DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN GAMBELLA ZURIA DISTRICT, SOUTH WEST ETHIOPIA

M.Sc. THESIS

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DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN GAMBELLA ZURIA DISTRICT, SOUTH WEST ETHIOPIA

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APPROVAL SHEET
SCHOOLOF GRADUATE STUDIES
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As *Thesis* Research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance, by Gutema Deressa, entitled Determinants of adoption of improved box hive in Gambella Zuria district, south west Ethiopia. I recommend that it be submitted as fulfilling the *Thesis* requirement.

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DEDICATION

This thesis is dedicated to my beloved family, my father Deressa Fetenssa, my mother Tiruwork Mihirete. And who sacrificed much to bring me up to this level but I lost them and to my wife Selamawit Engida and to My Son Nathan Gutema and my beloved Brother Kenessa Deressa.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is the result of my own work and that all sources or materials used for this thesis have been duly acknowledged. This thesis is submitted in partial fulfillment of the requirements for an advanced M.Sc. degree at Jimma University and to be made available at the University's Library under the rules of the Library. I confidently declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born on July 24, $1979_{EC.}$ in Gambella Town, from his father Mr.Deressa Fetenssa and his mother Mrs. Tiruwork Mihirete. He attended his elementary and junior secondary education at Gambella Ras Gobena Elementary and Junior Secondary School, and his secondary school education at Gambella Comprehensive Secondary School in Gambella Town. After successful completion of Ethiopian School Leaving Certificate Examination, he joined Ardaita ATVET College of Agriculture, in 2005 and graduated with Diploma Cooperative Organization Management and Marketing field of study in July 2008. Owing to his successful academic achievement, he was recruited Gambella Town Agriculture Office Served as a Core Processor of Cooperative Department Head. After Five years' service, he joined the Jimma University College of Agriculture and Veterinary Medicine in September 2013.andgraduated with B.Sc Degree in Agricultural Extension in July 2016. Then, he joined the School of Graduate Studies at Jimma University College Agriculture and Veterinary Medicine for his M.Sc. degree in Rural Development and Agricultural Extension, in October 2017.

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ABBREVIATIONS AND ACRONYMS

BC	Before Christ
CSA	Central Statistical Agency
EBA	Ethiopian Beekeepers Association
ETB	Ethiopian Birr
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GARD	Gambella Agriculture and Rural Development.
GARI	Gambella Agricultural Research Institute
GDP	Growth Domestic Product
HBRC	Holeta Bee Research Center
HH	Household
MOA	Ministry of Agriculture.
MOARD	Ministry of Agriculture and Rural Development
NDO	Netherlands Development Organization
NGO	Non-Governmental Organization
PTA	Perception of Technology Attributes
RWF	Rwandan Francs
SPSS	Statistical Package for Social Sciences
TAMPA	Tigray Agricultural Marketing Promotion Agency
TLU	Tropical Livestock Unit
USD	United States Dollar

DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN GAMBELLA ZURIA DISTRICT, SOUTH WEST ETHIOPIA

Despite the long tradition of beekeeping in Ethiopia and having potential for beekeeping the beekeepers in particular and the country in general are not well benefited from the sub-sector. The main objective of this study is to assess factors affecting adoption of modern beehive practices in the study area. The specific objectives are to assess beekeeping production system practiced in study area and to identify factors affecting adoption of modern beehive technologies in the study area. Stratified sampling technique was employed to identify the sample respondents. The sample respondents were categorized into adopters and non-adopters of modern bee hive. Based on probability proportional to size 59adopters and 71 non-adopters were identified out of 130 total sample respondents. The data were collected using structured interview schedule, group discussion, key informant discussion and observation; and were analyzed using descriptive statistics, and logit model. The binary logit model reveals that education level of household head, beekeeping experience, extension contact, apiary visit, perception, credit, were positively and significantly influencing adoption of modern bee hive, whereas age, sex, family size, land holding, livestock holding, market availability, honey bee pests, and availability of accessories were not significantly influencing adoption of modern bee hive. The modern beehive has a production potential of20-30kg per colony of honey while the traditional beehive produce5-10kg per colony of honey. Though different organizations strive to disseminate modern beehive, the adopters are not comparable with efforts have been excreted, and this might have different reasons such as institutional, socioeconomic and biophysical. Such information's might be different from according the circumstances in which the farmers are living and working, and still no information has been generated on socioeconomic, institutional and biophysical determinants of adoption of modern beehives in Gambella. The overall finding of the study underlined the importance of institutional support in the areas of availing beekeeping accessories, bee forage and improving beekeepers perception on the technology to enhance adoption of modern bee hive technology. Therefore, agricultural policy and development interventions should be given emphasis to the improvement of such institutional support.

Key Terms: Beekeeping, Modern Bee hive, Honey Production, Factors, Gambella

1. INTRODUCTION

1.1Background and Justification

Africa is blessed with numerous types of wild honeybees (Adjare, 1990). Ethiopia is one of the countries in the continent, which own huge honey production potential. Owing to its varied ecological and climatic conditions, Ethiopia is home to some of the most diverse flora and fauna in Africa. (Nuru, *et al.,* 2002). Its forests and woodlands contain diverse plant species that provide surplus nectar and pollen to foraging bees (Girma Deffar, 1998).

Ethiopia has a huge natural resource base for honey production and beekeeping is traditionally a well-established household activity in almost all parts of the country.(Beyene and David, 2007) Ethiopia has a longstanding beekeeping practices that has been an integral part of other agricultural activities, where more than one million households keep honeybees (Nuru, 2007) Beekeeping is one of the most important income-generating activities in the rural communities of Ethiopia (Kerealem *et al*., 2009). Ethiopia is famous for its notable variation of agro-climatic conditions and biodiversity which favored the existence of diversified honeybee flora and vast number of honeybee colonies (Nuru, *et al.,* 2007).

Beekeeping is such a promising off-farm enterprise, which directly and indirectly contributes to households' income in particular and nation's economy in general. The direct contribution of beekeeping includes the value of the outputs produced such as honey, beeswax, queen and bee colonies, and other products such as pollen, royal jelly, bee venom, and propolis in cosmetics, medicine and cultural and religious values. Besides, it provides employment opportunity (EARO, 2000; Gezahegn, 2001).

Ethiopia ranks the 10th producers of honey in the world and it is the largest one in Africa (USAID, 2012) and the fourth bees wax producing country in the world after China, Mexico and Turkey (Kebede, and Gebrekidan, 2011) The system of honey production commonly exercised were traditional (from the total of about 4,601,806 hives exist in the country 95.5% 4.3%, and 0.20% are traditional, transitional and modern bee hive respectively (David 2007).Ethiopia is one of those countries endowed with large Beekeeping resources. Having

such large resources, the country has potential of producing over 500,000 tones of honey per year and the annual production of honey and beeswax is low compared to its potential (EBA, 2014). Despite the long tradition of beekeeping in Ethiopia, having the highest bee density and being the leading honey producer as well as one of the largest beeswax exporting countries 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 potentiality for beekeeping. Productivity has always been low, leading to low utilization of hive products domestically, and relatively low export earnings. Thus, the beekeepers in particular and the country in general are not benefiting from the sub sector (Nuru, *et al.*, 2002).

Technology generation and development is an interactive process and requires feedback from the beneficiaries for further improvement of the technology. Adoption studies contribute much in identifying factors that affect adoption and assessing practices of modern bee hive.

Therefore, this study has critical importance to generate such information and as a sort of information for policy makers and planners of governmental and NGOs in setting their policies and strategies of honey production improvement interventions.

Gambella region is one of the honey producing areas of the country where better availability of bee forage from forests allows high quality honey production and the total hives found in the region, about 99.9% (84.9% forest hives and 15% backyard hives) are traditional, and had contributed 6.9% national honey production (GDS, 2009). Given the importance of honey production in the country, one would have expected that the region would have been the largest producer of beekeeping products. Therefore; this research was designed to study adoption of modern bee hive in a selected Gambella Zuria District.

1.2 Statement of the Problem

Ethiopia has huge potential for beekeeping production because of its endowment with diversity in climate and vegetation resources offer potentially favorable conditions for beekeeping. These have enabled Ethiopia to take the total share of honey production around 23.58% and 2.13% of the African and world's respectively (Workneh and Puskur, 2011).

Despite its long history, beekeeping in Ethiopia is still an undeveloped sector of agriculture. The knowledge and skill of honey production and honey and beeswax extraction of Ethiopian farmers is still very traditional (MoARD, 2006). Producing only 8.6% of its annual production potential, the benefit from the sub sector to the nation as well as to the farmers, traders, processors and exporter is not satisfactory (EBA , 2014; Beyene Tadesse and David Phillips, 2007).

Crane (1990) noted that modern technologies in beekeeping allow higher honeybee colony management and give higher yield and quality honey. The improved box hive has components like brood chamber, super (honey chamber), inner and outer cover. It has advantages over the tradition hive in that it gives high honey yield in quality and in quantity. The other advantages of improved box hive are its ease in swarming control by increasing supers and the ability to move bees from place to place in search for honeybee flowers and pollination services (Crane, 1990).

In order to improve the honey yield in quantity and quality, Agricultural and Rural Development Office and different Non-Governmental Organizations have introduced improved box hives, Zander type in Gambella Zuria District. However, there was no adequate information on the determinants of the technology adoption, socioeconomic and socio-psychological factors influencing adoption of beekeeping technology and the benefit of adoption of box hive technology.

Kerealem (2005) also stated that adoption rate of improved box hives is low in the country and the study suggested the importance of investigating factors influencing the adoption of improved box hives.

Southwest parts of the country is endowed with natural tropical rain forests with suitable climates that favor high honeybee population density and forest beekeeping is widely practiced (Nuru, 2007). In the area the majority of household keep honeybees as source of income from honey sell and beekeeping is an integral part of the farming communities of the area (Nuru, 2007). However, the honey production is very traditional which is practiced mainly by hanging traditional hives on tall trees in the dense forest far from human settlement areas (Hartman, 2004; Nuru, 2007).

In relation to adoption study, Ehui *et al.* (2004) revealed the difficulties of developing a universal model of the process of technology adoption with defined determinants and hypothesis that hold true everywhere. This is because of socio- economic and ecological distinctiveness of the different sites and dynamic nature of most of the determinants. Due to these facts, the authors recommended repeated study on determinants of adoption under different conditions.

Therefore, based upon the aforementioned realities the study was undertaken to find appropriate feedback on adoption of improved box hives and benefit of box hive along with practices pertinent to beekeeping such as feeding, planting bee forage, preparing shading, post-harvest handling of hive products, ant protection etc. to find information on their appropriate utilization.

1. 3. Research Objectives

1.3.1. General objective

- The overall objective of this study is to assess factors affecting adoption of modern bee hive in Gambella Zuria Woreda.

1.3.2. Specific objectives

- To assess beekeeping production system practiced in the study area.
- To analyze the profitability of improved box hive technology over the traditional beehive in the study area.

1.4. Research Questions

The central research question raised for addressing the objectives of the research is: how is the traditional beekeeping systems utilized and what underlying major factors are inhibiting the production of the sub sector.

1. What beekeeping production systems are practiced in the study area?
2. How does adoption of improved box hive is more profitable as compared to traditional beehive in the study area?
3. What are the factors affecting adoption of modern bee hive among farmers in the study area?

1.5. Significances of the Study

This study provides detailed information on the current service provision for beekeeping improvement, determinants of improved bee hive adoption, perceptions and attitudes of farmers regarding the benefits and factors of using improved box hive compared to traditional beehive, and profitability of adopting improved bee hive over traditional beehive in the area. Different groups and individuals are expected to benefit from this research output. The findings of this study may help different governmental organizations and development partners to evaluate the current status and to design their future programs and strategies with regard to beekeeping services provision and beekeeping improvement intervention in the study area. It may help researchers as an input for their further studies. Farmers may understand the advantages of beekeeping services provision and apiculture improvement intervention from this study result.

1.6. Scope and Limitations of the Study

The study dealt with improved box hive adoption by taking the sample from one district. It could not, represent the whole improved box hive population of the country. This hindered generalization about improved box hive situation in the country. However, the research recommendations can be applied in other areas having similar socio-economic characteristics.

1.7. Organization of the Thesis

The thesis is organized into five chapters. It starts with the introduction, which includes statement of the problem, research questions, objectives, significance of the study and scope and limitation of the study. The second chapter reviews literature that deals with past studies and information pertinent to the study. The third chapter explains research methodology including description of the study area, sampling techniques, methods of data collection and tools for data analysis. In the fourth chapter the main findings of the study are discussed. Finally, conclusions and recommendations are provided in chapter five.

2. LITERATURE REVIEW

2.1. Definition and concept of adoption

As of Feder *et al*. (1985) adoption is classified into individual and aggregate adoption according to its coverage. Individual adoption refers to the farmer's decisions to incorporate a new technology into the production process. Aggregate adoption is the process of diffusion of a new technology within a region or population. The study of improved box hive adoption is referring to the first type of adoption. The adoption pattern to a technological change in agriculture is not uniform at the farm level. It is a complex process, which is governed by many socio-economic factors. The farmers' socio-psychological system and their degree of readiness and exposure to improved practices and ideas i.e. changes like the awareness and attitude of farmers towards improved agricultural technologies and the institutional factors which act as incentives/disincentives to agricultural practices and the farmers' resource endowment like the land holding size and labor are some of the factors of considerable importance in bringing about the technological change in agriculture (Salim, 1986).

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

Feder, *et al.* (1985) defined adoption as the degree of use of a new technology when a farmer has full information about the technology and its potential. The authors also defined aggregate adoption as the process by which a new technology spreads or diffuses within a region.

Rogers (2003) defined adoption as the mental process through which an individual passes from first hearing about an innovation to final adoption. Rogers and Shoemaker (1971) defined adoption as a decision to make full use of new ideas as the best course of action available. The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, economical and social factors. The authors further

explained that adoption or rejection of an innovation is a decision to be made by an individual.

According to Dasgupta (1989), the term adoption is the continued use of a recommended idea or practice by individuals or groups over a reasonable long period. Ban and Hawkins (1996) also defined technology adoption as a decision to apply an innovation and to continue to use it.

2.2. Theoretical Background of adoption study

Technology generation and development is an interactive process and the supply of technologies needs to be driven by demand from the users. As noted by Langyintuo and Mulugeta (2005), the importance of adoption study are: to quantify the number of technology users over time to assess impacts or determine extension requirements; to provide information for police reform and to provide a basis for measuring impact.

The rural sociological research on the diffusion of agricultural innovations originated in the United States in 1920s when the U.S Department of Agriculture decided to evaluate the process of their programme of introducing improved farming practices among farmers (Dasgupta, 1989).

The sociological research on the diffusion on agricultural innovations grew rapidly in the 1950s and 1960s in the United States, and influenced the beginnings of similar studies in other countries. Agricultural technology adoption, among development economists has attracted considerable attention as the majority of the population of less developed countries derives their livelihood from agricultural production and a new technology apparently offers opportunities to increase production and productivity (Feder *et al.*, 1985)

Ban and Hawkins (1996) also state that adoption and diffusion of innovation research was high during the 1960s in less developing countries. This is because the ministries of agriculture saw the need for large numbers of farmers to use the result of scientific agriculture in order to prevent famine. The adoption of agricultural technologies during and after the Green Revolution is well documented (Gollin, *et a*l., 2005).

In Ethiopia, adoption study started three decades back. The study is mainly confined to crop, livestock and soil and conservation technology adoption (Itana, 1985; Getachew, 1993; Chilot, *1994*, Lelisa, 1998; Shiferaw and Holden, 1998; Kidane, 2001; Berhanu, 2002; Endries, 2003; Habtemariam, 2004, Million and Belay, 2004). In relation to beekeeping technology adoption, Melaku's (2005) study on Kenya Top Bar hive adoption is the only one that exists. Hence, this study contributes much in alleviating shortage of information on beekeeping technology adoption.

