# IMPACT OF MODERN BEEKEEPING PRACTICE ON THE HOUSEHOLD`S INCOME: THE CASE OF WONCHI DISTRICT OF OROMIA NATIONAL REGIONAL STATE, ETHIOPIA

**MSc THESIS**

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# Impact of Modern Beekeeping Practice on the Household`s Income: The Case of Wonchi District of Oromia National Regional State, Ethiopia

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# DEDICATION

I dedicated this Thesis to Oromo people those unfairly displaced from Ethiopian Somali region and passed away by hidden hands.

# STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

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# BIOGRAPHICAL SKETCH

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ATA | Agricultural Transformation Agency |
| ATT | Average Treatment Effect on the Treated |
| CSA | Central Statistical Agency of Ethiopia |
| DANRDO | District Agriculture and Natural Resource Development office |
| E.C | Ethiopian Calender |
| EBA | Ethiopian Beekeepers Association |
| ETB | Ethiopian Birr |
| FAO | Food and Agriculture Organization of the United Nations |
| GDP | Gross Domestic Product |
| Ha | Hectare |
| HBRC | Holota Bee Research Center |
| ILRI | International Livestock Research Institute |
| IMR | Inverse Mills Ratio |
| IVCA | Integrated Value Chain Analysis |
| Kg | Kilogram |
| Km | Kilometer |
| m. a. s.l | Meter Above Sea level |
| MBP | Modern Beekeeping Practice |
| MoA | Ministry of Agriculture |
| MVP | Marginal Value Product |
| NGOs | Non-Governmental Organizations |
| OLS | Ordinary Least Square |
| PSM | Propensity Score Matching |
| RD | Regression Discontinuity |
| SWSZ | South West Shoa Zone |
| TLU | Tropical Livestock Unit |
| WDLFDO | Wonchi District Livestock and Fishery Development Office |

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# Impact of Modern Beekeeping practice on the Household`s Income: The Case of Wonchi District of Oromia National Regional State, Ethiopia


## ABSTRACT

*Modern beekeeping development is considered as a potential area to enhance the income of smallholder farmers by the Ethiopian government. To this end, special emphasis has been given to research and extension activities on the modern beekeeping practice at different scales. However, scientific evidences on participation, it`s utilization and its impact on the household income in Wonchi district were not documented. Therefore, this study was conducted to identify the factors that determine the household`s participation in modern beekeeping and evaluate the impact of participation in modern beekeeping on the household`s income in the district. The two-stage sampling technique was used to select 167 target respondents and Cochran (1977) formula is used to determine the sample size. Primary data were collected by using an interview schedule, conducting focus group discussions, and key informants interview. Double hurdle model was employed to identify the determinants of participation and intensity of participation in the modern beekeeping while propensity score matching technique was used to quantify the impact. The result revealed that sex, land size, number of honey bee colony with traditional hive, access to extension services, number of livestock owned, market distance and income of the household head significantly determine the participation decision in modern beekeeping practice. The analysis from truncated part of the double hurdle model shows that access to modern beekeeping training, main road distance from the apiary site, access to modern bee equipment and access to credit significantly determine the intensity of participation in modern beekeeping. The propensity score matching result showed that participation in modern beekeeping had a significant positive effect (9245 ETB) on the household`s income and increased the income of the household by 9245 Birr. Some constraints and opportunities of modern beekeeping have been identified in this study in the district. To solve the problems and improve the participation in modern beekeeping practice, the government and nongovernment organizations, especially district`s livestock and fishery development office should attempt to hamper factors that hinder participation in the modern beekeeping practice and enhance factors that initiate participation in the modern beekeeping practice identified in the study area.*



**Keywords:** Determinants, Double hurdle model, Household`s income, Impact, Modern beekeeping, Participation, Propensity score matching

# 1. INTRODUCTION

## 1.1. Background

Ethiopia is believed to have the largest livestock population in Africa (CSA, 2016/17). It contributes 12% and 33% of the total and agricultural gross domestic product (GDP) respectively and provides livelihoods for 65% of the population. The sector also accounts for 12-15% of the total export earnings (FAO, 2013). Beekeeping is one of the important livestock subsectors contributes significantly to the improvement of livelihoods of the population and it is a promising sideline farm activity for the rural households, which is beneficial to the environment and increases the yield of food and forage crops through the pollination action of bees (Martin *et al.,* 2012). The country has huge apicultural resources that made it the leading honey and beeswax producer in Africa due to its` diverse ecological and climatic conditions (Sisay, 2015; MoA and ILRI, 2013). Ethiopia is one of the countries on the continent that has the largest honey bee population and owns a big honey production potential in its varied ecological and climatic zones. For instance, in 2013, the country produced about 45,000 tons of pure honey which accounted for about 27% and 3% of African and World honey production, respectively, which makes the country the largest producer in Africa and the tenth in the World (FAOSTAT, 2015).

Currently, more than 7000 species of flowering plants are estimated to be found in the country, of which more than 800 of them are honey bee plants (Yibrah, 2018). There are about 6,523,969 hives that are found in rural areas of Ethiopia and from this total hives, there are about 6,327,197 traditional, 69,399 transitional, and 127,373 modern beehives respectively (CSA, 2017/18). The ideal climatic conditions and diversity of floral resources allow the country to sustain around 10 million honey bee colonies (CSA, 2016). The country has the potential to produce about 47.71 million kilograms of honey per year and it has a share of around 23.58% and 2.13% of total Africa and World honey production respectively (CSA, 2016/17). Honey production requires little investment; land, labor, and individuals can attain significant production levels. Unlike many other commodities, bee products generate multiple market opportunities and are also nutritious food. In addition to this, the

process of honey production is not in competition with any other form of agriculture (Gallmann and Thomas, 2012).

Contribution of modern beekeeping includes the value of the outputs produced such as honey, beeswax, bee colonies, pollen, royal jelly, bee venom, and propels (Gezahegn, 2001). Modern beekeeping is a viable business that significantly contributes to increasing and diversifying the incomes of rural households. Modern beekeeping provides various benefits, such as income from the sale of bee products, self-employment opportunities, pollination and conservation of biodiversity (Al-Ghamdi and Nuru, 2013). In terms of potential economic contribution, modern beekeeping practice has been suggested that it is an environmentally friendly and farm business activity that has immense contribution to the economies of the society and the national economy as a whole (Gidey and Mekonen, 2010; ATA, 2016).

Modern beekeeping produces products with high market potentials while being more easily adapted to the constraints of low credit access and limited land access than other agricultural activities (Cristina and Molly, 2015). In this regard, modern beekeeping could be considered as a reliable source of alternative income. It is claimed that modern beekeeping has become popular among small scale farmers because farmers have resorted to making income in diverse ways (Famuyide *et al.,* 2014). Honey production is undertaken because it provides social, environmental, economic, and health benefits to rural communities and has received primary attention from the farmers. Rural poor dependent on subsistence agriculture and small farmlands often rely on alternative sources of income for their livelihoods. For such circumstances, (Yap and Devlin, 2015) propose that modern beekeeping practice is often promoted in the context of rural development because the practice provides monetary, nutritional, economic and social benefits to the poor families.

Modern beekeeping practice helps to eradicate poverty especially in the rural communities (Ayansola, 2012). It could add to the livelihoods of many different sectors within the society including village and urban traders of honey bee inputs and products, carpenters who make hives and hive stands, tailors who make veils, clothing, and gloves and those who make and sell tools and containers (Bradbear, 2009). Modern beekeeping allows for a degree of risk

avoidance by providing a reliable, high-value product that enables rural farmers to survive in times of economic crisis (Bradbear, 2006). Multiple studies have shown that many countries have tapped greater economic as well as the environmental potential of modern beekeeping. This is particularly true in the case of developed countries where beekeeping and honey production is a lucrative enterprise (Staveley *et al.,* 2014; Jaffé *et al.*, 2015). However, the potential of modern beekeeping practice in developing countries is far to often not exploited in development programs (Mazorodze, 2015). For example, Carroll and Kinsella, (2013) found that as compared to the Europe modern beekeeping, in Africa it is practicipated as a supplemental income source to the households.

Modern beekeeping practice is an activity that can be integrated with agricultural practices like crop production, horticultural crops and the conservation of natural resources. Besides selling honey and other bee products, such as beeswax, pollen grain, royal jelly, propels, and bee venom. Beekeepers can also provide pollination services (hive rental) to the farmers and Orchardists (Admin, 2011). By realizing potentials of apiculture sector and problems associated with a traditional beehive, Ethiopian government and nongovernmental organizations (NGOs) tried to introduce, demonstrate, disseminate, and scale up different modern beekeeping technologies to the farmers. For instance the establishment of beekeeping demonstration stations at different areas like Holeta, Nekemte, and Jimma etc in 1978 G.C to introduce modern beekeeping technologies (modern beehive, casting mold, honey extractor, honey presser, smoker, water sprayer, veil, glove, etc) imported from abroad to the farmers and to offer modern beekeeping training for farmers and experts can be mentioned (EBA, 2005).

Despite the long history of beekeeping in Ethiopia, having the highest bee density and being the leading honey producer as well as one of the largest beeswax exporting country in Africa, the share of the sub-sector in the GDP has never been commensurate with the huge numbers of honeybee colonies and the country's potential for beekeeping. Honey production and productivity in the country remain low, leading to low utilization of hive products domestically, and relatively low export earnings and this indicates the sector`s contribution to the farmers` livelihood is very low (Taye, 2013, Workneh, 2006).

## 1.2. Statement of the Problem

Modern beekeeping practice plays a great role in the country`s food provision and in generating and diversifying the income of subsistence Ethiopian smallholder farmers because it requires small land (Chala *et al.*, 2012). Modern beekeeping both directly and indirectly has a great impact on enhancing farmers' livelihoods through different dimensions like increasing household`s income, employment creation, etc. (Al-Ghamdi and Nuru, 2013). Modern beekeeping practice provides various benefits like income from the sale of hive products, self-employment opportunities, and biodiversity conservation (Al-Ghamdi *et al.*, 2017).

Oromia regional state has high beekeeping potential in the country and it produces honey and beeswax of about 46% of the total production in Ethiopia (Taye, 2013). Southwest Shoa Zone (SWSZ) is one of the Zones from Oromia region which has high beekeeping potential, but its level of utilization of beekeeping potential in the Zone is not as its potential (SWSZ livestock and fishery development office annual report, 2015). Wonchi district is found in SWSZ, which has the highest beekeeping potential and highest natural resources for the modern beekeeping development relative to the other districts in the region. Based on the level of technological advancements, three types of beehives are used for honey production in the district and the district has about 16,374 traditional hives, 2,039 transitional hive, and 2,802 modern beehives. Annual honey production in the district is estimated to 62,975 kg and most farmers keep their bees and use the income generated from it to purchase grains, agricultural inputs, clothes and to pay land tax and others (Wonchi district Livestock and Fishery Development Office (WDLFDO) annual report, 2015). Traditional way of beekeeping is very difficult for the management of honeybees and harvesting honey, and the maximum honey yield obtained from a traditional beehive is estimated on average to be below 7 kg per hive which is very low as compared to modern beehives which have an average production of 20- 30 kg per hive (Nuru and Eddesa, 2005).

To promote modern beekeeping as an alternative source of income generation, ten years ago by realizing the district`s potential of beekeeping sector and the problem associated to the traditional beehive, government organizations, specially Holota bee research center and non-

governmental organizations like German cooperation, Canada international development agency and others introduced, disseminated, demonstrated and scaled up different modern beekeeping technologies like modern box hive, casting mold, honey extractor, smoker, chisel and protective cloth to Wonchi district beekeepers to enhance modern beekeeping practice (EBA, 2005; HBRC, 2004; Workineh, 2011a; Taye, 2013). This intervention was expected to stimulate participation in modern beekeeping practice and improve honey production and productivity in the district.

Even though the district has a long history of beekeeping, a huge number of honey bee colonies and endowed with high natural resources which can increase production and productivity of modern beekeeping, and government and non-government organizations have demonstrated, disseminated and scaled up different beekeeping technologies in the district. However, the benefits that the farmers are obtaining from the improved beekeeping is not as its apicultural potential, and still now honey production and productivity is low in the district (Taye and Marco, 2014; WDLFDO annual report, 2017). This low production and productivity of bee products are the major economic weakness for the farmers in the Wonch district, and thus leading to the low utilization of hive products domestically and indicates the sector`s contribution to the farmer's livelihood is not proportionate with the district`s beekeeping potential. In addition to this, scientific evidence on the modern beekeeping utilization and its impact on the household`s income in Wonchi district is not documented. Therefore, this study will assess the households' income contribution as a result of participation in modern beekeeping intervention to comes up with the points of the solution so that the policy actions and extension activities, as well as further researches, can be undertaken. This may encourage the farmers to participate in modern beekeeping practice and utilize beekeeping resource on their farming to boost their production and productivity directly. Furthermore, this can change farmers` standard of living by increasing their income and contribute to the economic growth of the country.

## 1.3. Research Questions

This study has tried to answer the following questions

1. What are the institutional, socioeconomic, and other factors that influence participation in modern beekeeping practice by farmers in the study area?
2. What factors determine the intensity of participation in modern beekeeping practice by farmers in the study area?
3. What is the impact of modern beekeeping practice on household income?
4. What are the constraints and opportunities of practicing modern beekeeping to farmers in the study area?

## 1.4. Objectives of the Study

The overall objective of the study was to analyze the modern beekeeping practice by smallholder farmers to come up with the areas of improvements in the sector with the help of the following specific objectives.

I. To identify the determinants of farmers participation in modern beekeeping practice in Wonchi district;
II. To examine the determinants of the intensity of farmers participation in modern beekeeping practice in the study area; and
III. To analyze the impact of modern beekeeping practice on the household`s income in the study area.

## 1.5. Significance of the Study

The findings of this study could assist in development activities underway and to be planned in the future. Such information about decisions on matters of agricultural technologies is important for the investigators, investors, farmers, extension workers, and development workers engaged in the development and diffusion of improved beekeeping technologies. Because they can utilize the results of this study in setting research and extension agenda. Furthermore, information on farmers` characteristics will give feedback and enable investigators to modify and redirect research activities towards the most important issues. In addition to this, it will be useful to farmers in devising ways to increase their production and productivity and hence enhanced income and reduced poverty.

## 1.6. Scope and Limitations of the Study

This study was limited by different factors like time, data availability, and resources. Participation decision, the intensity of participation and impact analysis in a certain technology is undertaken by using different types of data. For example, it is conducted by the use of the panel data, time-series data and cross-sectional data by different researchers. Time series and panel data can give more information for such study than cross-sectional data. But because of the problem of availability of data as well as limited resources and time to complete the study these data types were not used in this study. In addition to this, it is better if the study can be conducted in the area including more districts, but due to the above-mentioned limitations it could not cover more districts and the findings of the study cannot be generalized for more than one district. Therefore, the research was only focused to the investigation of the determinant of participation decision, the intensity of participation by farmers and the impact of modern beekeeping practice on the household`s income in Wonchi district by using cross-sectional data collected from the sample farmers and available secondary data. The results of the study are applicable to the study area and other areas with similar physical and socioeconomic settings.

## 1.7. Organization of the Study

This thesis contains five main chapters which give general information in its introduction. Chapter two is a review of the literature. Chapter three presents the methodology used in this study while the fourth chapter is about the results and discussion. The last chapter presents the summary, conclusions and recommendations drawn from the results of the study.

# 2. LITERATURE REVIEW

This chapter covers the definition and basic terms, theories, concepts, theoretical and conceptual framework, and empirical studies on the modern beekeeping practice by farmers.

## 2.1. Definitions and Concepts

### 2.1.1. Definition of Basic Terms

In this study, participation in modern beekeeping practice would be considered as one of the technology option available to farm households owing to it enables them to increase their production and productivity of modern beekeeping and thereby increase their income.

**Beekeeping:** It is the act of keeping bees in the hives by human beings for the production of honey and other hive products to get the economic benefit (HBRC, 2004). It is the maintenance of honey bee colonies, commonly in hives by human beings (Qaiser *et al.,* 2013). It is raising, management and maintenance of honeybee colonies for the better economic and environmental benefit (Ezekiel *et al.,* 2013).

**Participation:** It is a decision to make full or partial use of innovations at the best appropriate course of action available (Rogers, 1983). Participation is the integration of new technologies into an existing practice and is usually proceeded by a period of 'trying 'and some degree of adaptation (Loevisohn *et al.,* 2013). Participation divided into two categories; the rate of participation and intensity of participation. The former is the relative speed with which farmers participate in innovations, or any practices and has as one of its pillars, the element of "time" (Debertin, 2012).

**The intensity of participation:** It refers to the level of use of a given technology at any time. It is measured in terms of a number of hectares planted with improved seed or amount of input applied per hectare is refer to the intensity of participation of technologies (Nkonya *et al.,* 1997). Even though it is difficult to bring into one single definition from the above

definitions of the respective terms, participation in modern beekeeping practice can be generally defined as below.

**Participation in modern beekeeping practice:** It can be generally defined as the farmers decision to the use of an innovations (new way) or modern beekeeping technologies like, honey extractor, honey container, having modern apiary site for beekeeping, queen catcher, casting mold for honeycomb preparation, protective cloth, adequate modern beekeeping management practice along with modern beehive with bee colony to increase production and productivity of beekeeping subsector by farmers (HBRC, 2004; Workineh, 2007).

**Modern beekeeping technologies:** They are improved beekeeping technologies such as honey extractor, honey container, honey bee feeder, modern apiary site, casting mold for honeycomb preparation, and protective cloth which have been used along with modern beehive and comfortable to undertake modern beekeeping practice (HBRC, 2004).

**Impact:** It is the change in the outcome of a treatment group that can be causally attributed to a particular intervention or program (Stern *et al.,* 2012).

### 2.1.2. Production and Productivity

production is defined as the organized activity of transforming resources into finished products in the form of goods and services and the objective of production is to satisfy the demand of such transformed resources (Bates and Parkinson, 1983). It is an act of transformation, which connects inputs and outputs (Samuelson and Marks, 2012). Production consists of various processes to add utility to natural resources for gaining greater satisfaction from them by changing the form and place of natural resources, making available materials at times when they are not normally available and making use of personal skills in the form of services. The process of producing goods in the modern economy is very complex. In this study honey production process by using modern beekeeping technologies are depends on the basic factors of production in economics. These factors include land, labor, human capital, entrepreneurship ability, and honey bee management practice. The land

is a special term used in economics because it represents natural resources, the fertility of the soil, water, air, natural vegetation, etc. (Pardey *et al.*, 2012).

**Productivity** is the economic output per unit of input (land, labor, machines, and energy) (Atkinson, 2013). Therefore productivity measures how efficiently production inputs are being used in an economy to produce a given level of output. Productivity is considered as a key source of economic growth and competitiveness and, as such, is basic statistical information for many international comparisons and country performance assessments (Debertin, 2012). For this study productivity of modern beekeeping would be measured as the amount of honey harvested per unit of modern box hive used per annum. Productivity is a measure of annual honey yield per type of hive which indicates the efficiency of modern beekeeping. An efficient farmer increases the probability of harvesting the maximum honey yield from each type of hive.

## 2.2. Beekeeping Practice in Ethiopia

There are three types of beehives to undertake beekeeping practices in Ethiopia (Tesfaye *et al.*, 2017). Farmers have been used three types of beehives depending on their economic status namely, traditional, transitional and modern beehive (Malede *et al.*, 2015). There are four types of beekeeping practices in Ethiopia namely, traditional forest, traditional backyard, transitional and modern beekeeping practice (HBRC, 2004; Bekele, 2015).

### 2.2.1. Traditional Beekeeping Practice

In Ethiopia, traditional beekeeping is the oldest practice, which has been carried out by the people for thousands of years. There are two types of traditional beekeeping practices in Ethiopia namely, forest beekeeping and backyard beekeeping (Tesfaye *et al.*, 2017). In some places, especially in the Western and Southern parts of the country, forest beekeeping by hanging many traditional hives on trees is widely practiced. In other most parts of the country backyard beekeeping with relatively better management is common (Workneh, 2006). It is exercised in forest-covered areas of the country where the population of the honey bee is abundant. The advantage of forest beekeeping is that the bees do not cause harm to the domestic animals and human being and the bees can get abundant forage plants in the forest.

### 2.2.2. Transitional Beekeeping Practice

It is one of the improved methods of beekeeping practices. The types of hives that have been used for this type of beekeeping practice are Chefeka hive, Kenya top bar hive, and Tanzania top bar hive. The hives can be constructed from timber, mud or locally available materials. Each hive carries 27-30 top bars on which honeybees attach their combs. The top bars have 3.2 cm and 48 cm width and length, respectively (HBRC, 2004). Transitional beekeeping practice has different advantages such as, it can be opened easily and quickly, the top bars are easily removable and this enables beekeepers to work fast, honeycombs can be removed from the hive for harvesting without disturbing combs containing broods. It is a type of beekeeping intermediate between traditional and modern beekeeping methods (Damisew, 2016; Sisay, 2015).

