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Socio-Economic Determinants of Movable Frame Hive Technology Adoption in Gamo Gofa Zone of the Southern Ethiopia

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Abstract
Beekeeping is a well established traditional farming enterprise and income generating activity since long time in Gamo Gofa Zone. Many attempts have been made to introduce improved beekeeping and modernize the production system so as to improve productivity and the benefit thereof. However, the attempts hadn't been met to the desired level and no technical study has been made so far to identify the gaps in promotional effort and farmers' response to it. The objectives of this study were identifying socio-economic determinants of movable frame hive technology adoption and measuring their responsiveness. Proportionate random sampling was employed to get sample respondents and they were categorized in-to non-adopters and adopters of movable frame hive technology. Out of the total 168 sample respondents, 99 were non-adopters and 69 were adopters of movable frame hive technology. The data were collected through semi-structured questionnaire interview. The data were analysed using descriptive statistics, binary probit model and partial effect analysis. The results of the binary probit model indicated that age, formal education, traditional beekeeping experience, availability of movable frame hive accessories, livestock holding, income and demonstration didn't have significant influence on movable frame hive technology adoption. While: wealth status, market access, extension service and training were found to influence significantly. The partial effect analysis revealed that wealth, market access, extension service and training influence movable frame hive adoption decision by 26.043%, 23.876%, 15.390% and 29.982% respectively. Therefore, different stakeholders working to improve the productivity of the sub-sector and promote movable frame hive technology should focus on these determining factors to achieve the intended goal.
Keywords: Adoption, Constraints, Determinants, Movable Frame Hive

Chapter 1. INTRODUCTION

1.1. Background and Justification

Beekeeping has been a tradition since long before other farming systems in Ethiopia (Gezahegne Tadesse, 1996). Yet it is impossible to know the exact time and place where beekeeping practice had started in the country due to lack of well documented evidence. Endowed with varied ecological and climatic conditions to host different vegetation and crops that are good sources of nectar, the country has immense potential for beekeeping (Girma, 1998 as cited in Assefa Abebe, 2009).

Owing to its varied ecological and climatic conditions, Ethiopia is home to some of the most diverse flora and fauna in Africa, making it highly suitable for sustaining a large number of bee colonies. Ethiopia reportedly has the largest bee population in Africa. According to Holota Research Institute, recent morphometric analysis came up with five types of bees in Ethiopia (Amssalu Bezabeh *et al.*, 2004; Johannes Agonafir, 2005).

Apiculture is practiced by a large numbers of people across the country except in areas with extreme climatic conditions. It also plays a major role in the cultural and religious life of the people and has long been valued for its medicinal uses. The largest share of honey produced in the country comes from forest beekeeping; the practice of honey collection from wild colonies in forest. Forest beekeeping is common to honey hunters mainly in the south, south-west, west and south-eastern parts of Ethiopia. Backyard beekeeping, on the other hand is practiced mainly in the central, northern and eastern parts of the country (Meskerem Shiferaw and Eyerusalem Regassa, 2012 as cited in Dayanandan, 2015)

Currently, there is an increased demand for honey and beeswax products in Ethiopia as well as in the international markets. Ethiopia has plenty of honey bees ready to meet the growing demand of honey. The country has the potential of producing up to 500,000 tons of honey and 50,000 tons of beeswax per annum. The average annual demand for honey products in Ethiopia in the next ten years (2013-2022) is expected to reach at 90,357 tons. This is as a result of the current high population and future growth trends, a growing number of urban centres and urbanized lifestyles, and finally the economic growth rates registered by the country and visible increased income levels of the general population (Preciseethiopia.com, 2013).

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According to CSA (2016), the annual total production of honey accounts for 50,790 tons which is only about 10% of the total national production potential. Out of the total honey produced roughly 70% is utilized for brewing *tej* (honey wine) with the balance being sold either as table honey or in other forms. For a long time, beekeepers targeted the *tej* market only and accordingly little or no effort was made to separate the honey from beeswax. *Tej* production does not require the same level of quality as table honey. Table honey requires post-harvest handling, which is the separation of honey from wax, comb and others; and moisture reduction if applicable. Wax is a by-product of *tej* production process and is sold to those who make the traditional candle mainly used in religious ceremonies and floor wax (Dayanandan, 2015).

1.2. Problem Statement

Despite its long history, beekeeping in Ethiopia is still an undeveloped sector of agriculture. The knowledge and skill of honey production and honey and beeswax extraction of Ethiopian farmers is still very traditional (MoARD, 2006). Producing only 8.6% of its annual production potential, the benefit from the sub sector to the nation as well as to the farmers, traders, processors and exporter is not satisfactory (EAB , 2014; Beyene Tadesse and David Phillips, 2007). Beekeeping is likely to be at its most profitable if improved beekeeping technologies with its all packages can be used and if pesticides are not used in such a way that the foraging bees are killed. However, traditional production system which result in low production and productivity, poor pre and post harvest processing and handling techniques and practices combined with poor marketing efforts has kept it part of the subsistent sector (Meaza G., 2010 as cited in Dayanandan, 2015). This is due to the reason that more than 95% of our beekeepers use traditional hive management practices which affect yield and quality. Traditional production system manifested by poor management skills coupled with shortage of honeybee forages, disease and pests attributed to low quality and quantity of product.

