable is positive but not significant. This means that although increases in the number of JHMB may increase the probability of adoption, we cannot make conclusions on whether or not Jimma horizontal modern beehive technology self-selects the poor in the study area.

Impacts of Jimma horizontal modern beehive Adoption

Production intensity and diversification indices, the production intensities of adopters and non-adopters are shown in table below. The P-values were obtained from a t-test of mean differences between adopters and non-adopters in the all site and for all farmers.In all cases, production intensity is greater than 1. The production intensities for Jimma horizontal modern beehive adopters are higher than for non-adopters in both regions but significant at 10percent in the Gera and Mettu. This implies that the adoption of the Jimma horizontal modern beehive increases production intensities, although the extent differs between locations and among farmers. The diversification index of farms does not differ significantly between Jimma horizontal modern beehive adopters and non-adopters.

Production intensity and diversification indices of adopters and non-adopters of Jimma horizontal modern beehive,

		Production intensity	Diversification indices
Metu	Adopters	1.48	0.30
	Non-adopters	1.42	0.28
	P-value	0.22	0.845
Gechi	Adopters	1.87	0.34
	Non-adopters	1.57	0.30
	P-value	0.085*	0.365
Bedelle	Adopters	1.68	0.32
	Non-adopters	1.52	0.29
	P-value	0.166	0.710
	Adopters	1.34	0.15
	Non-adopters	1.65	0.65
	P-value	0.33	0.343
Seka	Adopters	1.73	0.67
	Non-adopters	1.43	0.24
	P-value	0.25	0.20
Gera	Adopters	1.43	0.87
	Non-adopters	1.39	0.32
	P-value	0.065*	0.21
Dedo	Adopters	1.49	0.45
	Non-adopters	1.42	0.461
	P-value	0.34	0.48

Number of Beehive and Labor Productivity

The estimated equations represent a good fit of the data with a high coefficient ofdetermination of 72 percent and 63 percent for the estimated parameters for Jimma horizontal modern beehive adopters and non-adopters, respectively. The estimated coefficients represent the elasticities of honey production with respect to each input.

The analysis reveals that for Jimma horizontal modern beehive adopters the coefficients of number beehive technology, labor and strength of colony are positive and are significant at varying levels. This indicates that increases in these inputs will lead to an increase in the gross value of honey production. The sizes of the coefficients reveal that beehive and technology used have the highest impact on the gross value of honey production followed by number of beehive and labor. The gross value of honey production for non-adopters also increases with number of beehive and labor. These variables are significant at 1 percent and 5 percent, respectively.

Variable	Adopters		Non-adopters	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	4.926***	0.390	6.178***	0.231
Number of beehive	0.244***	0.062	0.216***	0.025
Labor	0.003*	0.002	0.008**	0.003
Strength of colony	0.285***	0.049	0.019	0.030
Number of JHMB	0.201**	0.076	0.054	0.038
R^2	0.712		0.630	
F value	29.170***		25.552***	
N	160		120	

Impact on livelihood status, a multivariate analysis was undertaken to assess the impact of Jimma Horizontal Modern Beehive adoption on livelihood using the Heckman two-step procedure. Essentially, the explanatory variables include the same household and community characteristics, as well as institutional factors, as in the adoption model. The second step of the Heckman two-step procedure estimates the determinants of livelihood and tests for selectivity bias by incorporating the Lambda into a linear regression.

The Lambda is the inverse Mills ratio saved from the probit equation describing adoption. The dependent variable is the log of the household per capita income. The selection of the identification variable was tested by estimating the determinants of livelihood. The model was estimated using the number of extension visits per year as the identification variable.

Table below presents the coefficients in the livelihood model from both the second step of the Heckman two step and the OLS (Ordinary Least Squares) estimation procedures. The Lambda coefficient is negative and is not significantly different from zero which indicates the absence of selectivity bias in the sample. This means that the error terms of the adoption and livelihood models are not correlated. The robustness of the identification variable was tested using the "identification onfunctional form" method.

This involves includingthe identification variable in the model. Again, the Lambda coefficient was not significant. The identification variable was also not significant, which implies that it does not influence the per capita income of farm households in the study area. Therefore, it is possible to judge the variable appropriate for an identification variable. Since the results from the estimation can, however, be sensitive to the choice of the identification variable and in the two models the Lambda is not significant, the model can be estimated using an OLS.

The result from the OLS estimation is used to explain the model. Three of the variables are positive and significant at different levels. These are years of schooling, number of beehive and number of JHMB adoption. The area dummy is also significant but has a negative sign. The years of schooling of household head is positive and significant at 1 percent. The per capita income will increase by 7 percent for each additional year of schooling. This implies that the education of household head had an impact on livelihood.

This is not surprising. Literacy can enhance the capacity to adapt to change, understand new practices and technologies, and improve a household's productivity and income. The number of beehive is positive and significant at 1 percent. A unit increase in number ofbeehive leads to about 74.9percent increase in per capita income. An increase in number of beehive will increase honey production with incomes and improve household per capita income.