2.3. Farmers` adoption decision

Adoption of an improved practice by a farmer is necessarily based on his/her capacity to acquire and absorb information about new techniques and on his/her capacity to convert this knowledge to practice (Aregay, 1980).

Adoption is a decision-making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001).

The conventional adoption framework further simplifies the analysis of the adoption decision by its implicit assumption of an individual "decision-maker." Within the farm household, the ability to make decisions regarding resource use and technology varies according to age, gender and other categories. Actual decisions can depend on a complex bargaining process among household members. Beyond the household, group processes and the ability to harness them can also play a crucial role in adoption decisions, particularly on conservation practices. Moreover, decisions about new technology are frequently prompted by an intervention in the form of a project (Cramb, 2003).

The study of Doss *et al*. (2003) on adoption of maize and wheat technology in Eastern Africa states that farmers cited several reasons for not adopting improved technologies. The first was simply being unaware of the technologies or that they could provide benefits; this may include misconceptions about the related costs and benefits. The second reason was that the

technologies were not profitable, given the complex sets of decisions that farmers make about how to allocate land and labor across agricultural and non-agricultural activities. This may be due to the fact that appropriate varieties for farmers' agro ecological conditions were not available or that farmers preferred characteristics found only in local varieties. It may also be due to institutional factors, such as the policy environment, which affect the availability of inputs (land, labor, seeds, and fertilizer) and markets for credit and outputs.
These institutional factors also affect input prices. It may also be that use of improved technologies may increase production risks: if crops fail, the financial losses would be higher. Finally, technologies were not adopted because they were simply not available.

Ehui *et al*. (2004) explain that a new technology is introduced to small holders farmer by itself alone does not guarantee for a wide spread adoption and efficient use. For efficient utilization of the technology the fulfillment of specific economic, technical and institutional conditions are required. From the farmers' perspective, the new technology should be economically more profitable than the existing alternatives. The new technology should also be technically easily manageable by small holders and adaptable to the surrounding socio cultural situations. Similarly, the availability of the new technology and all other necessary inputs to small holders at the right time and place and in the right quantity and quality should be ensured. As also noted by Yapa and Mayfeld (1978) adoption of an entrepreneurial innovation by an individual requires at least four conditions. These are: the availability of sufficient information, the existence of a favorable attitude towards the innovation, the possession of the economic means to acquire the innovation and the physical availability of the innovation. Research in the diffusion of agricultural innovations has demonstrated that knowledge/awareness of a new technology is a necessary first step in the adoption decision-making process (Rogers, 1995)

The rate of adoption is influenced by the farmers` perception of the characteristics of the innovation, the changes this innovation requires in farm management and the roles of the farm family (Ban and Hawkins, 1996). The authors further stated that innovations usually are adopted rapidly when they have a high relative advantage for the farmers; compatible with the

farmers' values, experiences and needs; are not complex; can be tried first on small scale and easy to observe the results.

The decision to adopt usually takes time. People normally do not adopt a new practice or idea as soon as they hear about it (Lionberger, 1960). The author further showed people appear to go through a series of distinguishable stages. These are:-

Awareness - at the awareness stage, a person first learns about a new idea, product, or practices. He/She has only general information about it. He/She knows little or nothing about any special qualities, its potential usefulness, or how it would likely work for him/her.

Interest- at this stage the farmer develops an interest in the new thing that s/he has learned about. He/She is not satisfied with mere knowledge of its existence. He/She wants more detailed information about what it is, how it is, how it will work, and what it will do. He/She is willing to listen, read, and learn more about it, and is inclined to actively seek the information desired.

Evaluation- at this stage a person weighs the information and evidence accumulated in the previous stages in order to decide whether the new idea, product, or practice is basically good, and whether it is good for him/her. In a sense, he/she reasons through the pros and cons mentally, and applies them to his /her situation. Perhaps this stage could very well be referred to as the `mental trial stage`. To be sure, evaluation is involved at all stages of the adoption process, but it is at this stage that it is most in evidence and perhaps most needed.

Trial- at this stage the individual is confronted with a distinctly different set of problems. He/she must actually put the change into practice. The usual pattern of acceptance is to try a little at first and then to make large-scale use of it if the small scale experiment process successful.

Adoption - at this stage a person decides that the new idea, product, or practice is good enough for full scale and continued use.

According to Rogers (1981), agricultural technology has its own factors, which affect its adoption by a given society. These factors are technologies relative advantage, compatibility, complexity, triability and observability. As to Byerlee *et al*. (1986) cited in Getachew (1993), the adoption patterns of a particular component is a function of five characteristics namely profitability, riskiness, divisibility, or initial capital requirements, complexity and availability.

Rogers (1983) also classified innovation decision process into five functions. These are:-

Knowledge- the function in which an individual is exposed to the innovation's existence and gains some understanding of how it performs.
Persuasion - the function in which an individual forms a favorable or unfavorable attitude towards the innovation.
Decision - at this function an individual engages in activities that lead to a choice to adopt or reject the innovation.
Implementation - it is a function in which an individual puts the decision (adoption or rejection) into practice.
Confirmation - it is a function in which an individual seeks reinforcement for the innovation decision made, at this stage the individual may reverse his/her decision if conflicting ideas about the decision occurred.

2.4. The role of extension in enhancing adoption

The major role of extension in many countries in the past was seen to be transfer of new technologies from researcher to the farmers. Now it is seen more as a process of helping farmers to make their own decisions by increasing the range of options from which they can choose, and by helping them to develop insight into the consequences of each option (Ban and Hawkins, 1996) Extension plays a great role in popularizing farm technologies. Currently, everyone is found in competitive globalized world. Hence, to make the farmer competent, it is expected from the extension to work closely with farmers than any other times. As noted by Hagmann, *et al* (2003) the role of extension includes: -

1. Building the capacity of farmers and farmer organizations to pursue their development goals by articulating high quality demand for services. This can be affected by

offering need-based practical training and close follow up which enable them to examine their farming environment comparing with other farming situation. This, in turn, develops farmers' aspiration for change through adopting different farm technologies that is suitable to their farming system.

2. Linking farmers and farmer organizations to other support agencies including markets and input supply systems, creating platforms for their interaction and facilitating negotiation between the different stakeholders.
3. Helping farmers search for new knowledge and technologies as well as creating partnerships that enhance application of the knowledge and technologies.
4. Facilitate farmers for collective and individual learning about innovations to enhance community's capacity to innovate. Collective action helps to find appropriate solution. Hence, participating different actors in learning and experimenting together and sharing experiences that enhance them to understand more about the technology.

Enhancing technology dissemination and adoption is part of an innovation system that starts with the technology development process itself. Concepts of participatory technology development (PTD) and now integrated agricultural research for development (IAR4D) indicate a shift from supply driven to more collaborative ways of generating and disseminating relevant agricultural technologies. This therefore, means that the responsibility to promote technologies cannot be left to extension agencies alone but rather a collective responsibility of researchers, extension agents, farmers and other service provides. Engaging in such collective responsibility demands new skills for integration and working together in partnership with key stakeholders. Skill for doing so has to be clearly identified and deliberately built in the system (National Agricultural Research Organization, 2004).

2.5. Overview and Importance of Beekeeping in Ethiopia

In Ethiopia, beekeeping has been a tradition since long before other farming systems practiced. Even though it is the oldest activity, there is no recorded evidence when and where it is first started. However, the Hieroglyphs of ancient Egypt refer to Abyssinia (ancient name of Ethiopia), as source of honey and beeswax and Abyssinia has been known for its beeswax export to Egypt for centuries when other items were not exported (Gezahegn, 1996). It is, thus assumed that the keeping of bees in baskets may have started about 5000 years ago in the

northern regions along with the early settlements. No country in the world may have ancient beekeeping as Ethiopia. Moreover, the oldest basket hive in the international bee museum is from Ethiopia (Gezahegne, 2001).

The contribution of bees and hive products, though difficult to assess, is probably one of the most important small-scale income generating activities for hundred thousands of smallholder beekeepers (Bradbear, 2003) and apiculture plays a significant role in the national economy of the country (Nuru, 2007). The majority of Ethiopians live in rural areas depending on agriculture as a source of their livelihood and apiculture is one of an important agricultural activity in most rural areas. As beekeeping has low start-up cost and requires little land and labor, it is accessible to many rural community and is promoted as a pro-poor income generation activity. Frequent droughts coupled with environmental degradation have threatened the livelihood of this rural community for several decades. However, regardless of other agricultural activities, bees survive in drought-threatened areas and supplement the vulnerable communities with nutritious food, honey and a source of income (MoARD, 2007). In line with this, beekeeping has managed to help a family become less vulnerable, strengthening their ability to look into the future, and reducing the chance that they will slip into poverty when there is farming failure (Ibid, 2003).Therefore, ranges of applications emerging from apiculture development are enormous and it is considered a major tool in combating food insecurity.

Beekeeping, in addition to its economic importance, has high social value in the country. The number of honeybee colonies and hives owned serves as a major wealth ranking in rural societies. Honey and beeswax have cultural and religious values such as in birth, marriages, funerals and Christmas ceremonies and traditional medication (Bradbear, 2003). Beekeeping has also a great role in natural resource protection. Beekeeping is environmentally friendly activity and beekeepers are more aware about the importance of conservation of natural resource than any ordinary farmers. Integrating natural resource conservation programs with income generating options like utilizing the forest resources, in the form of honey and beeswax, while maintaining the natural vegetation would be an appropriate approach (Nuru, 2007).

As noted by Robinson (1980) cited in Workneh (2007), beekeeping has various relative advantages compared to other agricultural activities and some of them are as follows:

Bees are cosmopolitan i.e. they adapt to wide range of environment. They can survive at altitude below400 m.a.s.l. where cattle production may be severely constrained due to tsetse or other reasons. Small holders and landless peasants can practice beekeeping. The hive occupies very little space and bees can collect nectar and pollen from anywhere they can get. Beekeeping does not compete for resources with other agricultural endeavors and can be run integrally with other agricultural activities. People cannot harvest and utilize nectar and pollen in the absence of bees. Bees' culture does not disturb ecological balance, as many cultivation of crops and practices of animal husbandry. The investment and running costs are relatively low with minimal risk. Beekeeping is possible even for people with few resources as the bees can be obtained from the wild. Equipment can also be made locally and in most cases bees do not need the beekeepers help. Globally, the honeybee provides pollination service. This is an indispensable activity in the crops and fruits production process. Therefore, beekeeping plays significant role to the agricultural economy at large. The honeybee produces honey, beeswax and propolis. These commodities have long shelf life without having special storage and transportation facilities as that of dairy and expanded according to the interest of the beekeepers and the time available. The whole family can become involved since men, women, or elder children can do the work in most cases at home. A beekeeper can develop knowledge and skill, which are rewarding and help to generate self-reliance. Other local trades benefit by making hives and equipment, and from using and selling the value added products. Honey, beeswax, pollen and propolis can be used in a variety of foods, cosmetics, ointment and other goods, which can be made and sold locally, creating more livelihood opportunities. Apitheraphy i.e. medicine using bees products, all societies have a wealth of traditional knowledge concerning the healing properties of bee products.

2.5.1. Ethiopian beekeeping practices

The most important and available insect in the world today is the honeybee. There are several species of honeybees existing, but *Apismellifera* is country famous. It is a wonderful and

popular bee type for its honey and bee wax production besides the major value obtained because of plant pollination (Ayalew, 2000).

Ethiopia is one of the homes of *Apismellifera adenosine* (Ayalew, 2000). The methods used by the motives are usually primitive; the hives are generally cylindrical in shape and regarded the Abyssinian hives as the oldest in existence, since in its general shape it recalls the hives constructed by Egyptians. Padre Bellani , who lived in East Africa for more than 25 years, records that in the neighboring territories of Kenya and Uganda never saw hives constructed like those of Abyssinia which suggest that Abyssinian apiculture has its origins in Egypt (Hussein, 2000).

According to recent investigation, about five million bee colonies exist in Ethiopia (Ayalew, 2000); out of these 200,000 colonies are found in Tigray (BoARD, 2006). Due to natural vegetation that was present in the past and biodiversity of Ethiopia; the bees have made their own natural selection for nesting in lowland; mid-highland and in highland areas to rear and propagated. Except for some places in Afar and Somalia regions honeybees are fairly distributed in the country adapting varying degree of weather conditions. They all produce honey, the nutritious natural food good for both man and animals (FAO, 1990).

Ethiopia is generally believed to be one of those countries endowed with large apicultural resources. However outmoded and traditional production system, poor post-harvest processing and handling techniques and practices combined with poor marketing efforts has kept it part of the subsistent sector. Perhaps because of these fertile conditions beekeeping has been in practice for centuries in the country. The number of bee colonies in the country is believed to be large; but estimation with regard to the number of bee colonies in Ethiopia varies significantly. A recent CSA survey on the livestock of Ethiopia puts the number of bee colonies at 4.5 million, and the honey production at 30 million kg or 30,000 tons (CSA, 2005). Of this, 99% is of traditional beekeeping while the rest is modern hive. Because of this data, the yield per colony per year would be 6.7 kg. The CSA (2005) record suggests that the number of beehives in the country have growing at about 4.7% per annum.

Beekeeping in Ethiopia is an important activity for many rural people - both men and women -and is also carried out in home gardens and even houses in all parts of the country. There is

no nationality in Ethiopia which doesn't have beekeepers and for some, beekeeping, and the collection and selling of honey and other bee products, is a major economic activity (Mehari, 2007).

Many societies have considerable traditional knowledge and skills concerning bees, honey and related products. The products of beekeeping are often used by women: the important tej (honey wine) industry in Ethiopia, for example, is run by women. Elsewhere in Africa, women brew and sell honey beer. These are the types of human assets or skills needed to create livelihoods within a society. Beekeeping projects have sometimes ignored existing knowledge or implied that it was wrong or out of date, which is worse. The best beekeeping projects recognize existing skills and build on them for greater income generation and to ensure sustainability. Many African women add to their livelihoods by brewing and selling honey beer. Ethiopian women make and sell tej (honey wine) and non-alcoholic drinks based on honey (Brad bear, 2003).

2.5 2. Beekeeping production Systems in Ethiopia

1. Honey hunting System

The earliest honey hunting evidence comes from rock paintings, equipment used and anthropological studies obtained first in Spain, which is dated back to 30,000-10,000 B.C. This practice (honey hunting), as a beekeeping system, is also widely practiced by some tribes of the south and southwest Ethiopia (This sort of hunting is practiced in Gambella these days).

2. Traditional beekeeping system

In Ethiopia, traditional beekeeping is the oldest and the richest practice, which has been carried out for thousands of years. Traditional beekeeping is mostly practiced with different types of traditional hives. The most universal type of traditional hives, known to have been in use is simple cylindrical type. Beekeeping started with traditional or fixed comb hives, so called because the combs are attached to the top and sides of the hive itself and the beekeeper cannot easily remove and replace them. In its primitive form, only one end of the hive could be open, but in more advanced forms each end of the cylinder will be fitted with a removable

closure. The types of hives and the way of keeping bees vary from area to area. Based on locally available materials used for construction of hives, environmental conditions and positions used to keep bees, the following variants of basic design are found throughout the country: hollowed logs, bark hive, bamboo or reed grass hive, mud (clay) hive, animal dung (mixed with ash) hive, woven straw hive, gourd hive, earthen pot hive and so on (Gezahegne, 2001). The beekeepers that are experienced and skilful in using these hives could do many operations with less facility.