For the last 40 years, many efforts had been made to generate, modify and disseminate beekeeping technology packages to increase productivity and maximize benefit keeping natural resource conservation sustainable. These packages include: improved box hives (movable frame hives); ant-protection technologies; pre and post-harvest processing and handling techniques; improved honeybees management techniques, simple queen raring methods and honeybee forage development. The annual crude honey yield per traditional beehive is very low in quality and quantity (5-7kg) as compared to the national average of transitional (15kg) and box hive (20-25kg). This indicates that it is possible to obtain surplus production through practicing improved beekeeping technology with its full package. According to Holeta Bee Research Centre [HBRC] (2004), improved beekeeping technology involves the use of modern (box hives with movable and centrifugable frames) hives with all the necessary accessories and management practices.

Research centres, livestock agencies, Non-Governmental Organizations (NGO), and private sectors have been striving to disseminate and scale up beekeeping technologies to maximize benefit from the subsector. However, commensurate study hadn’t been made so far on factors limiting fast dissemination of the technologies and on the level of dissemination. Several studies had been made in different parts of the country but it is difficult to universally apply the findings to all parts of the country due to tangible difference of the areas in many perspectives. It is difficult to develop hypothesis that hold true everywhere because of socio-economic and ecological distinctiveness of the different sites and dynamic nature of most of the determinants (Ehui *et al.,* 2004). Hence, it is recommended to conduct study on determinants of adoption under different conditions.

Adoption studies have significant contribution in identifying factors limiting the dissemination rate of a given technology. In such a way, they facilitate development through acquiring feedback from the beneficiaries for further improvement of a given technology. Therefore, this study is expected to fill the information gap with respect to movable frame hive technology adoption and indicate possible interventions to facilitate dissemination of the technology.

1.3. Objective

1.3.1. General objective

- This study is concerned with identifying movable frame hive technology adoption determinants and measuring their responsiveness in Gamo Gofa zone.

1.3.2. Specific objectives

- To identify determinants of movable frame hive technology adoption, and
- To measure the responsiveness of the determinants of adoption of movable frame hive technology.

Chapter 3. MATERIALS AND METHODS

3.1. Study Areas Description

3.1.1. Geographical location

Being one of the 14 Zones and 4 special Districts of the SNNPR, Gamo Gofa zone situated nearly to the centre of the region with the astronomical location roughly $5^0\ 57''$– $6^0\ 71''$N latitude and $36^0\ 37''$- $37^0\ 98''$E longitude. It is bordered with Wolaita and Dawuro Zones in the north; Debub Omo Zone & Derashe special district in the south; Amaro special district in the East and Konta & Basketo special districts in the West. Elevation of the zone ranges from 600 to 3300 meters above sea level with an undulating topographic feature favouring the existence of different climatic zones in the area. The zonal administrative town, Arba Minch, is located at 505 km from Addis Ababa and 275 km south west of Hawassa.

With a total area of 12581.4km^2 (11.34%), Gamo Gofa Zone ranks 3rd in area coverage as compared to other zones and special districts in the region. It is divided into 15 districts & 2 town administrations.

3.1.2. Topography and Climate

Topography: - The highest pick in Gamo Gofa zone as well as in the region is mount Guge which is 4207 m.a.s.l. and is a part of usually known as Gamo highlands. These mountains generally stretch from north to south and east to west directions with their elevation sharply decreasing towards the rift valleys & to the low lands. The high lands are sources of many rivers such as Sego, Sile, Kulfo, Harie, Dimie, Masta, Domba, Zagie, Mazie, Shela, etc and their tributaries.

There are two lakes, Abaya and Chamo, situated adjacent to Arba Minch, administrative town of Gamo Gofa zone; giving it breathes taking beauty and other social and economic advantages. There are also two national parks, Nech Sar and Maze, hosting different types of wildlife (plants and animals) and attracting tourists around the globe.

Climate: -The mean annual temperature of the zone varies in between 20^{0}c to 25^{0}c where as the total average annual rainfall varies from 200mm to 2000mm. Gamo Gofa zone is classified in to four agro ecologies climatically:

Table 3. 1 Distribution of agro ecologies climatically

Agro-Ecological Zones	Altitude in meters	Area Coverage
Moist Highland	>3500	0.45
Highland	2500-3500	30.13
Mid-altitude	1500-2500	41.44
Lowland	500-1500	28.4

Source: -*Gamo Gofa Zone Economic & Social Profile, 1993 E.C.*

3.1.3. Population and ethnicity

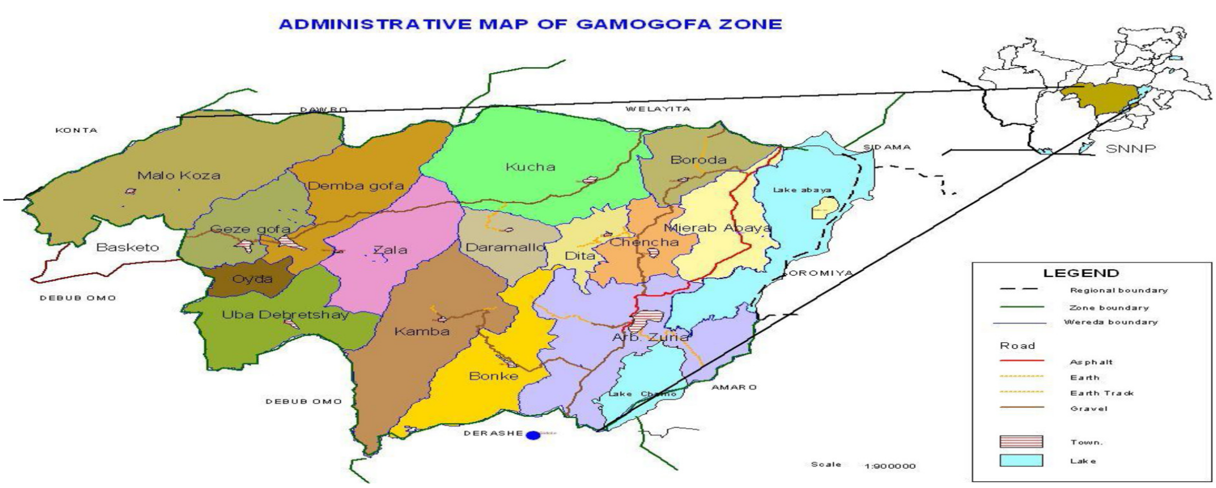
According to CSA (2007), the total population is estimated to be 1,597,767 pressing the population density to reach 80 inhabitants per kilo meter square. The dominant ethnic groups found in Gamo Gofa zone are Gamo, Gofa, Zeyise, Oyida and Gidicho though there are also many other ethnic groups living together in different parts of the zone.

