DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN ATSBI WEMBERTA DISTRICT OF EASTERN ZONE, TIGRAY REGION

M.Sc. Thesis

Workneh Abebe

June, 2007

Haramaya University

DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN ATSBI WEMBERTA DISTRICT OF EASTERN ZONE, TIGRAY REGION

A Thesis Submitted to the Department of

Rural Development and Agricultural Extension, School of Graduate Studies

HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

(RURAL DEVELOPMENT AND AGRICULTURAL EXTENSION)

By

WORKNEH ABEBE

June, 2007

Haramaya University

School of Graduate Studies

Haramaya University

As *Thesis* Research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance, by Workneh Abebe, entitled Determinants of adoption of improved box hive in Atsbi Wemberta district of Eastern zone, Tigray region
I recommend that it be submitted as fulfilling the *Thesis* requirement.

Dr. Ranjan S. Karippai	_____	_____
Major Advisor	Signature	Date
Dr. Ranjitha Puskur	_____	_____
Co-advisor	Signature	Date

As member of the *Board of Examiners* of the *M.Sc Thesis Open Defense Examination*, We certify that we have read, evaluated the Thesis prepared by Workneh Abebe and examined the candidate. We recommended that the Thesis be accepted as fulfilling the *Thesis* requirement for the Degree of *Master of Science* in Agriculture (Rural Development and Agricultural Extension).

_____	_____	
Chairperson	Signature	Date
_____	_____	
Internal Examiner	Signature	Date
_____	_____	
External Examiner	Signature	Date

DEDICATION

This thesis is dedicated to my wife, Wosene Tilaye and our children Galetom and Kena

STATEMENT OF THE AUTHOR

I hereby declare that this thesis is my bona fide work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc degree at Haramaya University and is deposited at the University Library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the Department of Rural Development and Agricultural Extension, the Dean of the School of Graduate Studies, Haramaya University, when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Workneh Abebe Wodajo
Place: Haramaya University, Haramaya
Date of Submission: June, 2007
Signature----------

LIST OF ABBREVIATIONS

ARD	Agricultural and Rural Development
KTBH	Kenya Top Bar Hive
DAs	Development Agents
DCSI	Dedebit Credit and Saving Institution
EBA	Ethiopian Beekeepers Association
EMA	Ethiopian Mapping Agency
ESAP	Ethiopian Society of Animal Production
FAO	Food and Agricultural Organization
FTC	Farmer Training Center
HBRC	Holeta Bee Research Center
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
IPMS	Improving Productivity Market Success
ITK	Indigenous Technical Knowledge
NGOs	Non Governmental Organizations
OARI	Oromiya Agricultural Research Institute
PAs	Peasants' Associations
SPSS	Statistical Package for Social Sciences
TTBH	Tanzania Top Bar Hive

BIOGRAPHICAL SKETCH

The author was born from his father Abebe Wodajo Jula and his mother Jije Wodajo Jeba in Jimma Arjo district, East Wollega Zone of Oromiya, in September 1973. He attended his primary and secondary school education at Mekonen Demisew (Jima Arjo District) and completed his secondary school at Nekemte comprehensive secondary school (Nekemt) in 1993. After successful completion of Ethiopian School Leaving Certificate Examination, he joined Ambo College the then Ambo college of Agriculture, in 1993 and graduated with Diploma in General Agriculture in July 1995. Owing to his successful academic achievement, he was recruited as a technical assistant in the same college. After two years service, he joined Haramaya University the then Alemaya University, in September 1997 and graduated with BSc degree in Agricultural Extension in July 2000. After his graduation he was employed at Oromiya Agricultural Research Institute, Holeta Bee Research Centre as assistant researcher in Research – Extension- Farmers Linkage Division. He was serving as Assistant Researcher in the Centre until he pursues his study. Then, he joined the School of Graduate Studies at Haramaya University for his M.Sc. degree in Rural Development and Agricultural Extension, in October 2005.

Name: Workneh Abebe Wodajo
Place: Haramaya University, Haramaya
Date of Submission: June, 2007
Signature: …….