### 2.2.3. Modern Beekeeping Practice

Modern beekeeping practice involves the use of improved technologies that are easy to manipulate and manage to harvest honey crop season after season without harming honey bees (HBRC, 2004). Modern beehive consists of precisely made rectangular box hives superimposed one above the other. The number of frames is varied seasonally according to the population size of bees. Practically modern beehive was invented in 1851 by the Lorenzo Lorraine Langtroth in U.S.A (Crane, 1976). Later on, different countries developed their modern beehives for instance; Zander, Dadant, and Langthtroth are the prototype of movable frame hives used today. In many countries, Langthtroth hive has proved to be convenient for handling and management (Vivian, 1985; HBRC, 2004; Bekele, 2015).

In Ethiopia, about five types of modern beehives were introduced since 1970 E.C and the most commonly used are, Zander and Langthtroth style hives. Modern box hive is good for honey production but has the lowest beeswax production (IVCA, 2009). Since honey from the modern beehive is suitable for the production of table honey both for local and export markets, it is currently promoted vigorously by the government and several private sector processors who have integrated farms (IVCA, 2009). Modern box hives have components like brood chamber, super (honey chamber), inner and outer cover. Improved box hive has advantages over the others in that it gives high honey yield in quality and

quantity, box hives allow all range of managements to maximize the productivity of colonies like regular inspection, volume adding and reducing and swarm controlling (Workneh, 2011a). It is convenient to inspect and observe problems in the hive and also it is possible to migrate bees for better forage for honeybees. The amount of honey produced is high, 20 kg _ 30kg per hive per annum averagely (Workneh, 2011b; Sisay, 2015; HBRC, 2004; and Tessega, 2009).

On the other hand, the disadvantages of modern box hive are the bee equipment are relatively expensive, and it requires skilled manpower and the equipment needs very specific precaution (HBRC, 2004). Modern beekeeping consists of precisely made rectangular box hives superimposed one above the other and increase as bee population increase and decrease likewise. The main types of hives used are the comb hives and the movable frame hives. Other accessories that go together with modern beekeeping include the queen catcher, box hive, smoker, honey container, protective cloth, hive tool, bee brush, and the honey extracting and refining (Sisay, 2015; Yibrah, 2017; Wongelu, 2014).

## 2.3. Management of Modern Beekeeping Practice

Honey bee management practice is the regular inspection of modern beehive with honey bee colonies to know the status of brood condition, to give additional hive super for expansion of colony during flowering season, to distinguish and harvest the ripen honey, to space reduction, to feeding and maintaining colonies during dearth periods and for detection and control of bee pests which enhances colony performance such as reduced absconding, improved colony strength and higher hive yields (HBRC, 2004 ; Wilson, 2006; Yibrah, 2017). In modern beekeeping activities like placement of bee colonies at appropriate site, keeping them disease-free; guarding the hive from external predators; and maintaining or increasing bee population and honey production, seasonal management of honey bee colonies, apiary site management, internal and external colony inspection and management, preparation of colonies for transferring, routine colony inspection, colony division, adding and reducing supper based on the size of honey bee colonies that are found in the modern beehive, supplementary feeding and pest control (HBRC, 2004; Wilson, 2006; Tessega, 2009).

## 2.4. Theoretical Framework

### 2.4.1. Theoretical Framework for Participation Decision in Modern Beekeeping Practice

The participation in a certain technology depends on the advantage it will bring to the participant. The advantages can be seen in different ways either the increase in physical outcomes or the satisfaction of the participant. Therefore, the participation decision of the farmers in modern beekeeping practice is based on the utility difference they obtain between the use of modern beekeeping and not using it. The utility theory would have been used in the formulation of the participation decision of households in modern beekeeping practice.

For this study, the decision of whether to participate in modern beekeeping practice or not depends on the expected utility of participating and not participating in modern beekeeping practice. The farmers participate in modern beekeeping practice when they expect that the utility from participating in modern beekeeping practice is greater than not participating in it. Otherwise, if the expected utility from using modern beekeeping practice is lower than the expected utility from not using it, the decision of the farmers will be non-participation in modern beekeeping practice. The utility is assumed to depend on income, but also takes into account other factors such as institutional, socioeconomic and demographic factors that affect the income of the farmer. The objective of the producer is profit maximization, but profit is used to purchase goods and services that maximize the utility of the owner of the firm (Debertin, 2012). Therefore, utility theory based on the production choice was used as a theoretical basis for the participation decision of farmers in modern beekeeping practice comparing the utility of nonparticipation (status quo) with participation (the new state).

We could denote utility for the two states as follows:

Utility for the status quo would be:

$$U_{oj} = U\,(Y_j, Z_j, q^o\ \varepsilon_{oj}) \text{----------} (1)$$

And utility for the final state would be:

$$\boldsymbol{U_{1j}} = U\,(Y_j, Z_j, q^1\ \varepsilon_{1j}) \quad (2)$$

Based on this model, respondent j participate in modern beekeeping practice, if utility with the participation in modern beekeeping practice exceeds the utility of the status quo.

$$U_1 (Y_j, Z_j, q^1\varepsilon_{1j}) > U_o (Y_j, Z_j, q^o\varepsilon_{oj}) \text{----------(3)}$$

Where $U_o$ denotes the utility function from the status quo, $U_1$ denotes the utility from participation in modern beekeeping practice, Y is income, $q^1$ and $q^0$ is the alternative level of the good indexes with and without modern beekeeping practice respectively, (with $q^1 > q^o$, indicating that $q^1$ refers to the improved total output of the farmer after participating in modern beekeeping practice. $Z_j$ is a vector of individual characteristics.

Assuming that farmers maximize utility, the decision by farm household j to participate in modern beekeeping practice (MBP=1) or not participating in modern beekeeping practice (PMB= 0) is based on a comparison of expected utilities of both situations. Using the difference in expected utilities it gives the following decision rule:

$$MBP = \begin{cases} 1, if E[U_{j^1} - U_{j^0} \mid Zj] > 0 \\ 0, if\ E[U_{j^1} - U_{j^0} / Zj] \leq 0 \end{cases} \text{----------(4)}$$

Where E is the expectation operator, $U_1$ and $U_0$ are the same as mentioned earlier. Farmers in the way they form expectations on the utility levels of both choices. These differences are due to farmer`s characteristics. Vector, Zj accounts for variables that are assumed to have an impact on the utilities of both choices and the way expectations are formed on these utilities.

### 2.4.2. Theoretical Framework for Intensity of Participation in Modern Beekeeping

The number of modern beehives used for undertaking modern beekeeping practice is based on the expected return from practicing more modern beekeeping based on the costs involved and the level of output expected from a unit increase in the number of modern beehives with bee colony used. The expected return from modern beekeeping practice depends on the production and the returns to scale of production. Therefore, the theoretical framework for

analyzing how farmers decide on the share of modern beekeeping practice starts with a production function.

Assuming that the production function is given as follows:

$$Q = f(X, L, A_{I,} A_{NI}) + \varepsilon.g\ (X, L, A_{I,} A_{NI}) \text{----------} (5)$$

Where Q is output, X is variable inputs, L is labor, $A_I$ is a number of modern beehives used for modern beekeeping practice, and $A_{NI}$ is the number of non-modern beehives that the farmers own. The function Q = f(X, L, $A_{I,} A_{NI}$) gives the mean output level and $\boldsymbol{\varepsilon}$.g (X, L, $A_{I,} A_{NI}$) reflects the variation in output, where ε is a random term that reflects the production risk (e.g. due to drought, bee disease, honey bee supplementary feed shortage, etc.) and where ε.g (X, L, AI, $A_I$, $A_{NI}$) indicates how inputs and other variables related to these production risks. Some inputs may reduce the effects of these risks, whereas others may increase it. Important assumptions are that output is increasing in $A_I$ at a decreasing rate, that means ($\frac{\partial f}{\partial A_I} > 0; \partial^2{}_f / \partial A_{I^2} < 0$), and that modern beekeeping practice is risk-reducing ($\partial g/\partial A_I < 0; \partial^2 g/\partial A_{I^2} < 0$).

The one-season benefit of an additional unit of a modern beehive with bee colony is given by the marginal value product (MVP), which is the combined value of the marginal increase in output and the marginal decrease in output risk due to an additional unit of the modern beehive:

$$MVP = p.\frac{\partial Q}{\partial A_I} = p[\frac{\partial f\ (X,\ L,\ A_{I,}\ A_{NI}\ )}{\partial A_I} + \varepsilon.\frac{\partial g\ (X,\ L, A_{I,} A_{NI}\ )}{\partial A_I}] \text{----------} (6)$$

Where p is the output price.

The decision of the farmers on the use of the modern beehive for modern beekeeping practice depends on the net return from the increase in a number of the modern beehive with bee colony and the cost requirement for practicing modern beekeeping on an extra unit of the modern beehive. If the return, MVP from one unit of a modern beehive with honey bee colony is greater than the cost of the one unit of a modern beehive with a honey bee colony,

the farmer increases the allocation of the modern beehive for modern beekeeping. Recognizing that both benefits and costs are a function of $A_I$, the optimal number of the modern beehive with a honey bee colony, $A_I^*$ can be determined. If expected benefits are higher than the acquisition costs, $A_I^*$ is positive, otherwise, it is zero. The modern beekeeping cost per unit of modern bee-hive with bee colony incurred is a function of credit D, income saved from various sources (e.g. Non-farm income, N), family size as labor, L, other factors and the number of modern beehives used for modern beekeeping ($A_I$):

$$A_I = \begin{cases} A_{I^*},\ if\ P\left[\frac{\partial f(X,\ L,\ A_I, A_{NI})}{\partial A_I} + \varepsilon . \frac{\partial g(X,\ L,\ A_I,\ A_{NI})}{\partial A_I}\right] - C_1[D, L,\ N, A_1] > 0 \\ 0,\ otherwise \end{cases} \quad ---(7)$$

The optimal number of modern beehives with bee colony allocated to modern beekeeping practice is thus, a function of variables affecting the returns and costs of modern beekeeping as a function of the number of modern beehives with honey bee colonies used. Therefore, the theoretical framework for the analysis of the determinants of the intensity of participation in modern beekeeping practice depends on microeconomic theory, the optimal allocation of resource for production (Debertin, 2012).

## 2.5. Empirical Review on Determinants of Modern Beekeeping

Many studies showed that some demographic, socioeconomic, institutional, and environmental factors that are influenced the participation in different technologies utilization among smallholder farmers in developing countries.

For instance, a study conducted by Tamirat (2015) by using the probit model shows that the main determinants of participation in modern beekeeping technologies usage in Arsi Zone, Ethiopia are family size, number of local beehives that the farmers possessed, beekeeping experience, access to credit, training provided to beekeepers, participation of beekeepers on demonstration of modern beekeeping activities, wealth status of beekeepers and participation of beekeepers on the non farm income sources.

The study conducted by Workineh (2007) on the adoption of modern beekeeping practice in Asbi Wemberta district of Tigray region, by using the binary logit model shows that the main determinants of participation in modern beekeeping practice are access to credit, age of household head, apiary site distance from the vehicle road, availability of bee forage, knowledge on practical activities of the technologies, education level of household head, frequency of extension contact with district bee experts, positive perception on modern beekeeping technologies and apiary site visit demonstration were the most determinants of participation in modern beekeeping practices.

The study conducted by Belets and Berhanu (2014) on the adoption of modern beekeeping practices in Northern Ethiopia, by using first hurdle model were identified that the main determinants of adoption of modern beekeeping practice are access to non-farm activities, wealth status of the farmers, beekeeping training, beekeeping experience, availability of bee forage and bee equipment, access to credit, distance to the market, frequency of extension contact, and market information about the price of input and output of bee products.

The study conducted by Asmiro *et al.* (2014) identified that the determinants of adoption of modern beekeeping practices in the North Wollo Zone of Ethiopia and they identified that distance to the beekeepers home from the farmer training center, participation in the off-farm activities, access to credit, household head education level, sex of household head, age of household head, number of honey bee colonies with traditional hive that the farmers own, and number of livestock that the farmers own are the main determinants of adoption of modern beekeeping practice in the study area.

Availability of necessary input to smallholders at the right time, place, in the right quantity and quality, increases farmers interest to participate in a new agricultural technologies usage (Ehui *et al.,* 2004). Modern beekeeping requires protective clothes and equipment like a smoker and others to operate the hive with honey bee colonies. The availability of bee equipment influences the participation decision of farmers in modern beekeeping practices. But the result of the study conducted by Workineh (2007) on determinants of adoption of modern beekeeping practices by using logit regression model indicated that beekeeping equipment was not the barriers for participating in the modern beekeeping practices.

## 2.6. Empirical Review on Impacts of Participation in Modern Beekeeping on the Household`s Income

Impact evaluation has been conducted by different scholars with different goals. Different methods can be used to evaluate the impact of the program based on different underlying conditions and availability of the data. Among these methods, difference-in-difference which is based on before versus after and with and without data, Propensity score matching, which depends on creating counterfactual or comparison groups based on observable characteristics or propensity score, are some of them. Here in this section, previous studies on the impact of modern beekeeping practice were analyzed and reviewed.

The study conducted by (Meaza, 2010) in Asbi Wemberta district of Tigray region, Ethiopia on impacts of modern beekeeping practice by using Propensity score matching indicated that the mean income of modern beekeepers is significantly higher than that of non-participant in modern beekeeping and it revealed that the average household income gained due to participating in modern beekeeping ranges from 4679 to 4888 ETB per household in a year. This study also showed that the average per capita income gained due to undertaking modern beekeeping practice ranges from 428.4 ETB to 493.5 and it was significant at a 1% significance level based on the nearest neighbor, caliper and kernel matching algorithms.

The study undertaken by Affognon *et al*. (2015) in Mwingi district of Kenya on the impacts of modern beekeeping practice on honey production by using propensity score matching revealed that average honey production of the farmer participants in the modern beekeeping practice was significantly higher than that of nonparticipants in modern beekeeping at a 1% significance level. This study also revealed that the technical efficiency of the farmer participants in the modern beekeeping practice was significantly higher than that of nonparticipants in the modern beekeeping at 1% significance level by using data envelopment analysis, and this implies that participation in modern beekeeping practice has a positive effect on efficiency in honey production.

The study conducted by Samson, (2016) in Mikunku district of Zambia on the impacts of modern beekeeping practice by using propensity score matching revealed that participation

in modern beekeeping had no impact on the participants` income and this evidence is estimated by the use of the three matching algorithms (nearest matching, caliper matching, and kernel matching).

The study conducted by Ajao and Oladimeji (2013) in Kwara State of Nigeria on contribution of modern beekeeping practice to the household income and poverty alleviation found that the average net return per kg of honey harvested ranges from $10 to $15 while average income per season per colony ranges from $32 to $39. While the study provided valuable findings it is surprising. However, the contribution of modern beekeeping towards household income was not explicitly addressed. Given that the study aimed to assess the contribution of modern beekeeping towards household income, one would expect household income to be the dependent variable, not modern beekeeping income as done in Ajao and Oladimeji`s (2012) study.

Qaiser *et al.* (2013) conducted an impact assessment of modern beekeeping on sustainable rural livelihood in Chakwal and Sargodha district in Pakistan by using descriptive statistics, modern beekeeping practice was found to increase farmers' income although this ratio appeared low in the targeted study area.

A study conducted by Chazovachii *et al.* (2012) in Chitanga village of Mwenezi district of Zimbabwe on the impact of modern beekeeping on household income by using primary data collected through structured questionnaires concluded that food, income in the form of cash, employment and scenery creation for tourism are major benefit derived from modern beekeeping practices that the farmers could obtain in the study area.

From the reviewed studies, the main weakness that all studies, in exception of Ajao and Oladimeji (2012), Meaza, (2010), and Samson, (2016) inherited was to examine the role of modern beekeeping practices in a purely descriptive manner. In this regards, the present study would attempt to improve the existing literature by relying on econometric modeling. Unlike Ajao and Oladimeji (2012), the present analysis could ensure that the dependent variable is household income such that the response of income to modern beekeeping practice as a livelihood strategy can be addressed.

Aikaeli (2010) on the other hand made a provocative analysis on the determinants of rural income in Tanzania but unfortunately failed to capture the contribution of modern beekeeping practice in the model.

## 2.7. Analytical Framework

The models that are used in analyzing participation and intensity of participation are reviewed in this subsection. Based on the dependent variables in this study, Participation decision of the farmers and intensity of participation in the modern beekeeping practice, various models can be used. Heckman two-step procedure, double hurdle, and Tobit models are the models suited to analyze the factors determining the probability of participation and intensity of participation under different underlying assumptions.

### 2.7.1. Methods of Analysis of Participation and Intensity of Participation

Tobit model is an improvement to the probit model and it can be used to analyze both the participation decision of the farmers in modern beekeeping practice (probability of participation) and the intensity of participation in the modern beekeeping practice (number of modern beehive with honey bee colonies used) by the farm households in this particular study by the use of single non-linear least square estimation using maximum likelihood method. The likelihood-function contains two parts, that is probit part or the slope of the line in the Tobit part and linear part, which is the uncensored part of the model. Therefore Tobit model can be used to analyze the factors influencing household's participation decision in modern beekeeping practice and the intensity of participation in modern beekeeping practice by the farmers simultaneously using a single coefficient (Gujarati, 2004).

Another option model for such study is the Heckman two-step procedure proposed by James Heckman (Heckman, 1979). The Heckman two-step procedure is an improvement to the Tobit model. It accounts for sample selection bias. This option consists of a two-step estimating procedure. The first estimation is the probability of participation, which is done based on the probit model as determinants of participation. Then we estimate the second, OLS (Ordinary least squares) regression model by adding the variable called inverse mills

ratio (IMR) that are calculated using our selection equation as an independent variable, if it is significant, for the intensity of participation. Heckman treats the selection bias as an omitted variable bias. The Heckman procedure yields consistent estimates of the parameters as of Tobit model, but they are not as efficient as Tobit model maximum likelihood estimates.

Different scholars use different models for participation decision and intensity of participation. For instance, double hurdle model was used by Efa *et al.* (2016), in conducting the study on determinants of market participation and intensity of marketed surplus of *Teff* producers by reasoning out double-hurdle model is an improvement to standard Tobit model. The Double hurdle is an improvement to standard Tobit model but it has its own additional assumption under which we can use a Double hurdle instead of Tobit model. The main assumptions of the Double hurdle model are that the two dependent variables are independent and they are to be determined by different sets of explanatory variables (Burke, 2009). Double hurdle model has two parts which are estimated by two hurdles. The first one is the probit model used in estimating the factors determining the probability of participation in modern beekeeping practice and the second one is truncated regression that is used to estimate the intensity of participation in modern beekeeping of the farmers. Based on Burke (2009), Double hurdle model with the two parts are specified using two different latent variables, to model each decision process, with a probit model to determine participation decision and a truncated regression model to determine the intensity of participation in the modern beekeeping practice.

### 2.7.2. Impact Evaluation Methods

Impact evaluation is an important policy issue either to strengthening the existing activity to be sustainable or to improve the program interventions. But evaluating the impacts of modern beekeeping practice is not straightforward because it is a complex and ever-changing environment (Stern *et al*., 2012). Another problem is the bias resulting from self-selection in the adoption of technological innovation (Caliendo and Kopeinig, 2005; Khandker *et al.,* 2010). Furthermore, there may be a hidden bias that results from unobserved heterogeneity

in the participation decision, which can, in turn, influence the outcome of participating in technological innovation (Smith and Todd, 2005).

Under nonexperimental methods, there are some methods by which impacts can be evaluated. These include difference-in-difference, regression discontinuity design, instrumental variable estimation, randomized selection methods and propensity score matching (Khandker *et al.,* 2010).

Regression Discontinuity (RD) is one of the rigorous nonexperimental impact evaluation approaches that can be used to estimate program impacts in situations in which candidates are selected for treatment based on whether their value for a numeric rating exceeds a designated threshold or cut-point (Jacob and Zhu, 2012). It is based on the cut-off point in observable characteristic, often called the rating variable. RD techniques are considered to have the highest internal validity (the ability to identify causal relationships in this research setting), but their external validity (ability to generalize findings to similar contexts) may be less impressive, as the estimated treatment effect is local to the discontinuity (Baum, 2013). The treatment is not randomized, but there is some process that deterministically dictates whether a unit is treated or not, cut-off point. In this design, units receive treatment based on whether their value of an observed covariate is above or below a known cut-off (Calonico *et al.,* 2013). But when using the instrumental variable for causal inference, one must assume the instrument is exogenously generated as if by a coin-flip (Lee and Lemieux, 2010). This implies that in the instrumental variable method there is a randomized variable that is correlated with the treatment.