3.1.4. Beekeeping activity

There are 91,536 beehives in Gamo Gofa zone of which, 91,247 (99.7%) of them are traditional. The annual honey production of the zone is estimated to be 637,201kg and almost all of the produce is from traditional hives with an average of 1.75 harvesting frequency per annum (CSA, 2015).

The farmers in Gamo Gofa zone are engaged in beekeeping for one of the three reasons: - only for income generation, only for home consumption or for both purposes. Most (57.7%) of the beekeepers keep their bees at backyard, 21.2% under simple shade built to place hives, 13.5% under the eaves of their homes, 5.1% on trees in the forest and 2.6% on home stead trees. They have two honey flow periods which enables them to harvest honey twice a year: - at the beginning of October and at the end of December. The average honey yield from traditional, transitional and modern (MFH) hive is 5.88kg, 14.07kg and 20.64kg, respectively (Nebiyu Yemane and Messele Taye, 2013). This indicates that the production is very much lower than its potential given that improved beekeeping is practiced.

Figure 3. 1 Administrative map of Gamo Gofa zone



3.2. Sampling Technique

The population has been grouped in to three strata based on agro-ecological representation (Highland, Mid-altitude & Lowland). Among the 15 districts found in Gamo Gofa zone, three districts have been selected purposively based on potentiality, agro-ecology representation and accessibility. From each of the selected districts two PAs[1] have been selected based on presence of beekeeping practice (potentiality) and accessibility. During beekeepers selection within each stratum, proportionate random sampling was employed and the total sample size is 180 individuals. Prior to sampling, adopters are specified as those farmers who are practicing improved beekeeping (using movable frame hive) at least in one hive or those who used to practice it before and now gave it up due to some reason; while non adopters as those beekeepers that have never experienced improved beekeeping. The sample size of individuals to be selected for the study from each PA has been determined based on the proportion of total beekeepers of the two sampled PAs in each district. The selection of individuals has been carried out randomly from the sorted list of beekeepers into two categories as adopters and non-adopters in each PA.

3.3. Source of Data and Collection Method

Both primary and secondary data have been used. Primary data was collected using both informal and formal survey procedure. Informal survey was carried out mainly through key informants interview and focus group discussion. The formal survey was conducted through administering semi-structured questionnaire to beekeepers. Secondary data was collected from different sources such as office of agriculture at different levels, NGO, publications, journals, books, internet, etc.

3.3.1. Informal survey procedure

In order to obtain primary data, informal survey was conducted through key informants interview and focus group discussion. To conduct the informal survey, checklists were prepared with some of the predetermined questions. New questions have also been raised during the interview in response to the answers from those interviewed. Then the data obtained has been analyzed and based on the result, workable hypothesis is formulated and semi-structured questionnaire is developed for the formal survey.

Key informant interview: - Key informants were interviewed: five from each district. Participants were from zone, district and PA level livestock development office experts, experienced beekeepers and PA administration chairpersons. The selection was carried out with the participation of livestock experts at zone, district and PA level; and researcher. And the selection criteria considered representation of age, gender, year of settlement (>10 years) and beekeeping experience. Open ended questions were used and the media for the discussion was the local language of the study area.

Focus group discussion: - With the purpose of getting more insight in the issue and validating the information obtained from key informant interview, a more detailed discussion has been held with one focus group (consisting of 8-10 individuals) in each PA. The group consisted beekeepers of both gender (male and female where available) with different age groups (elders and youngsters). The media for the discussion was the local language of the study area.

3.3.2. Formal survey procedure

Based on the result of informal survey, semi-structure questionnaire was developed and administered after it has been pretested and passed through the necessary amendments. Six enumerators (Development Agents) that have knowledge on apiculture have been recruited and trained how to collect data. Constant supervision and follow up has been made by the researcher during data collection. From the total of 180 beekeepers selected for the study, 179 were interviewed out of which, 11 questionnaires were rejected due to several inconveniences and 168 questionnaires were analysed.

3.4. Data Analysis

The data obtained in the form of completed questionnaires edited, cleaned and coded. It was encoded and analysed using SPSS (version, 23) and LIMdEP/ NLOGIT respectively.

Some independent t-test and cross tabulations were used before running the binary probit model. The logit and probit models are used to analyse conditions where the choice problem is whether to adopt or not to adopt (0-1 value range). The probit specifications have advantage over logit models in large samples (Gujarati, 2004). The marginal effect is used to measure the responsiveness of explanatory variables on adoption. The present study employed the probit.