Traditional beekeeping is of two types: forest beekeeping and backyard beekeeping. In some places, especially in the western and southern parts of the country, forest beekeeping by hanging a number of traditional hives on trees with no management is widely practiced. In other most parts of the country, backyard beekeeping with relatively better management is common (Nuru, 2002). According to Holeta Bee Research Center (2004), traditional forest beekeeping is placing of hives in the forest on very tall trees for catching swarms. It is commonly exercised in forest-covered areas of the country where the population of honeybees are abundant. The advantage of forest beekeeping is that the bees do not cause harm to the domestic animals and humans and the bees can get abundant forage plants in their vicinity. Its disadvantages are lack of close follow up and damage the honeybee colony during honey harvesting period as the beekeeper drops down the hive from the tree. It is also dangerous for the beekeeper to climb tall tree at night. On the other hand, backyard traditional beekeeping is undertaken in safeguarded area for honeybees mostly at homestead. The advantages of such practices are: construction is very simple; it does not require improved beekeeping equipment's; and it does not also require skilled manpower. Whereas its disadvantages are associated to the inconvenience to undertake internal inspection and feeding, too small sizes that causes swarming. This type of beekeeping has been commonly practiced in the study area for many years until the introduction of improved beekeeping and still is in practice.

3. Transitional beekeeping system

The use of transitional beekeeping started in Ethiopia since1976.The types of hives used include Kenyan to-bar hive (KTBH), Tanzanian top-bar hive (TTBH) and Mud-block hives. Among these, KTBH is widely known and commonly used in many parts of the country.

Transitional beekeeping practice has different advantages such as, it can be opened easily and quickly, the top-bars are easily removable which enables beekeepers to work fast, easier to construct than frames, honey-combs can be removed from the hive for harvesting without disturbing combs containing broods, and the hive can be suspended with wires or ropes which gives protection against pests. Transitional beekeeping has its own disadvantages such as, top-bar hives are relatively expensive than traditional beehives, combs suspended from the top-bars are more easy to break off than combs which are building within frames (HBRC, 1997).

4. Modern beekeeping system

This type of beehive is aimed at obtaining the maximum honey crop season after season without harming bees (Brad bear, 2003). Movable-framed hive consists of precisely made rectangular box hives superimposed one above the other in a tier. The number of boxes is varied seasonally according to the population size of a colony. At first time, Lorenzo Lorraine Langstroth invented movable-frame hive in U.S.A in 1851 (Crane, 1976). Later on different countries developed their own types of movable-framed hives (for instance Zander, Dadant). In many countries Langstroth hives have proved to be convenient for handling and management (Jones, 1999).

In Ethiopia about five types of movable-framed hives were introduced since 1970 (HBRC, 1997). The most commonly used are Zander and Langstroth style hives. Dadant, Modified Zander and foam hives are found rarely. These hives differ in number and size of frames. The most commonly used hive type in Ethiopia is Zander type. Attempt was made to construct improved box hive from bamboo but with timber frames. Improved box hives have components like brood chamber, super (honey chamber), inner and outer cover. Movable framed hives allow appropriate colony management and use of a higher level of technology with larger colonies, and can give higher yield and quality of honey. The other advantage of improved box hive is its possibilities of swarming control by supering the bees from place to place for searching honeybee flower and pollination services. On the other hand, its disadvantages are the equipments are relatively expensive, requires skilled manpower and the equipment needs very specific precaution (Crane, 1990).

The productivity of beehive types is different depending on the level of technology used to construct the beehive. Traditional beehive can yield a modest amount of honey and the proportion of crude beeswax produced is about 8-10% of the crude honey weight. This harvest is

Achieved with minimal cost and labor, and it is valuable to people with low level of living standard. However, the amount of beeswax produced from improved box is 0.5-2 percent of the honey yield, which relatively requires high investment cost (HBRC, 1997). The average productivity of the three beehive types under farmers' condition and in research center is given below in Table 1.

Table1. Average productivity of the different types of hives in Ethiopia

Hive type	Farmers' average yield (kg/hive/year)	Research center yield (kg/hive/year)
Traditional	5-7	NA
Transitional (Intermediate)	15-25	25
Improved hive/Framed hive	30-45	40

Source*:* Global Development Solutions, 2009NA: Not Applicable

2.6. African beekeeping practices

Beekeeping is an important component of agriculture and rural development programmed in many countries. The role of beekeeping in providing nutritional, economic and ecological security to rural communities at the household level and is an additional income generating activity. This being a non-land-based activity does not compete with other resource demanding components of farming systems.

Enormous agricultural & agro-based opportunities exist in the rural areas to generate income and employment. In Nigeria, beekeeping is a useful means of strengthening livelihoods and has been identified as a viable agriculture practice that could alleviate poverty and sustain rural employment (Messely, 2007).

Although beekeeping can only rarely become the sole source of income and livelihood for people in the Third World, its role as a source of supplementary earnings, food, and employment should not be underestimated. Key points in the argument that beekeeping is a key element in promoting rural self-reliance are that (Pete et al., 1998):

Beekeeping promotes rural diversification and hence is an alternate source of income and employment, particularly in areas where arable land is restricted and demographic growth is resulting in insufficiently profitable landholdings. Beekeeping is an activity that has successfully been adopted by women in many parts of the continent. 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. This is particularly true of beeswax, which can be stored indefinitely. Beekeeping clearly is a low-cost, sustainable undertaking with a low environmental impact. The spin-off of enhanced plant pollination is an invaluable one. Although honey is not a primary source of food, it can be used as a dietary supplement. In addition, its cultural significance should not be ignored.

According to Brad bear (2006) African honey is rarely produced by farmers who are organized and empowered in this way: Nevertheless Bees for Development believes that African honey is a highly ethical product with very important pro-poor benefits. These are:
Honey is harvested by some of the poorest and most vulnerable households, and sales bring income into their homes, and are spent on necessities such as school fees and medicine.
Beekeeping is accessible to the poor as there are no high start-up costs. This means that beekeeping can be without the risk of debt. Beekeeping is undertaken by the young and old, men and women; it is a gender inclusive activity. Beekeepers produce products (honey and beeswax) that require little further processing. Therefore, they should capture relatively more of the end value of the final product. Honey has multiple market opportunities. If an export market collapses, people can still sell or use the product within towns and villages at home, or eat it. This is unlike other commodities such as coffee or vanilla.

Bees are indigenous and a natural component of the local ecosystem, and they contribute to biodiversity through pollination. Bees in most of Africa are disease free, which means that no

medicines are used to maintain bee health - quite apart from the fact that poor people could not anyway afford them. Beekeeping causes no disturbance to the natural environment. Compare this to a tea estate, which even if certified organic, has involved replacement of natural vegetation with an imported monoculture. Beekeeping creates an economic incentive for rural African people to conserve natural vegetation. This is good news. Imploring people to conserve forests for non-tangible benefits are usually a non-starter. Compare this with earning an income, through beekeeping, from natural forest ecosystems. It is recognized that the beekeeping sector holds potential for creating sustainable incomes for Africa's rural beekeepers. But this potential is hardly tapped because these producers do not have access to infrastructure and organizational systems to allow them to reach the niche/specialty markets their products would otherwise reach, especially in the EU. To open new market opportunities for these beekeepers, a resolution is made for the Fair trade Labeling Organization (FLO) to take cognizance of the situation in Africa, and put in place a system of recognizing and registering small-scale private sector firms that are linking the producers to buyers in the fair trade market (Balya, 2006).

Apiculture Trade Africa believes that African honeys are special products. They are produced in the "last frontier", with indigenous bee stocks and no introduced bee diseases or predators, therefore enabling bee colonies to survive without the use of medicines to maintain bee health.

African honey is harvested by smallholder farmers, many of whom are the poorest in society. Selling bee products can provide a feasible way out of their poverty. Beekeeping is the ultimate environmentally sustainable activity. The indigenous species of honey bees contribute to biodiversity through pollination and provide economic incentive for rural African people to conserve natural forests, which provide an abundance of excellent bee forage (Bee for development, 2006).

A study from Tanzania shows beekeeping activities involved both genders at different stages of honey and beeswax processing and marketing. Traditionally, men are responsible for honey harvesting which is normally carried out at night because they are scared of honey bees during the day. In Milola and Kinyope villages in Tanzania, division of labor was evident while men

specialize in the construction of hives and honey harvesting; women are involved in carrying unprocessed honey home from the forest. The dominance of men in beekeeping activities in the Milola and Kinyope villages seemed to have downplayed the role and contribution women have made with respect to managing bee reserves and habitats, harvesting of crude honey, and the processing of bee products (Lalika, 2008).

Smallholder beekeepers in Tanzania have rich indigenous knowledge of beekeeping. They also have good knowledge of different types of hives, bee smokers and honey containers. In terms of hive types, it was found that most smallholder beekeepers use local style gourd hives. The reason is that they are cheaper than other types of hive and are locally available (Lalika, 2008).

The gourd hive is one of the oldest items of indigenous equipment and has been adopted in areas of Tanzania where alternative materials for hive making are scarce. This indigenous knowledge enables smallholders to carry out beekeeping activities at minimal cost, as it does not need heavy investment in terms of financial and human capital, for equipment and extensions. Nevertheless, in terms of production, indigenous knowledge has an adverse impact on the quantity and quality of bee products (Lalika, 2008)

The aroma, taste and color of honey are determined by the plants from which the bees have gathered nectar. Sunflowers, for example, give a golden yellow honey; clover gives a sweet, white honey; agaves species give honey a bitter taste that is popular in some societies.

Successful beekeeping enterprises require production equipment and infrastructure such as transport, water, energy, roads, communication systems and buildings. There are many ways to manage bees and obtain crops of honey, beeswax or other products. In sustainable beekeeping projects, all equipment must be made and mended locally which, in turn, contributes to the livelihoods of other local people (Bradbear, 2003).

Beekeeping can add to the livelihoods of many different sectors within a society including village and urban traders, carpenters who make hives and stands, tailors who make veils, clothing and gloves and those who make and sell tools and containers (Bradbear, 2003).

Where bee hives are located make the difference between a good crop and none at all. The characteristics of a good honey producing yard (Balya, 2006).

- The area has a history of good honey production.
- Crops which produce nectar/pollen must be within short flying distance for the bees.
- The yard must be accessible to truck and other vehicles at all times.
- The site must be level or nearly level and have water available nearby.
- It must not be in a low area subject to flooding
- The site must be within close driving distance to other bee yards.
- The site must not be close to human dwellings.

Honey bees are known to forage great distances from the hive but the fact is they gather nectar generally close to their hives. For the honey producer, the closer the better because a honey bee can make more trips to the field in a single day and use less energy in flying to the crop.

Dark honey usually has a strong flavor and often has a high mineral content; pale honey has a more delicate flavor. The popularity of dark and light honey varies from country to country. Color can also indicate quality, because honey becomes darker during storage or if it is heated. However, some perfectly fresh and unheated kinds of honey can be dark in color. Glucose is a major constituent of honey. When the glucose crystallizes, the honey becomes solid and is known as granulated honey.

Depending on the plants the bees are visiting, some kinds of honey are more prone to granulation than others; almost all honey granulates if its temperature falls below 15–24 °C. As with color, different people favor different qualities of honey. Some prefer granulated honey, while others choose liquid honey. Granulation is a natural process; there is no difference in nutritional value between solid and liquid honey. Some kinds of honey look cloudy because they contain a high level of pollen. Such honey is sometimes said to be of low quality, although the presence of pollen makes the honey even more nutritious (Bradbear, 2003).East African nations export tremendous quantities of wax. Ethiopia and Tanzania produce about2.5% and 1.15% of total world honey production, respectively. Keeping bees in

beehives as practiced in Egypt, Kenya, Tanzania, is not well known in other part of Africa (Hussein, 2000).

2.6. Development and Extension Services in Relation to Beekeeping in Ethiopia

Apicultural research is very old in Ethiopia. Holeta Bee Research Center (HBRC) founded around 1964, was the pioneer institution mandated to undertake research in areas that include: improving the quality of hive products, identification and development of races, evaluation of honey plants, improvement of traditional bee-keeping and beekeeping equipment, and investigation of diseases (Mustafa, 2000). The various organizations and institutions that have made substantial efforts to raise income from selected potential areas of the country includes: i) "The European Development Fund" beekeeping project mobilized in 1977 in Gambella District; ii) A "Beekeeping Development Project" that was carried out in Wolayita; iii) "Land Potential of Coffee and Oil Crops, Apiculture Component" a project initiated in 1988 to make preliminary assessment of the suitability of "Western Forest of Kaffa" for the production of crops, other than coffee; iv) "Assistance in Apiculture Development" in 1988, a project that aimed to increase production of honey in Ethiopia through the introduction of modern beekeeping. In addition, beyond workshops and trainings that are organized by the Ministry of Agriculture, courses in Apiculture are offered at Haramaya University and Veterinary faculty of Addis Ababa University at Debrezeit.

As indicated in the recently issued Amharic version of Comprehensive Honey and Beeswax Development and Marketing Plan (2nd Draft document), the country has set a long-term plan to raise the current 30,700 tons of honey and 3020 tons beeswax annual yield to a level of 149,056 tons and 9928.96 tons of honey and beeswax, respectively. It is also planned to export 80 percent and 50 percent of the total honey and beeswax production (MOA, 2003).
In the 3 years (2003-2005) development strategic plan of the Amhara National Regional State (ANRS), objectives have been set to introduce improved and intermediate beekeeping technologies to moist and moisture stress areas respectively. In these objectives it has planned to increase the number of top-bar hives from 8,081 to 996,000; box hives from 1,691 to 66,400, to boost the honey yield from 2.8 million kg to 19.29 million kg and to increase the participation of women in beekeeping by 30 percent (BOA, 2003a).

2.7. Beekeeping Production System in Gambella Region

Beekeeping production practice in Gambella is similar as elsewhere in Ethiopia. Honey hunting is practiced by many people on an opportunistic base in the forest dominated localities in the zone (Solomon, 2007).

In the region, there is better natural forest and cultivated crops. In addition, the region has suitable climatic condition. As a result, large honeybee population exists in the area. Nuru (2002) explains that in the area beekeeping is mostly practiced in the forest by hanging hives on very big trees. It is common to observe up to 50 honeybee colonies in one tree. However, in this region, after the honey harvest, they shake down the bees and store the empty hives until the next swarming season. In the region, there is cultural belief of the beekeepers that once the colony is touched for honey harvest, the colonies tend to abscond and never stay in their hive. The same author identified major problems of beekeeping of the area. Some of the problems are: - hanging the hive on tall tree is difficult to manage the bees properly, forest beekeeping is a very difficult work for women and old men, shaking the bees during honey harvest causes the loss of thousands of colonies every year, the nomadic nature of the bees, forest fire in dry seasons, excessive swarming, lack of knowledge and skill on better handling methods of bees. In this region, transitional, improved, and honey hunting practices are also being undertaken. There are also beekeepers that keep their bees under the roof and use the colony for a long time. Such beekeepers can be used as demonstrators for beekeepers who destroy their colonies during honey harvest in the belief that those bees do not stay in their hives after being disturbed.

2.8. Factors Affecting Honeybee Productions

Low productivity and poor quality of bee products are the major economic impediments for rural beekeepers (Nuru, 1999). Also, limited availability of bee forage (due to deforestation), shortage of honeybee colonies, backward technology, poor pre and post-harvest management has been reported affecting the supply of honeybee's products (FAO, 2012). Furthermore, inadequate government support and poor extension services, lack of improved technologies, shortage of trained human power, and lack of access to credit services and weak road and market infrastructures in production areas. The present increasing use of pesticides and

herbicides is severely threatening bee colonies implying conflicts of crop and honey production (FAO, 2012).

2.8.1. Limitation of rural credit service

The improved hives and working tools to the rural community are beyond the pockets of farmers and not easily available. There is limitation of the credit services for landless youths as well as households. Even if the rural credit service is around they do not easily serve due to limitation of awareness creation (Kerealem Ejigu *et al* 2009.)

2.8.2. Types of Beehives used

The ability to increase the supply and quality of honey is determined primarily by the beehive type in which it is produced. The beekeeper plays an important role in improving the types of beehives used for better quantity and quality bee products production. The quality of the products can scarcely be improved once they have been removed from the hive, but their quality can be diminished during harvesting extraction, further processing and storage (Mutsaers*et al*., 2005). Durability can be improved by further processing but this also diminishes the quality in certain ways: the product loses its freshness and its therapeutic value is reduced. The edible products (honey, pollen, bee bread, bee milk and bee brood) all contain biologically active ingredients that can lose some of their effectiveness. Beeswax, propolis and bee venom, on the other hand, retain their original qualities much better after extraction and further processing.