The difference-in-difference design for empirical analysis of causal effects has a long history in and outside econometrics and it is one of the most heavily used empirical research designs to estimate the effects of policy changes or interventions in empirical micro-economics nowadays (Lechner, 2010). The difference in difference could be an attractive choice when using research designs based on controlling for confounding variables or using instrumental variables is deemed unsuitable, and at the same time, pre-treatment information is available (Albouy, n.d.). It has the advantage that the basic idea is very intuitive and thus easy to understand for an audience with limited econometric education. Compared for example to

matching methods it has a further advantage, that there is no need to control for all confounding variables since we have a double difference. In many applications, time is an important variable to distinguish the treated and control groups in the difference-in-difference (Roberts and Lemmon, 2007). The difference-in-difference has the assumptions such as the model in equation (Outcome) is correctly specified, the error term is on average zero and error term is uncorrelated with the other variables in the equation (Albouy, n.d.). This method is best applied to the mentioned assumptions and merits.

Propensity score matching (PSM) has two key underlying assumptions (Baum, 2013). The first one is conditional independence, there exists a set x of observable covariates such that after controlling for these covariates, the potential outcomes are independent of treatment status. The other one is common support, for each value of x, there is a positive probability of being both treated and untreated. It is used when it is possible to create a comparison group from a sample of nonparticipants closest to the treated group using observable variables. Both groups are matched based on propensity scores, predicted probabilities of participation given some observed variables. PSM consist of four phases most commonly: estimating the probability of participation, i.e. the propensity score, for each unit in the sample; selecting a matching algorithm that is used to match beneficiaries with nonbeneficiaries in order to construct a comparison group; checking for balance in the characteristics of the treatment and comparison groups; and estimating the program effect and interpreting the results (Caliendo and Kopeinig, 2005).

For this study, in analyzing the impact of modern beekeeping practice on the household`s income, PSM has been used for several reasons. Firstly, there was no baseline data on participants and nonparticipants as it is common in many research works conducted on impact evaluation. Secondly, the participants in modern beekeeping practice may be self-selected to participate. Furthermore, the availability of field data was based on cross-sectional data. Finally, it is possible to identify some features, in this case socio-economic, institutional and physical characteristics, to match the participants and nonparticipants.

The interest of the impact analysis of this study may be determining the average treatment effect on the treated (ATT) of modern beekeeping practice. But the estimation of this effect

may be impossible based on the before and after because of the absence of baseline data and it needs substituting the counterfactual mean of treated, by the mean outcome of untreated (Caliendo and Kopeinig, 2005). Even though it is possible based on with and without data it would be biased estimator under selectivity biases. For such a problem, PSM provides an appropriate solution (Rosenbaum and Rubin, 1985). It accounts for sample selection bias due to observable differences between treatment and comparison groups. It controls for self-selection by creating a statistical comparison group by matching every individual observation of the treatment group with individual observations from the control group with similar observable characteristics. Therefore, PSM could be used to solve such kinds of problem.

PSM has different matching algorithms that can be used to determine the treatment effect on the treated. But the most common matching algorithms used in PSM include radius matching, kernel matching and nearest-neighbor matching (Caliendo and Kopeinig, 2005). These matching methods use different means of matching the treated to the control group to determine the average effect of a given intervention.

**Radius caliper matching:** To avoid the risk of poor matches, radius matching specifies a "caliper" or maximum propensity score distance by which a match can be made. The basic idea of radius matching is that it uses not only the nearest- neighbor within each caliper but all of the comparison group members within the caliper. In other words, it uses as many comparison cases as are available within the caliper but not those that are poor matches (based on the specified distance). In short, in 'radius caliper' matching a maximum propensity score radius, a 'caliper' is established, and all non-beneficiaries within the given radius of a beneficiary are matched to that beneficiary.

**Nearest neighbor matching:** It is one of the most straightforward matching procedures. Each program beneficiary is matched to the non-beneficiary unit with the closest propensity score. Non-beneficiaries for which there are no beneficiaries with a sufficiently similar score are discarded from the sample; the same is true for beneficiaries for which it is the non-similar beneficiary. A variation of nearest neighbor matching matches multiple (for example, the five) non-beneficiaries to one single beneficiary with different caliper distance. But

matching on more distant neighbors can reduce the variance of the estimator at a cost of an increase in bias. Therefore, reasonable distance should be taken to reduce bias. Variants of nearest neighbor matching include “with replacement” and “without replacement,” where, in the former case, an untreated individual can be used more than once as a match and, in the latter case, is considered only once. These different nearest-neighbor matching would be tested to estimate the treatment effect on the treated.

**Kernel Matching:** Is a nonparametric matching estimator that compare the outcome of each treated person to a weighted average of the outcomes of all the untreated persons, with the highest weight being placed on those with scores closest to the treated individual. One major advantage of this approach is the lower variance, which is achieved because more information is used. A drawback of this method is that some of the observations used may be poor matches. Hence, the proper imposition of the common support condition is of major importance for this approach. When applying Kernel matching, one also has to choose the kernel function and the bandwidth parameter.

## 2.8. Conceptual Framework

Many factors affect participation in modern beekeeping practice by farm households. The findings of different studies conducted on participation in modern beekeeping practice in different parts of the world indicate different factors that can influence the modern beekeeping practice of the farmers. The factors which may be affected farmer’s participation and intensity of participation in modern beekeeping practice are categorized into demographic, Socioeconomic, physical, institutional, environmental, and knowledge source variables either negatively or positively related to modern beekeeping participation among farm households. Based on the literature review and empirical studies, a conceptual framework can be formulated as below by considering household head characteristics, socio-economic, institutional, environmental, physical, and other factors that could affect farmers’ participation and intensity of participation in the modern beekeeping practice in the study area. The conceptual framework of the study is shown in figure one below. The arrows that are pointing only unidirectional shows the effect is only from one to the other but not the

reverse. The arrows that point two ways indicates that there is an interaction between the concepts in both ways.

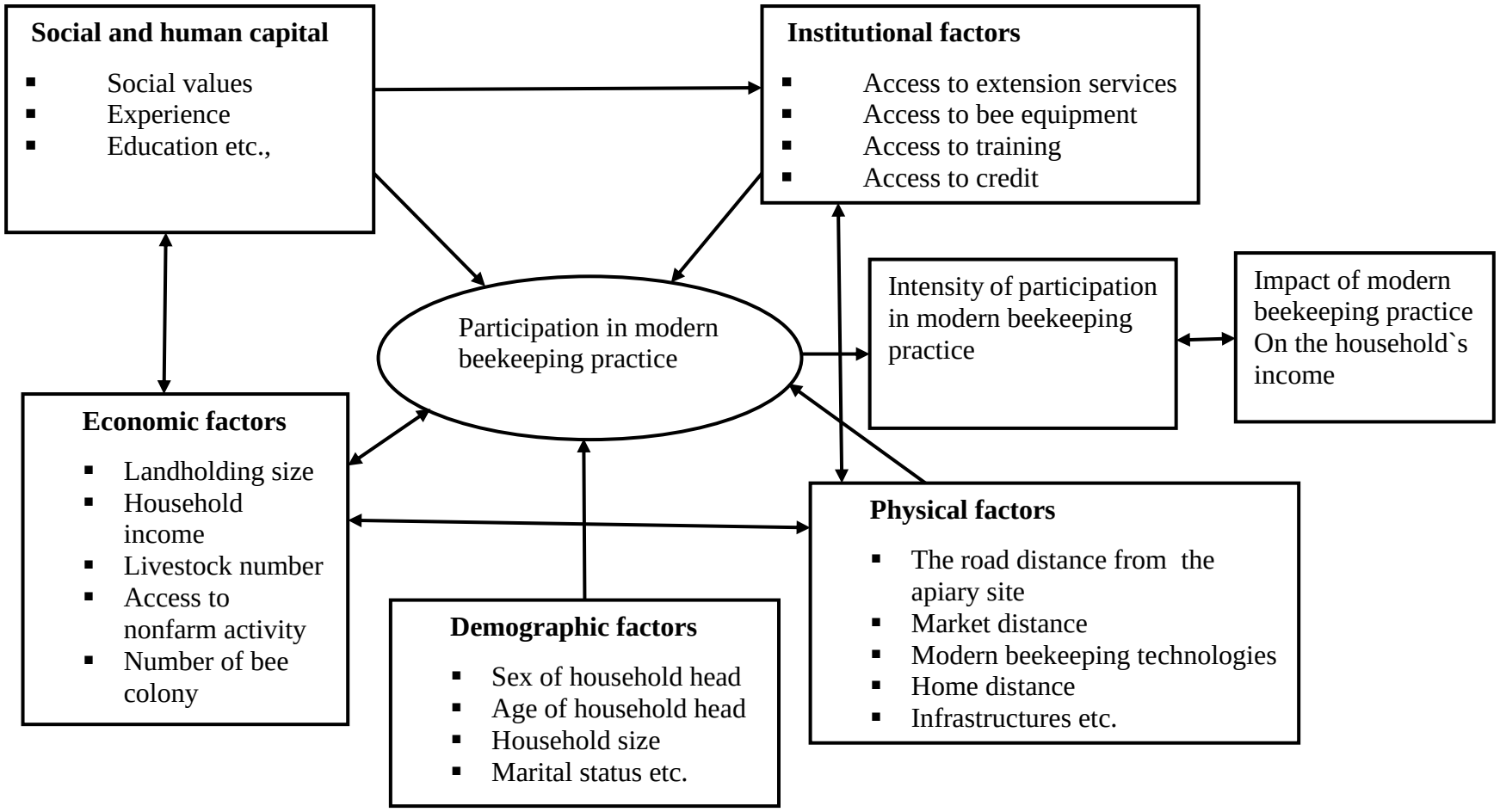


Figure 1. Conceptual framework of the study

# 3. RESEARCH METHODOLOGY

This chapter presents a description of the study area, sampling method and sample size, data types, data sources and method of data collection, method of data analysis, and description of variables and hypothesis.

## 3.1. Description of the Study Area

Wonchi district is one of the 11 districts in South West Shoa Zone of Oromia regional state of Ethiopia, containing 25 Kebeles (23 rural and 2 urban Kebele), located at latitude of 8° 43'N and 37° 53'E and the Capital city of the district Citu town is 155km from Addis Ababa to South West of Addis Ababa. The district is bordered on the SouthWest by Ameya district, on the North East by Dandi district, on the North West by Ambo district and on the South East by Woliso district. The area receives rainfall in the two seasons of the year. The long rainfall occurs from June to September and the short rainfall occurs from March to April with the peak record usually in July and August. The total area of the district is estimated to be 475.6km$^2$, approximately 39, 35, 8, 5, and 13% of the total area are cultivated land, non-cultivated land, water bodies, settlements, and woodlands and forests, respectively (District agriculture and natural resource development office (DANRDO), 2017). Based on the 2007 national census, a total population for this district is estimated to be 119,736 with the proportion of 58,671 (49%) male and 61065 (51%) female. The major religions found in the Wonchi district are Protestant (51%), Orthodox (47.2%) and Muslim (1.8%). The population of the study area composed of Oromo ethnic group (98.8%), Amhara ethnic group (0.84%) and Guraghe ethnic group (0.36%) (CSA, 2013).

The altitude of the study area ranges from 1700 to 3380 meters above sea level (masl) with two agro-ecology, high land which accounts for 40% and mid high land which is cover 60% of the district. The northern part of the district (high land part), which is mainly situated at an altitude ranging from 2560 to 3380 masl is covered by hilly topography and forest trees, which consists many honey bee forage plants (Taye and Macro, 2014). At the midland part, most farmers practice mixed farming systems that integrate both crops and livestock. These areas are under intensive cultivation of Barley (*Hordeum vulgare L*), *Teff* (*Eragrostis*),

Maize (*Zea mays L.)*, pulse crops, Potato, Haricot bean, Wheat (*Triticum aestvum L.*), Faba bean (*Vicia faba L.)*, which are the major crops grown by rain-feed agriculture (DANRDO annual report, 2017). The main vegetable crops cultivated by farmers in the district are Tomato, Potato, Onion, and Garlic. The main fruits, which are cultivated in the district, is Avocado, Mango, Papaya, and Apple and also there is a root crop like Inset and Sweet potato in the district (Taye, 2013; Taye and Macro, 2014).

The major livestock raised in the district are: cattle, horses, donkey, goats, sheep, poultry and honey bee colonies. Regarding beekeeping potential, the district has a high potential for beekeeping because relatively the area is covered with high natural resources and thus in the district apicultural resource is immense. Currently, there are 16,374 traditional hives with bee colonies, 2,039 transitional hives with bee colonies, and 2,802 modern hives with bee colonies (WDLFDO annual report, 2018).

The recent years of Meteorological data of the nearby representative stations, Citu metrological stations showed that the mean annual minimum and maximum temperatures of the district are 10 and 30 ℃ respectively and the mean annual rainfalls range from 1650 to 1800mm (Taye and macro, 2014).

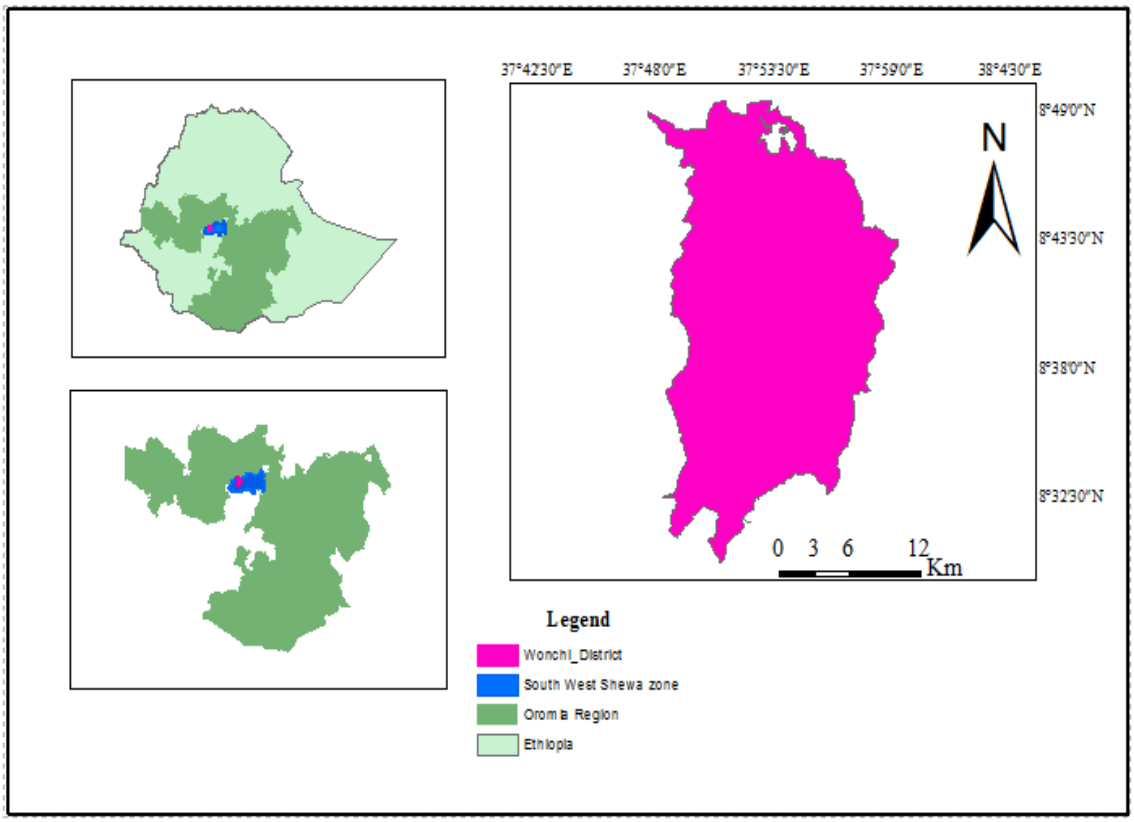


**Figure 2**. Location map of Wonchi district, Southwest Shoa Zone, Oromia region and Ethiopia

Source**:** own design with the help of GIS expert

## 3.2. Sampling Method and Sample size

The farming households were the ones making day to day decisions on-farm activities. Therefore, a household was the basic sampling unit. All rural kebeles are honey producer in the district. In this study, a two-stage sampling technique was used to generate the required primary data. At the first stage, five kebeles from 23 non-urban kebeles, mid land (9 kebeles) and high land (14 kebeles) farmer kebeles in the district were selected randomly. On the second stage, by stratifying the households into participants and non-participants, a probability proportional to sample size sampling procedure was employed to select 167 sample households from which 75 participants and 92 non-participants were randomly selected and used in the analysis, after preparing sample frame of participants and nonparticipants in the selected kebeles.

To determine the sample size from the study area, the formula for sample size determination adjusting the degree of precision to 0.07 due to the shortage of resource, following Cochran (1977) has been used. Cochran (1977) stated that if there is heterogeneity and high population this formula is appropriate for sample size determination.

The sample size from each kebele was determined by proportionality formula. Therefore, the sample size is determined by the formula (8).

$$n = \frac{Z^2 * (p)(q)}{d^2} \text{----------} (8)$$

n - Sample size

Z – Standard normal deviation (1.81 for 93% confidence level)

p = 0.5 (The proportion of the population participating in modern beekeeping, that is 50% due to unknown variability)

q = 1-p = 0.5 (50%)

d – Desired degree of precision level, which is 0.07 in this case

Proportional sampling method has been used to select the sample from each of the five kebeles. The sample selected from each selected kebeles was proportional to the population in each kebele and the formula for this purpose was determined by the formula (9).

$$n_i = \frac{N_i\ (n)}{\sum N_i} \text{----------} (9)$$

Where $n_i$ – the sample to be selected from i`s kebele

*Ni* – the total population living in the selected i`s kebele

∑ - the summation sign

∑ *Ni* – the sum of the total population in the selected five kebeles

*n* – Total sample size

Table 1. Distribution of sample selected from the five kebeles

| Name of Kebeles | Total number of households | Sample selected (participant/non-participant) | Proportion |
|---|---|---|---|
| Fite | 1109 | 37(27/10) | 22.16% |
| Haro Wonchi | 871 | 29(11/18) | 17.37% |
| Meti | 1010 | 34(11/23) | 20.36% |
| Sonkole Qaqe | 1050 | 36(16/20) | 21.56% |
| Waldo | 919 | 31(10/21) | 18.55% |
| Total | 4959 | 167(75/92) | 100% |

source: own survey data, 2019

## 3.3. Data Types, Data Sources, and Methods of Data Collection

Both secondary and primary data were collected for this study. The sources for secondary data are local offices, higher governmental organizations, different publications and policy documents whereas the primary data were collected from the sample farmers using face to face interview. To obtain primary data, semi-structured questionnaire, with closed and Open-ended questions was used as a tool to collect data from sample households. For conducting this study, important variables on economic, social and institutional factors related to the households in the study area were collected. For the sake of getting data on the determinants of modern beekeeping practice, the questionnaire covered a range of topics including demographic characteristics of households and socioeconomic structure, market access, access to credit, number of modern box hive that the farmers own, distance of the main road from apiary site, access to extension services, access to beekeeping training and other related factors were considered.

For the collection of primary data, data collectors, with at least secondary education that can speak local languages were recruited. Necessary care was taken in recruiting the enumerators. They were given intensive training on data collection procedures, interviewing techniques and the detailed contents of the questionnaire. The households` questionnaire was translated into the local language (Afan Oromo), to convey the questions effectively to the rural interviewees and it was pre-tested, administered, filled by the trained and experienced data collectors. Strict supervision was made by the researcher during the survey.

Secondary data were collected from publications and documents of different organizations and relevant zonal, district and local offices as well as journal documents. In addition to this, available documents, such as strategies, guidelines, policies, and reports relevant to modern beekeeping have been reviewed. For the sake of getting detailed and relevant information about households` modern beekeeping practice and its influencing factors in Wonchi district, key informants interview and focus group discussion was made in Wonchi district. For both, key informants and focus group discussion interviews, unstructured interview(guiding question) was used as a tool of data collection. Four focus groups namely, Zonal level livestock and fishery development office coordinator, district livestock and fishery development office coordinator, district bee experts and each selected village administrations consisting of 5 to 8 purposively selected farm households heads were used for collecting the detailed data using the guiding questions and the district livestock and fishery development office coordinator and district honey experts were interviewed considering them as key informants. These data were more qualitative and they were used in supporting the quantitative data.