The adoption of the Jimma Horizontal Modern Beehive is positive and significant at 1 percent. The result shows that the Jimma Horizontal Modern Beehive adoption increases per capita income by 28.1 percent relative to that of non-adopter

Table Determinants of Adoption Intensity

variable	Heckman second step with number of extensions as identification variable	Heckman second step and identifying on functional form	OLS estimation
	Coefficient	Coefficient	Coefficient
Age	-0.001(p=0.87)	-0.001(p=0.89)	-0.001(p=0.83)
Years of schooling	0.073***(p=0.00)	0.073***(p=0.00)	0.072***(p=0.00)
Household size	-0.005(p=0.78)	-0.005(p=0.77	-0.005(p=0.78)
Dependency ratio	0.016(p=0.85)	0.016(p=0.86)	0.027(p=0.76)
Number of beehive	0.739***(p=0.00)	0.742***(p=0.00)	0.749***(p=0.00)
Number of JHMH	-0.031(p=0.74)	-0.035(p=0.71)	-0.036(p=0.71)
Number of extensions		0.002(p=0.87)	0.001(p=0.91)
Reliability of beehive	-0.001(p=0.98)	-0.002(p=0.98)	0.007(p=0.93)
Adoption of JHMH	0.247**(p=0.04)	0.243**(p=0.03)	0.281***(p=0.00)
Districts	-0.205*(p=0.06)	-0.205*(p=0.06)	-0.194*(p=0.07)
Lambda	-0.012(p=0.45)	-0.011(p=0.44)	

*** Significant at 1%; ** Significant at 5%; * Significant at 10%.

CONCLUSION

In Jimma and Ilubabor zone the Jimma horizontal modern beehive is a technology that can replace the existing beehiveswhich is very labor-intensive. Thus a major attractive feature of the Jimma horizontal modern beehive is that it reduces time and labor requirements for honey production. Other factors which made the Jimma horizontal modern beehive attractive to farmers included opportunities to increase the number of beehiveand cost reductions for honey production due to reduce the initial cost of modern beehive. It was not possible to ascertain whether or notJimma horizontal modern beehive technology self-selects the poor as is hypothesized. Even with this low-cost technology, the purchase cost was seen as the most significant barrier to adoption.

The technology is clearly not gender-neutral in all selected are, and there are significant social barriers to the adoption by women.This study confirms the positive impacts of Jimma horizontal modern beehive technology including increasing farmers' livelihood, by enabling increases in honey production intensities, number of beehive and farmers' incomes. More importantly perhaps,Jimma horizontal modern beehive use in the study areas increased number of beehive and labor productivity, which is essential for poverty alleviation.

The government has to put in place a number of policies in order to improve the adoption of Jimma Horizontal Modern Beehive technology in study area. In particular, the government should makeconcerted effort to address all the villages through participatory extension services. In addition, efforts should be made in order to increase access of Jimma horizontal modern beehive by introducing Jimma horizontal modern beehives. Finally, government will take the lead in technology promotion and dissemination at the initial stages and in creating an enabling environment for effective participation of the private sector.

REFERENCES

Cragg, J. G. (1971): Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods, Econometrica, Vol.39, No.5, pp.829–844

CSA. (2017). Livestock and Livestock Characteristics, Agricultural sample Survey. Addis Ababa, Ethiopia. Statistical Bulletin, 2(583), 9–13.

Haile Abebe, and Teklemariam Tesfaye, 2008. The feed value of indigenous multipurpose for sheep in Ethiopia. The case of veronica amygdaline, Buddleias polystachya and Maesalancaolata. Live Stock Research for Rural Development.V.20, No.45. Ratread December 12, 2009, from http//www.lrrd.org/lrrd 20/3/hail htm

Heckman, J. J. (1979): Sample Selection Bias as a Specification Error, Econometrica, Vol.47, No.1, pp.153–161.

Million Tadesse and Kassa Belay. 2004. Factors Influencing Adoption of Soil Conservation Measures in Southern Ethiopia: The Case of Gununo Area. Journal of Agriculture and Rural Development in the Tropics and Subtropics. Vol. 105(1): 49-62

Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Wooldridge JM. Estimating panel data models in the presence of indigeneity and selection. Journal of Econometrics. 2010 Aug 1;157(2):375-80.

World Bank. 2010. World Development Report 2010: Development and Climate Change. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/4387 License: CC BY 3.0 IGO."

ACKNOWLEDGEMENTS

First and foremost, I would like to honor the Almighty God for giving me the strength to persevere through the long and often challenging process of writing a research. I would also like to gratefully thank Oromia agricultural research institute for financing support of my research. All above the research reported here was supported by the men and women farmers who generously shared their knowledge and perceptions in personal interviews. I would also like to thank the enumerators for their professional integrity. I wish to thank my good friends Goshu hailu from JAERC planner. My wife Debritu Mezmur and my daughter Merob Mengistu and my son segni mengistu deserve special thanks. Thank you so much!