Beehive construction varies from one area to the other (Olagunju, 2000). The traditional beehives were initiated in an attempt to utilize the cheap and plentiful local materials for hive construction. Modern beehives on the other hand adopt the principle of having a box-like enclosure with removable top or frames, which facilitate routing inspection of the established colonies. The increasing awareness about honey consumption viz a viz other hive products in the world have called for a concerted effort on boosting honey production and its quality (Olagunju, 2000). Moreover, beekeeping is an appropriate and well-adapted farming practice to extensive range of ecosystems of the country. To date, over 10 million of bee colonies are found in the country, which include both feral and hived ones (Ayalew, 2001).

2.8.3. Harvesting and Processing Methods

At farm household level basic processing of bee products may be traditionally managed. However such methods may not be proficient in supporting yields and quality and hence will need support from advisors. For example, in many countries when honey is capped from comb, the wax is disregarded or used for other purposes that do not have any market value. Awareness creation and training should be provided that builds on traditional skills and improves them (FAO, 2012).

Many tropical countries have successfully processed and marketed crude honeys using producers, cooperatives and small-scale processors (Crane, 1990). Processing crude honey has been also proved in improving honey quality and better utilization of resources. It is possible, even honey properly harvested from traditional and transitional hive, to process and market to produce a better quality table honey, since a traditional hive honey is a good quality as far as it is in the hive (Townsend, 1976). The inferior quality of honey comes from only mishandling of the product starting from harvesting through storage to marketing.

Yet another challenge arises when equipment is required, one option is the creation of honey collection centers where such equipment can be bought collectively and/or the formation of producer and marketing groups. However, appropriate training and an appraisal of the 'spare parts' supply chain to maintain such equipment in operation is required (FAO, 2012). As value is added to bee products, not only is training required in improved processing methods for value adding, but quality control and quality maintenance training are also required(FAO,2012).

In Ethiopia manual processing method of honey and beeswax is the most common and affordable way for small holder farmers. However, research result showed that the mechanical jack presser is 50% more efficient in recovering pure beeswax than manual method (Gemechis*et al*., 2012). Moreover, the efficiency of traditional beeswax rendering method is very low with an average yield of 3.42 kg of pure beeswax per 10 kg of crude beeswax compared to mechanical rendering method which is 6.47 kg of pure beeswax. It is also reported that there was significant difference between different sources (comb, *sefef*and crude

honey) and methods of processing (manual, submerged and solar) on the yield of beeswax, but no difference in quality (Gemechis *et al.*, 2012)

2.8.4. Packaging and Packing Materials

Packaging can be a major constraint to bee product marketing as mostly this is carried out in rural and remote areas using recycled drinking bottles and other packaging materials sourced locally. However, very often these types of packaging materials are unsuitable for wider distribution of bee products to town, city and export markets. Improved packaging materials, for example new glass jars with lids for honey, are not commonly available in many areas and their cost can be high (FAO, 2012). Yet again honey collection centers and/or producer organizations can provide the needed funds to buy packaging in bulk and hence reduce its unit costs as well as offering packaging services for its members.

2.8.5. Honeybee Diseases, Pests and Predators

Honeybees are subject to many diseases and pests like any other livestock. The major problem in many countries is that honeybee diseases and pests that do not affect *Apismellifera* are not fully understood and researched adequately. Moreover, it is also the lack of understanding on behalf of beekeepers combined with lack of regulations and enforcement that has enabled the increasingly rapid spread of pathogens during the past thirty years (FAO, 2009).

The bees and their products are vulnerable to various diseases, parasites and pests. The existences of two adult honeybee diseases namely *Nosema apis*and *Melpighamoeba mellificae* and their distribution was studied and reported (Gezahegn and Amsalu, 1991; Desalegn and Amssalu, 1999). Some major types of honeybee pests and predators, magnitude of their damage, and some possible solutions to minimize the damage they cause on bees and their products were discussed (Desalegn, 2001).Moreover, the occurrence of small hive beetle (*Aethinatumida*Murray; *Coleoptera*: *Nitidulidae*) in honeybees was assessed (Desalegn and Amssalu, 2006) and recently the effect of ant (*Dorylusfulvus*) on honeybee colony and their products in West and Southwest *Shewa* zones was examined (Desalegn, 2006). The most commonly known honeybee diseases reported to exist in Ethiopia are Nosema, Amoeba and Chalk brood diseases (Gezahegn and Amssalu, 1991; Desalegn and Amssalu, 1999; Desalegn,

2006). Furthermore, research review of different times in Ethiopia indicates that investigations of about 16 different types of pests and three microbial diseases are found in the country (Desalegn, 2015).

2.8.6. Seasonal Management

Like many other agricultural enterprises bees follow a seasonal cycle. Bees will respond to the nectar flow and that of pollen. The nectar and pollen flow are defined by weather and seasons. If there is a good flow of both nectar and pollen then the colony will increase its brood (egg lying). As colonies grow in size, the ratio of brood to adult's decreases hence enabling more adults to go out and forage and not look after brood. The essence of good management is to obtain a large adult population to coincide with the major nectar flow in an area allowing for a resulting maximum honey flow (FAO, 2012).

In tropical and sub-tropical regions there is often one major flow of nectar followed by several lesser flows. This is a challenge as it is difficult to ascertain exactly when the major nectar flow occurs. This usually occurs after the rainy season or may come after initial rains following a long dry period. A healthy colony that is increasing in population requires a queen that has a good capacity to lay eggs, availability of nectar and pollen, space in the hive as well as honey storage for the dearth period, along with a good worker bee population that can look after and feed the brood, forage and maintain temperature control(FAO, 2012). Good management of these factors in terms of enhancing and improving them are important. Labor is one of the most important management factors. Labor needs to ensure that bees have good stores of honey and pollen for the dearth period. Labor also needs to increase and reduce space in the colony when and where it is needed. Extra space is needed in the nectar flow season so more honey storage is possible as well as for more brood. In the dearth period less space is required and hence unused comb needs to be removed (FAO, 2012).

It is important that management interventions occur at the appropriate time and this requires understanding the yearly colony cycle. Management is required in all three phases of the cycle, but is most important in the dearth period (FAO, 2012).

As many tropical countries, past efforts have shown that in Ethiopia there are numerous practices of seasonal bee colonies managements was under taken to improve the performances

of local honeybee colonies. Like feeding system, supering method, swarming and migration control, pests and predator control, and also other practices are under way. However, the annual movement of honeybees is common phenomenon in Ethiopia (Gemechis*et al*., 2012)

Experienced beekeepers in Ethiopia had colony management practices like Borena (South Wello) of Amahara region move their hives once a year to an outstanding honey flow area and 2 to 3 times honey harvest is possible. For maximization of honey production and efficient utilization of resources, migratory beekeeping can be exercised in areas where honey forages provide rich honey flows in succession (Keralealem Ejigu, 2005).

2.8.7. Use of agro-chemicals (Herbicides and pesticides)

The promotion of some agricultural inputs such as pesticides and herbicides for cereal crops production as well as the use of deadly chemicals for malaria eradication program have substantially reduced honey production (Gezahegn, 2001). As a result, bee products marketing has retrogressively promoted to petty trading. The use of chemicals and pesticides for crop pests, weeds, *Tsetse* fly, mosquitoes and household pests control brings in to focus the real possibility of damaging the delicate equilibrium in the colony, as well as the contamination of hive products. Of the various kinds of chemicals only insecticides and herbicides are now major problems to the beekeepers. The chemicals used for crop protection are the main pesticides that kill the bees. Moreover, there are two other circumstances in which bees are killed on plants by chemicals. These are by insecticides applied to non-crop pests such as mosquitoes and *Tsetse* flies and by herbicides applied to plants on which the bees are foraging. Insecticides have a much more dramatic effect on population of bees, thus, the important contribution made by bees to the production of food and human nourishment is being jeopardized. On the other hand, herbicides, which are commonly not toxic to bees, destroy many plants that are valuable to bees as source of pollen and nectar. The types of chemicals used include Malathion, Sevin, DDT, 2-4 D and Acetone. As it was seen from the beekeeper point of view, poisoning of honeybees by agrochemical has been increased from time to time. Some beekeepers lost totally their colonies due to agrochemical (Kerealem *et al*., 2009).

2.9. Empirical Review studies on determinants of adoption

Introduction of new technology to smallholder farmers by itself does not guarantee for a widespread adoption and efficient use of technologies. Adoption decisions of farmers are influenced by different factors. Factors associated with economic, institutional, demographic and physical characteristics can influence farmers' decisions on adoption of agricultural innovations. For ease of grouping, the variables identified as having relationship with adoption are categorized as household personal, economic factors, institutional factors, and intervening (psychological) factors. (Wongelu, 2014).

2.9.1 Personal variables

Household's personal variables are among the most common household characteristics which are mostly associated with farmers' adoption behavior. From this category, variables like age, education and experience were reviewed in this study.

2.9.2 Age of the household head

Age is an important household characteristic influencing the adoption behavior of subsistence farmers. It is usually considered with the assumption that older farmers will have more knowledge and skill with farming which enables them to easily understand the benefits of the technology better than others. However, with regard to age different studies report different results. A study conducted by Workineh (2007) on determinants of adoption of box hive indicated that adoption of box hive decreases as the age of the beekeepers increases. A similar result confirmed that when a farmer's age increases the probability of using improved technology decreases (Bekele *et al.,* 2000; Kidane, 2001; Yitayal, 2004; Taha, 2007). A reason given by the authors for the negative relationship between age and adoption of improved technologies is an assumed longer planning horizon for younger farmers relative to older ones. In contrast, Adesina and Chianu (2000) have found that age influences positively the adoption of alley farming agro forestry technology in Nigeria. The two reasons given for this effect are: First, older farmers may have accumulated more knowledge of the benefits of fallow, from their years of experience. Secondly, older farmers may find the management of the conventional alley farming system too labor-intensive. Similar study in Ghana reported positive relationship of age with adoption (Asante- Mensah and Seepersad, 1992).

2.9.3 Education level of the household

Exposure to education is generally supposed to increase a farmer's ability to obtain, process, and use information relevant to the adoption of improved agricultural technologies. Tesfaye *et al.* (2001) revealed that education level contributed positively to adoption of improved wheat varieties and chemical fertilizer. Similarly an adoption studies found positive relationship between education and adoption of technologies (Bekele *et al*., 2000; Tesfaye and Alemu, 2001; Teferi, 2003; Workineh, 2007). Contrary to this, a study conducted by Asnake *et al.* (2005) showed that education had no significant effect on the adoption of improved chickpea varieties.

2.9.4. Beekeeping experience

Farming experience is another important household related variable that has relationship with adoption. Longer farming experience implies accumulated farming knowledge and skill, which has contribution for adoption. Many studies supported farming experience have positive and significant relation with adoption (Kidane, 2001; Endrias, 2003; Melaku, 2005; Yishak, 2005). In contrary, other studies reported negative relationship of farming experience with adoption (Gockowski and Ndoumbe, 2004; Ebrahim, 2006). However, Rahmeto (2007) reported that farming experience has no statistically significant relationship with adoption.

2.9.5. Economic variables

Economic variables influence household's adoption decision of agricultural technologies. This is due to the reason that in most cases adoption of new technology requires certain level of resource ownership. Based on this fact, livestock holding, holding were discussed in light of the previous empirical studies.

2.9.6. Livestock holding

Livestock holding is an important indicator of household's wealth position. Livestock are also an important income sources which enables farmers to invest on adoption of improved agricultural technologies. It influences the adoption of improved technologies differently by different people across different areas. In most cases, it has positive contribution to household's adoption of agricultural technologies. Many adoption studies reported positive effect of livestock holding on adoption (Degnet and Belay, 2001; Kidane, 2001; Birhanu, 2002; Techane, 2002; Endrias, 2003; Haji, 2003; Taha, 2007). Contrary to this, Wubeneh (2003) showed that livestock holding influenced negatively the farm level adoption of

improved sorghum varieties. His explanation for this reason is that livestock are generally considered a symbol of wealth and farmers with large livestock herd sizes tend to focus more on their livestock operations and pay less attention to their crop production. However, Abrhaley (2006) showed that livestock holding and oxen ownership had no significant effect on adoption of sorghum and wheat technologies.

2.9.7. Land holding

Land related variables influence farmers' adoption behavior, as land holding is an important unit where agricultural activities take place. Concerning land holding, Asnake *et al.* (2005) conducted a study on adoption of improved chickpea varieties in Ethiopia and found that farm size was positively related to the adoption of improved varieties. Many adoption studies reported positive effect of land holding on adoption (Mulugeta, 2000; Tesfaye and Alemu, 2001; Yishak, 2005 and Taha, 2007).

2.9.8. Institutional factors

Institutional factors are part of broader environment which affects farmers' adoption decision of agricultural technologies. From this category, variables such as frequency of contact with extension agents, attendance in extension events and availability of accessories were discussed in light of the previous empirical studies.

2.9.9. Frequency of contact with extension agents

Extension provides farmers with information related to agricultural technologies. Many adoption studies showed that access to extension service increases farmer's likelihood of adopting improved agricultural technologies. A study by Degnet and Belay (2001) on factors influencing the adoption of high yielding maize varieties in southwestern Ethiopia reported that, frequency of contact with extension workers positively and significantly affected farmers' adoption decision. Similar studies showed that frequency of contact with extension agent positively and significantly contributed to adoption (Kidane, 2001; Girmachew, 2005; Abrhaley, 2006; Rahmeto, 2007).

2.9.10. Attendance in extension events

Attendance in extension events like demonstration, training and participation on field days are also crucial in improving farmers' experience, building capacity and developing confidence on the advantages of improved agricultural technologies. A study by Asfaw *et al.* (1997)

revealed that participation on field days had influenced adoption of maize technologies positively and significantly. On the other hand, Tesfaye and Alemu (2001) reported that participation in on-farm demonstration and attendance of training contributed positively to farmers' adoption decision. Similar studies found that participation in extension events had positive and significant relationship with adoption (Yishak, 2005; Abrhaley, 2006; Minyahel, 2007; Rahmeto, 2007).

2.9.11. Availability of protective clothes and equipment

The availability of the new technology and all other necessary inputs to small holders at the right time and place and in the right quantity and quality should be ensured (Ehui *et al.,* 2004). Beekeeping requires protective clothes (over all suit, bee veil and glove) and equipment's like smoker to operate the hive with honey bee colony. The availability of the above materials influences the adoption of the technology. But the result of the study conducted by Workneh (2007) on determinants of adoption of box hive in Atsbi Wemberta woreda of Eastern zone, Tigray region indicated that accessories were not the barriers for using improved box hive.

2.9.12. Psychological variables

Non-adoption of new technologies can be traced back to unwilling (lacking need) or incapable (related to aspects of perception and knowledge) to adopt (Duvel, 1994). In this study need, perception and knowledge were the intervening variables.

2.9.13. Perception of beekeepers

Perception with the way the attribute of innovation is perceived and the respondent's perception of the technology attributes such as (I) awareness of relative advantages, (II) awareness or concern of disadvantages. Then the differences between the two are taken as total perceived attribute of the package. Perceived Total Attribute variable is expected to have positive relation with adoption behavior. For instance, a study by Abrhaley (2006) on farmers' perception and adoption of integrated striga management technology in Tahtay Adiabo woreda, Tigray region Ethiopia found that farmers' perception of technology attributes influence positively and significantly the adoption and extent of use of integrated striga management technologies. Similarly, Ebrahim (2006) reported that perceived total attribute of the package positively and significantly influenced the overall dairy adoption. Similar

research studies showed that farmers' perception of technology attributes have positive and significant influence of adoption of technologies of their respective studies (Enderias, 2003; Mesfin, 2005; Kebede, 2006; Taha, 2007)

2.10. Conceptual Framework for the Study

Based on the literature review, adoption of a given technology is hypothesized to be influenced by personal attributes (age, family size, perception, experience etc), environmental (bee forage, disease, pest), institutional (credit, market, extension, etc) and socio- economic (income, total number of honeybee colonies, backyard size etc.) factors. As noted by Degnet and Belay (2001) the reasons for adoption or non-adoption at farm level vary over space and time. Factors influencing adoption are neither exclusively economic nor purely non-economic. Both economic and non-economic reasons are essential motives for shaping the farmers attitude towards the new technology and its final adoption.