## 3.4. Methods of Data Analysis

### 3.4.1. Descriptive Statistics

Descriptive statistics were used to explain the different characteristics of the households in the Wonchi district. The descriptive statistics such as minimum, maximum, standard deviation and mean were used for these analyses. Statistical significance of the variables was used for both dummy and continuous variables using chi-square ($x^2$) and student`s t-test statistics, respectively by using Stata version 13 software.

### 3.4.2. Econometric Model Specification

#### 3.4.2.1. Participation models specification

In this study, the participation decision of the farmers in modern beekeeping practice and intensity of participation in modern beekeeping practice are the dependent variables. Household`s participation decision in modern beekeeping practice is dichotomous(binary), it takes a value of 1 if the household has participated in modern beekeeping practice and zero

otherwise. If the scope of this study is only the participation decision of the farmers it is possible to use either binary logit or binary probit model. As indicated in Gujarati (1995), logit or probit models are widely applied to the analysis of determinant studies for a limited dependent variable and their result is similar. Contrary to this, Green (2003) suggests that although both models result with similar outputs, the logit model is easier in the estimation, even though this is not the problem nowadays since it is the work of the computer software within a couple of seconds. These two models are used only for the analysis of the probability of participation in a particular technology. Both are only suited in determining the probability models but not for linear models. Tobit model, Heckman two-steps procedure and double hurdle model are the models suited to analyze the factors determining the probability of participation and intensity of participation under different underlying assumptions.

Initially, it was proposed that the intensity of participation is dependent on the participation decision of the farmers in modern beekeeping practice. Based on this assumption, Tobit model following Tobin (1958), was initially proposed to be used to analyze the determinants of participation of farmers in modern beekeeping practice, by using one coefficients estimate, to estimate both the probability and intensity of participation in modern beekeeping practice. After collecting the primary data, the estimation was undertaken by Heckman two-step procedures and Lamda ($\lambda$) which indicates the inverse mills ratio (IMR) was insignificant, which indicates that there was no significant sample selectivity bias and the use of Heckman two-step procedure is inappropriate.

Furthermore, it was found that the two dependent variables were determined by different sets of explanatory variables from Double hurdle model result, which fulfill the assumption of Double hurdle model, not Tobit. In addition to the above condition, test on the best fit of the models among Tobit and Double hurdle model using the log-likelihood ratio test following Newman *et al.* (2003), was made and Double hurdle model was found to be the best fit than the Tobit model and the test can be referred from appendix part (Appendix table 1). The coefficients for the two dependent variables were different and their significant variables were not the same for the two dependent variables. Therefore, the double hurdle model was selected and used for the sake of analyzing the determinants of participation

decision (first hurdle) and intensity of participation (the second hurdle) in modern beekeeping practice.

The first hurdle model, which is probit is used in estimating the factors determining the probability of participation in modern beekeeping practice. The level of participation in modern beekeeping practice by the farmers was measured in terms of the number of modern box hive with honey bee colonies used to undertake the modern beekeeping practice by farmers. Therefore, this variable (intensity of participation in modern beekeeping practice by farmers) is a continuous dependent variable. It takes a value of one and greater than one. Truncated regression as one part of Double hurdle model has been used in estimating the factors determining intensity of participation in modern beekeeping practice by farmers using the data that is truncated from below with the lower limit of the number of the modern beehive with honey bee colony at zero.

Double hurdle model has two parts which are estimated by two hurdles. The first one is the probit model used in estimating the factors determining the probability of participation in modern beekeeping practice and the second one is truncated regression that is used to estimate the determinants of intensity of participation in modern beekeeping by the farmers. Based on Burke (2009) Double hurdle model with the two parts is specified using two different latent variables, to model each decision process, with a probit model to determine participation decision and a truncated regression model to determine the intensity of participation in modern beekeeping practice.

Participation decision equation is specified as follows:

$$Y_{i1^*} = x_1 \beta_1 + \varepsilon_{i1}, \varepsilon_{i1} \sim N(0, \delta_{1^2}) \text{----------(10)}$$

$$Y_{i1} = \begin{cases} 1, if \ Y_{i1^*} > 0 \\ 0, if \ Y_{i1^*} \leq 0 \end{cases}$$

Participation intensity equation is specified as:

$$Y_{i2^*} = X_2\beta_2 + \varepsilon_{i2}\ ,\ \varepsilon_{i2} \sim N(0,\ \delta_{2^2}) \text{ ----------(11)}$$

$$Y_{i2} = \begin{cases} X_{2\beta_2} + \varepsilon_{i2}, & \text{if } Y_{i1=1} \text{ and } Y_{i2^*} > 0 \\ 0, & \text{if } Y_{i2^*} \leq 0 \end{cases}$$

Where $Y_{i1^*}$ is unobserved (latent) variable for the participation decision in modern beekeeping practice,

$Y_{i1}$ is the observed discrete decision of the farmer whether he/she has participated or not in modern beekeeping practice, the subscript i refers to the $i^{th}$ household, the subscripts 1 and 2 refer to the variable and parameters related to the participation equation and the intensity of participation, respectively.

$X_1$'s are the index of explanatory variables determining the participation decision of the farmers in modern beekeeping practice,

$X_2$'s are the index of explanatory variables determining the intensity of participation in modern beekeeping practice by the farmers,

$\beta_1$ refers to the index of parameters related to explanatory variables determining participation decision of the farmer,

$\beta_2$ refers to the index of parameters related to explanatory variables determining the intensity of participation in the modern beekeeping practice by farmers,

$\varepsilon_{i1}$ is the error term of the participation equation which is normally distributed $\boldsymbol{(\varepsilon_{i1} \sim N(0, \delta_1^2))}$, with zero mean and constant variance,

$\varepsilon_{i2}$ is the error term of the intensity of the participation equation which is normally distributed $(\varepsilon_{i\,2} \sim N(0, \delta_2^2)$ with zero mean and constant variance,

$Y_{i2^*}$ is unobserved (latent) variable for the intensity of participation in modern beekeeping practice,

$Y_{i2}$ is the observed actual number of the modern beehive with honey bee colony allocated for modern beekeeping practice by the farmer.

**Analysis of the Marginal Effects of Participation Decision**

The marginal effects that are determined from the estimation of probit part of double hurdle model in this particular study interest could be determined by using the formula of partial derivations/ partial effects based on Burke (2009).

The marginal effect, the effect of a unit change or discrete change in explanatory variables on the probability of participating in modern beekeeping practice can be given as follows.

$$\frac{\partial P\,(Y_{i1=1/X_i})}{\partial X_j} = \beta_j \emptyset(X\beta) \text{----------} (12)$$

Where $\beta_j$ is the coefficient on $x_j$ and $\emptyset(x\beta)$ is the standard normal probability density function which would be evaluated at $(\beta_0 + \beta_1 X_1 + \beta_2 X_{2+\cdots})$.

For the continuous explanatory variables, these marginal effects are used to calculate elasticity at the sample means because the slope of the dependent variable is not constant at different per unit change of the variables. For the discrete or categorical variables, the marginal effects are used to calculate percentage changes in the dependent variable when the variable shifts from zero to one, ceteris paribus.

**3.4.2.2. Strategies of impact evaluation**

For this study, the propensity score matching method was used. Propensity score matching (PSM) is used when it is possible to create a comparison group from a sample of non-participants closest to the treated group by using observable variables. Both groups are matched based on the propensity score, predicted probability of participation given some observed variables. PSM consists four phases most commonly: estimating the probability of participation, i.e. the propensity score, for each unit in the sample; selecting a matching

algorithm that is used to match beneficiaries with nonbeneficiaries in order to make a comparison group; checking for balance in the characteristics of the treatment and comparison group; and estimating the program effect and interpreting the results (Caliendo and Kopeinig, 2005).

For analyzing the impact of modern beekeeping practice on the household income in this particular study PSM has been used for several reasons. Firstly, the participants in modern beekeeping practice may be self-selected to participate. Secondly, there was no baseline data on participants and nonparticipants as it is common in many research works conducted on impact evaluation. Furthermore, the available field data was based on a cross-sectional survey. Finally, it is possible to identify some features, in this case physical, institutional and socioeconomic characteristics, to match the participants and nonparticipants.

Different matching algorithms can be used to determine the treatment effect on the treated in (PSM). But the most common matching algorithms used in propensity score matching include nearest neighbor matching, Radius matching, and Kernel matching. These matching methods use different means of matching the treated to the control group to determine the average effect of a given intervention.

The above three matching algorithms were tested to be used in the estimation of the impact of participation in modern beekeeping practice and the best of the three was selected after undertaking the test for the three most common PSM algorithms. But there is no clear rule for determining which algorithm is more appropriate in each context. However, a key issue that has been considered was that the selection of the matching algorithm implies a bias/ efficiency trade-off. For instance, by using only one nearest neighbor we guarantee that we are using the most similar observation to construct the counterfactual. This minimizes the bias since the characteristics between both units will be, in general, very similar. However, using this technique will ignore a lot of information from the sample, since many untreated units are not used for the estimation. Therefore, the reduction in the bias comes with an increase in the imprecision of the estimates that will be caused by a higher variance, i.e., a decrease in efficiency. On the other hand, when using many neighbors, the estimator is more

efficient since it exploits a larger quantity of information from the untreated pool, but at the expense of increasing the bias by using poorer matches.

The choice of the matching algorithms would be based on the most important tests to reduce the bias and inefficiency simultaneously. These tests include mean bias, the number of matched sample, the value of pseudo R square, and the number of the balanced covariates. When considering the mean bias, the one with the lowest mean bias is the better matching algorithm. Based on the number of samples that will be matched, the one with the highest matched number of observation is the best and will be selected. When coming to the value of the pseudo R square after matching, the matching algorithm with the lowest pseudo R square is the best matching algorithm. On the other hand, the matching algorithm with the highest number of balanced covariates is more appropriate. Hence, based on the overall test of these criteria the kernel caliper matching algorithm was selected and used in the determination of the effect of participation in modern beekeeping practice on household income.

## 3.5. Definition of Variables and Hypothesis

### 3.5.1. Dependent Variables

The first dependent variable was the participation decision in modern beekeeping practice taking the value of 1 if the farmer participated and 0 if not participated in modern beekeeping practice. The main purpose here is to identify the factors determining the participation of the farmers in modern beekeeping practice. The intensity of participation is a continuous variable measured in terms of the number of a modern beehive with honeybee colony (modern beekeeping practice) allocated for modern beekeeping practice by farmers. It represents the actual number of a modern beehive with bee colony under modern beekeeping practice by the households in 2018/19. It takes continuous value greater than zero if the farmer is the participant.

### 3.5.2. Definition of Explanatory Variables

For explanatory variables, there is no underlying principle for what variables should be included in the model (Anderson *et al.,* 2011). Hence, the study was based on economic theory and empirical studies conducted previously to know which independent variables influence farmers` participation in modern beekeeping practice at the farm household level. Therefore, based on the previous studies, environmental and socio-economic conditions of the study area, the following factors were expected to influence positively or negatively participation decision of farmers in modern beekeeping practice and participation intensity in modern beekeeping practice.

**Age of household head (Age):** It is a continuous variable and measured using completed years of life. From the findings of different studies, age of household head is found negatively affected the participation in improved beekeeping practice by farmers and intensity of participation in improved beekeeping (Bunde and Kibet, 2016; Workineh, 2011b). However, the study by Carroll and Kinsella (2013) found that beekeepers in Kenya who adopted new technologies tended to be, on average, older than the general population and more economically endowed with significantly higher income. Therefore, this variable was hypothesized as influencing the modern beekeeping practice participation and intensity of participation of the farmers negatively.

**The number of honey bee colony with a traditional hive that the household own:**
It is a continuous variable measured in the number of honey bee colonies with a traditional hive owned by respondent. As the sources indicated in the literature review part of this document, the farmers with higher number of honey bee colonies with traditional hive were found to participate in modern beekeeping practice and with higher intensity of participation than those with lower number of honey bee colonies with traditional hive (Asmiro *et al.,* 2017; Tamirat, 2015). It is anticipated that farmers who have more honey bee colonies with a traditional hive can participate more in modern beekeeping practice than the farmers who have less honey bee colonies with the traditional hive. This is due to the reason that to undertake modern beekeeping practice, it requires transferring of honey bee colonies from traditional beehive to modern box hive. Hence, the variable was hypothesized as affecting

modern beekeeping participation decision of the farmers and intensity of participation positively.

**Credit access (Credit):** This variable is a dummy variable taking the value of 1 if the farmer used credit or 0 if the farmer did not use credit. Different researchers were found that use of credit has been affecting participation decision in beekeeping practice of the farmers positively (Malede *et al.,* 2013; Tadele, 2016) indicated that a farmer who uses credit can easily participate in modern beekeeping practice than the farmers who did not use credit service. The reason behind this is that credit service minimizes the financial constraints of the farmers which enable them to purchase modern bee-hive technology. Therefore, this variable is hypothesized to affect participation decision and intensity of participation in modern beekeeping positively.

**The distance of farmer's home from district livestock and fishery development office (Home distance):** This variable is a continuous variable measured in terms of Kilometer. This variable affects the participation decision of farmers in modern beekeeping practice and its intensity of participation negatively. A study conducted by Asmiro *et al.* (2017) indicated that the farther the distance of the farmer's home from the district livestock and fishery development office, the lower the probability of the farmer's participation in modern beekeeping practice and its intensity of participation. This might be due to the reason that farmers who are far from the district livestock office did not easily access the modern beehive for undertaking modern beekeeping practice. Therefore, this variable was hypothesized to influence participation in modern beekeeping practice and its intensity of participation negatively.

**Educational level of the household head (Education):** This variable is continuous variable measured in terms of years of schooling. This variable is found by different researchers as the literate household head most probably participate in improved beekeeping practice than the illiterate household head (Hippolyte *et al.,* 2015; Akudugu *et al.,* 2012); and Emmanuel, 2011). This can be due to the knowledge of the technologies they can get from education or by reading or utilizing social media. On the other way round, the literate farmers may be able to plan for getting a higher income by using modern beekeeping practice rather than

being reluctant to participate in modern beekeeping practice than illiterate farmers. Therefore, this variable was hypothesized as being more an educated the respondent the more probability of participating in modern beekeeping practice than illiterate farmers.

**Beekeeping experience with modern beekeeping practice (Experience):** This variable is a continuous variable measured in a number of years. This variable is found by different researchers as the more experienced farmer respondents most probably participate in beekeeping activities than less experienced respondents (Belets and Berhanu, 2014; Samson, 2016). This can be due to the reason that experience helps the farmers to think in a better way and makes a person more mature to take the right decision at the right time. Therefore, this variable was hypothesized as being the more experienced respondent in beekeeping activities the more probability of participating in modern beekeeping practice than the less experienced respondent.

**Distance of the main (Vehicle) road from the apiary site (Main road distance):** This variable is a continuous variable measured in terms of Kilometer. Distance to the main road (Vehicle road) affects participation decision and its intensity of participation positively (Taddele, 2016; Belets and Berhanu, 2014). This might be as apiary site far from vehicle road there is a probability that the apiary site densely covered with different vegetation, which is sources of honey bee forages. As the same time honey bees are highly sensitive to car sound disturbance, which may result in honey bee colony absconding. Therefore, this variable was hypothesized to influence participation in modern beekeeping practice and its intensity of participation positively.

**Access to extension services (Extension):** This variable is a dummy variable which takes a value 1 if the farmer has got access to extension services or 0 if the farmer has not got access to extension services. Some researchers have found that the use of extension services have been affecting participation decision in improved beekeeping practice of the farmers positively. The study conducted by (Belets and Berhanu, 2014; Taddele, 2016) indicated that a farmer who has access to extension services are more likely to adopt modern beekeeping technologies than those who have not accessed to extension services. Because the farmers who have got access to extension services about the modern beekeeping issues tend to be

more progressive and more aware of the modern beekeeping practice and more likely to experiment with modern beekeeping practice. Therefore, this variable was hypothesized to affect participation decision and intensity of participation in modern beekeeping practice positively.

**The distance of the nearest market (Market distance):** This variable is a continuous variable measured in terms of Kilometer (Km). It is directly related to the transaction cost and it is used as a proxy. When transaction cost increases it discourages participation in modern beekeeping practice. A study conducted by Belets and Berhanu(2014) indicated that the farther the distance of the market from the farmer`s residence area, the lower the probability of the farmer`s participation in modern beekeeping practice. Therefore, this variable is expected to affect participation decision and intensity of participation in modern beekeeping practice negatively.

**Access to modern beekeeping equipment (Bee Equipment):** This variable is dummy variable taking the value 1 if there were the availability of modern beekeeping equipment for the farmer in the district or 0 if there were not the availability of modern beekeeping equipment for the farmer in the district. Studies by Wongelu (2014) and Amanuel (2018) showed that availability of beekeeping accessories and equipment, which the farmers use for inspecting honey bee hive with honey bee colonies, for effective management of honey bee colonies with modern beehive and honey bee products after its` harvested, and for reducing sting of honey bees during honey harvesting time affects participation decision of farmers in the modern beekeeping positively. To undertake modern beekeeping activities, protective clothes (such as glove, boots and bee veil) and equipment (at least smoker) are critical to operate the hive with a honey bee colony, ease for operation, reduce bee sting and even manage the honey bee colony. Therefore, this variable was hypothesized to affect participation decision and intensity of participation in modern beekeeping practice positively if it is available in the district.

**Household size (Household size):** It is continuous variable and measured by taking man equivalent of household members. Different studies show that the farmers with higher family size were found participating in improved beekeeping practice more than those with lower

family size (Workineh, 2011b; Bunde and Kibet, 2016; and Malede *et al.*, 2013). This may be the case when the family members are used as the labor force in improved beekeeping practice. This will reduce the cost incurred in hiring external labor. It also enables the availability of labor on time at the time of undertaking beekeeping activities reducing the searching time for labor. Therefore, this variable was hypothesized to influence participation in modern beekeeping practice and its intensity positively.

**The total annual income of the household (Income):** It is a continuous variable, which is the total annual income that the households can obtain from different sources of income and measured in Ethiopian Birr. Evidence (Tamirat, 2015; Taddele, 2016) show that this variable is positively and significantly affecting the modern beekeeping practice participation of the farmers. The higher the total income of the household, the higher the probability of participation in modern beekeeping practices by the farmers. This could be the case if the farmers with higher income can cover the modern beekeeping cost easily than lower-income households. The farmers with higher-income can easily buy the inputs required for modern beekeeping than lower-income households. Therefore, this variable was hypothesized as influencing the modern beekeeping participation decision of the farmers and its intensity positively.

**Landholding size of household (Land size):** This variable is a continuous variable measured in terms of a hectare. Those farmers having a larger area of land were found to participate more in modern beekeeping development than those farmers having a small area of land (Samson, 2016; Tamirat, 2015). The large size of the land is sometimes seen as social status. Because the status they have in the society may encourage those farmers to participate in modern beekeeping to maintain their status in society. Therefore, this variable was hypothesized as influencing the modern beekeeping practice participation without predetermination of the direction positively.

**Total livestock owned by household (Livestock):** This is a continuous variable measured in Tropical Livestock Unit (TLU). Some sources show that the higher the total livestock owned by the respondent the higher the probability of participation in modern beekeeping practice (Amanuel, 2018; Tamirat, 2015). This result could be related to the possibility of

using the livestock sale at the time of undertaking modern beekeeping activities as a source of income that can be used for expanding on modern beekeeping activities. This means the wealth can be used for more investment. Therefore, this variable was hypothesized to enhance participation decision and intensity of participation of the farmers in modern beekeeping practice.

**Access to non-farm activity (Nonfarm activity):** This variable is a dummy variable taking on 1 if the household head has involved in non-farm activity or 0 otherwise. Some evidence shows that the farmers having access to a nonfarm source of income were found participating more in improved beekeeping practice than the farmers not having access to non-farm income source (Malede *et al.,* 2013; Tamirat, 2015). This may be due to the reason that the farmer having access to nonfarm income source may use this extra income on the expense required for undertaking modern beekeeping practice. Therefore, based on this idea the variable was hypothesized to influence participation in modern beekeeping activity positively.

**Sex of household head (Sex):** It is a dummy variable taking the value of 1 if the sex of the household head is female or 0 if the sex of the household head is male. This variable is expected as the probability of participating in modern beekeeping practice would be higher for male-headed household as compared to female-headed households as sources from different studies indicate (Bunde and Kibet, 2016; Asmiro *et al.,* 2017). In most cases, modern beekeeping practice in rural areas is carried out as extra farm activity and supplementary source of income for covering the extra household expenditures and the effort required may be hard to female-headed households to participate in undertaking modern beekeeping practice. Therefore, this variable was hypothesized as, if the household head is female there would be a low probability of participating in modern beekeeping practice than if the household head is male.