ACKNOWLEDGEMENTS

Above all, thanks to my almighty God for his help in passing me through the complicated situations I faced for pursing my study (from high school to university) and for his help and courage during my whole study time.

I would like to express my sincere gratitude to my major advisor Dr. Ranjan S. Karippai for his invaluable comments, suggestion, and encouragement. He deserves special appreciation for the input he added on my work from the initial proposal writing, interview schedule preparation and to the final thesis writing.

I owe my deepest thanks to my co-advisor Dr. Ranjitha Puskur for her invaluable and unreserved assistance during the whole work of this study. I am very much indebted to her for the amount of work she put into this task, which made the study to be completed successfully.

I express my deepest and sincere gratitude to my mother Jije Wodajo, my father Abebe Wodajo, my uncles Owata and Berhanu Wodajo, my brothers Ejigu, Tamene, Bacha and Gameda for being the pillar for my academic progress.

I would like to thank International Livestock Research Institute; IPMS project for sponsoring the study without which the completion of this study would not have been possible in such a successful way.

My thanks and appreciation also goes to OARI, particularly, Dr. Assefa Ta`a, Deputy General Director of Oromiya Agricultural Research Institute for his timely decision in providing me recommendation which contributed much for university admission.

I wish to express my thanks to all Technical and Administrative staff of Holeta Bee Research Center particularly, (in alphabetical order) Adimasu Adi, Dr. Amsalu Bezabih, Bezunesh Dendena, Debisa Lamecha, Dereje Woltedji, Desalegn Begna, Enani Beshawurad, Kebede

Debele, Kibebew Wakijira, Motuma Turi, Dr. Nuru Adigaba, Shimelis Dejene, Tadese Zebre, Tsegaye Edo and Zewudu Ararsa for their encouragement, provision of relevant reference materials and computer facility.

I owe my special thanks to Atsbi Wemberta Agricultural and Rural Development staff, particularly Hailay Berhanie, Alemayehu Fikadu, Gebreab Gebremedhin, Nigusie Hailu, Mulugeta Gebremariam and Habtom Nigusie for their unreserved assistance during data collection. Development agents and selected sample beekeepers are also deserved special thanks for their cooperation and hospitability during data collection.

My thanks also goes to Dr. Gebremedhin Gerbrewahid, Dawit Woldemariam and Amare Girmay, Astbi Wemberta IPMS project staff, for their cooperation and excellent facilitation during field work.

I owe my sincere gratitude to all my friends specially Kenea Feisa, Wondimu Fikadu, Tafese Bikila, Tadesse Berhe and Addis Alemayeh for their encouragement during the whole study time.

Finally but most significantly, I would like to express my deepest thanks to my wife, Wosene Tilaye for her shouldering the whole responsibilities of family issues, particularly looking after our children, Galetom and Kena. She also deserves special appreciation for the interest she has in my academic progress.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

DETERMINANTS OF ADOPTION OF IMPROVED BOX HIVE IN ATSBI WEMBERTA DISTRICT OF EASTERN ZONE, TIGRAY REGION

ABSTRACT

Though beekeeping is a common farming enterprise and income generating activity in Atsbi Wemberta, and promotional efforts were made to improve it, no systematic study has been undertaken to evaluate the promotional efforts and people's response to it.