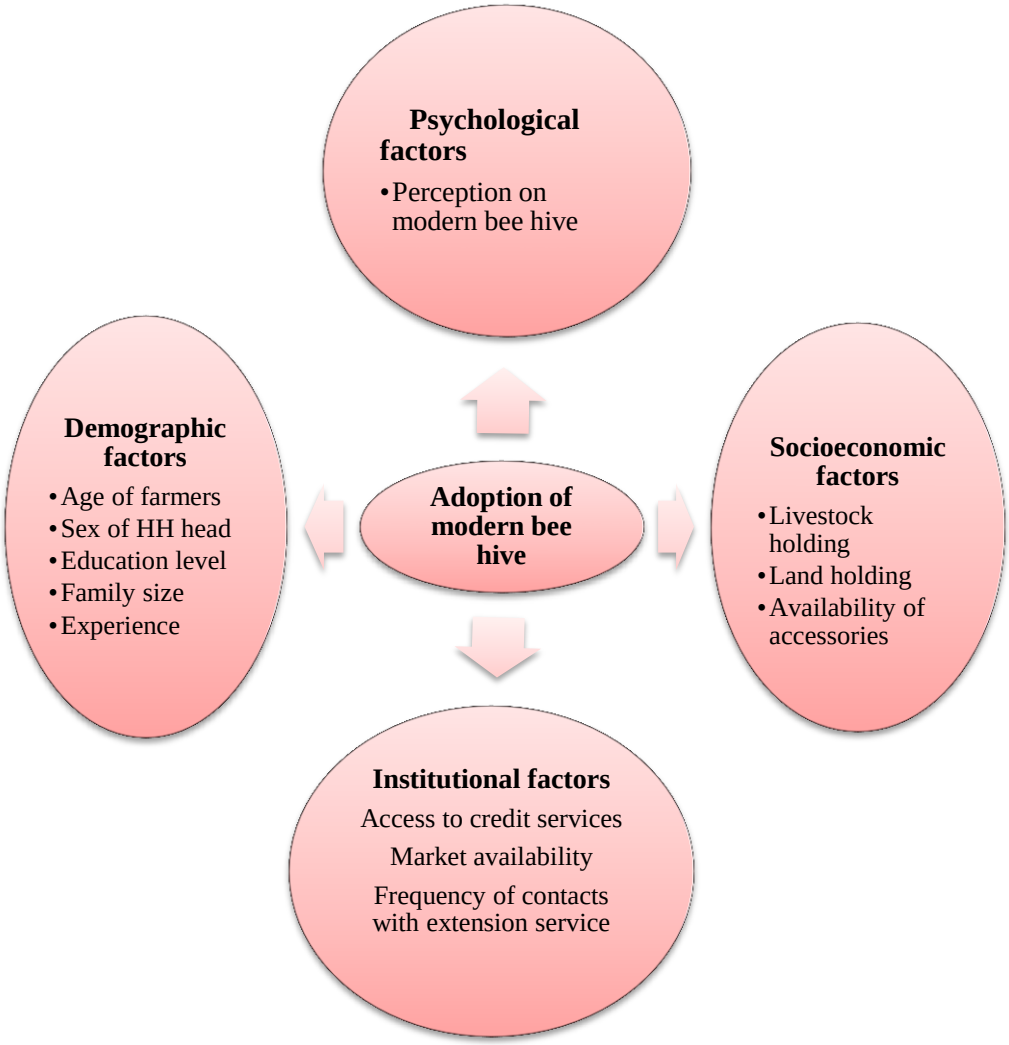

Figure1: Conceptual framework of the study

Source: Own construction from Literature

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location

Gambella peoples national regional state is located in south western Ethiopia between the geographical coordinate 6028’38’to8034’ North latitude and 330 to 350 11’’N East Longitude, which covers an area of about 34,063 km2 and about 760 km from Addis Ababa. The region is bounded to the North, North East and East by Oromia National Regional State, to the south and southeast by the southern Nations and Nationalities people’s Regional state and to the southwest, west and Northwest by the Sudan Republic.

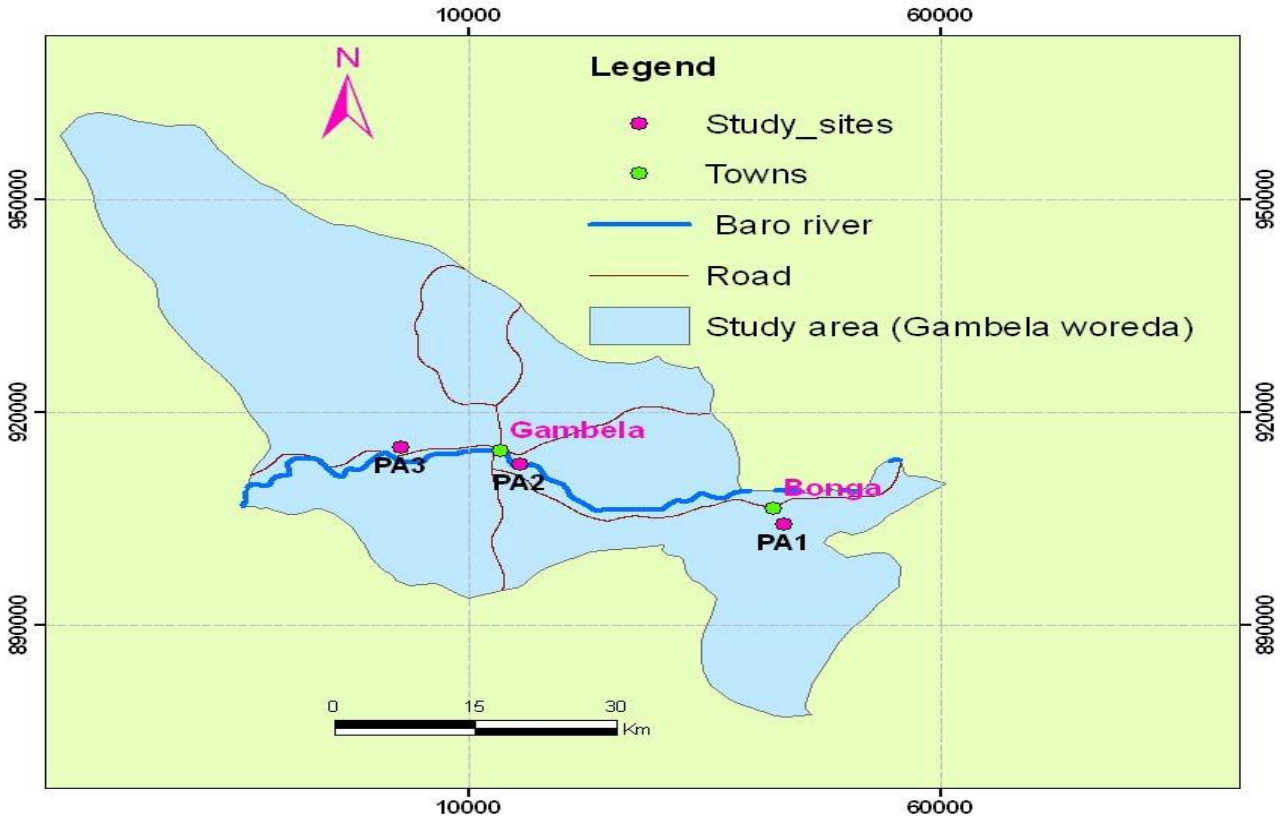

Figure 2: Map of the Study Area

Source:-Gambella People’s Regional state land use/ land allotment study (2004)

3.1.2. Demographic structure

Based on the 2007 Census conducted by the CSA, this Woreda has a total population of 10,590, of whom 5,069 are men and 5,521 women; with an area of 3,118.79 square kilometers, Gambella has a population density of 3.40, which is less than the Zone average of 4.83 persons per square kilometer. While 1,096 or 10.35% are urban inhabitants, a further 264 or 2.49% are pastoralists. A total of 2,595 households were counted in this Woreda, which results in an average of 4.1 persons to a household, and 2,528 housing units.

3.1.3. Topography

Topography is an integral part of the land surface. It influences soil formation, drainage, run off, erosion, exposure and accessibility etc. The topography of the study area is in the lower piedmont Gambella Woreda, between 500 to 1000 masl and the flood plain of below 500m contours. The plain is gently inclined westwards and prone to inundation and water logging during the wet season from June to September.(**Source: -** Gambella People's Regional state land use/ land allotment study (2004)

3.1.4. Climate and altitudes

The climate of the region comes under the influence of the tropical monsoon from the Indian Ocean, characterized with high rainfall in the wet period from May to October and a dry period from November to April. The mean annual temperature of the region varies from 17.50c to 28.3 0c and annual monthly temperature varies throughout the year from 270c to 330c. The absolute maximum temperature occurs in mid-march and is about 470c and the absolute minimum temperature occurs in December and is about 10.40c. (**Source:-** Gambella Region Land Use and Land Allotment Study, 2004).

The annual rainfall of the Region in the middle altitudes varies from 900- 1500mm, at higher attitudes; it ranges from 1,900-2000mm, at lower altitudes it varies from 900-1000mm. The annual evapo-transpiration in Gambella region reaches about 1612 mm and the maximum value occurs in March and is about 212 mm. (**Source:-**Gambella People's Regional state land use/ land allotment study (2004)

3.2. Research Design

A cross-sectional survey design was used for this study. It allows for collection of information at one point in time. The study employed multiple data collection tools and methods of analysis..

3.3.Sampling Techniques and its Determination

3.1.1 Sample size determination

There are several approaches to determine sample size. These include using a census for small populations, imitating a sample size of similar studies, using published documents, and applying formulas to calculate a sample size. This study applied a simplified formula provided by Yamane (Yamane, 1967). If sample size is too small, the objectives of analysis may not be addressed precisely.

To determine the required sample size at 92% confidence level, degree of variability = 0.8 and level of precision = 8% (0.08)

$$n = \frac{N}{1 + N(e)^2} = 130$$

Where n is the sample size, N is the population size (total household heads size), and e is the level of precision.

3.1.2. Sampling Techniques and Sample Size

Identification and definition of the study population is important prerequisite for research sampling design. Accordingly, study population for the study was all beekeepers of the study area. To obtain accurate data about a given population, it is obvious that using census study is better. But due to financial and time constraints, a complete coverage of the population is not an easy task. As consequence, sampling is preferable method that enables the researcher to study relatively small unit in the place of the population, and was obtain data that are representative of the whole population (Sarantakos, 1998).

Based upon their beekeeping potential and number of modern hive introduced, nearest geographical location and accessibility three Kebeles were selected purposely from 12 kebeles

of this district. Based on the criteria, Bonga, Kobane, Sire majang kebeles were selected. Beekeepers were stratified into farmers having modern hive (adopters) and farmers having traditional hive (non adopters). According to Storcket al. (1991), the size of the sample depends on the available fund, time and other reasons and not necessarily on the total population. A total 130 of sample sizes were randomly drown from the selected three kebeles and each kebeles had a proportional size on the sample. Sample size of adopters was 59 and sample size of non-adopters 71.

Table 2: Sample size distribution in the study area

Name of selected Kebeles	Total HH heads	Sampled HH
Bong	450	57
		47
Kobane	390	
Sire majang	210	26
Total	**1050**	**130**

Source: (Gambella Woreda, 2010)

3.1.3. Types and Sources of Data

This study employed a mix of qualitative and quantitative types of data. It was thus, maximized the use from the combination of the two methods in collecting both qualitative and quantitative data to tackle problems under the study. The quantitative data were used to gather information related to factors determining adoption of modern bee hive. In addition, qualitative data were employed to get reliable information about challenges of adoption of modern bee hive among farmers. Both primary and secondary data sources were used for the study. The primary data were collected from sampled household respondents, focus group discussion key informants interview and personal observation. Secondary data collection: The secondary data were obtained from previous research findings, journals, internets, report of MoARD at different levels, report of GOs and NGOs at different levels and other published and unpublished documents.

3.1.4. Methods of Data Collection

Data were collected using various instruments of data collection as the nature of the study demands the integration of varied forms. Therefore, for this study both qualitative and

quantitative methods were used to collect the data. In order to collect data through qualitative methods, the study employed focus group discussion, key informant interview and field observation while household survey for quantitative method .Finally primary data were supplemented with secondary data in order to confirm adequacy and reliability of information gathered.

3.1.5 Household Survey

This method was used as primary instrument to collect primary data from the selected sample households from three kebeles. To collect data, structured interview were used. This method was believed to provide data that is reliable and most important to address objective of the study. Before beginning to on the formal survey (i.e. interview) pre- testing of the interview schedule was carried out and accordingly revision was made and finalized. Three enumerators with the close supervision of the researcher were trained on the methods of data collection, interviewing technique and on the contents of the questionnaire. Finally, survey was conducted on 130 sample households and all information was obtained from the head of households.

3.1.6. Key Informant Interview

Key informant interviews used in order to understand the factors of different modern bee hive beekeepers that were directly or indirectly affect adoption of modern bee hive. Semi-structured interview was used. This is because semi-structures interview questions are flexible and can clarify the issue when ambiguity has occurred. Key informant interviews were conducted with different individuals at different levels. The investigator interviewed six individuals that have been purposively selected because of sharing their knowledge and experience about modern bee hive in the study area. The potential respondents of Key informants were three from *Woreda* office agriculture and, five development agents (DAs) working in each *kebeles*, and three *Kebeles* chair persons. A kind of an in depth interviews were undertaken, with the help of checklist.

3.1.7. Focus Group Discussion

Focus Group discussion (FGD) is representatives of communities who have good experience in modern bee hive technology, was selected to discuss specific issues related to the purpose of the study and members to share their background, opinion and experience on the issues

under study. Focus group discussion was held on in specific topics with small groups of people that consist of eight (three females and five males) farmers who have intimate knowledge about the topic under consideration. The main purpose of focus group discussion in this study was to supplement the data obtained during the main survey. The discussion was facilitated by the researcher together with the development agent. A checklist also used to guide the informal discussion conducted to generate data that cannot be collected from individual interviews.

3.1.8. Personal Observation

The observation method is the most commonly used method. It is the most important technique to collect original data that maximize the validity of our data, the information obtained under this method relates to what is currently happening. Thus, observations method used in the study particularly to look the effectiveness of adoption modern bee hive technology in the study areas.

3.1.9. Method of Data Analysis

3.1.10 Descriptive analysis

Different approaches of analyses were adopted to enable attainment of the objectives of the study using the available data. Both descriptive and econometric methods of data analysis were employed. The descriptive statistical procedures like average, percentage, frequency, mean, minimum, and maximum and other tests of significance such as chi-square test and t–test were employed using SPSS version 20 software. Mean tests of variables were made to test the significance of the difference between adopters and non-adopters. The results obtained from different categories of the respondents were interpreted accordingly.

3.1.11. Model Specification for Adoption Decision

Logit Model

Independent Linear Probability Model (LPM), Probit or logit models have been widely used to analyze factors that influence discrete behavior such as the adoption decisions (Greene, 1993; Gujarati, 2004). The linear probability model (LPM) which is expressed as a linear function of the explanatory variables is computationally simple. However, despite its computational simplicity, as indorsed by Pindyck and Rubinfeld (1981),Amemiya and Gujarati (1988), it has a serious defect in that the estimated probability values can lie outside

the normal (0-1) range. Hence logit model is advantageous over LPM in that the probabilities are bound between 0 and1.