**Access to training on modern beekeeping issues (Training):** Training is a dummy variable which takes a value of 1 if the farmer has got at least one training on the modern beekeeping practice or 0 if the farmer did not get training regarding the modern beekeeping issues. It is one of the most essential extension methods used to transfer information,

knowledge, and skill for improving traditional and modern beekeeping management practices. Evidence indicated that the farmer that obtained training on beekeeping were found to participate in modern beekeeping practice more as compared to the farmers that did not get training on modern beekeeping (Wongelu, 2014; Adeday *et al.,* 2012; Amanuel, 2018). Training can create awareness for the farmers on the advantage of modern beekeeping, the management of modern beekeeping, and the know-how and this may enable the farmers to participate more in modern beekeeping. Therefore, this variable was hypothesized to influence participation in modern beekeeping positively.

Table 2. Summary of explanatory variables` definition and hypothesis

| List of explanatory variables | Nature and measurement unit of explanatory variables | Hypothesized direction of significance |
|---|---|---|
| Age of household head (Age) | Continuous (Years) | Negative |
| Number of bee colonies with traditional hive (Bee colony) | Continuous (Number) | Positive |
| Credit access (Credit) | Dummy (1 if used, 0 if not) | Positive |
| Farmer`s home distance from the district livestock office | Continuous (Kilometer) | Negative |
| Educational status of respondent (Education) | Continuous (Class year) | Positive |
| Beekeeping experience with modern boxhive (Experience) | Continuous (Number of years) | Positive |
| Distance of the main road from apiary site (Road distance) | Continuous (Kilometer) | Positive |
| Access to extension services (Extension) | Dummy (access=1, 0 if not) | Positive |
| Distance of the nearest market (Market distance) | Continuous (Kilometer) | Negative/ Positive |
| Access to beekeeping equipment (Bee equipment) | Dummy (access=1 , 0 if not ) | positive |
| Household size | Continuous (Man equivalent) | Positive |
| Total income of the household (Income) | Continuous (ETB) | Positive |
| Landholding size of household head (Land size) | Continuous (Hectare) | Positive |
| Total livestock owned by household head (Livestock) | Continuous (TLU) | Positive |
| Access to nonfarm activity (Nonfarm activity) | Dummy (Access=1, 0 otherwise) | Positive |
| Sex of household head (Sex) | Dummy (1 if female, 0 otherwise) | Negative |
| Access to the training on the modern beekeeping (Training) | Dummy ( Access =1, 0 if not) | Positive |

# 4. RESULTS AND DISCUSSION

This chapter discusses the results obtained from the primary and secondary data. It consists the descriptive analysis of the farm household characteristics in the study area, factors determining the participation decision of the farmers in modern beekeeping practice as well as factors determining the intensity of participation and the impact of participating in the modern beekeeping practice on the household`s income. Lastly, major opportunities and challenges of modern beekeeping practice in the study area are presented in this chapter.

## 4.1. Descriptive Analysis

### 4.1.1. Socioeconomic Characteristics of the Sample Respondents

Demographic, environmental, institutional, physical, and socioeconomic features of the farm households are presented in this sub-section.

The distribution of the categorical variables related to modern beekeeping practice participants and non-participants is given in Table 3. The proportion of the respondents falling into these categories is given and the difference of the proportion across non-participants and participants were tested by using chi-square test. The summary of the socioeconomic characteristics of the farmers along with the mean difference test (t-test) of continuous variables is presented in Table 4. As it can be observed from Table 4, the mean, standard deviation, minimum and the maximum values of the variables are computed for the entire sample and the groups, non-participants, and participants. After estimating the mean values, the significance of the mean difference test was undertaken by two-group mean comparison test for the continuous variables. The detailed discussion of both categorical and continuous variables is presented under different conceptual groups.

#### 4.1.1.1. Demographic characteristics

**Age of household head:** It is one of the variables used in the analysis of the characteristics of the farm households in the study area related to modern beekeeping practice. The mean age of the total sample households in the study area was 45.09 years. The mean age of non-

participants was 48.60 years with minimum and maximum age of 22 and 84 years, respectively, and that of participants was 40.80 years, with minimum and maximum values of 22 and 80 years, respectively. The descriptive analysis revealed a significant difference in age of household heads between participants and non-participants in modern beekeeping. The mean difference age of household head between the non-participants and participants was significant at 5% (Table 4). The result indicated that the age of non-participants was higher as compared to participants.

**Household size:** The mean household size of the total sample households in the study area was about 6 adult equivalent with minimum and maximum household size of 2 and 13 respectively. The mean household size of participants was 5.36 with minimum and maximum household size of 2 and 13 adult equivalent respectively, and that of nonparticipants was 6.62 adult equivalent, with minimum and maximum household size of 2 and 13 adult equivalent respectively. The descriptive analysis revealed there was no a significant difference in the household size of household heads between participants and nonparticipants in modern beekeeping practice.

**Sex of household head**: For the total observation, 84.43% of the sample households` were male-headed, whereas 15.57% of households were female-headed. About 93.33% and 77.17% of male-headed households were participants and nonparticipants respectively. Female-headed households were 6.67% participants and 22.83% nonparticipants (Table 3). There was a highly significant difference between participants and nonparticipants in terms of the sex of households' at 10% significance level. The result of this variable indicated that male-headed households participate more in modern beekeeping practice than female-headed households.

#### 4.1.1.2. Social and human capital

**Experience with modern beekeeping practice:** The mean modern beekeeping experience of the total households in the study area was 7.08 years, with minimum and maximum experience of 0 and 27 years, respectively with the standard deviation of 6.48 year. But the mean modern beekeeping experience of the non-participants was 5.6 with the minimum and

maximum experience of 0 and 21 respectively and standard deviation of 4.99, whereas that of the participants was 8.8, 1 and 27 respectively with a standard deviation of 7.64 (Table 4). The descriptive analysis revealed that there was a significant difference in the year of experience of households between participants and non-participants in modern beekeeping practice. The mean difference of modern beekeeping practice experience between the non-participants and participants was highly significant at 1% level of significance. This implies that the experience of the participants was higher as compared to non-participants. Someone may assume that the modern beekeeping experience of non-participants would be zero, but in this particular case of study, the experience of non-participants on average was different from zero because they were participating in the modern beekeeping practice some years ago, but not practicing currently. This indicates that there was dis adoption in modern beekeeping and it is one problem observed in the study area which needs further analysis for the reason behind dis-adoption by researchers in the future.

**Education level**: The mean education of the total households in the study area was 7.81 in terms of years of schooling, whereas the non-participants and participants had a mean education level of 6.89 and 8.94 years of schooling, respectively (Table 4). There was a significant difference in the education level between participants and non-participants household heads at 1% level of significance. The result indicates that the education level of the non-participants was lower as compared to the participants` education level.

**Access to training on modern beekeeping issues:** For the total observation about 44.31% of households did not obtain training access on modern beekeeping practice. About 76.09 % of the non-participants and 5.33% of the participants had not obtained training access on the modern beekeeping while 94.67% of the participants were obtained training access on the modern beekeeping issues (Table 3). There was a significant difference between the participants and nonparticipants in terms of access to modern beekeeping training at 1% significance level. The result of this variable indicates that the modern beekeeping participant households had obtained training on modern beekeeping issues more than the nonparticipant households.

#### 4.1.1.3. Asset holding/economic characteristics

**Cultivable land size:** This variable was used in the analysis of the characteristics of the farm household in the study area. The result of the descriptive analysis shows that the mean cultivable land size calculated for the total sample households in the study area was 2.14 ha, with minimum and maximum cultivable land size of 0.25 and 5 ha, respectively. On the other hand, the mean cultivable land size of the household for non-participants was found to be 1.92 ha, with the minimum and maximum cultivable land size of 0.25 ha and 4.7 ha, respectively, whereas that of the participant is 2.32 ha, with minimum and maximum of 0.25 ha and 5 ha, respectively. The descriptive analysis revealed that there was no significant difference in the cultivable land size of households between participants and non-participants in modern beekeeping practice.

**Total livestock holding:** It is one of the economic characteristics of the farm household analyzed in the study area. The mean total livestock holding of the total households is 11.96 TLU. But the mean livestock holding of the non-participants was 9.5 TLU, with minimum and maximum of 0.195 TLU and 26.6 TLU respectively while that of the participants was 14.96 TLU, with minimum and maximum of 1.75 and 32.46 TLU respectively. The t-test revealed that there was no significant difference between participants and non-participants.

**The number of honey Bee colonies with traditional hive (Bee colony):** Concerning the number of honey bee colonies with a traditional hive owned, the number of honey bee colony owned by total households in the study area was 10.16 on average, and the minimum and maximum number of honey bee colonies with traditional hive were 0 and 25, respectively. The mean number of honey bee colonies with traditional hive owned for the non-participants was 8.76, whereas that of the participants was 11.89. The descriptive analysis revealed that there was a significant difference at a 1% level of significance on the number of honey bee colonies with a traditional hive owned by households between participants and non-participants in modern beekeeping practice. This implies that the number of honey bee colonies with a traditional hive of the participants was higher as compared to the non-participants.

**Access to non-farm activity:** The proportion of households that do not have access to the nonfarm activity was about 51.50 % for the total sampled households. The proportion of households that have access to non-farm activity for non-participants was about 48.91% whereas that of participants was about 48.00% and the chi-square value of the proportionality test for this variable indicates that there was significant difference between participants and nonparticipants in the modern beekeeping practice at 1% significance level .

**Total income of the households:** This variable was analyzed as characterizing the farm households in the study area related to the participation in modern beekeeping practice. The mean annual income of the sampled households in the study area was Birr 57124.2, with minimum and maximum annual income of Birr 3900 and Birr125700, respectively. But the mean annual income of the non-participants was Birr 48480 with minimum and maximum annual income of Birr 3900 and 90000 respectively, whereas that of the participants is Birr 67720, with minimum and maximum annual income of Birr 10600 and 125700 respectively. The descriptive analysis revealed that there was a significant difference in the annual income of households between participants and non-participants in modern beekeeping. The mean difference between the non-participants and participants was significant at 5% significance level. This implies that the income of the participants was higher as compared to non-participants` income.

#### 4.1.1.4. Institutional characteristics

**Market distance:** This variable was analyzed across the farm households as their characteristics in the study area related to modern beekeeping practice. This factor is a proxy for transaction cost. From the descriptive analysis, the mean distance of the market for the total sample households in the study area was 13.4 km, with minimum and maximum market distance of 3 km and 32 km, respectively. But the mean market distance of the non-participants was 18.0 km with the minimum and maximum market distance of 3.6 km and 32 km respectively, whereas that of the participants was 7.77 km, with minimum and maximum values of 3 km and 26 km respectively. The descriptive analysis revealed that there was a significant difference in the distance of the market from a household residence

between participants and non-participants in modern beekeeping practice at 1% significance level. The result indicates that the market distance for the non-participants is higher as compared to that of participants.

**Access to the modern beekeeping equipment:** This variable is also analyzed across participants and non-participants in modern beekeeping practice in the study area. For the total observation, 50.30% of households do not have modern beekeeping equipment access, whereas 26.67% of the participant and 69.57% of nonparticipants have no access to modern beekeeping equipment. The chi-square value indicates that there was a significant difference between participants and nonparticipants on the accessibility of modern beekeeping equipment at 1% level of significance.

**Access to extension services:** For the total observation about 36.53% of households did not obtain extension services on the modern beekeeping practice. About 47.83% of the non-participants and 22.67% of the participants had not obtained access to extension services on modern beekeeping issues. There was a significant difference between the participants and non-participants in terms of accessibility of extension services at 1% significance level. The result of this variable indicates that the modern beekeeping participant households had obtained extension services on modern beekeeping issues more than the nonparticipant households.

**Credit access:** This variable is analyzed across participants and non-participants. For the total sampled households, about 43.71% did not use credit, whereas the proportion of those did not use credit are 41.30% for non- participants and 46.67% for participants. Chi-square test indicated that there was no significant difference between participants and nonparticipants.

Table 3. Distribution of the categorical variables across participants and nonparticipants

| | For the total observation =167 | | Participants = 75 | Nonparticipants =92 | $Chi^2$ value |
|---|---|---|---|---|---|
| Explanatory variables | | Frequency (Proportion/%) | Frequency (Proportion/%) | Frequency (Proportion/%) in %) | |
| Bee equipment | Access | 83 (49.70) | 55 (73.33) | 28 (30.43) | 16.35*** |
| | No access | 84 (50.30) | 20 (26.67) | 64 (69.57) | |
| Credit | Access | 94 (56.29) | 40(53.33) | 54 (58.70) | 0.65 |
| | No access | 73 (43.71) | 35 (46.67) | 38 (41.30) | |
| Extension | Access | 106 (63.47) | 58 (77.33) | 48 (52.17) | 13.03*** |
| | No access | 61(36.53) | 17 (22.67) | 44 (47.83) | |
| Nonfarm activity | Access | 81 (48.50) | 36 (48.00) | 45 (48.91) | 9.09*** |
| | No access | 86 (51.50) | 39 (52.00) | 47 (51.09) | |
| Sex | Male | 141 (84.43) | 70 (93.33) | 71(77.17) | 1.66* |
| | Female | 26 (15.57) | 5 (6.67) | 21 (22.83) | |
| Training | Trained | 93 (55.69) | 71 (94.67) | 22 (23.91) | 18.73*** |
| | Not trained | 74 (44.31) | 4 (5.33) | 70 (76.09) | |

*** And ***** shows significant at 10% and 1% level of significance

**Source:** Own computation result from survey data, 2019

#### 4.1.1.5. Physical characteristics

**Distance of the main road from the Apiary site:** This variable is analyzed across the farm households as their characteristics in the study area related to the modern beekeeping practice. The mean distance of the main road from the apiary site for the total households in the study area was found to be 3.16km, while the mean figures are 4.40 km and 2.16 km, concerning the distance of the main (vehicle) road from the apiary site for participants and nonparticipants, respectively. The minimum and maximum distance of the main road from the apiary site for the participant was 0.25 km and 7.5 km respectively, whereas that of the nonparticipant was 0.125km and 7.5 km respectively. There was a significant difference in the main road distance of households between participants and nonparticipants at 1% significance level. The result of the analysis shows that the distance of the main road from the apiary site for participants was higher as compared to the nonparticipants` distance of the main (vehicle) road from the apiary site.

**Distance of the household head`s home from the district livestock and fishery development office:** It is used in the analysis of the characteristics of the farm household in the study area. The mean distance of the household`s home from the district livestock for the total households in the study area was found to be 15.07 km, while the mean figures are 8.78km and 8.95km, concerning the distance of the household`s home from the district livestock office for participants and nonparticipants respectively. The minimum and maximum distance of household`s home from the district livestock office for the participants was 3km and 28km respectively, whereas that of the nonparticipant was 3.7 km and 28 km respectively. There was a significant difference in the home distance of households between participants and non-participants at 1% level of significance. The result of the analysis shows that the distance of the household`s home from the district livestock and fishery development office for the participants was lower as compared to the non-participants.

Table 4. Summary statistics of continuous variables

| | For the total Observation =167 | | | | Participants=75 | | | | Non-participants=92 | | | | Mean diff. test (t value) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Dev** | **Min** | **Max** | **Mean** | **Std. Dev** | **Min** | **Max** | **Mean** | **Std. Dev** | **Min** | **Max** | |
| Age | 45.09 | 15.5 | 22 | 84 | 40.8 | 12.9 | 22 | 80 | 48.60 | 16.6 | 22 | 84 | 1.96** |
| Bee colony | 10.16 | 5.73 | 0 | 25 | 11.89 | 5.94 | 2 | 25 | 8.76 | 5.18 | 0 | 24 | 5.88*** |
| Education | 7.81 | 3.50 | 0 | 13 | 8.94 | 3.11 | 1 | 13 | 6.89 | 3.56 | 0 | 13 | -4.358*** |
| Experience | 7.10 | 6.47 | 0 | 27 | 8.82 | 7.60 | 1 | 27 | 5.6 | 4.99 | 0 | 21 | 3.04*** |
| Home distance | 15.07 | 9.38 | 3 | 28 | 8.78 | 5.11 | 3 | 28 | 20.19 | 8.95 | 3.7 | 28 | 5.30*** |
| Household size | 6.05 | 3.16 | 2 | 13 | 5.36 | 3.08 | 2 | 13 | 6.62 | 3.11 | 2 | 13 | 0.3332 |
| Income in Birr (1000) | 57.12 | 27.56 | 3.9 | 125.7 | 67.72 | 32.56 | 10.6 | 125.7 | 48.48 | 18.94 | 3.9 | 90 | -2.29** |
| Land size | 2.14 | 1.10 | 0.25 | 5 | 2.32 | 1.06 | 0.25 | 5 | 1.92 | 1.12 | 0.25 | 4.7 | -1.20 |
| Livestock (TLU) | 11.96 | 7.76 | 0.195 | 32.46 | 14.96 | 7.58 | 1.75 | 32.46 | 9.50 | 7.04 | 0.195 | 26.6 | -0.40 |
| Market distance | 13.40 | 8.89 | 3 | 32 | 7.77 | 4.26 | 3 | 26 | 18.00 | 9.05 | 3.6 | 32 | 4.05*** |
| Road distance | 3.16 | 2.12 | 0.125 | 7.5 | 4.40 | 1.93 | 0.25 | 7.5 | 2.16 | 1.69 | 0.125 | 7.5 | -2.52*** |

**** and ***** indicates significant at 5% and 1% level of significance

**Source:** Own computation result from the survey data, 2019

### 4.1.2. Annual Honey Production and Productivity in the Study Area

Concerning the number of a modern beehive with honey bee colonies (Modern Beekeeping), the total number of Modern Beehive with Honey bee Colony (Modern Beekeeping) owned by the participant in the study area was found to be 378 hives. The mean number of a modern beehive with honey bee colony (modern beekeeping) owned by the participants was found to be 5.04. The minimum and maximum number of a modern beehive with honey bee colony (modern beekeeping practice) for participants were found to be 2 and 12 hive respectively. All(100%) respondents responded that honey harvested twice in a year in the study area. The main honey harvesting period of the two agroecology of the district was October to December, and May to June, while October and June are a peak honey harvesting months of the two-season in both agroecology to obtain the largest quantity and quality honey. The total honey production from the modern beehive is 5,030.55 kg for the participants in 2018/19 production year. The minimum and maximum honey productivity of the participants from the modern hive was 11.5 and 27 kg per colony in one season while average honey productivity was 20.25kg per colony in the study area.

Table 5. Distribution of participant sample households by their kebele in the study area

| Name of kebele | Frequency | Percentage (%) | Cumulative percentage (%) |
|---|---|---|---|
| Fite | 27 | 36.00 | 36.00 |
| Haro wonchi | 11 | 14.67 | 50.67 |
| Meti | 11 | 14.67 | 65.34 |
| Sonkole qaqe | 16 | 21.33 | 86.67 |
| Waldo | 10 | 13.33 | 100.00 |
| Total | 75 | 100.00 | |

Source: Own computation from survey data, 2019

## 4.2. Factors Determining Participation in Modern Beekeeping Practice

The probit regression part of double hurdle model result, given in Table 6, reveals that out of the 17 explanatory variables, seven explanatory variables were found significantly determined the participation decision of the farmers in modern beekeeping practice, at

different significance levels. These variables influence the participation decision of the farm household in different directions.

**Sex of household head (Sex):** The sex of the household head was found significantly affected the participation decision of farmers in modern beekeeping practice at 10% level of significance. The value of the marginal effect of this variable (0.3530), indicates that the probability of participating in modern beekeeping decreases by 35.30% for the farmers who are female–headed as compared to the farmers who are male headed household. This finding is in-line with the result reported by ((Bunde and Kibet, 2016; Asmiro *et al.,* 2017).

**Number of honey Bee colonies with a traditional hive that the household head own (bee colony):** This variable was found significant at 5% significance level and positively related to household participation decision in modern beekeeping practice. It shows that all other factors being kept constant, predicted probability of modern beekeeping participation decision increases as the number of honey bee colonies with a traditional hive that the household own increases. The marginal effect of this variable, 0.223 indicates that a unit increase in the number of honey bee colonies with a traditional hive that the household head own leads to increase in the probability of participating in modern beekeeping by 2.23%, holding other factors constant at their mean level. This is due to the reason that to undertake modern beekeeping practice, it requires transferring of honey bee colonies from traditional beehive to modern box hive. Therefore, those farmers, who have honey bee colonies with traditional hive could participate in the modern beekeeping practice more than those farmers, who do not have honey bee colonies with the traditional hive, because it requires high price to purchase a single honey bee colony with the traditional hive. The same finding was reported by the Tamirat (2015) and Asmiro *et al.* (2017).