3.4.1. Specification of the Probit model

The Probit analysis model assumes that there is an underlying response variable y_i^* defined by the regression function

$$y_i^* = \beta' x_i + u_i \quad (1)$$

[1] PA: Peasant Association

In practice, y_i^* is unobservable. What we observe is a dummy variable y defined by

$$\begin{aligned} y_i &= 1 \quad \text{if } y_i^* > 0 \\ y_i &= 0 \quad \text{otherwise} \end{aligned} \tag{2}$$

Where: - y_i* is a K× 1 vector of latent dependent variable, in this case desire to adopt the improved technology;

- β **i**s a k× 1 vector of unknown parameters;
- x_i is a k× 1 vector of explanatory variables;
- y_i is the vector of observed dependent variable(observed adoption);
- u_i is residuals that are independently and normally distributed, with mean zero and common variance σ^2.

From the relation (1) and (2), we get

$$\begin{aligned} \text{Prob}(y_i = 1) &= \Pr ob\ (u_i > -\beta' x_i) \\ &= 1 - F(-\beta' x_i) \end{aligned} \tag{3}$$

Where F is the cumulative distribution function of u_i.

The observed values of y just realization of a binomial process which probabilities given by (3) and varying from trial to trial (depending on x_i). Hence the likelihood function is

$$L = \prod_{y_i=0} F(-\beta' x_i) \prod_{y_i=1} \left[1 - F(-\beta' x_i)\right] \tag{4}$$

The functional form of F in (4) depends on the assumption we made about u_i in equation (1). If the cumulative distribution of u_i is the logistic, we have the logistic model. In this case

$$F(-\beta' x_i) = \frac{\exp F(-\beta' x_i)}{1 + \exp F(-\beta' x_i)} = \frac{1}{1 + \exp F(\beta' x_i)} \tag{5}$$

Hence, $$1 - \exp^{F(-\beta' x_i)} = \frac{\exp F(\beta' x_i)}{1 + \exp F(\beta' x_i)} \tag{6}$$

In this case we say there is a closed form expression for F, because it does not involve integrals explicitly. However, in the probit model, we assume that $u_i\ are\ IN(0, \sigma^2)$. In this case,

$$F(-\beta' x_i) = \int_{-\infty}^{-\beta x_i / \sigma} \frac{1}{(2\pi)^{1/2}} \exp(-t^2/2) dt$$

3.4.2. The marginal effect in the Probit model

To determine the elasticity of the significant variables (determinants of adoption), the formula for derivatives was used. In this part of analysis the exogenous variables, which had only significant effect on the adoption level, were considered. For marginal effect of the exogenous variables the following equation was used.

To find the partial effect of roughly continuous variables on the response probability, we must rely on calculus. If *explanatory variable* is a roughly continuous variable, its partial effect on $p(x) = p(y = 1|x)$ is obtained from the partial derivative:

$$\frac{\partial p(x)}{\partial x_j} = f(\beta_0 + \beta' x)\beta_j \quad \text{where} \quad f(\beta_0 + \beta' x) = \frac{dF(z)}{dz} \quad \text{and} \quad z = (\beta_0 + \beta' x) \tag{8}$$

Because F is the cumulative distribution function (cdf) of a continuous random variable, f is a probability density function. In the logit and probit cases, $F(.)$ is a strictly increasing cdf, and so $f(z) > 0$ for all z. Therefore, the partial effect of x_j on $p(\mathbf{x})$ depends on $\mathbf{x}$ through the positive quantity $f(\beta_0 + \beta' x)$, which means that the partial effect always has the same sign as β_j.

If, say, x is a binary explanatory variable, then the partial effect from changing x_1 from zero to one, holding all other variables fixed, is simply

$$G(\beta_0 + \beta_1 + \beta_2 x_2 + ... + \beta_K x_K) - G(\beta_0 + \beta_2 x_2 + ... + \beta_K x_K)$$

3.5. Definition of Variables

The dependent variable in this study is adoption of movable frame hive technology and is represented by 1 if the beekeeper uses at least one movable frame hive and 0 otherwise.

The independent variables for this study were selected based on the information obtained through FGD, KII, literatures and personal experience. They are briefly discussed hereunder:

Age (AGE): - Being a continuous variable, it is measured by the number of years the beekeeper lived. It is expected that flexibility to adopt MFH technology decreases as the age of the beekeeper ascends since young people more readily adopt new technologies than older ones (Motamed and Singh, 2003).So, it is expected that age has negative effect on adoptions.

Formal Education (LITHATE): - It is a dummy variable which takes the value 1 if the beekeeper has exposure to formal education and 0 otherwise. Education improves understanding about a given technology and hence facilitates adoption. So, it is expected that having formal education has higher adoption as compared to their counterpart (not having formal education).

Wealth: - Wealth status is one of the most detrimental factors of technology adoption. Here in our study, several variables had been used to determine the wealth status of the beekeepers: - the type of house they are residing in, livestock holding and income. It is hypothesized that wealthiest farmers are more likely to adopt MFH technology than others.

- **The type of house the beekeeper resides in (CRGIS)**: - this is a dummy variable and takes the value 1 if the beekeeper lives in a house with corrugated iron sheet roof and 0 otherwise, i.e., if the beekeeper lives in traditional grass roofed house.
- **Livestock holding (LIVHTLU)**: - it is a continuous variable and it indicates the total number of animals a beekeeper owned expressed as Tropical Livestock Unit (TLU). One TLU is equivalent to 0.7 cattle, 0.8 horses, 0.7 mules, 0.5 asses, 0.1 shoat or 0.01 poultry (FAO, 1987).
- **Income of the household head (INCOME)**: - this is a continuous variable and indicates the total amount of money (in Ethiopian Birr) a given household could get per annum.