The logit model assumes cumulative logistic probability function whereas the probit model is associated with the cumulative normal distribution (Gugarati, 2004). Although logit and Probit models yield similar parameter estimates, a cumulative logistic regression model is preferred because of easier to compute and interpret than the Probit and Tobit models (Pindyck and Rubinfeld, 1991). The logit model has less restrictive assumptions and a simpler functional form than the probit model (Gujarati &Sangetha, 2009). The character of adopters and non adopters was essentially a univarate approach where difference between the means of selected characteristics of adopters and non adopters were compared using pair wise statistical test. A binary choice model, using the logit specification, was also used to examine the adoption decision in a multivariate framework. Logit model used to identify factors affecting farmers' decision whether to adopt modern beehive or not. According to the logit model, the probability of an individual farmer adopting a modern beehive given a well defined set of a socio-economic and physical characteristic (X) is represented accordingly. Following Pindyck and Rubinfeld (1981), the cumulative logistic probability function is specified as:

$$p_i = \frac{1}{1 + e^{-z_i}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where p_i is the probability of being willing to adopt technology for the i^{the}farmers and zi $_{is}$ a function of **n** explanatory variables (x_i) and expressed as:

$$z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n X_n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where βo is the intercept and βi are the slope parameters in the model. The slope tells how the log-odds in favor of being willing to adopt modern bee hive technology as independent variables change.

Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean Pi, interpretation of the coefficient was understandable if the binary logistic model can be rewritten in terms of the odds and log of the odds, (Gujarati, 1995). The odds was defined as the ratio of the probability that a

farmer will adopt modern bee hive (Pi) to the probability of non-adopter farmers not adopt modern (1-Pi).

But

$$(1 - p_i) = \frac{1}{1 + e^{z(i)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

Therefore,

$$\left(\frac{p_i}{1 - p_i}\right) = \frac{1 + e^{z(i)}}{1 + e^{-z(i)}} = e^{z(i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4)$$

And

$$\frac{p_i}{1 - p_1} = \frac{1 + e^{z(i)}}{1 + e^{-z(i)}} = e^{\beta_0} + \sum_{i-1}^{m} \beta_i Y_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (5)$$

Taking the natural logarithms of the odds ratio of equation (5) will result in what is known as the binary Logit model as indicated below.

$$ln\left(\frac{p_{(i)}}{1 - p_{(i)}}\right) = \ln\left[e^{\beta_\circ} + \sum_{i-1}^{m} \beta_i x_i\right] = z_{(i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

If the disturbance term Ui is taken in to account the Logit model becomes:

$$z_i = \beta_\circ + \sum \beta_i x_i + u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (7)$$

3.1.12. Definition and Hypothesis of Variables (for Improved Box Bee Hive Technology Adoption)

In this study, there were dependent and independent (explanatory) variables that show the inter-link but between explanatory variables and dependent variable. To solve the problems identified, expected variables that have potential to affect beekeepers was measured or assessed on different aspects of modern beehive adoption by asking beekeepers. Both quantitative and qualitative methods of data collection in connection with all the information needed will be analyzed to answer the research questions.

The variables of the study

Adoption of modern beehive technology is the dependent variable of the study. It is represented by 1 if the beekeepers adopt the box hive and 0, otherwise.

The independent variables that influence the adoption of improved box hive technology are selected based on literatures and personal experience. It is discussed and hypothesized as follows:

1. Age of the household head: - It is a continuous variable. It has a negative influence on the extent of beekeeping implying that the older the head, the less likely that a household would practice. This arises from the fact that as the household head grows older, they become risk averse. Furthermore, older households are less energetic and therefore find it hard practicing in an activity which requires quite some energy. Labor productivity is a function of age because it is believed that old people tends to adhere strictly traditional methods of production while young people tends to be more willing to adopt new production methods in order to increase their output (Ajiao and Oladimeji, 2013).

2. Sex of household head (SEX): being female is assumed to expose to different cultural discrimination from large society and excluded from different extension services and have negative impact on adoption probability (dummy; 1 = male and 0 = female) (Bekele *et al.,* 2000; Kidane, 2001; Yitayal, 2004; Taha, 2007).

3. Education level of the household heads (EDULHH):

The mean years of schooling of bee farmers could have affected their chances of shifting from traditional beekeeping to modern beekeeping. Therefore, beekeepers would be receptive to innovations to boost bee production hence, profit level; all other factors remaining unchanged (Ajiao and Oladimeji, 2013). This is a continuous variable and it represents the level of formal schooling completed by the household during the survey time and measured in terms of number of grades attended in school. It assumed that formal schooling is expected to enhance farmer's ability to perceive, interpret and respond to new events. Furthermore, education level increases farmer's ability to get process and use information and increase farmers' willingness to adopt a new technology. Therefore, it is hypothesized that education influences adoption of improved bee hive technology package positively. Previous research results have also revealed that education would influence adoption positively (Girmachew, 2005; Dereje, 2006).

4. Beekeeping experience (BEEKEEXP): Farming experience is another important household related variable that has relationship with adoption. Longer farming experience implies accumulated farming knowledge and skill, which has contribution for adoption. Many studies supported farming experience have positive and significant relation with adoption (Kidane, 2001; Endrias, 2003; Melaku, 2005; Yishak, 2005). In contrary, other studies reported negative relationship of farming experience with adoption (Gockowski and Ndoumbe, 2004; Ebrahim, 2006). However, Rahmeto (2007) reported that farming experience has no statistically significant relationship with adoption.

5. Family size (FAMSIZE): It is a continuous variable and will be measured taking total number of household members. Farmers with large family size might significantly adopt the technology, to satisfy the need of their family (Workneh, 2007). Hence, it will be hypothesized that household with large family would adopt the technology more.

6. Livestock holding of household: (LVSHOLD): is continuous variable Livestock holding is an important indicator of household's wealth position. Livestock are also an important income sources which enables farmers to invest on adoption of improved agricultural technologies. It influences the adoption of improved technologies differently by different people across different areas. In most cases, it has positive contribution to household's adoption of agricultural technologies. Many adoption studies reported positive effect of livestock holding on adoption (Degnet and Belay, 2001; Kidane, 2001; Berhanu, 2002; Techane, 2002; Endrias, 2003; Haji, 2003; Taha, 2007). Contrary to this, Wubeneh (2003) showed that livestock holding influenced negatively the farm level adoption of improved sorghum varieties. His explanation for this reason is that livestock are generally considered a symbol of wealth and farmers with large livestock herd sizes tend to focus more on their livestock operations and pay less attention to their crop production. However, Abrhaley (2006) showed that livestock holding and oxen ownership had no significant effect on adoption of sorghum and wheat technologies.

7. Land holding (LANDHOLD): Land hold is an indicator of wealth and social status and influence within community. This means that farmers have relatively large size will be more initiated to adopt improved technologies (Mesfin, 2005). In addition, the reverse is true for

small size farmers and as a continuous variable as will be as hypothesized to have positive relationship with adoption process.

8. Frequency of contact with extension agents (FCONTEXA): Extension provides farmers with information related to agricultural technologies. Many adoption studies showed that access to extension service increases farmer's likelihood of adopting improved agricultural technologies. A study by Degnet and Belay (2001) on factors influencing the adoption of high yielding maize varieties in southwestern Ethiopia reported that, frequency of contact with extension workers positively and significantly affected farmers' adoption decision. Similar studies showed that frequency of contact with extension agent positively and significantly contributed to adoption (Kidane, 2001; Girmachew, 2005; Abrhaley, 2006; Rahmeto, 2007).

9. Apiary visit (VISTDEM): A study by Makokha *et al* (1999), confirmed that farmers characteristics such as participation in field days and demonstration enhance adoption of farm technology. Visiting apiary sites of other beekeepers or demonstration site help the beekeeper to develop his/her insight in beekeeping. It is dummy variable and was represented using 1 if the beekeepers visit apiary/demonstration site and 0, otherwise. It was hypothesized that beekeepers those who visit apiary/demonstration site adopt improved box hive more.

10. Market for the products (MKTAVAIL): Input and output markets are known to positively influence the adoption of improved agricultural technologies (Augustine and Mulugeta, 2005). It is dummy variable and was measured using 1 if the respondent has market for their product and 0, otherwise. Availability of the market for the hive products determines the decision of adopting the technology. So, it was anticipated that there is positive relationship between market and adoption of the technology.

11. Availability of accessories (**AVACC)**: The availability of the new technology and all other necessary inputs to small holders at the right time and place and in the right quantity and quality should be ensured (Ehui*et al.,* 2004). To undertake beekeeping activities, protective clothes (such as glove and bee veil) and equipment (at least smoker) are critical to operate the hive with honey bee colony, ease for operation, reduce bee sting and even manage the colony. It is dummy variable and takes value 1 if available and 0 otherwise and hypothesized as it has positive influence on the adoption of the technology.

12. Honeybee pests (PESTPRBLM): It is dummy variable and will be measured using 1 if the problems occur and 0 otherwise. The existence of honeybee disease, pests and predators strongly affect the honeybees, as the consequence, the hive products are highly affected. It is hypothesized that the adoption of beekeeping technology will be adversely affected by the existence of honeybee disease, pests and predators in the study area.

13. **Use of credit (CREDIT)**: In the literature it has been argued that the lack of credit is a constraint to adoption (Augustine and Mulugeta, 2005). So, lack of initial capital hinders the farmer from adopting the technology, particularly resource poor farmers. It is dummy variable and was measured using 1 if the respondent receives credit from credit institution when they require 0, otherwise. As receiving and utilizing credit for intended purpose, can increase the adoption of improved bee hive technology, it was expected that receiving credit and adoption of the technology has positive relationship.

14. Perception: The rate of adoption is influenced by the farmers` perception of the characteristics of the innovation (Ban and Hawkins, 1996). Perceived relative advantage of improved box hive and its relative disadvantage measured using five point scales. It was hypothesized that the total positive results of the perceived attributes (advantages and disadvantages of the technology) affects adoption positively.

Table 3: Definition of explanatory variables for analyses

No	Explanatory variables	Measurement	Expected sign
1	Age of house head	Continuous	-ve
2	Education level of the house hold head	Continuous	+ve
3	Beekeeping experience	Continuous	-ve
4	Livestock holding	Continuous	+ve
5	Land holding	Continuous	-ve
6	Family size	Continuous	+ve
7	Perception	Continuous	+ve
8	Sex of the respondents	Dummy	+ve
9	Apiary visit	Dummy	+ve
10	Access to credit	Dummy	+ve
11	Extension contact	Dummy	+ve
12	Market availability	Dummy	-ve
13	Honey bee pests	Dummy	+ve
14	Availability of accessories	Dummy	+ve

4. RESULTS AND DISCUSSIONS

This chapter, being the core of the thesis work, consists of the overall findings of the study to be presented under different sections. The first section deals with description of influence of independent variables on adoption of modern bee hive, the second is summary of results of descriptive analysis, the third is results of the econometric model and the forth is about benefit of adopting modern bee hive technology and the yield and income in the area.

5.1. Demographic Characteristics of the respondents

Table 4: Mean comparison of adopter and non- adopter by demographic socio economic factors variables (n 130)

	Adopter		Non-adopter		T value	P value
Variables	M	SD	M	SD		
Family size	7.5932	2.4134	7.000	2.19089	1.45	0.149^{NS}
Beekeeping Experience	10.10	6.5855	3.9859	3.2447	6.887	0.000***
Land holding	0.7024	0.24560	0.8624	0.50493	-2.224	0.028**
Livestock Holding	4.8588	1.00	5.7352	6.05347	-1.099	0.274^{NS}
Age of house hold head	46.2034	9.25273	49	10.56	-0.405	0.686^{NS}
Education	5.55	2.925	2.3521	1.321	8.281	0.000***
Perception	7.288	2.1739	2.5211	2.28573	12.103	0.000***

M=mean, SD= Standard Deviation, Ns=non-significant Source: Field survey, February, 2018.

In the tables above, the descriptive statistics such as frequencies, percentages, mean, and standard deviations as well as the probability levels of all explanatory variables were used to analyze and interpret the data. Inferential statistics such as t-tests for continuous, and chi-square tests ($\chi 2$) for categorical explanatory variables were used to examine data for differences, relations and interactions to answer hypotheses. The descriptive analysis result of the explanatory variables used for the study defined in (Table4.)Based on descriptive results household characters and socio-economic factors are presented as follow.

4.1.1. Age of house hold head

As shown in many empirical literatures, the role of age in explaining adoption decision of new technology is somewhat controversial. In most adoption studies older people have more

farming experience that helps them to adopt new technologies. According to Mignouna et al, 2011; Kariyasa and Dewi 2011, older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers. On the other hand, a study by Abatania (2005) and Rahmeto (2007) shows that age and adoption decision are inversely associated. As farmers age increases, the likelihood of new technology adoption tends to decline. Because of risk averting nature aged farmers is high; they need to minimize risk taking action of newly introduced technology and they become more conservative (not ready to accept the new one) than the youngest one to adopt new technology. The survey result depicts that the average age of household head for adopters and non-adopters is 46.2 and 49 years, respectively. (Table 4.)

4.1.2 Education level of the house holds

Household head farmers who can read and write are more advantageous in understanding new technology and Beekeeping practices when compared with those who cannot read and write. Literate farmers can manage and interpret production instructions themselves any time with what they had written and printed materials. Moreover, household heads that have better education level are more likely to adopt modern hive than those who are illiterate. Literate beekeepers are more ready to understand new idea and concepts provided by extension workers and other informants. Regarding the educational level of respondents mean grade of adopters and non-adopters were 5.55 and 2.35 respectively. The test for the difference between the means of households who adopt or not adopt of modern bee hive was significant at 1% level (t=8.28; p=0.000) among the different educational level of house hold head. The variation of education level was 3.6949and 0.9296respectively. (Table 4)

4.1.3 Livestock holding

In rural context, livestock holding is an important indicator of household wealth. In addition, livestock is considered to be a source of income, food and drafting power for crop cultivations. The number of livestock owned by farmers was hypothesized to be positively associated with adoption decision in most adoption literature. The average livestock in tropical units of non-adopters and adopters were 5.73and 4.85respectively. This shows the average livestock in tropical livestock unit of adopters greater than that of non-adopters and

there was no significant difference between two groups. It reveals that there is no significant difference in the wealth status of both categories measured by livestock holding.(Table 4)

4.1.4 Land holding

Land is the single most important endowment, as it is a base for any economic activity especially in rural and agricultural sector. Farm size influences household's decision to adopt or not to adopt new technologies. It is expected that more land holding and adoption decision are positively correlated, Nzomoi *et al.(*2007), Beliyu, Tewodros and Edward(2010) and Kaguongo(2010).The average land sizes of adopter and non-adopter was 0.70 and 0.8 hectare respectively. The t-test indicates that, the mean difference of farm size between adopters and non-adopters is not statistically significant. But it important to see the advantage of having the most constraints to agricultural technology adoption is, the availability of cultivable land (de Janvry *et al*, 2011; Carletto *et al*, 2007; Pingali *et al*, 1987). (Table 4)

4.1.5 Family size

In this study family size is considered as the number of individual who resides in the respondent's household. Large family size assumed to be an indicator of better labor availability in the household. Beliyu, Tewodros and Edward 2010 works, indicates that as a household size increases, adoption also expected to increases and correlate positively. The average family size of adopters and non-adopters is 7.59 and 7.0 respectively. Even if there is no statistically significant difference between adopters and non-adopters with respect to their average family size, still adopters have relatively high number of family size and they are also in better position of adoption status.(Table 4)

4.1.6 Beekeeping experience

Having cumulative knowledge of keeping bees is a prerequisite to producers' ability to obtain process and use information relevant to the practice. The higher the numbers of years spend in farming by a farmer, the more he become aware of new production techniques (Iheanocho, 2000) thereby increasing the level of his productivity. It will be assumed that experience leads to enhanced skills and better management of the enterprise which would result in higher production and productivity.