**Land Size:** This variable is found significant at 5% significance level and positively related to household participation decision in modern beekeeping practice. It shows that all other factors being kept constant, predicted probability of modern beekeeping participation decision increases by 12.23% as the land size owned by the household head inceases by 1ha.This might be due to the reason that large size of the land is sometimes seen as social

status. Because the status they have in the society may encourage those farmers to participate in modern beekeeping to maintain their status in society. This finding was consistent with the findings of (Samson, 2016; Tamirat, 2015).

**The total annual income of the household (Income**): This variable was found significant at 5% significance level and positively related to household participation decision in modern beekeeping practice. The marginal effect of this variable, 0.37075 indicates that all other factors being kept constant, the predicted probability of modern beekeeping participation decision of the farmers increases by 37.075% for the higher total income of households than the lower total household`s income. This could be the case if the farmers with higher income can cover the modern beekeeping cost easily than lower-income households. The farmers with higher-income can easily buy the inputs required for modern beekeeping than lower-income households. The study result was consistent with the work of (Tamirat, 2015; Taddele, 2016)

**Access to extension services (Extension):** This variable was found significant at a 5% significance level and positively related to the household participation decision in modern beekeeping practice. The result of the marginal effect of this variable, 0.1860 reveals that the predicted probability of participating in modern beekeeping increases by 18.60% for the farmers having access to the extension services as compared to the farmers who do not have access to the extension services. The possible reason for this result may be the farmers who have got access to extension services about the modern beekeeping issues to tend to be more progressive and more aware about the modern beekeeping and more likely to experiment with modern beekeeping practice. This finding was similar to the finding of Taddele (2016).

Table 6. Determinants of participation in modern beekeeping

| Variables | Coefficient | Robust Std. Err. | Z | Marginal Effect |
|---|---|---|---|---|
| Age | -0.0196 | 0.0124 | -1.58 | -0.0077 |
| Bee colony | 0.0571** | 0.0272 | 2.10 | 0.0223 |
| Bee equipment access | 0.1352 | 0.2949 | 0.46 | 0.0529 |
| Credit access | -0.3097 | 0.2427 | -1.28 | -0.1202 |
| Education | 0.0358 | 0.0416 | 0.86 | 0.0140 |
| Experience | 0.0387 | 0.0292 | 1.32 | 0.0151 |
| Extension access | 0.4877** | 0.2404 | 2.03 | 0.1860 |
| Home distance | -0.0117 | 0.0244 | -0.48 | -0.0045 |
| Household size | -0.0779 | 0.0859 | -0.91 | -0.0305 |
| Income | 0.00001** | 7.05e-06 | 2.27 | 0.37075 |
| Land size | 0.3124** | 0.1517 | 2.06 | 0.1223 |
| Livestock | 0.0399** | 0.0196 | 2.03 | 0.0156 |
| Market distance | -0.0343* | 0.0179 | -1.91 | -0.0134 |
| Non-farm activity access | 0.1424 | 0.2729 | 0.52 | 0.0554 |
| Road distance | -0.0793 | 0.0709 | -1.12 | -.0310 |
| Sex | 0.9373* | 0.5137 | 1.82 | 0.3530 |
| Training access | 0.1806 | 0.4094 | 0.44 | 0.0703 |
| Constant | -0.4778 | 0.8830 | -0.54 | |
| Observation number = 167 | | | | |
| | | Wald chi2 (17) = 63.14 | | |
| | | Prob > chi2 = 0.0000 | | |
| Log pseudo likelihood = -78.637275 | | Pseudo R2 = 0.3155 | | |

* and **indicates significant at 10% and 5% level of significance respectively.

**Source:** Own computation result from survey data, 2019

**Total livestock owned by household (Livestock):** This variable was significant at 5% level of significance and have a positive relationship with household participation decision in modern beekeeping practice. The marginal effect of this variable, 0.0156 indicates that all other factors being kept constant, the predicted probability of modern beekeeping participation decision increases by 1.56% as the number of livestock owned by the household increases by one TLU. As the livestock holding was considered as a proxy for farmers' wealth status, highly wealthy status farmers can earn more cash-income that might enable them to participate more in modern beekeeping practice. This result could be related to the possibility of using the livestock sale at the time of undertaking modern beekeeping practice as a source of income that can be used for expanding on modern beekeeping

practice. This means the wealth can be used for more investment. The same finding was reported by Amanuel (2018); H.D. Affognon *et al.(*2015); and Tamirat (2015).

**Distance of the nearest market:** It was found negatively and significantly affected the participation decision of the farmers in the modern beekeeping practice at 10% significance level. The estimated marginal effect of this variable (-0.0134), in dicates that the probability of participating in modern beekeeping decreases by 1.34% as the market distance increases by one km. This is due to the fact that as the farmers reside far from the nearest market, the transport cost for selling their bee product would be high which, in turns, to reduce farmers' decision to participate in modern beekeeping practice. This finding was the same with the finding of Belets and Berhanu (2014).

## 4.3. Factors Determining Intensity of Participation in Modern Beekeeping Practice

The intensity of participation in modern beekeeping practice was one of the dependent variables in this study. It was specified as the truncated part of the double hurdle model under the methodology part of this study. Therefore, factors determining the intensity of participation in modern beekeeping by the farmers in Wonchi district were analyzed using the truncated part of the double hurdle model. The result is presented in Table 7. The factors that were found to have significant determining power on the intensity of participation were four variables, out of 17 explanatory variables included in the model. These significant variables that determine the intensity of participation were access to modern beekeeping training, access to modern bee equipment, main road distance and access to credit. These variables determine the intensity of participation of the farm household in different directions.

**Credit access (Credit):** This variable was found significantly and positively influencing the intensity of participation in modern beekeeping practice by the farmers, at a 10% level of significance. From the result of truncated regression, it indicates that the number of a modern beehive with honey bee colony (modern beekeeping practice) increases by 2.010 for the

discrete change in this variable from 0 to 1 (change from the farmer that did not use credit to the farmer that used credit). In other words, the number of a modern beehive with honey bee colony (modern beekeeping) owned by the farmers that used credit exceeds the number of a modern beehive with honey bee colony (modern beekeeping) owned by the farmers with who did not use credit by about 2.010%%. As the credit service provision of the household head change, the intensity use of modern beekeeping practice increased by 2.010 modern beehives with honey bee colony (modern beekeeping) per household. The reason behind this result is that credit service minimizes the financial constraints of the farmers which enable them to intensify the modern beekeeping practice. This finding is in-line with the result reported by Asmiro *et al.* (2017); Belets and Berhanu (2014*);* Mazorodze (2015); and Malede *et al.* (2013).

**The distance of the main road from apiary site (Main road distance):** This variable significantly influenced the intensity of participation in modern beekeeping practice by the farm households at 5% significance level. The coefficient(0.5606) of this variable indicates that an increase in the distance of the main road from the apiary site by one km, leads to an increase in the number of a modern beehive with honey bee colony (modern beekeeping) by 56.06%%, holding other factors constant. This might be as the apiary site of the farmer far from the main (vehicle) roads there is the probability that the vicinities densely covered with different vegetation and natural resources, which is the sources of honeybee forages. As the same time honey bees are highly sensitive to car sound disturbance, which results in honey bee colony absconding. With this observation, the apiary site of the farmers resides far from the main (vehicle) roads substantially intensify the modern beekeeping practice. This finding is consistent with the work of Belets and Berhanu (2014).

**Access to modern beekeeping equipment (Bee Equipment):** This variable was found significantly determining the participation intensity of the farmers in modern beekeeping practice at 1% probability level. It positively influenced the participation intensity of the farmers in modern beekeeping practice. From the result of truncated regression, it indicates that the number of modern beehive with honey bee colony (modern beekeeping practice) increases by 0.7113 for the discrete change in this variable from 0 to 1 (change from the farmer that did not have access to modern beekeeping equipment to the farmer that had

access to the modern beekeeping equipment). This finding is in-line with the result reported by Wongelu (2014) and Amanuel (2018).

Table 7. Determinants of intensity of participation in modern beekeeping

| Variables | Coefficient | Robust Std. Err. | Z |
|---|---|---|---|
| Age | -0.0280 | 0.0621 | -0.45 |
| Bee colony | -0.0512 | 0.0879 | -0.58 |
| Bee equipment access | 0.7113*** | 0.2788 | 2.5512 |
| Credit Access | 2.010* | 1.1059 | 1.82 |
| Education | -0.1229 | 0.1658 | -0.74 |
| Experience | 0.0183 | 0.1419 | 0.13 |
| Extension access | -0.0043 | 1.1469 | -0.00 |
| Home distance | -0.1043 | 0.1148 | -0.91 |
| Household size | 0.0118 | 0.3748 | 0.03 |
| Income | 0.000094 | 0.000015 | 1.29 |
| Land size | 0.1954 | 0.6426 | 0.30 |
| Livestock | -0.0721 | 0.0984 | -0.73 |
| Market distance | -0.0950 | 0.1224 | -0.78 |
| Non-farm activity | -0.2318 | 1.5792 | -0.15 |
| Road distance | 0.5606** | 0.2836 | 1.98 |
| Sex | -0.3503 | 2.2722 | -0.15 |
| Training access | 0.3570** | 0.1591 | 2.24 |
| Constant | 5.4493 | 4.3194 | 1.26 |
| /Sigma | 3.2967 | 0.3633 | 9.07 |
| Limit: Lower =0 | | Number of observation = 75 | |
| Upper = +∞ | | Wald chi$^2$ (17) = 33.61 | |
| Logpseudo likelihood = -172.95 | | Prob > chi2 = 0.0094 | |

*, ** and *** shows significant at 10%, 5% and 1% level of significance respectively

Source: Own estimation from survey data, 2019

**Access to training on modern beekeeping (Training):** This variable was significant at 5% level of significance and has a positive relationship with the household`s intensity of participation in modern beekeeping practice. From the result of truncated regression, it indicates that the number of modern beehive with honey bee colony (modern beekeeping practice) increases by 0.3570 for the discrete change in this variable from 0 to 1 (change from the farmer that did not have access to modern beekeeping training to the farmer that

had access to the modern beekeeping training). In other words, the number of modern beehive with honey bee colony (modern beekeeping) owned by the farmers those who had training access on modern beekeeping issues exceeds the number of modern beehive with honey bee colony (modern beekeeping) owned by the farmers who did not have training access on modern beekeeping issues by about 0.3570. The positive relationship between trained farmers and intensity of participation in modern beekeeping practice is that the farmers who have clear information about the use, method of implementing and managing the modern beekeeping practice had the highest opportunity to intensify the modern beekeeping practice. This finding is consistent with the work of Wongelu (2014); Adeday *et al.* (2012) and Amanuel (2018).

## 4.4. Impact of Participation in Modern Beekeeping on the Households` Income

This subsection is about the impact evaluation of participation in the modern beekeeping by farmers on the household`s income. The impact evaluation in this particular case of the study was conducted by the use of propensity score matching (PSM) method of impact evaluation mainly because of the absence of baseline data. PSM consists of four phases:estimating the probability of participation, i.e. the propensity score, for each unit in the sample; selecting a matching algorithm that is used to match beneficiaries with nonbeneficiaries in order to construct a comparison group; checking for balance in the characteristics of the treatment and comparison groups; and estimating the program effect and interpreting the results (Stuart, 2010). Therefore, the above-mentioned issues are presented below.

### 4.4.1. Propensity Score Matching

Any model relating a binary variable to a set of predictors can be used. Therefore propensity score can be constructed using a logit or probit regression to estimate the probability of a unit’s exposure to the program, the probability of participating in modern beekeeping practice, conditional on a set of observable characteristics that may affect participation in modern beekeeping practice. In this study, the propensity scores are constructed using the logit regression, because it is the most common model for propensity score estimation as stated in Stuart (2010). Then the overlap condition was determined for the total observations.

For the propensity scores to correctly estimate the probability of participation, the characteristics included in the propensity score estimation have been well-considered and were exhaustive. However, characteristics which may have been affected by the treatment must not be included, that means Propensity score estimation requires the dependent variables to be included in the model must be exogenous and unaffected by the intervention (Caliendo and Kopeinig, 2008). For this reason, the income of the household and experience of households with modern beekeeping practice are excluded from the covariates included in the estimation of the propensity score. Table 8, shows the value of the covariates related to the estimation of propensity scores for the individual observations, which is the probability of assigning the observation to participate in the modern beekeeping practice.

Table 8. Logit model coefficients in the estimation of propensity score

| Variables | Coefficient | Std. Err. | Z | P >Z |
|---|---|---|---|---|
| Age | -0.0274 | 0.0223 | -1.23 | 0.219 |
| Bee colony | 0.1163 | 0.0434 | 2.68 | 0.007 |
| Access to bee equipment | 0.2334 | 0.5405 | 0.43 | 0.666 |
| Credit access | -0.5453 | 0.4293 | -1.27 | 0.204 |
| Education level | 0.0711 | 0.0715 | 0.99 | 0.320 |
| Extension services access | 0.7551 | 0.4421 | 1.71 | 0.088 |
| Market distance | -0.0719 | 0.0319 | -2.25 | 0.024 |
| Household size | -0.0145 | 0.1369 | -0.11 | 0.915 |
| Land size | 0.4667 | 0.2772 | 1.68 | 0.092 |
| Livestock | -0.0254 | 0.0275 | -0.92 | 0.356 |
| Home distance | 0.0160 | 0.0383 | 0.42 | 0.676 |
| Access to nonfarm activity | 0.5182 | 0.4415 | 1.17 | 0.241 |
| Road distance from apiary site | -0.1335 | 0.1182 | -1.13 | 0.259 |
| Sex | 1.4843 | 0.9067 | 1.64 | 0.102 |
| Access to training | 0.4078 | 0.6695 | 0.61 | 0.542 |
| Constant | -0.7914 | 1.3021 | -0.61 | 0.543 |
| Number of observation = 167 | | | Pseudo R2 = 0.2722 | |
| Log likelihood = -83.619361 | | | LR chi2 (15) = 62.54 | |
| Prob > chi = 0.0000 | | | | |

Source: Own estimation from survey data, 2019

common support region is where the values of propensity scores of both participants and comparison groups can be found. The basic criterion of this approach is to delete all

observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group (Caliendo and Kopeinig, 2008). The common support region (overlap condition) for the estimated propensity score is constructed based on the summary statistics of the participants and non-participants. Therefore, the common support region was determined by taking the maximum of the minimums and minimum of the maximums for the two groups' propensity scores. Based on this technique the common support region was found to be between the value of propensity score of 0.0812 and 0.9255 (Table 9). In other words, households with estimated propensity scores less than 0.0812 and greater than 0.9255 would not be considered for the matching exercise. As a result of the overlap condition, 25 observations (9 participants and 16 non-participants) were found to be out of the common support and hence they were excluded from the observations used to analyze the impact of participation in modern beekeeping practice on the households` income (treatment effect on the treated).

Table 9. Summary of common support region for the estimated propensity score

| Variable | | Observation | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|---|
| Propensity score | Common support | 142 | 0.4491 | 0.3578 | 0.0377 | 0.9757 |
| | Non-participants | 76 | 0.3024 | 0.2371 | 0.0377 | 0.9255 |
| | Participants | 66 | 0.6289 | 0 .2356 | 0 .0812 | 0.9757 |

**Source:** Own computation from survey data, 2019

### 4.4.2. Matching Algorithm Selection

Once the propensity scores are estimated, units in the treatment group (beneficiaries) are then matched with non-beneficiaries with similar propensity scores or probability of participating in the program. There are some matching algorithms which can be employed in undertaking the impact evaluation to get the effect of the treatment. The most common matching algorithms used in PSM include kernel matching, nearest-neighbor matching, and radius matching. These matching methods use different means of matching the beneficiaries to the control group to determine the average effect of certain program intervention.

The test for three common matching algorithms in PSM with different criteria were used to test among the matching algorithms and within the matching algorithm under different

scenarios (different caliper distance and number of nearest neighbor). The simultaneous test of the matching algorithms, the mean bias, the number of matched observations, the number of balanced covariates and the value of the pseudo R square for best nearest-neighbor matching are 6.6, 142, 15 and 0.031; for radius caliper matching are 6.6, 142, 15 and 0.031, for kernel matching are 3.8, 142, 15 and 0.012, respectively. Based on this values of the test, the matching algorithm with the lowest mean bias, lowest pseudo R square after matching, equal number of matched observations and equal number of balanced covariates after matching compared to other matching algorithms, kernel matching is found to be the best, in addition to the fact that this matching algorithm consists of more information in estimating the effect which reduces the variance. Therefore, kernel caliper matching with bandwidth 0.06 was selected because it represents the best matching algorithm. Hence, the kernel matching algorithm was selected as the best matching algorithm under PSM and it was used to estimate the impact of participation in modern beekeeping on the household`s income.

Table 10. Test on the propensity score matching algorithms

| Matching algorithm | Mean bias | Pseudo R square | No. of matched observations | No. of insignificant covariates after matching |
|---|---|---|---|---|
| **Nearest neighbor matching** | | | | |
| nearest neighbor with replacement | 6.6 | 0.031 | 142 | 15 |
| Nearest neighbor without replacement | 24.2 | 0.117 | 132 | 8 |
| **Caliper matching** | | | | |
| Radius 0.06 | 6.6 | 0.031 | 142 | 15 |
| Radius 0.08 | 6.6 | 0.031 | 142 | 15 |
| Radius 0.1 | 6.6 | 0.041 | 142 | 15 |
| Radius 0.25 | 6.6 | 0.031 | 142 | 15 |
| **Kernel matching** | | | | |
| Bandwidth 0.06 | 3.8 | 0.012 | 142 | 15 |
| Bandwidth 0.08 | 4.0 | 0.013 | 142 | 15 |
| Bandwidth 0.1 | 4.5 | 0.013 | 142 | 15 |
| Bandwidth 0.25 | 5.7 | 0.015 | 142 | 15 |
| Bandwidth 0.5 | 16.4 | 0.047 | 142 | 14 |

**Source:** Own computation from survey data, 2019

### 4.4.3. Matching Quality

Another important step in investigating the validity or performance of the PSM estimation is verification of the overlap condition (Caliendo and Kopeinig, 2008). By choosing kernel matching, we restrict ourselves to an area of common support which is defined by the bandwidth set to 0.06 of the standard deviation of the balancing score. The distribution of the estimated propensity scores and the overlap between participants and nonparticipants are shown in Figure 3. The figure shows the cases excluded from the analysis to avoid bad matches. The overlap between treatment and control groups can be verified with relatively straightforward strategies. One obvious approach is through visual inspection of the propensity score distributions for both groups. Simple graphs for the two groups, together with a comparison of the minimum and maximum propensity score values in each distribution, can typically provide to the researchers a good, initial reading of the extent to which there is an overlap in the propensity scores of the treatment and control units (Heinrich *et al.,* 2010). A visual inspection of the density distribution for participants and nonparticipants in the modern beekeeping in figure 3 indicates that the common support condition is satisfied as there is substantial overlap in the distribution of the estimated propensity scores for the two groups.