Experience (EXPRC): - It is a measure of the number of years since the beekeeper started beekeeping practice. Experience gives the beekeeper more knowledge about the advantage of beekeeping and how to carry it out in a more successful way. Experience gives a farmer a better chance and input to make matured decision (Rahman, 2007). So, it is anticipated that beekeepers with more experience on beekeeping opt to adopt MFH technology than less experienced beekeepers.

Availability of MFH Accessories (MFHACC): - Improved beekeeping, which involves the use of Movable Frame Hive with its full package, necessitates relatively higher level of skill and the use of beekeeping accessories. If the accessories are not available, it will be difficult to carry out improved beekeeping and is not worthy than traditional beekeeping. Here in our study, the availability of accessories is a dummy variable which takes the value 1 if the accessories are available and 0 if not. It is anticipated that availability of beekeeping accessories will significantly influence the adoption decision of movable frame hive technology.

Extension Service (EXTBK): - Extension service plays key role in promoting agricultural technologies to farmers. So it is hypothesized that extension service on beekeeping will significantly influence adoption decision of movable frame hive technology. It is a dummy variable which takes the value 1 if the beekeeper has obtained extension service on beekeeping so far and 0 if not.

Apiary Demonstration (DEMON): - Beekeeper's visit to other apiary will provide a better chance to the beekeeper to learn easily, share experience and learn new and improved way of doing things. It is a dummy variable and is represented as 1 if the beekeeper had a chance to visit other apiaries and 0 otherwise. It is anticipated that apiary visit has a significant influence on movable frame hive adoption decision.

Training on Improved Beekeeping (TRAIN): - Training is a key element to improve the knowledge, skill and confidence of the farmers towards new technology. Hence it is hypothesized that training has significant influence on movable frame hive technology adoption decision of beekeepers.

Chapter 4. RESULTS AND DISCUSSION

4.1. Socio-demographic Characteristics

This study is the result of 168 beekeepers' interview; among them, 99 (58.9%) were non-adopters and 69 (41.1%) were adopters of movable frame hive technology. The mean age of the sample respondents was 44±12.576 years with the range of 20 and 80 years and their educational level ranging between zero and 10+3. The sample beekeepers had mean traditional beekeeping experience of 10.76±9.532 years with the minimum of 1 year and maximum of 51 years. They had average livestock holding (in TLU) of 3.2177±2.48121 which ranges between zero and 14.80TLU. The mean annual income of the sample beekeepers was 25098.0387±366292.9597ETHB with the range being 700 and 388,000ETHB (Table 4.1).

Table 4. 1: Results of descriptive statistics of continuous random variables

Covariates	N	Min.	Max.	Mean	Std. Deviation
Age of the Household Head	168	20	80	44	12.576
Educational Level	168	0	10+3	4.59	3.933
Years of Experience	168	1	51	10.76	9.532
Livestock Holding in TLU	168	.00	14.80	3.2177	2.48121
Annual Income (in '000)	168	0.7	388	25.1	36.7
Extension Frequency per Month	168	0	6	1.07	1.202

From the respondents, only 4 (2.4%) were women and the rest 164 (97.6%) were male beekeepers. This is because of the fact that most households in the study area are male headed. Out of the total respondents, 114 (67.9%) attended formal education while the remaining 54 (32.1%) didn't. Among the sample beekeepers, 97 (57.7%) of them live in corrugated iron sheet roofed houses while the rest 71 (42.3%) live in grass roofed ones. Most (113~67.3%) sample beekeepers had access to movable frame hive accessories while the rest 55 (32.7) respondents hadn't. Considering market availability, 116 (69%) of the sample beekeepers said that there was no satisfactory market for hive products while 52 (31%) of them saying there was. One hundred (59.5%) sample beekeepers obtained extension service at least once a month whereas 68 (40.5%) did not get. Only 57 (33.9%) of the sample beekeepers took part in movable frame hive technology training and the remaining 111 (66.1%) didn't get the chance. Most of the respondents (111~ 66.1%) participated on apiary demonstrations prepared by different stakeholder while the rest were devoid of this chance (Table 4.2).

Table 4.2: Descriptive statistics of Categorical Variables

Covariates	Status	Frequency	Percent
Gender	Female	4	2.4
	Male	164	97.6
Formal Education	Illiterate	54	32.1
	Literate	114	67.9
House type the beekeepers live in	Grass Roof	71	42.3
	Corrugate Iron Roof	97	57.7
MFH Accessories Availability	Not Available	55	32.7
	Available	113	67.3
Market Access	Not Available	116	69
	Available	52	31
Extension Service	Not Obtained	68	40.5
	Obtained	100	59.5
Apiary Demonstration	Not Participated	129	76.8
	Participated	39	23.2
Training on MFH Technology	Not Obtained	111	66.1
	Obtained	57	33.9

4.2. Results of Inferential Statistics

The independent t-test shows that all the continuous random independent variables are not statistically significant. That is, there is no statistically significant mean difference between adopters and non-adopters of MFH technology (Table 4.3).