Farm experience helps the farmer to get more understanding of management practices of the farm activities. In relation to beekeeping, as indicated in (Table 4), there is statistically Significant mean difference between adopters and non-adopters. The mean year of the respondents experience in beekeeping for adopter and non-adopters is 10.1and 4.0 years, respectively. Beekeeping experience alone cannot draw the beekeeper to adopt the technology.

4.1.7 Perception of beekeepers about modern bee hive

It was found important to identify perceived relative advantage of modern bee hive and its relative disadvantage so as to get the general perception of beekeepers about modern bee hive. High yield, ease for inspection, ease of harvesting of products, quality honey is the major relative advantages of modern bee hive, which were identified by the majority of beekeepers. On the other hand, high cost, need of high skill, need of accessories, and unavailability of the technology are the main relative disadvantages of modern bee hive. The respondents were provided with both categories of relative advantages and disadvantages to rate on scale of five. The result of each category was summed up separately. The difference of the total relative advantage and disadvantage was found to be positive.

It was also found that the total attributes of perception was highly correlated with adoption of modern bee hive (Table 4). This implies that the beekeepers in the study area positively perceived about modern bee hive which is a good opportunity for beekeeping extension intervention. Similarly, statistically it is significantly different at $P<0.000$ with t-value=12.103.The result reveals that beekeepers who had positive perception of the technology adopt the technology more.

Table 5: Descriptive result of relationship between categorical variables and adopters and non-adopters of modern bee hive (n=130)

Variables		level of adoption of the respondents							
		Adopters		Non-adopters		Total			
1	**SEX**	N	%	N	%	N	%	X^2	P value
	FEMALE	11	18.6	10	14.0	21	16.2		
	MALE	48	81.3	61	85.9	109	83.8	0.495N	0.482^{NS}
2	**MKTAVAIL**								
	Yes	48	81.3	43	60.5	91	70	6.634	0.010**
	No	11	18.6	28	39.4	39	30		
3	**VISTDEMN**								
	Yes	34	59.6	38	53.5	72	55.4		
	No	25	42.3	33	46.4	58	44.6	0.220	0.639^{NS}
4	**EXTCONTA**								
	Yes	47	79.6	44	61.9	91	70	4.801	0.028**
	No	12	20.3	27	38.0	39	30		
5	**PESTPRBLM**								
	Yes	33	55.9	42	59.15	75	57.7	0.137	0.711^{NS}
	No	26	44.0	29	40.8	55	42.3		
6	**AVACC**								
	Yes	33	55.9	37	52.1	70	53.8	0.189	0.664^{NS}
	No	26	44.0	34	47.88	60	46.2		
7	**CREDIT**								
	Yes	26	44.0	43	60.56	69	53.1	7.187	0.007***
	No	33	55.9	28	39.4	61	46.9		

NS Non-significant, Source: Own survey data, 2018

Descriptive Statistics of Categorical Variables

Sex of the respondents

Sex is another factor which affects the adoption of modern bee hive. Due to the prevailing socio-cultural values and norms males have freedom of mobility, participate in different meetings and trainings. Consequently, those have more access to information to use new innovation than female-headed households, which have a capacity to influence by the cultural norms and traditions. In line with this, from the total respondents, 83.8% and 16.2% of the adopter sample farmers were male and female-headed households respectively. Therefore, sex is statistically insignificant and relationship with the adoption decision with ($\chi 2$=0.482; p=0.495) there is no significant (Table 5).This implies that, male-headed households had

capability to participate freely in different social organization to have better exposure on the production of the selected variety than their counterparts.

Market Availability

Distance from farmers' house to product market was positively related to the adoption of modern hive technology. The probability adoption of technology was significantly affected by market distance at 5 percent significance level (Table 5). The market gain of honey sale is positively increased as farmers were sale their product at reasonable market price if they are travel far away from their local market. Beekeepers can sale their honey bee product at home to locale traders at low price which is inconvenience to motivate them for farther honey production and farmers always travel to search the right price and place even if it has travel cost. These all honey producers are most likely motivated by big cities honey price to adopt new bee technology. But the finding is inconsistent with finding was identified by (Hailu, 2008), as market distance increases adoption and intensity of adoption decreased.

4.1.8. Apiary visit

The other means through which beekeepers get beekeeping information is through participating in extension event like apiary visit arranged by different institutions. A farmer who had chance to visit apiary will have enough information about the new technology and a result would be more likely to adopt new innovation than others. Based on the finding of this study, With respect to apiary visit site in(Table 5) 59.6 percent of adopters and 53.5 percent of non-adopters visit apiary site and 42.3 percent of adopters and 46.6 percent of non-adopters indicated that they do not visit the apiary site. The result reveals that majority of adopters visit the apiary site compared with non-adopters. But, there is no significant difference between two groups of the respondents. This showed that the beekeepers that got an opportunity of visiting the apiary adopt more the technology this is due to the reason that technology demonstration has strong influence on modern bee hive adoption.

4.1.9. Access to Extension Contact:

Extension is as major sources of agricultural information for adoption process is seen as the main important service to farmers. The adoption of agricultural technologies primarily depends on access to information and on the willingness and ability of farmers to use information provided by extension agents. Information helps decision-making process is to

reduce risk and uncertainty and enable farm households to made right choices from available technologies. Out of the total sample households79.6 percent of adopters they had got extension service; whereas the remaining 61.9 percent had not got extension service. As indicated (Table 5), 20.3 and 38.percent of adopter and non-adopter had access to extension service respectively. This implies that majority of the adopters had access to extension service which enable them to have more information about new technologies. The result shows there was significant difference between adopters and non-adopters groups at 5 percent significance level.

4.1.10. Honeybee pest problems

Honeybees are exposed to a broad range of various environmental stressors, which can be having an impact to apiculture. Most beekeepers distinguished the problem of their bee colonies and the time at which this problem occurred. According to the respond of beekeepers, birds, ants, spiders, wax moth, mice, lizards, small hive beetles and honey badger were identified as the major honeybee pests and predators. The existences of honeybee pests can create obstacle for adopting improved box hives as they attack honeybees and hive products. The study shows 57.7 percent of the respondents replied that the honey bee attacked by pest and 42.3 percent of the respondents said honey bee not attacked by pests. The 55.9 percent of non-adopters and 59.15 of adopters indicated honey bee attacked by pest. The 40.8 percent of adopters and 44 percent of non- adopters said honey bee not attacked by pest. This implies that majority of respondents indicated honey bee not attacked by pest. There was no significant difference between experience and level of adoption. The study reveals majority of honey bee adopters attacked by honey bee pest. The chi-square test did not show significant difference between adopters and non-adopter groups. (Table 5)

4.1.11. Credit

Feder *et al.* (1985) observed that credit programs enable farmers to purchase inputs or acquire physical capital needed for technology adoption. Credit may be essential to acquire farm technologies like modern beekeeping which the farmers perceive to be a costly activity to engage in (Workneh, 2007). In other words, the availability of credit facilitates technology adoption. It is more essential for farm technologies like beekeeping, which the farmers perceive the technology to be costly to engage in the activity. In the study area,(.The table5) indicates that 53.1 percent of respondents obtained credit and remaining 46.9% of respondents

not obtained the credit. The 60.56% of non-adopters and 44% of adopters obtained credit services. The 55.9% of adopters and 39.4 % of non-adopters not obtained credit. This implies that majority of adopters constrained of credit services. This shows significant difference between adopters and non-adopters at 1 percent significance level.

4.1.12. Availability of accessories

Beekeeping requires protective clothes and equipment's such as veil for protecting the face of the person from honeybees, glove for protecting the hand of the person from the honeybees, and smoker for cooling down the honeybees. This equipment's are required for effective management of beekeeping and reduce sting of honeybees. The 53.8% of the respondents have availability of accessories (Smokers, Veil and Glove) and 46.2 percent of the respondents no have availability of the accessories. (Smokers, Veil and Glove)The 52.1% of non-adopters and 55.9% of non-adopters of got training. This implies that majority of adopters have no accessories. There was no significant difference between accessories and level of adoption.(Table 5)

4.1.13 Factors for Adoption of Modern bee hive

Estimates of the variables expected to determine the adoption of modern bee hive technology are displayed in Table 6. A total of 14 explanatory variables were included into the econometric model out of which six variables were found to significantly influence adoption of modern bee hive. These are education level of household head, beekeeping experience, extension contact, apiary visit, perception, and credit. Age, sex, family size, land holding, livestock holding, market availability, honey bee pests, and availability of accessories were insignificant.

Table 6.Binary Logistic regression for factors influencing improved box bee hive adoption

Variables	B	S.E.	Wald	Sig.	Odd ratio
SEXHHH	-0.300	1.311	0.052	0.819	0.741
AGEHHH	-0.034	0.057	0.366	0.545	0.966
EDUCLV	0.808	0.310	6.811	009***	2.244
BKEXP	1.425	0.797	3.194	0.074*	4.156
FAMSIZE	0.088	0.111	0.621	0.431	1.092
LANDHOLD	-1.060	2.192	0.234	0.629	0.347
LVSHOLD	-0.179	0.492	0.132	0.716	0.836
EXTCONTA	2.742	1.315	4.351	0.037**	15.522
MARKTAVALB	1.791	1.310	1.870	0.172	5.996
APAIRVIST	2.154	1.238	3.027	0.082*	8.622
HONYBEPEST	-0.727	1.115	0.425	0.514	0.483
PERCEPTION	0.771	0.260	8.810	0.003***	2.163
USEOFCREDIT	2.922	1.279	5.217	0.022**	18.570
AVAOFACCES	0.704	1.208	0.339	0.560	2.021
Constant	-11.322	5.190	4.759	0.029	.000

Chi-square 143.20 Sources: Model output, 2018

-2 Log likelihood 35.907

Percentage Correct 96.2

***, **and* represents 1%, 5% and10% level of significance, respectively.

Explanation of significant variables.

The explanatory variables that were significantly influencing adoption of modern bee hive are discussed as follows;

1. Household head education level: Educational level of the household head is important to note as determinant of adoption to beekeeping technologies. The possible reasons for more adoption of modern hives by beekeepers with higher educational backgrounds could be that education may increases access to information and their knowledge to understand the technology. Beekeepers, who can read and write, can have simple and diversified communication ways to extension services. As the logit estimation result indicates (Table 6), education status of house hold head is positive and significantly correlated with adoption at 1% level of significance. The odds in favor of adopting modern bee hive increase by a factor of 2.24for beekeepers that had more education level. The result is also supported by earlier studies (Workneh et. al., 2007)

2. Beekeeping experience: Farm experience helps the farmer to get more understanding of management practices of the farm activities. As the Logit model result indicates, this variable had positive and significant influence on the adoption of modern bee hive technology at10% significant level. The odds in favor of adopting modern bee hive increased by a factor of 4.156 for beekeepers who had as increase by one year beekeeping experience. The possible reason might be more experienced beekeepers will be in a position to experience much with their traditional beekeeping and are expected to be less responsive to newly introduced beekeeping technologies. Small experienced beekeepers are younger beekeepers and they are more knowledgeable and are likely to bear risk due to longer planning horizon. This finding is in agreement with findings of Girmachew (2005) and Almaz (2008)**(**Table 6)

3. Frequency of contact with extension agent: Access to extension service has positive influence on the probability of modern hive adoption at 5 % significance level. The result shows odds ratio of 15.522 for frequency of contact with extension agent implies that an increase in contact with extension agent by one time, increases the odds ratio in favor of adopting modern beehive by a factor of 15.522 (Table 6). From this result it is possible to state that those household who have access to extension service like training and

demonstration are more likely to adopt modern hive than those who have not. In addition to offering information and creating awareness, extension service also includes advices, training, demonstrations and timely distribution of inputs. Farmers who are frequently visited by extension agents tend to be more progressive and more likely to experiment with modern hive technology. The result is consistent with Shiferaw et al.(2008) for improved pigeon pea varieties in Tanzania, Kristjanson et al. (2005) for cowpea varieties, Kaliba et al.(2000) for maize varieties and Gebreselassie and Sanders (2008) for sorghum in Ethiopia. Similarly, this finding is also match with the finding of Rahimeto (2007), Beliyu, Tewodros and Edward (2010).

4. Apiary visit- Apiary is the place where the honeybee colonies are kept. In this context, the apiaries are in the bee farms of model farmers. Visiting the apiary helps the beekeeper to learn more about the technology. It also motivates the beekeepers towards adopting the technology. It is statistically significant at10% level. The odds in favor of adopting modern bee hive increased by a factor of 8.622 for beekeepers who had an opportunity of visiting apiary. This shows that the beekeepers who got an opportunity of visiting the apiary more adopt the technology. During visit, farmers can clearly understand the advantage of improved box hive from their colleagues. Beekeepers more believe each other than outsiders. Hence, apiary visit is an appropriate means of introducing improved beekeeping technology. The result coincides with Melaku (2005), who explains that there is significant association between adoption and apiary visit by farmers.(Table 6)

5. Perception – Positive perception of beekeepers about the technology increases adoption decision and it influences adoption of modern bee hive positively and significantly at 1%.The odds in favor of adopting modern bee hive increased by a factor of 2.163 for beekeepers who positively perceived the technology. The result reveals that beekeepers who had positive perception of the technology adopt the technology more. (Table 6) The finding is supported by Shiferaw and Holden (1998) who found that perception influences adoption positively. The result is also in agreement with study of Tadesse and Belay (2004) on factors influencing adoption of soil conservation measures in south Ethiopia, Gununo area that explains perception of soil conservation problem influenced positively and adoption of soil conservation technology.

6. Credit – In the study area, modern bee hive was perceived as costly by the beekeepers. Under such circumstances, credit plays a significant role in enhancing the technology promotion. As anticipated, credit affects positively and significantly at 5%, the odds in favor of adopting modern bee hive increased by a factor of 18.570 for beekeepers who had received credit. The result reveals that the availability of credit and receiving enhances beekeepers adoption decision on modern bee hive. The result is supported by Lelisa (1998) who studied determinants of fertilizer adoption, intensity and probability of its use that revealed access to credit is one determinant of fertilizer adoption and intensity of its use. Doss et al. (2003), Feder et al. (1985), and Cramb (2003) also reached the same conclusion that credit correlated with the use of modern inputs. (Table 6)

In the study area 45.4 % of the respondents practiced the modern production and54.6 % practiced traditional system in the study area.

Table 7

Production(Bee hive)	N	%
Traditional bee hive	71 (Non- Adopter)	54.6
Modern bee hive	59 (adopters	45.4
Total	130	100

Source*:* own survey data, 2010

Table: 8 shows the average yield from traditional bee hive and improved box bee hive were 23.3692 and 43.7769 kg respectively. The minimum and maximum yield of the traditional beehive were 18 and 28 kg crude honey respectively, whereas the minimum and maximum of the modern where 35 and 50 kg respectively. The average amount of yield from income from traditional was 3565 birr in year and its minimum and maximum were 2700 and 6000 respectively and also; the average amount of income from modern was 6984 birr in year and its minimum and maximum were 3750 and 6300 respectively.

Table: 8 The yield and income in the study area

Production(Bee hive)	N	Minimum	Maximum	Mean	SD
Yield from traditional	130	18.00	28.00	23.3692	2.48761
Yield from modern beehive	130	35.00	50.00	43.7769	2.64213
Income from traditional beehive in year	130	2700.00	6000.00	3565.000	524.42844
Income from improve box hive per year	130	3750.00	63000.00	6984.000	4972.68
Valid N (list wise)	130				

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. SUMMARY

Gambella Zuria district is grouped under high areas potential for beekeeping. The district is covered with natural vegetations, shrubs and man-made forest, annual and perennial crops. Moreover, it has adequate water resources and large bee colonies which create conducive environment for beekeeping.