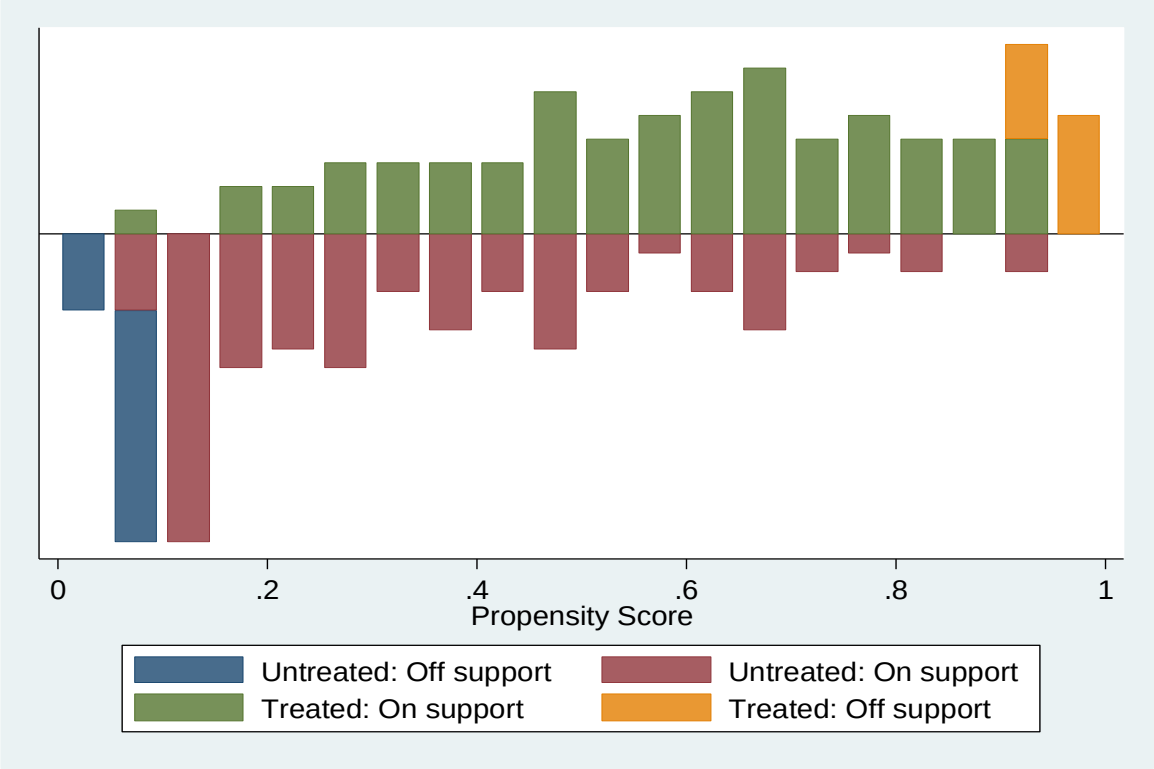


**Figure 3.** Propensity score distribution and common support area by pairwise comparison of participants and non-participants in the modern beekeeping practice
**Source:** Own estimation from the survey data, 2019

### 4.4.4. Checking for Balance

Once units are matched, the characteristics of the constructed treatment and comparison groups should not be significantly different; i.e., the matched units in the treatment and comparison groups should be statistically comparable. The process of matching creates a high degree of covariate balance between the treated and comparison groups. This can be seen from the executed t-test in the balanced test (pstest). This test helps to check if there are significant differences in covariate means for both groups (Rosenbaum and Rubin, 1985). Before matching, differences are expected, but after matching the covariates should be balanced in both groups and hence no significant differences should be found (Caliendo and Kopeinig, 2008). Balance is tested using a t-test to compare the means of all covariates included in the propensity score to determine if the means are statistically similar in the

treatment and comparison groups. This test, the t-test is preferred when the evaluator is concerned with the statistical significance of the results (Solivas, 2007). If the balance is not achieved; i.e., the means of the covariates are statistically different, a different matching option or specification should be used until the sample is sufficiently balanced. In this case, the balance for the covariates is tested for balance in the mean of covariates across the participants and non-participants and it revealed that the balanced test of the covariates is satisfied by t-test.

In addition to the above statistical test, the balance of covariates to be trustworthy, the absolute standardized differences of means of covariates should be less than 20% and the overall absolute mean bias should be between 5 and 3% (Rubin, 2001; Rosenbaum and Rubin, 1985). This criterion has also been satisfied because the individual covariates mean difference between participants and non-participants are less than 20% and the overall absolute mean bias is 3.8% which is between 5 and 3%.

Finally, the joint significance test and the pseudo $R^2$ are also good indicators. The pseudo $R^2$ indicates how well the regressors $X$ explain the participation probability (Caliendo and Kopeinig, 2008). After matching there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo $R^2$ should be fairly low. Furthermore, one can also perform a chi-square test on the joint significance of all regressors and it should be insignificant after matching. The low pseudo $R^2$ (compared with other pseudo R square's resulted using different matching estimators) and the insignificant likelihood ratio tests (indicated by the higher p-value after matching) support the hypothesis that both groups have the same distribution. The result of the test is given in Table 11.

Table 11. Test of the balance of covariates after matching

| Variables | Unmatched | Mean | | % Bias | %reduct \|bias\| | t-test | |
|---|---|---|---|---|---|---|---|
| | Matched | Treated | Control | | | t | P > t |
| Age | U | 41.76 | 46.51 | -30.9 | | -1.97 | 0.051 |
| | M | 41.83 | 42.29 | -3.0 | 90.4 | -0.17 | 0.866 |
| Bee colony | U | 10.98 | 6.26 | 90.6 | | 5.89 | 0.000 |
| | M | 9.92 | 9.82 | 1.9 | 98.0 | 0.09 | 0.925 |
| Bee equipment | U | 0.64 | 0.32 | 65.8 | | 4.23 | 0.000 |
| | M | 0.60 | 0.62 | -4.0 | 93.9 | -0.22 | 0.822 |
| Credit access | U | 0.45 | 0 .39 | 12.5 | | 0.80 | 0.422 |
| | M | 0.45 | 0.41 | 7.8 | 37.7 | 0.44 | 0.657 |
| Education | U | 7.96 | 5.52 | 68.0 | | 4.36 | 0.000 |
| | M | 7.80 | 7.56 | 6.6 | 90.3 | 0.37 | 0.710 |
| Extension access | U | 0.8 | 0.532 | 58.8 | | 3.74 | 0.000 |
| | M | 0.78 | 0.81 | -6.6 | 88.8 | -0.43 | 0.668 |
| Home distance | U | 10.86 | 18.11 | -83.6 | | -5.30 | 0.000 |
| | M | 11.50 | 11.15 | 4.0 | 95.2 | 0.25 | 0.806 |
| Household size | U | 5.34 | 5.48 | -5.1 | | -0.33 | 0.739 |
| | M | 5.25 | 5.28 | -1.1 | 77.9 | -0.06 | 0.952 |
| Land size | U | 1.98 | 1.79 | 18.6 | | 1.21 | 0.230 |
| | M | 1.95 | 1.94 | 1.4 | 92.6 | 0.08 | 0.933 |
| Livestock | U | 12.51 | 12.00 | 6.3 | | 0.41 | 0.686 |
| | M | 12.65 | 12.46 | 2.4 | 62.3 | 0.13 | 0.897 |
| Market distance | U | 10.14 | 15.31 | -63.4 | | -4.05 | 0.000 |
| | M | 10.63 | 10.74 | -1.4 | 97.8 | -0.08 | 0.933 |
| Nonfarm activty | U | 0.78 | 0.56 | 48.4 | | 3.08 | 0.002 |
| | M | 0.75 | 0.76 | -1.8 | 96.3 | -0.11 | 0.913 |
| Road distance | U | 3.44 | 2.63 | 39.6 | | 2.53 | 0.012 |
| | M | 3.62 | 3.72 | -4.9 | 87.6 | -0.26 | 0.792 |
| Sex | U | 0.09 | 0.04 | 19.7 | | 1.29 | 0.199 |
| | M | 0.045 | 0.046 | -0.3 | 98.4 | -0.02 | 0.983 |
| Training access | U | 0.81 | 0.48 | 71.9 | | 4.57 | 0.000 |
| | M | 0.78 | 0.74 | 10.5 | 85.8 | 0.62 | 0.536 |

**Overall balance indicators of covariates**

| Sample | Pseudo $R^2$ | LR $chi^2$ | p > $chi^2$ | Mean Bias | Median Bias |
|---|---|---|---|---|---|
| Unmatched | 0.274 | 62.96 | 0.0000 | 45.5 | 48.4 |
| Matched | 0.012 | 2.90 | 1.000 | 3.8 | 3.0 |

**Note:** U-Unmatched, M- Matched

**Source:** Own computation from survey data, 2019

From the result of testing for the balance of the covariates between the treated and comparison group, it shows that there was no significant difference between the two groups on the covariates after matching because the t-test shows the absence of significant difference. Therefore, the covariates balance criterion is satisfied. Accordingly, the low pseudo $R^2$ value and insignificant likelihood ratio test evident that both groups have the same distribution in all covariates after matching. These result clearly showed that the matching procedure can balance the characteristics in the treated and the matched comparison groups. Therefore, these results used to evaluate the effect of modern beekeeping practice among groups of households having similar observable characteristics. This allowed comparing observed outcomes of the participant with comparison groups sharing common support.

### 4.4.5. Estimation of the Effect of Treatment and Interpretation of Results

According to Caliendo and Kopeinig (2008), an important decision which has to be made in the empirical analysis is when to measure the effects. He noted that the major goal in this procedure is to ensure that participants and non-participants are compared in the same economic environment and the same individual lifecycle position. The estimation of the impact of a certain technology intervention is based on the above-mentioned steps of propensity score matching when we do not have the baseline data.

The ATT is only determined in the region of common support. Hence, an important step is to check the overlap and the region of common support between participants and the comparison group. To do so several ways are suggested in the literature, where the most straightforward one is a visual analysis of the density distribution of the propensity score in both groups (Caliendo and Kopeinig, 2008). Following the estimation of propensity scores, the implementation of a matching algorithm, and the achievement of balance, the intervention's impact may be estimated by averaging the differences in outcome between each treated unit and its neighbor or neighbors from the constructed comparison group. The difference in averages of the subjects who participated in the intervention and those who did

not can then be interpreted as the impact of the program. The impact evaluation of the average treatment effect on the treated of participation in modern beekeeping practice for this study was conducted using kernel matching. The bootstrap method was used to estimate standard errors for matching estimator to account for the fact that the propensity score is also estimated. Table 12 shows the impact of participation in modern beekeeping practice on the household`s income.

Table 12. Impact of participation in modern beekeeping practice on the household`s income

| Variable | Sample | Treated | controls | Differen -ce | Std. Error (b -ootstrapped | T-stat |
|---|---|---|---|---|---|---|
| Househol -d income | Unmatched ATT | 58712.9 59066.2 | 50934.5 49820.7 | 7778.3 9245.5 | 3395.8 4622.3 | 2.29 2.00** |

**Note: **** indicates significant at 5% significance level

ATT: Average Treatment effect on the Treated

Source**:** Own estimation using kernel matching from survey data, 2019

After estimating the treatment effect, Rosenbaum (2002) proposes using Rosenbaum bounding approach to check the sensitivity of the estimated ATT. For this study, sensitivity analysis, Rosenbaum bound estimation was conducted between the gamma values of 1 and 3, by adding 0.25 on 1 and continuing up to 3, to test whether the treatment effect on the treated is sensitive to the hidden bias (unobservables) (Appendix Table 3). The sensitivity analysis is conducted at gamma 1, 1.25, 1.5…3. The analysis result indicated that the average treatment effect on the treated is not sensitive to an increase in hidden bias (unobservable).

From Table 12, the average treatment effect on the treated is about ETB 9245 and it is significant at a 5% significance level. This finding is consistent with the result reported by (Meaza, 2010). Therefore, modern beekeeping practice in the study area should have been encouraged and the problems that are hindering the modern beekeeping development should be attempted to be solved by government and any other stakeholders.

## 4.5. Constraints and opportunities of the Modern Beekeeping Practice in the Study Area

There are many constraints and opportunities in Wonchi district related to modern beekeeping development. From the survey as well as focus group discussion and key informant interview it has been indicated that the farmers face many challenges in modern beekeeping development. Besides the challenges the data from different sources shown that there are opportunities for modern beekeeping development. These challenges and opportunities are discussed below.

### 4.5.1. Constraints

As indicated in the Table 13 below, 29.94% of respondents ranked high cost of modern bee equipment like (modern beehives, wax printers and honey extractors) which hinders the farmers to implement appropriate improved beekeeping management practices like (external and internal inspection of box hive, adding and reducing of super, even to harvest the honey) on time as the first major constraint, and 19.76% of respondents ranked poor management practices, knowledge, and skill of farmers about the modern beekeeping as the second major constraint in the study area. 16.76% of respondents ranked agrochemical application like herbicide and pesticide as the third major modern beekeeping constraints. The fourth, fifth, sixth and seventh major modern beekeeping constraints were the presence of honey bee pests and predators, lack of credit, lack of modern beekeeping training, and poor extension services respectively.

Table 13. Major constraints of modern beekeeping practice in the study area

| Major Constraints | Frequency | Percentage (%) | Rank |
|---|---|---|---|
| The high cost of modern bee equipment | 50 | 29.94 | 1st |
| Poor management practices, knowledge, and skill of farmers | 33 | 19.76 | 2nd |
| Problems of agrochemical application | 28 | 16.76 | 3rd |
| Presence of honey bee pests and predators | 23 | 13.77 | 4th |
| Lack of credit access | 16 | 9.58 | 5th |
| lack of modern beekeeping training | 10 | 5.99 | 6th |
| Poor extension services | 7 | 4.2 | 7th |
| Total | 167 | 100.00 | |

**Source:** own estimation from the survey data, 2019

The most critical challenges that was indicated in the study area by the focus group discussion as well as by the key informant was poor modern beekeeping management practice, problem of agrochemical application, absence of research-based extension systems, lack of infrastructure, honey bee colony absconding, shortage of honeybee colonies for transferring purpose, high cost of modern beekeeping equipment and lack of modern beekeeping training and shortage of trained manpower(bee experts).

Key informants also mentioned that most beekeepers do not regularly clean hives after absconding of bees, thus hives remain unsuitable for reoccupation by natural swarms and they have not awareness on how to inspect internally and externally modern beehive with honey bee colony (modern beekeeping).

### 4.5.2. Opportunities

According to the respondent response, the major opportunities for modern beekeeping in the study area include the availability of a large number of bee floral species in each season of the year (25.15%), availability of favourable climate condition with diverse agro-ecology (19.76%), Presence of beekeepers` association in the district (17.36%), presence of government and non-government organizations, which mainly support natural resource conservation programs within which modern beekeeping is encouraged (14.97%), indigenous knowledge of the farmers about the beekeeping development (13.17%), and increased honey demand by tourists (9.6%) in the study area.

Therefore, if the government, nongovernment organizations and beneficiaries give more support in terms of modern beekeeping development, the study area would be more beneficial for its society as well as feeding the other areas and contributing to the economic development of the country.

# 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Summary and Conclusions

This study examined the factors determining participation in and intensity of participation in modern beekeeping practice by the farm households. It also analyzed the impact of participation in modern beekeeping practice on the household`s income. In addition to the above issues, it has also identified some of the major constraints and opportunities that the farmers in the Wonchi district faced in improved beekeeping development. The study used Propensity score matching to determine the impact of modern beekeeping practice on the household`s income and double hurdle model to analyze the determinants of participation and intensity of participation in modern beekeeping practice in the study area. The sample of 167 farm households selected by two-stage sampling technique and used in the analysis.

Participation in modern beekeeping practice and intensity of participation in modern beekeeping practice are shown to be independent of each other and determined by different sets of explanatory variables. After identifying the best fitting model, the study identified the demographic, economic, institutional and physical factors jointly determined the participation of the farm households in modern beekeeping practice. It also identified that the different set of explanatory variables such as economic, institutional, farm characteristics and household characteristics were found determining the participation decision and intensity of participation in modern beekeeping practice. For the participation decision of the farmers in modern beekeeping practice, the first hurdle of double hurdle model was used by including 17 explanatory variables hypothesized based on previous empirical studies conducted by different scholars and economic theories.

The intensity of participation in modern beekeeping was analyzed using truncated regression part of the double hurdle model, taking 17 different explanatory variables included in the model. Out of these included explanatory variables, seven of them were found to be significant determinants of participation decision of the farmers in modern beekeeping development. These variables were sex, number of honey bee colonies with the traditional

hive, access to extension services, number of livestock owned, market distance, land size owned by household head and total annual income of household head.

The number of honey bee colonies with traditional hive owned, access to extension services, number of livestock owned, and land size were positively and significantly determined participation decision of the farmers in modern beekeeping, while sex of household head and market distance were negatively and significantly determined the participation decision in modern beekeeping practice. This implies that, those farmers who have higher number of honey bee colonies with traditional hive, have access to extension services, have higher number of livestock, and have higher land size were found participating more in modern beekeeping practice than those farmers with lower number of honey bee colonies with traditional hive, lack of extension services, lower number of livestock, and have lower of land size.

The determinants of intensity of participation in modern beekeeping was analyzed using truncated regression part of the double hurdle model, taking 17 different explanatory variables included in the model. Out of these included explanatory variables, four of them were found to determine the intensity of participation in modern beekeeping development significantly. These variables include access to modern beekeeping training, access to modern bee equipment, main (vehicle) road distance from the apiary site and access to credit.

Access to modern beekeeping training, access to modern bee equipment, main (vehicle) road distance from the apiary site and access to credit were found positively and significantly determining the intensity of participation in modern beekeeping by the farmers. This implies that, the farmers who have access to modern beekeeping training and modern bee equipme nt, user of credit and those farmers with farther distance of the apiary site from the main (vehicle) road were had higher number of modern beehive with honey bee colonies (modern beekeeping) in the study area as compared to their counterparts.

The impact analysis of participation in modern beekeeping practice on the household`s income by propensity score matching using of kernel matching algorithm revealed that there was a significant difference in the income of households between participants and non-participants due to participation in modern beekeeping practice. The average treatment effect on the treated was ETB 9245 and it was significant at 5% significance level. Therefore, modern beekeeping practice should have to be encouraged in the study area.

Furthermore, many modern beekeeping practice constraints and opportunities were pointed out by farmer respondents, focus group discussant, and key informant interviewee in the study area. These major opportunities can be used to the maximum possible benefits if there is a collective action by the farmers. Effective support from different institutions, governmental and any other concerned civic associations could also be a key role player. Therefore, it needs calling upon these stakeholders to take part in enhancing the modern beekeeping practice by reducing the hindrances and strengthening available enabling factors in the study area.

## 5.2. Recommendations

The findings of this study lead to the following specific recommendations

Access to training on modern beekeeping issue was positively related with intensity of participation in modern beekeeping practice; hence training should be given by giving attention to the wise way (timely application) of using different agrochemicals especially herbicides and pesticides to minimize the death of honey bees, on the management practice of modern beekeeping, honey bee queen rearing mechanism, and post-harvest handling of the bee products.

Access to credit was positively related with intensity of participation in modern beekeeping practice, hence provision of credit services to the farmers to widen the financial bases of poor households should have to be accessible by different government and nongovernment organizations. Households can use the loan to buy modern beehives and modern beehives accessories like a honey extractor, smokers, brush, gloves, wax stumper, and others to undertake and enhance modern beekeeping practice in the study area.

The main road distance from the apiary site was positively related to participation intensity in modern beekeeping practice. Therefore, more attention must be given to the apiary site selection for undertaking modern beekeeping. Apiary site must not be near to the main (vehicle) road as much as possible to protect the car disturbance, absconding of the honey bee colony and to obtain sufficient honey bee plants, herbs, shrubs and other which are the sources of honey bee food.

The number of honey bee colony with a traditional hive was related positively with participation decision in modern beekeeping practice, hence to enable farmers to have honey bee colonies for transferring purpose from traditional hive to modern beehive for undertaking modern beekeeping practice, honey bee queen rearing mechanism should have to be started and practiced in the study area by the farmers and honey bee experts at the household level, so that the farmers can use it for transferring of honey bee colonies to the modern box hive for undertaking modern beekeeping practice rather than buying honey bee colonies with traditional hive by high price for transferring purpose.

Facilitating access to extension services like giving training on modern beekeeping, demonstration of modern beekeeping site, and beekeepers to beekeepers experience sharing should be given by the government and non-government organizations to encourage farmer`s participation decision in modern beekeeping. Since, recently, governments' provision of extension services have increased; policies that encourage the development of farmers' training centers at village level along with the capacity building of extension workers through training, upgrading their education and provision of incentives so that accessibility of this service more ensured will contribute to the participation of the households in the modern beekeeping practice.

The local market linkage between honey bee product producers and small traders as well as linkage to other markets should be created to the farm-gate if possible to reduce the hindrance coming because of market distance and access problem that discourages participation and intensity of participation in modern beekeeping practice.

Facilitating access to modern bee equipment and accessories especially honey extractor, queen excluder, sieves, chisel, wax stumper and protective clothes which can increase the modern beekeeping productivity which in turn can positively affect farmer`s participation decision in modern beekeeping should have to offer to the farmers by different government and nongovernment organizations.

The study also revealed that there was dis-adoption in the study area as it can be seen from the descriptive result on experience in modern beekeeping practice, but the reason behind dis-adoption was not covered by this study. Therefore, further study should be conducted on the reasons for dis-adoption in modern beekeeping in the study area.