Table 4.3: Independent sample t-test for continuous random variables

Covariate	Non Adopters	Adopters	Mean Difference	t	Sig. (2-tailed)
AGE	44.69	43.19	1.49		
	(13.15)	(11.74)	(1.97)	.759	.449
EXPRC	10.71	10.83	-.119		
	(10.02)	(8.85)	(1.49)	-.079	.937
LIVHTLU	3.14	3.32	-.18		
	(2.40)	(2.60)	(.39)	-.464	.643
INCOME	27.1	22.2	4.9		
	(42.9)	(25.3)	(5.8)	.843	.400

Table 4.4 shows the non parametric test of categorical study variables. From the total of 168 respondents, 69 (41.1%) of them were adopters and one among the adopters was female while the remaining 68 adopters were male. From the 99 non-adopters, 3 were female and the remaining 96 were male. The chi-square value (x^2= .437) indicates that there is no significant (P>10%) interaction between gender and movable frame hive technology adoption implying that movable frame hive technology can be carried out successfully irrespective of gender difference. Sample beekeepers who had attended formal education were 114 among which 62 (54.4%) and 52

(45.6%) were non-adopters and adopters of movable frame hive technology respectively. While from 54 respondents who didn't attend formal education, 37 (68.5%) and 17 (31.5%) were non-adopters and adopters respectively. With x^2 value of 3.024, formal education has marginally significant influence on movable frame hive technology adoption (P<10%). This indicates that formal education positively influences technology adoption through building farmers' capacity to get more information and knowledge about new technologies. Out of 71 respondents who live in grass roofed houses, 54 (76.1%) and 17 (23.9%) were non-adopters and adopters respectively. While from the total of 97 respondents who live in corrugated iron roofed houses, 45 (46.4%) and 52 (53.6%) were non-adopters and adopters respectively. The house type the beekeepers live in had highly significant positive influence on adoption with x^2 =14.905 (P<1%).

Movable frame hives need more accessories than traditional or transitional hives. It is difficult to keep bees in movable frame hives without their accessories. Thus availability of accessories is mandatory. Out of 113 respondents who responded that movable frame hive accessories are not available, 30 (54.5%) and 25 (45.5%) were non-adopters and adopters respectively. Whereas 69 (61.1%) non-adopters and 44 (38.9%) adopters said that there is no problem related with availability of accessories. Availability of movable frame hive accessories was not found significantly affecting the adoption decision of farmers with x^2 value of .649 and significance P>10%.

Availability of market for hive products enhances MFH technology adoption. Out of 116 respondents who said they are facing challenge to get market to sell their products, 78 (67.2%) were non-adopters and the rest 38 (32.8%) were adopters. While 21 (40.4%) and 31 (59.6%) non-adopters and adopters respectively faced no challenge to sell their products. Market access significantly affects adoption decision of beekeepers with x^2 value 9.707 (P<.01).

Extension service is the key to achieve the goal of disseminating MFH technology at the desired level and intensity. In order to provide successful extension, the extension agents (DAs) themselves first need to be equipped with the necessary skill, knowledge and attitude towards the technology. From the sampled six PAs in the study area, two of them lack development agents graduated in livestock production (apiculture). This leaves a huge gap in the extension service. In addition to this, most of the development agents had no enough skill and knowledge about the MFH technology and beekeeping in general. Out of 68 respondents who didn't obtain extension service, 57(83.8%) were non-adopters and 11 (16.2%) were adopters. Whereas 42 (42%) and 58 (58%) non-adopters and adopters respectively received extension service at least once a month. Extension service had significant positive influence on the adoption of movable frame hive technology with x^2 value of 29.253 (P<1%).

Apart from teaching the farmers, providing them a chance to participate in demonstration of new technologies motivates the farmers to adopt the new technology. Beekeepers who visit apiaries of other farmers would have better chance of adopting movable frame hive technology than others. Farmers more understand from each other than from others. Therefore, demonstration activities create better opportunity for farmers to learn from each other and hence enhance adoption of new technology. Out of the total respondents, 129 had never participated in any apiary demonstrations and 87 (67.4%) of them were non-adopters whereas the remaining 42 (32.6%) being adopters. From those respondents who were participated in demonstrations, 12 (30.8%) and 27 (69.2%) were non-adopters and adopters respectively. The chi-square value (x^2 = 16.640) indicates that apiary demonstration has highly significant (P<1%) positive influence on technology adoption.

Training on modern beekeeping improves the skill, knowledge and confidence of beekeepers thereby boosted productivity and production. Among the respondents, only 57 (34%) of them had access to training on improved beekeeping. This indicates that there is still limited access to training in the study area. Even from those adopters, 28 (41%) beekeepers didn't obtain any training on MFH technology. That means they are provided with the hives without training. This reduces the benefit to be obtained from the technology since it needs knowledge and skill; and even triggers negative adoption (rejection of the technology). Out of 57 respondents who obtained training, 16 (28.1%) were non-adopters and the remaining 41 (71.9%) were adopters. While 83 (74.8%) and 28 (25.2%) non-adopters and adopters respectively had not access to training on movable frame hive technology. With chi-square value (x^2 = 33.942), training had significant (P<1%) positive influence on movable frame hive technology adoption.