The objectives of the study were to identify factors affecting adoption of modern bee hive and to analyze benefits of adopting modern bee hive technology. Stratified sampling method has been used to identify the required sample. Accordingly, the respondents were divided into adopter and non-adopter households. Based upon their proportionality to size 59adopters and 71 non-adopters were taken for the study through systematic sampling method. Quantitative and qualitative data were collected using personal interviews, observations, focus group discussions, key informant interviews etc.

The findings indicated that lack of extension services with respect to beekeeping is also one of the major factors affecting beekeeping in the study area. Moreover, the local beekeepers due to lack of trainings by the concerned bodies how to process and produce beeswax they are not processing and producing beeswax.

The district agriculture and rural development office in general and development agents in particular focus on crops. Development Agents do not provide them the required trainings with respect to improved beekeeping method. Furthermore, expensiveness of improved hives and accessories and lack of credit facilities also among the main reasons contributed to traditional beekeepers to be remaining in traditional beekeeping method.

Among the market constraints lack of producers' organizations and lack of involvement of traders that collect beekeeping products and provide inputs to the beekeepers, and lack of roads and transportation services are the major market constraints that beekeepers are facing in the study area.

5.2. Conclusions

Education level of house hold head and practical knowledge of the technology were found to be positively and significantly influencing adoption decision of modern bee hive. The educated beekeepers can easily understand the basic management practices of beekeeping and they also know the advantage that is obtained from modern beekeeping by comparing with traditional beekeeping.

Apiary visit was found to be significantly influencing adoption of modern bee hive. The beekeeping extension, NGOs and Private Sectors should emphasize on organizing apiary visits of FTCs', private sector' and beekeepers'. This requires allotting of development agents who are competent and knowledgeable in beekeeping so as to positively influence the promotion of improved beekeeping materials. It is also an urgent need to offer in-service training on improved beekeeping practices to DAs which, in turn, help them to develop practical knowledge of the technology. The other means of popularizing the technology is also important to be used, for instance, field days to be organized on the farmers' field to increase the awareness level of the beekeepers along with practical knowledge of improved beekeeping practices. This, in turn, helps the beekeepers to develop positive perception of the technology.

According to beekeepers' perceptions, even though adoption of modern bee hive has relative benefits over traditional beehive, still it is constrained by expensive and lack of inputs technology and skilled manpower requirement and low honey market demand compared to traditional beehive. Therefore, great effort should be made in supplying improved inputs on the basis of farmers' purchasing power and develop capacity of beekeepers regarding modern bee hive improvement.

Frequent follow-up by the extension agents should be given to reach the technology to every beekeeper and to increase the number of modern bee hive by adopters. This implies, for an effective information communication, the relationship between farmers and extension agents must be improved, encourage farmers to participate in different extension programs regarding apiculture improvement.

Credit service must be offered to adopters in order to intensify the technology and counsel the development of rural micro-finance to promote not only to provide credit at reasonable terms of repayment and interest rate but also savings.

5.3. Recommendations

Based on the findings of the study, the following recommendations are suggested to be considered by Governmental and Non-governmental Organizations in their future intervention strategies aimed at providing apiculture supportive services and introduction of improved bee hive technology to improve honey production in the study area in particular and other areas with similar settings.

To increase the production, productivity and its economic contributions to the livelihoods of honey producers in the study area farmers should be given adequate training on rudiments of traditional bee farming using community based/informal education. More over it requires intervening to change the very old traditional beekeeping practices through adopting improved technologies and management practices, practical skill trainings, promoting beekeepers important indigenous knowledge and expansion of backyard beekeeping practice. Thus, beekeepers are therefore, aware of their potentiality capable of increasing not only the profitability of the bee enterprise but also make efficient use of bee farming resources.

From group discussion held with beekeepers, in the study area, beekeeping is predominantly practiced by and defined as a men's occupation. The district agricultural office and other NGOs who want to develop beekeeping in the study area should encourage women to participate in beekeeping and support them through provision of training, credit services and modern beekeeping technologies.

More attention must be given to less traditionally experienced beekeepers for rapid decision to adopt modern bee hive and great effort should be made by the concerned bodies to traditionally experienced beekeepers to utilize new ideas which helps them in adoption decision.

It has been found that absconding, migration and swarming were major problems of beekeeping in the study areas so to minimize the problems appropriate management practices should be practiced. These include improving pre and post harvest handling of colonies, beekeepers of the area should be aware on the possibilities of maintaining their colonies for successive harvesting, regular supervision and monitoring of the colonies.

Rendering of intensive training for beekeeper farmers that cover the overall aspect of beekeeping with practical exercise is essential to maximize the honey production. All Development Agents who would be involved in beekeeping must have the training first to enable them adequately provide technical assistance to the beneficiaries.

Emphasis should be given to the WARDO on bee product diversification. Wax produced in the area is either discarded as well or put in to domestic use. Therefore, creating awareness on the value of beeswax and other hive products and processing and marketing mechanism should be design to ensure the right benefit from the activity.

Government and Non government bodies should endeavor to stimulate farmers to boost honey production by providing and subsidize if need be necessary supports and enabling environment which provide impetus that will ease farmers' transition from traditional to improved beekeeping easy.

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7. APPENDIX

Instruction

1. Understand clearly all the questions before stating the interview
2. Introduce yourself to the respondents and make them clear about the objective of theinterview
3. Be patient during the interview and express yourself in understandable way to therespondents.
4. Reliable information leads to right generalization. Hence, please write the beekeepersown response properly for each question.

Date of interview_____

Peasant association_____

Code_____

.Part One: General Information

1.1 Kebele Administration _____

1. 2 Category: 1. Adopter 2. None Adaptor

1. 3 Date of interview _____

1.4 Name of the enumerator_____ Signature _____

1. Personal Information

2.1. Name of household head _____

2.2. Sex _____ Age_____

2.3. Marital status 1. Single 2.Married 3.Divorced 4.Widow 5. Widower

2.4. Educational level of head of the household

1. Illiterate 2. Can read and write 3. Primary education (1-4)

4. Junior (5-8) 5. Secondary education (9-10) 6. Other (specify)_____

2.5 Religion of the household

1. Orthodox 2. Muslim 3.Catholic 4.Protestant 5. Other (specify)__

2.6 Total family size (husband, wife, children etc) _____

2. Landholding

3.1 Do you own farm land. 1. Yes 2. No

3.2. If yes, what is your farmland? Owned .., rented in…, shared in… (specify measurement)

3.3 If no source for farm land (specify) _____

Rented in_____ Shared in_____

3. Livestock holding

3.3 Do you own livestock? 1. Yes 2.No

3.4 If yes, how many do you own currently, 2009 and 2010 E.C.? (Fill in table)

1. Oxen	6. Goats	11.Mule
2.Cows	7. Goats young	12.Donkey
3.Young	8.Sheep	13.Donkey young
4. Calves	9.Sheep young	14.Poultary
5.Heifers	10.Horse	

Part Two: Beekeeping Practices/Experience

A. Honeybee ownership

1. Do you keep honeybees? 1. Yes 2. No

- ✓ If yes, when did you start beekeeping? _____ year (s).

2. How you start beekeeping?

1. By catching the swarm 2. By purchasing the honeybee colony

3. Through inheritance 4. 1 & 2 5.1, 2 &3 6. Any other (specify)

3. How many honeybee colonies you owned? _____

- ✓ Number of modern hive ----------
- ✓ Number of traditional hive ----------

4. Where did you keep your bee colonies?

1. Hanging on trees near homestead 2. Hanging on trees in forest

3. 1& 2 4. Backyard 5. Under the eaves of the house 6. Inside the house

5. For how many years your colony remains or stays in the hive?

- ✓ Minimum _____year (s) Maximum _____years

6. Do you have empty beehives? 1. Yes _____ 2. No_____

- ✓ If yes, the number of empty hives you have._____

7. What is the trend of your colony number and honey yield?

- ✓ 1. Increasing 2. Stable 3. Decreasing 4. No harvest

□□If there is an increase in trend in number of bee colonies and honey yield over the years, what are the causes?_____

- ✓ If there is a decrease in trend in the number of bee colonies and honey yields over the year, what are the causes in order of importance? Give Rank 1 to most important and 7 to the least important causes.

_____

No Causes **Rank in order of importance**

_____

1 Lack of bee forage

2 Migration

3 Absconding

4 Pests and predators

5 Diseases

6 Decrease in price of honey/marketing problem

7 Deforestation

_____

8. What are the sources of the beehives you used?

1. Constructed by himself/herself 2. Constructed locally and bought

3. Supplied by governments free of charge

4. Supplied by NGOs free of charge 5. Bought from market

9. What are the major advantages of your beehives? Rate the level of advantage.
1=very poor 2= poor 3= Good 4= Very good

10. What are the major limitations of your beehives?

1. _____

2. _____

3. _____

B. Colony Characteristics and Management

1. What are the local names and their respective color for your bees ----------?

2. Do you visit and inspect your beehives and colonies? 1. Yes____2. No_____

3. If yes, which type of inspection you perform?

1. External hive inspection 2. Internal hive inspection

5. Frequency of inspection

✓ External hive inspection: (circle one or more)

1. Frequently 2. Sometimes 3. Rarely

Internal hive inspection: (circle one or more)

1. Frequently 2.Sometimes 3. Rarely

C. Absconding

1. Is there absconding problem in your apiary? 1. Yes 2. No

✓ If yes, how many colonies had absconded?_____

2. What was the reason do you think for absconding?

1. Due to pests and predators of honey bees 2. Due to shortage of feed

3. Due to honey bee diseases 4. Due to bad weather 5. Others (specify)

3. What measures do you undertake to prevent absconding?

_____

_____

_____

4. at which seasons of the year do absconding occurs frequently?

1. March to May 2. June to august

3. September to November 4. December to February

5. How do you get extra honeybee colonies for the absconded colony?

1. By caching the swarm 2. By purchasing 3. Multiplying the existing colony

4. from family 5. Any other (specify)_____

D. Swarming

1. Does swarming occur in your colonies or locality? 1. Yes 2.No

- ✓ If your response is yes, what is the frequency?

1. Every season 2. Every year

3. Every end of flowering 4. Once in two years

2. When does swarming occur more frequently? (Months).

1. March to may 2. June to august

3. September to November 4. December to February

3. Describe the advantages of swarming?

1. To increase my number of colony 2. To sale and get income

3. To replace non-productive bee colonies 4.Others specify: _____

4. Do you control/ prevent swarming? 1. Yes 2.No

5. What methods do you use to control / prevent swarming?

_____

_____

6. Do you have swarms catching experience and use swarm attractant materials?

1. Ye 2. No

- ✓ If yes, describe what types of attractants and methods of application you use?

_____

_____

_____

7. How many swarms do you catch in this production year? _____

E. Honey harvesting

1. What kind of beehive products you produce?

1. Honey 2. Crude Beeswax 3.Honey & beeswax 4. Others, specify

2. List the amount of your beehive products kg/hive and frequency of harvest per annual?

- ✓ Honey kg/hive _____ frequency _____
- ✓ Crude beeswax kg/hive _____ frequency _____

3. When is the peak honey production period?

1. December to January 2. January to march 3. May to June

4. How do you identify exact honey harvesting time?

1. by observing the honeybee symptom 2. By the end of flowering period
3. by smelling of the honey 4. By cluster of the honeybees around the entrance
5. by internal inspection of the hive 6. By external inspection of the hive

5. While harvesting does you remove all honeycombs? 1. Yes 2. No

6. Do you harvest all brood combs? 1. Yes 2. No

7. While harvesting does your bee colony evacuate? 1. Yes 2. No

8. List the home use of honey.

1. As a food 2. As a medicine 3. For beverages
4. For cultural and ritual ceremonies 5. Others (specify):_____

9. If you collect crude beeswax list the sources.

1. Empty honeycomb during harvesting 2. Discarded, old and broken combs
3. From colony absconding hives 4. After home utilization of honey
5. Uncapping and spout beeswax 6. Others, specify _____

10. Why you are collecting crude beeswax?

1. For income generation 2. Candle making
3. Foundation sheet making 4. Religious and cultural use
5. Others, specify:_____

- ✓ If you don't collect/produce beeswax what is (are) the reason (s)?

1. Lack of knowledge 2. Lack of processing skills 3. Lack of processing materials
4. Lack of awareness about the importance 5. Lack of market

III. Institutional, organizational and support conditions

A. Extension services

1. Have you ever been received extension service on beekeeping activity? 1. Yes 2. No

2. How many times per year did you receive extension advice on beekeeping in previous year?

   1. Once 2. Twice 3. Three times 4. If more (specify) ____

3. Have you ever visited beekeeping demonstration site? 1. Yes 2. No

   ✓ If yes, where did you visit?

1. Neighbor apiary site 2. ARD demonstration site

3. Research centre 4. NGO demonstration site 5. Any other (specify)_____

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

   ✓ If yes, from where did you got the training

1. Research centre 2. ARD 3. NGO 4. Any other (specify)____

   ✓ If yes, on what area did you get training?

   1. Colony multiplication 2. Bee management

   3. Hive products 4. Marketing

□□How many times did you get beekeeping training? _____ Times.

5. Do you make experience sharing with beekeepers? 1. Yes 2. No

   ✓ If yes, on what occasion do you undertake?

1. during formal PA meeting 2. During beekeeping training

3. during `idir` meeting 4. Any other_____

6. Is there any organization working on beekeeping activities in your PA? 1. Yes 2. No

   ✓ If yes, which organizations are working on beekeeping? _____

7. Is there beekeeping cooperatives or associations in your area? 1. Yes 2. No

   ✓ If yes, are you a member of it? 1. Yes 2. No

8. Have you been supported by any of the organizations to undertake beekeeping activities?

   ✓ 1. Yes 2. No

   ✓ If yes, specify the supports you have got so far. _____

B. Credit Sources and Availability

1. Do you ever-obtained credit for your farming operations? 1. Yes 2. No
   - ✓ If yes, for what purposes you get credit?

_____

_____

2. Who are / were your sources of credits? (Circle one or more).
   1. Micro finance institutions (name it): _____
   2. Service cooperatives 5. Relatives
   3. Ministry of Agriculture 6. Individual lenders
   4. NGO 7. Others, specify: _____
3. Do you receive credits for your farming activities during this cropping season?
   1. Yes 2. No
   :If yes, for what activities you are using the credit? ----------

   _____

4. What are the major problems you face to get input on credit?
   1. Inaccessibility of credit agents 2. Unavailability of credit
   3. Debit collection problem 4. High interest rate 5. Others, specify: _____

C. Marketing Condition

1. Was there ready market for your colony products? 1. Yes 2.No
   - ✓ If your answer is yes, where did you sell your honey?

1. At market found in nearby town 2. At farm gat 3. 'Tej' house
   4. Farmer to farmer 5. Cooperative 6. Any other (specify) ------
2. Who are your customers?
   1. 'Tej' houses 2. Middlemen
   3. Retailers 4. Wholesalers 5. Consumers
3. Was the market absorbed all the quantity you produced to sell? 1. Yes 2. No
4. For how far do you have to walk from your home to sell your products? ____ Kms
5. Did you have or get market information for your products? 1. Yes 2. No

- ✓ If your answer is where did you get or who provided the information?

1. from farmers 2. From extension agents 3.through themselves 4. Others, specify

6. What is the average price of hive products?

- ✓ Average price of honey/kg _____birr Average price of beeswax/kg _____birr
- ✓ Average price of one hive _____ birr Average price of one colony ____ birr

8. What is the annual income from sale of hive products?

No	Type of produce	quantity	Unit price (birr)	Total price (birr)
1	Honey			
2	Crude beeswax			
3	Beehives			
4	Bee colonies			

9. What are the factors that govern the price of the honey in your locality?

1. Seasons of the year 2. Colors and taste of the honey
3. Distance from market 4. Others

10. How do you evaluate the local market price? 1. High 2. Medium 3. Low

11. How is the price trend of honey in your locality?

1. Increasing 2. Stable 3.Decreasing 4. Unknown

.IV. Constraints

What are the major factors of beekeeping in the area?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Compiler name _____ signature _____

Date _____ starting time _____ ending time _____