As indicated by using Kernel matching algorithm modern beekeeping practice is contributing more to the household income of the participants. Therefore, the government, nongovernment organizations, and beneficiaries should have to enhance modern beekeeping practice by using different improved beekeeping technologies to boost their production and productivity directly. Furthermore, this can change farmers` standard of living by increasing their income and contribute to the economic growth of the country

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# 7. APPENDICES

## Appendix Tables

Appendix Table 1. Likelihood ratio test of Tobit model specification

| Log likelihood ratio | Tobit = -14.027 |
|---|---|
| | Probit = -14.771 |
| | Truncated = 26.267 |
| Hypothesis | H0= Tobit Specification |
| | H1= Double Hurdle Specification |
| Test statistic | 51.046 |
| Critical value | $X^2_{17,\ 0.5}$= 23.685 |
| Decision | Reject H0 |

**Source:** Own computation from survey data, (2019)

Appendix Table 2. Distribution of modern beehive with honey bee colony (Modern beekeeping practice) in 2018/19 per household for all sample and participants.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Modern bee hive with bee colony (all sample) | 167 | 2.125 | 3.126 | 0 | 12 |
| Modern bee hive with bee colony (participants) | 75 | 5.04 | 3.422 | 2 | 12 |

**Source:** Own computation from survey data, (2019)

Appendix Table 3. Sensitivity analysis result of outcome variable after matching by Rosenbaum bounds

| Gamma | sig+ | sig- | t-hat+ | t-hat- | CI+ | CI- |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 55053.7 | 55053.7 | 51000 | 59550 |
| 1.25 | 0 | 0 | 52600 | 57850 | 48450 | 62800 |
| 1.5 | 0 | 0 | 50450 | 60300 | 46350 | 65517.5 |
| 1.75 | 0 | 0 | 48750 | 62466.5 | 44404.8 | 67810 |
| 2 | 1.1e-15 | 0 | 47253.7 | 64300 | 42900 | 69866.5 |
| 2.25 | 3.9e-14 | 0 | 46000 | 66000 | 41654 | 71725 |
| 2.5 | 6.8e-13 | 0 | 44811.2 | 67500 | 40547.5 | 73030 |
| 2.75 | 7.0e-12 | 0 | 43750 | 68700 | 39500 | 74617.5 |
| 3 | 4.9e-11 | 0 | 42852 | 69918 | 38650 | 75850 |

gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

Sig- _ lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .95)

CI- - lower bound confidence interval (a= .95)

**Source:** Own computation from survey data, (2019)

Appendix Table 4. Conversion rate of livestock into the standardized unit (TLU)

| Animals | Total Livestock Unit( TLU) |
|---|---|
| Calf | 0.25 |
| Weaned calf | 0.34 |
| Heifer | 0.75 |
| Cows and Oxen | 1.00 |
| Horse | 1.10 |
| Donkey(adult) | 0.70 |
| Donkey(young) | 0.35 |
| Camel | 1.25 |
| Sheep and Goat (adult) | 0.13 |
| Sheep and Goat (young) | 0.06 |
| Chicken | 0.013 |

**Source:** Abebe (2000), cited in Asres (2003)

**Appendix Table 5**. Household questionnaire

**Instruction**

1. Understand clearly all the questions before starting the interview

2. Introduce yourself to the respondents and tell them about the purpose of the study

3. Be patient during the interview and express yourself in understandable way to the respondents

4. Reliable information leads to right generalization. Hence, please write the respondents own response properly for each question.

5. Check that all questions are asked and responses are filled accordingly.

**General Identification information**

Research site: District _____, Kebele _____, Name of interviewee: _____

Mobile number:_____, Date of interview:_____, Sample respondents' ide ntification number:_____

**I. Demographic Background information of the household head**

1.1. Sex: _____, 1.2. Age_____

1.3. Marital status: 1) Married 2) Single 3) Widowed 4) Divorced

1.4. Education level: 1) Literate 0) Illiterate; if literate the formal education in grade: ___

1.5. How many family members do you have? _____

1.6. Could you please tell me their characteristics?

| no | name | Sex | age | marital status | education level |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

**Code; Sex:** 1) male 2) female, Marital status: 1) married 2) single 3) widowed 4) divorced **Education level:** 1) illiterate 2) literate

**II. Beekeeping practice**

2. Have you ever experienced in Beekeeping activity? 1) Yes 0) No

2.1. If yes, for how long you have been practicing beekeeping activity? _____ (yrs)

2.2. Which beekeeping systems do you use? 1) Modern beekeeping 2) traditional beekeeping 3) Transitional beekeeping 4) 1 & 2 5) Three of them 6) others specify (if any) _____

2.2.1. How many modern hive do you have with honey bee colony (modern beekeeping practice)? _____

2.2.2. How many traditional hive do you have with honey bee colonies? _____

2.2.3. How many transitional hive do you have with honey bee colonies? _____

2.3. When did you start beekeeping? _____

2.4. What are the driving forces to have bee colonies? A) Income B) Home consumption C) a & b D others (specify) _____

2.5. How did you start beekeeping? A) By catching the swarm B) By purchasing the honeybee colony C) Through inheritance D) A & B E) A, B &C F Any other (specify) _____

2.6. Which extension media helped you most to learn about improve and modern beekeeping?

A) Extension agent and bee experts B) Radio C) Field days D) Printing materials E) Telephone and internet source F) others (specify if any) _____

2.7. Who is responsible (the actor) for the improved and modern beekeeping management along its value chains? (Such as modern hive, honey extraction & market information)

A. Agricultural and rural development agents B. Non-Governmental Organization (NGO) C. agricultural research centers D. International research E. Any other (specify) _____

2.8. What kind of beekeeping products did you produce using modern bee hives?

A) Pure Honey B) Pure Beeswax C) Queen rearing D) Pure honey and beeswax E. All products mentioned above

2.9. Did you ever get beekeeping training? 1) Yes 2) No

2.10. If your answer for Q.2.9 is yes, from where did you have the training? A) Research c enter B) Agricultural and rural development C) NGO D) Any other (specify if any) _____

2.11. If your answer for Q.2.9 is yes, on what area did you get training?

A) Colony split B) Honey bee colony management practices C) Processing, handling & storage D) Market information and linkage E) Input utilization F) Bee forage develop ment G) Other (specify if any)_____

2.12. If your answer for Q.2.9 is yes, what methods were employed during training?

A) Lecture B) Demonstration C) Group discussion D) Combination of all E) Any other_____

2.13. If your answer for Q.2.9 is yes, did you find the training useful? 1. Yes 2.No

2.14. If your answer for Q.2.13 is yes, what benefits have you gained due to training?

A) Understanding effective beekeeping management using modern hives B) Understanding improved beekeeping management (e.g. feeding, inspecting, supering swarm control) C) Any other (specify if any) _____

2.15. Where do you keep your honeybees? A) Backyard B) Under the roof D) in the house E) any other (specify if any) _____

2.16. Have you ever used improved modern hive? 1. Yes 2. No

2.17. If your answer for Q.2.16 is yes, when did you start using modern hive? _____E.C

2.18. How many times do you harvest honey per annum per colony? A) One times B)Two times C) Three times D) Other (specify if any)_____

2.19. When is the peak honey production period? From_____to_____Month

2.20. What kind of management practice has been applied for safe honey storage?

_____

2.21. Did you use honey extractor in 2018/19? A) Yes B) No

2.22. Is the honey extractor equipment mobile or permanent? _____

2.23. In transferring bee colony from traditional to modern hive did the quality of honey and beeswax improved? A) Yes B) No

2.24. If your answer in Q.2.23 is yes, how?

Harvesting _____

Extractor_____

Storage (container) _____

Market _____

2.25. Did you have honey quality related problems when selling? 1) Yes 2) No

2.25. What is the amount of honey bee products you got in 2018/19?

| No | Honey bee product | unit | Traditional hive | Transitional hive | Modern hive |
|---|---|---|---|---|---|
| 1 | Pure honey | Kg/colony/year | | | |
| 2 | Pure bees wax | Kg/colony/year | | | |
| 3 | Crude honey | Kg/colony/year | | | |
| 4 | Bee colony | Kg/colony/year | | | |

2.26. What was the participation and decision of the household members? Show by rank.

Rank: 1 = 0, 2= 1-20%, 3 = 21-40%, 4= 41-60%, 5= 61-80%, 6= >81%

| Activity in beekeeping | women | men | children | Hired labor | other |
|---|---|---|---|---|---|
| Input supply: hive, equipment, feeding, water | | | | | |
| Beekeeping improved technology(queen rearing, split, swarm control) | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Processing:careful harvest, honey extract, storage and transport | | | | | |
| Honey marketing | | | | | |
| Colony marketing | | | | | |
| Deciding what to produce? Colony or honey? | | | | | |

**III. Market**

3.1. Was there ready market for your honey bee products? 1) Yes 2) No

3.2. If your answer for Q.3.1 is yes, where did you sell your honey?

A) At market found in nearby town B) At farm gate C) Cooperative D)'Tej' house E). Farmer to farmer F) Any other (specify if any)_____

3.3. If your answer for Q.3.1 is yes, where did you sell your bee wax?

A) at market found in nearby town B) At farm gate C) Cooperative D) 'Tej' house e. Farmer to farmer F) Any other (specify if any) _____

3.4. To whom did you sell your hive product? More than one answers is possible

A) Consumers B) Intermediaries C) Retailers D) Farmers E) Whole sellers

3.5. The channel/coordination mechanism you use for selling honey? A) Fragment market B) national market C) Through cooperatives D) Any other trader E) others

3.6. How long did you keep the honey until you get the market? _____

3.6.1. How long did you keep the wax until you get the market? _____

3.6.2. How long did you keep the colony until you get the market? _____

3.7. Was the market absorbed all the quantity you produced to sell in 2018/19? A)Yes B) No

3.8. If your answer for Q.3.7 is yes how much did you earn from sales in 2018/19? _____

3.8. Indicate the advantages of modern beekeeping practice compared to the traditional hive. Show in table using ` √ `

| Advantages | Very low(1) | Low(2) | Medium(3) | High(4) | Very high(5) |
|---|---|---|---|---|---|
| Honey yield | | | | | |
| Quality honey | | | | | |
| Skill | | | | | |
| Supply | | | | | |

| | Very easy(1) | Easy(2) | Medium(3) | Difficult(4) | Very difficult( 5) |
|---|---|---|---|---|---|
| Honey harvesting | | | | | |
| Honey extracting | | | | | |
| transferring | | | | | |
| inspection | | | | | |
| Colony split | | | | | |
| feeding | | | | | |

**IV. Benefits**

4.1. Income from bee products during the cropping season in 2018/19?

| Item | unit | Yield (kg)/type of hive | | Unit price( Birr) per kg | |
|---|---|---|---|---|---|
| | | traditional | modern | traditional | modern |
| Pure honey | kg | | | | |
| Crude honey | kg | | | | |
| Bees wax | kg | | | | |
| Bee colony | number | | | | |
| total | | | | | |

4.2. What was the trend of beekeeping product since your beginning operation?

A) Sharply increased B) Increased C) Decreased D)Significantly decreased E) No change

4.3. What does the trend of your profit on beekeeping?

A) Sharply increased B) Increased C) Decreased D)Significantly decreased E) No change

4.4. What was the average honey price (Birr/kg honey) for the top quality honey in 2018/19?

_____

4.5. For what purpose did you use the money obtained from sell of bee products? More than one choice is possible

A) Saving B) School fee C) Medical fee D) Buying food items E) House construction F) All

4.6. If your answer for Q.4.5 is saving where did you save your money? More than one choice is Possible. A) at home B) Oromia credit and saving institution C) Other banks D) Equb E) Cooperatives

4.7. What additional advantages did you obtained by participating in modern beekeeping? More than one choice is possible

A) Buy additional modern hive B) Buy additional honey bee colony C) Animal feed D) Social Acceptance due to additional income E) Buying domestic animal

**V. Access to credit and Land utilization**

5.1. Did you borrow money for buying beekeeping inputs in 2018/9? 1) Yes 2) No

5.2. Was there any time you could not use modern beekeeping practice due to lack of access to credit in 2018/19? 1) Yes 2) No

5.3. Did you think that credit will help to modern beekeeping practice? 1) Yes 2) No

5.4. If your answer for Q.5.1 is yes can you clarify how credit contributes to your beekeeping activity in 2018/19?_____

5.5. If your answer for Q.5.1 is yes from where did you get credit in 2018/19?

A) Oromia institution of credit and saving B) Individuals C) other banks D) Credit and saving association E) other (specify if any) _____

5.6. Do you own land? 1. Yes 2. No

5.7. How do you evaluate the quality of your land compared to others?

A) Very low B) Low C) Medium D) High E) Very high

**Thank you!!!**

**Appendix Table** 6. Interview guide for key informants

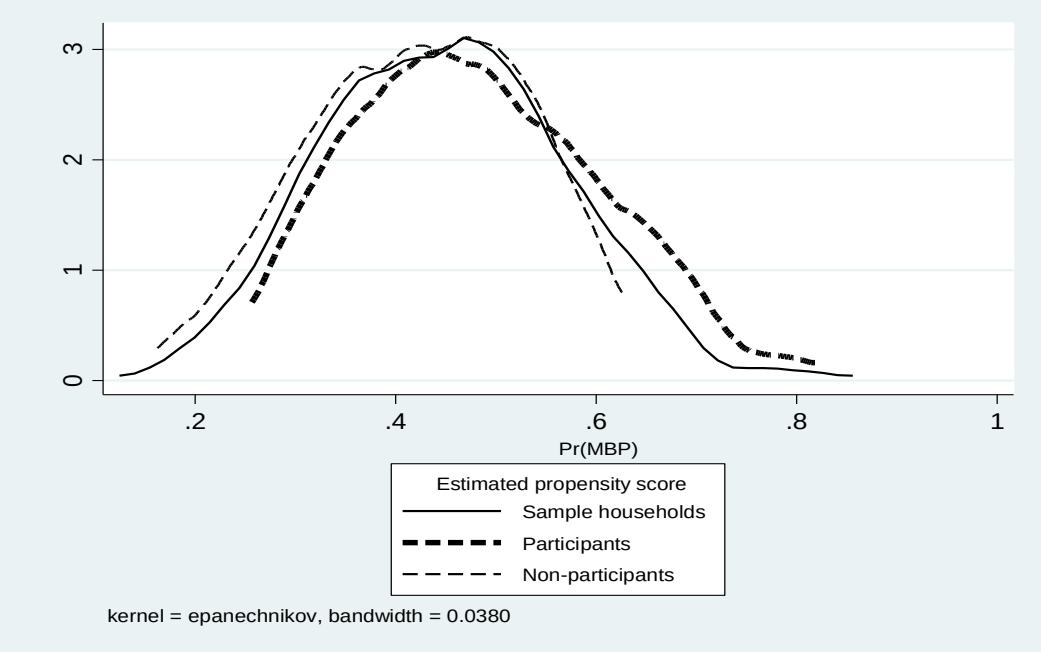
1. What is the trend of beekeeping activity in the past five years in the district?
2. How do you view the strength and weakness of the modern beekeeping practice? (In relation to the technical and social aspects), what are the opportunities and challenges?
3. What are the existing policies in relation to beekeeping in general and modern beekeeping practice in particular and how do you view them?
4. How do you view the role played by Ethiopian government in beekeeping development in the district?
5. What are important strategies for beekeeping development in the area?
6. What are the cultural and religious factors that affect the household's economic activity? and their holdings?
7. What is the agro-climatic condition of the study area?
8. What are the major social organizations in the area and what are their roles in relation to the Beekeeping activities?
9. What are non-farm activities available in the district?

10. What do you think are the major environmental problems in the area?

**Appendix Table 7**. Guiding questions for focus group discussions

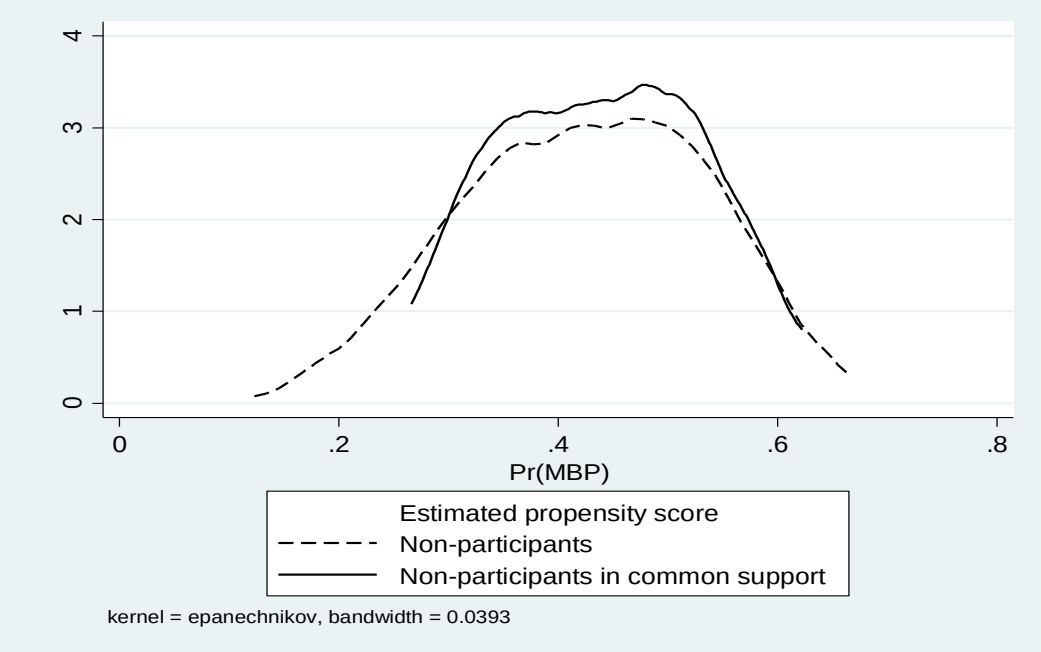
1. What are the major opportunities in your local area to utilize beekeeping potentials?
2. How do you view the strength and weaknesses, of the bee keeping systems? (in relation to technical and social aspects)
3. What are the main constraints you face during utilization of modern beekeeping potential in your local area?
4. Is there any restriction on the use of existing bee keeping potentials for beekeeping activities?
5. How do you view the role played by the government in modern beekeeping development in the area?
6. What are important strategies for modern beekeeping development in the area? What type of beekeeping potentials do you think is more advantageous for the farmers in the area?
7. What are the indicators for wealth ranking according to the local community standards? Is there any relationship with modern beekeeping practice?
8. What are the cultural and religious factors that affect the household's economic activity and their holdings?
9. Discuss the following issues in your group; access to basic school facilities, health facilities, drinking water (for humans & animals), beekeeping training, access to extension services, credit facilities, access to modern beekeeping inputs
10. What are the major social organizations in the area and what are their roles in relation to the beekeeping activities?
11. What are non-farm activities available in the district and how do you view its advantage related to the modern beekeeping practices in the study area?
12. What do you think are the major environmental problems in the area related with modern beekeeping practice?

**Appendix Figures**



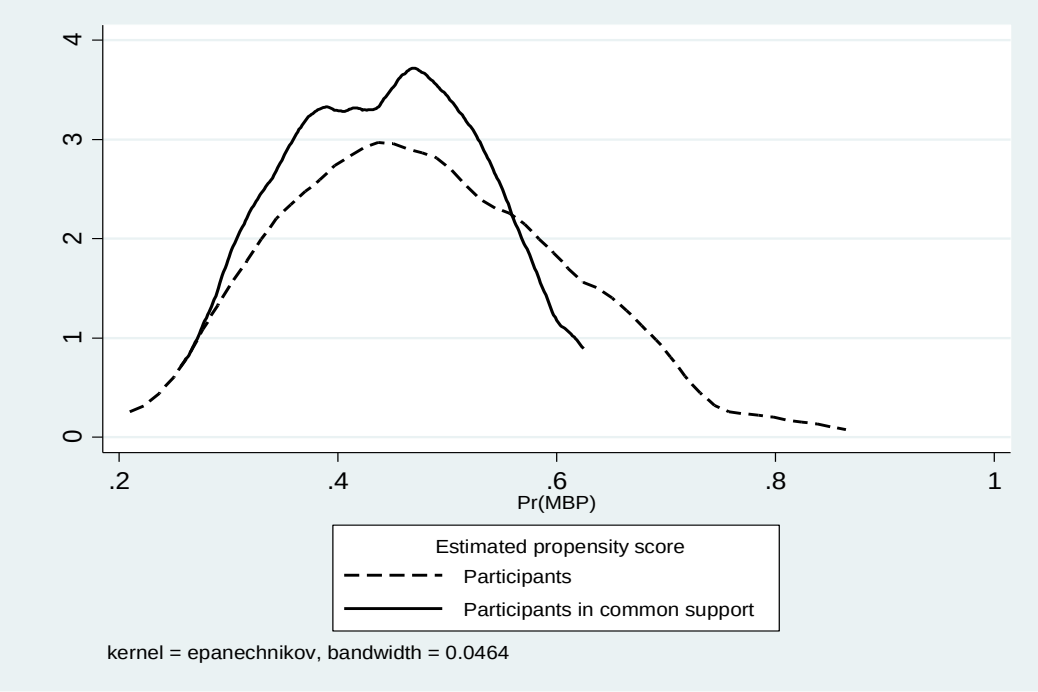

Appendix Figure 1. Kernel density of propensity scores before matching

**Source:** Own estimation from survey data, (2019)




Appendix Figure 2. Kernel density of propensity scores of non-participants

Source: Own estimation from survey data, (2019)




Appendix Figure 3. Kernel density of propensity scores of participants

**Source:** Own estimation from survey data, (2019)