Table 4. 4: Results of cross tabulation

Covariate		Non-adopter	Adopter	x^2 Val.	Sign.
Gender	Female	3 (75%)	1 (25%)	.437[a]	.508
	Male	96 (58.5%)	68 (41.5%)		
Formal Education	Illiterate	37 (68.5%)	17 (31.5%)	3.024[a]	.082
	Literate	62 (54.4%)	52 (45.6%)		
The type of house the beekeepers live in	Grass roof	54 (76.1%)	17 (23.9%)	14.905[a]	.000
	Corrugated iron sheet	45 (46.4%)	52 (53.6%)		
Movable frame hive accessories availability	Not available	30 (54.5%)	25 (45.5%)	.649[a]	.420
	Available	69 (61.1%)	44 (38.9%)		
Market access	Not available	78 (67.2%)	38 (32.8%)	10.700[a]	.001
	Available	21 (40.4%)	31 (59.6%)		
Extension service	Not obtained	57 (83.8%)	11 (16.2%)	29.253[a]	.000
	Obtained	42 (42%)	58 (58%)		
Apiary demonstration	Not participated	87 (67.4%)	42 (32.6%)	16.640[a]	.000
	Participated	12 (30.8%)	27 (69.2%)		
Training on MFH technology	Not obtained	83 (74.8%)	28 (25.2%)	33.942[a]	.000
	Obtained	16 (28.1%)	41 (71.9%)		

4.3. Results of Econometric Model

The results of the binary probit model showed that age, status of formal education, traditional beekeeping experience, availability of MFH accessories, livestock holding, income and apiary demonstrations were not found significantly affecting adoption decision of beekeepers. Among these variables, experience and access to MFH accessories were seen negatively related with adoption though they didn't have significant influence on adoption. Farmers resist new way of doing things (technology) due to different reasons. They usually stick to their old agricultural practices in fear of risks and uncertainties. They get more familiar and more experienced with their old beekeeping practices that they don't want to change their way of doing it. The binary probit result indicates that as the years of experience in traditional beekeeping increases, so does the resistance to adopt MFH technology. Some of the most experienced beekeepers expressed their fear of losing their colony if they transferred to MFH; consequently they are reluctant to use the technology. However, this finding disagrees with Belets Gebremichael and Berhanu Gebremedhin (2014) in which beekeeping experience is marginally significant ($P<5\%$) in adoption decision of beekeepers. On the other, the finding is in line with Ajewole (2010) who found farm experience negatively influencing organic fertilizer adoption in Nigeria; and Charles Annor-Frempong (2013) in which no relationship was seen in farm experience and recommended lime practice; improved seed; and basal and top dressing fertilizer.

The negative relation of MFH accessories availability is probably attributed to two reasons. The first one is associated with the high price of the accessories as compared with the financial capacity of the beekeepers. Most of the respondents said that the accessories are too expensive and they are not constructed locally due to knowledge gap (especially honey extractor, honey press and casting mould). This (the high price of MFH) is reported by several studies conducted so far in different parts of our country (Tessega Belie, 2009; Gidey Yirga & Mekonen Teferi, 2010; Taye Beyene & Marco Verschuur, 2014). Consequently, the farmers are not able to buy them privately and hence several NGOs working in the study area are providing them with the accessories through organizing them in to several groups of beekeepers' association. This action, though it is a good progress, has some limitations. The beekeepers are organized from different locations even some times very much dispersed from one another. In such a way, the equipment are exposed to different spoilages during transportation from one beekeeper to another. In addition to this, the beekeepers are not able to get the equipment all the time they need since they have to travel to another beekeeper's locality to get them, wasting much time and energy; and even they need to wait until their turn. Because of this, many beekeepers were seen complaining that the equipment are not providing them with sufficient service. The second one is related with the skill gap on how to use this equipment. Apart from being expensive, the accessories need high knowledge and skill as compared to traditional hives. Yet the beekeepers are not obtaining the required level of training in reasonable time to cope with them. Even from those adopters, more than 25% were not trained on MFH technology (Table 4.4). That means they are provided with the hives without enough skill and knowledge. This will trigger negative perception on the importance of the technology.

Table 4. 5: The binary probit result of the study variables

Variables	Coefficient	Standard Error	Z	Prob. |z|>Z*	95% Confidence Interval	
Constant	-3.36646***	1.28894	-2.61	.0090	-5.89274	-.84018
AGE	.00501 NS	.02330	.22	.8296	-.04066	.05069
LITHATE	.69574 NS	.53682	1.30	.1950	-.35640	1.74788
CRGIS	1.76167***	.47639	3.70	.0002	.82797	2.69538
EXPRC	-.02145 NS	.03160	-.68	.4973	-.08338	.04049
MFHACC	-.63364 NS	.52304	-1.21	.2257	-1.65878	.39150
MRKACC	1.58382***	.55879	2.83	.0046	.48861	2.67902
LIVHTLU	.04624 NS	.09263	.50	.6176	-.13531	.22780
INCOME	-.1106D-04 NS	.8247D-05	-1.34	.1796	-.27233D-04	.50954D-05
EXTBK	.98887**	.44509	2.00	.0458	.01851	1.95923
DEMON	.74691 NS	.51619	1.45	.1479	-.26480	1.75863
TRAIN	1.78488***	.48823	3.66	.0003	.82796	2.74179

Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==> significance at 1%, 5%, 10% level.

The binary probit model revealed that the house type the beekeepers live in, market access, extension service and training were significantly influencing the decision of farmers whether to adopt or not to.

The wealth status of farmers is one of the determining factors for technology adoption. Wealthier farmers probably have higher risk taking margins and better access to credit that enables them to adopt new technologies easily. Here in our study, the type of shelter (house) they live in, their livestock holding and income were regarded as proxy indicators of their wealth status. However, there was no difference in the wealth status of the beekeepers between the groups (adopters & non-adopters) that could be measured by livestock holding and income. In fact there was a difference in wealth status of the beekeepers that is manifested by their living style i.e., the type of house the beekeepers reside in. Farmers those with their living standards improved usually change their house from traditional (grass roof house in our case) to improved (corrugated iron sheet roof) one. The binary probit model showed that the wealth status of beekeepers manifested in the type of house they live in (corrugated iron roof) had highly significant positive influence on MFH technology adoption, that is, significant at 1% (Table 4.5). The marginal effect result indicated that farmers living in corrugated iron roofed house will have 26.043% higher chance of adopting MFH technology than their counterparts. This fining is consistent with Belets Gebremichael and Berhanu Gebremedhin (2014) in which holding all other variables constant, a unit increment in TLU (a proxy indicator of wealth status) will increase the number of MFH in 0.2.

Availability of market for agricultural inputs and outputs is very crucial for technology adoption. And market for the products depends on the quality of the products. Honey from traditional hives is poor in quality because it is mixed with much pollen, debris of dead bees, wax, brood and some other extraneous materials included during harvest. As a result, honey from traditional hives has less demand as compared to that of honey from MFH. Consequently, there was a market access difference between adopters and non-adopters. Some of non-adopters said that they get no one to buy their honey even when they want to sell it with the least price. That is why higher proportion (67.2%) of the non adopters lack market than adopters (32.8%) (Table 4.4). This is in line with the finding of Workneh Abebe (2007); and Gidey Yirga & Mekonen Teferi (2010); they found out that honey obtained from movable frame hive has better quality and hence have higher demand than honey which is obtained from traditional hives. The binary probit model result showed that market availability has highly significant positive influence on MFH technology adoption (Table 4.5). This finding agrees with Workneh Abebe (2011) in which market availability has significant positive impact on MFH adoption. The partial effect analysis indicated that a unit increment on availability of market elevates the chance of adoption by 23.876%. Therefore, extension workers, GOs and NGOs need to work on hive products value chain improvement and awareness creation through provision of training and taking other capacity building measures.

Extension service plays a great role in providing and promoting technology options to households so that they can improve their productivity. It helps farmers to identify the possible technology options and possible risks and opportunities associated with using them. The binary probit model revealed that extension service has significant positive influence on MFH adoption decision of farmers with 5% significance. This result agrees with the finding of Workneh Abebe (2011), in which extension frequency was seen significantly influencing the decision to adopt MFH. The partial effect analysis indicated that a unit increment in extension service will lift the farmer's adoption decision up by 15.390%. This finding is in line with Belets Gebremichael and Berhanu Gebremedhin (2014) that a unit increment in extension frequency in a month would increase the probability of MFH adoption by 45.8%.

Training improves the knowledge, skill and confidence of farmers and hence improves the efficiency of a given technology through ascertaining proper usage. Some of the beekeepers were seen using the boxes of MFH for unintended purpose. Their reason for doing so when they were asked was because they don't know how to use them. They are not provided with the necessary training. The binary probit result showed that training is highly and positively significant (at 1%) in terms of MFH technology adoption decision. The partial effect result revealed that farmers who have got training will have ~30% elevated chance of adopting MFH technology than their counterparts. This finding coincides with Sisay Yehuala *et al.*(2013). Therefore, extension workers, GOs, and NGOs need to focus on facilitating training to beekeepers so that the adoption of MFH technology would reach the required level in coverage and intensity.

Table 4. 6: Results of the partial effect analysis

Variables	Partial Effect	Standard Error	Z	Prob. |z|>Z*	95% Confidence Interval	
AGE	.00072	.00333	.22	.8297	-.00581	.00724
LITHATE	.10007	.07614	1.31	.1888	-.04917	.24931
CRGIS	.26043***	.06295	4.14	.0000	.13705	.38382
EXPRC	-.00306	.00452	-.68	.4975	-.01191	.00579
MFHACC	-.09177	.07522	-1.22	.2225	-.23920	.05566
MRKACC	.23876***	.08034	2.97	.0030	.08130	.39622
LIVHTLU	.00660	.01322	.50	.6173	-.01930	.03251
INCOME	-.15809D-05	.1178D-05	-1.34	.1795	-.38893D-05	.72744D-06
EXTBK	.15390*	.07999	1.92	.0544	-.00289	.31068
DEMON	.11424	.08243	1.39	.1659	-.04734	.27576
TRAIN	.29982***	.08141	3.68	.0002	.14026	.45938

Partial effect for dummy variable is E[y|x,d=1] - E[y|x,d=0]
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

Chapter 5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The binary probit model revealed that the wealth status, market access, extension service and training had significant influence on adoption of MFH technology while age of the household head, status of formal education, traditional beekeeping experience, availability of MFH accessories and apiary demonstration had no significant influence.

Availability of market enhances MFH technology adoption. But, market is dependent on several factors such as quality, quantity, market linkage and others. However, the honey from traditional hive is very poor in quality; consequently, it is under low demand and hence lower price.

Extension service is the major input to disseminate MFH technology at the desired level and intensity. However, the extension service so far was not sufficient in coverage and intensity due to insufficient human resource and skill gap.

Training on movable frame hive technology improves the skill, knowledge and confidence of beekeepers and hence facilitates the dissemination of the technology significantly. Since then, the training being offered to the farmers as well as extension workers was not commensurate with the necessity. Many of the extension workers were not in a stand to provide the service since they lack the skill and knowledge at the level expected from them.

5.2. Recommendations

- Extension agents need to follow up beekeepers frequently so as to increase the number of adopters and the number of hives per individual adopter
- Capacity building trainings should be facilitated by GOs and NGOs to aware beekeepers to adopt movable frame hive technology; and train beekeepers on post harvest management of hive products so that they can produce quality product
- The governmental as well as non-governmental organizations need to work in integration to fulfil skilled human resource shortage through provision of long and short term training
- Movable frame hive technology promotion activities need to focus on young beekeepers to improve dissemination rate because youngsters are less resistant to new technologies than older ones.

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