*The objectives of the study were to identify determinants of improved box hive adoption by the beekeepers; and to analyze financial benefits of adopting improved box hive technology in Atsbi Wemberta district of Eastern Zone, Tigray Region of Ethiopia. Stratified sampling technique was employed to identify the sample respondents. The sample respondents were categorized into adopters and non-adopters of improved box hive. Based on probability proportional to size 45 adopters and 85 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, partial budgeting, and logit model. The logit model reveals that credit, Knowledge, education level of household head, perception and visit demonstration were positively and significantly influencing adoption of improved box hive, whereas a*ge, *family size, extension contact, market availability and beekeeping training were not significantly influencing adoption of improved box hive. Concerning financial benefit, partial budgeting result reveals that the beekeepers benefited by adopting improved box hive. The total net benefit from improved box hives exceeds the benefit from traditional hive by more than twice. Major problems for promoting improved beekeeping practices were identified in the study area. Ranking revealed that drought; honeybee pests and disease; lack of beekeeping materials; death of colony; lack of extension support; marketing problem; shortage of bee forage; lack of beekeeping skill and reduction of honeybee colonies were found to be the major constraints in the beekeeping development of the district in their order of importance. Cost of improved box hive was also found to be one of the determining factors for the technology promotion. Hence, it is recommended that Beekeeping extension, Research and NGOs should enhance research and extension activities on absconding management, selecting moisture stress tolerant bee forage, developing a technology from locally available materials, promotion of ant protection methods and organizing apiary demonstration.*

1. INTRODUCTION

The performance of the Ethiopian agriculture has been poor and the sector has not been able to feed the nation. About 50% of the Ethiopian population currently lives in absolute poverty (BSE, 2004). To reduce poverty, focusing on high potential areas of agricultural sector and making them more productive is of paramount importance. Beekeeping is one sub sector where such potential exists.

There is no well-documented evidence that indicates when and where the beekeeping practice started in Ethiopia. However, according to Ayalew (1978) beekeeping had started in the country between 3500-3000 B.C. In Ethiopia, Beekeeping extension was initiated in 1965 with the establishment of Holeta Bee Research Center (the then Holeta Beekeeping Demonstration Station) and other similar stations in different parts of the country. According to EBA (2005), formally organized beekeeping extension started in 1978. The country has a potential in beekeeping as the climate allows growing of different vegetation and crops, which are a good source of nectar and pollen for honeybees. Due to suitable natural environment of the country, large honeybee colonies, which are estimated to be about 10, million, exist in the country (Ayalew, 1978).

As of Ruttner (1988) the moderate climate of Ethiopia makes one of the most successful countries in the tropics in box hive utilization. Ethiopia has a share of around 23.58% and 2.13% of the total Africa and world honey production, respectively. The country is the leading honey producer in Africa and one of the ten largest honey-producing countries in the world (Ayalew, 1990). The country is also one of the four largest bees-wax producing countries. In Ethiopia, beeswax is one of the 12 major exportable agricultural products (Mammo, 1976). The author also states that in the country about one million farmers are estimated to be engaged in beekeeping.

Beekeeping in Ethiopia plays an important role in income generation for beekeepers (farmers). In the country, an average of 420 million Eth. Birr is obtained annually from the sale of honey. Honey production of the country meets beverage requirements of the urban and rural population. It is also demanded for its nutritional and medicinal values. The others hive

products such as beeswax; royal jelly, propolis, and bee venom have high demand globally. The country produces about 28,500 tons of honey and 5000 tons of beeswax annually (HBRC, 2004).

In addition, honeybees play a great role in pollinating plants. Particularly, self-sterile plants should get pollinating agents to maintain viable seed. The yield of plants pollinated by honeybees can be increased in quality and quantity. According to Crane (1990) honeybees can increase the yield of *Citrus sinensis* by 30%, water melon by 100% and tomatoes by 25%. Adimasu *et al.* (2004) also reported that onion yields had increased by 94% due to honeybee's pollination.

In addition, beekeeping sub sector has a lot of relative advantages. For instance, it does not require fertile land as well as large area. Males and females of all working age groups can practice it. It also requires little initial capital.

Improved box hives have been introduced and promoted in the country for the last 40 years. However, there was no adequate study on its adoption. Therefore, this research project was designed to study adoption of improved box hive in a selected District of Eastern zone, Tigray Region.

1.1 Statement of the Problem

The Ethiopian government, realizing the potential of beekeeping sub sector of the country in 1965, established beekeeping demonstration stations at Holeta, Nekempt, Jima etc. The main objectives of the demonstration stations were to introduce improved beekeeping technologies (box hives, casting mold, honey extractor, honey presser, smoker, water sprayer, veil, glove etc) imported from abroad to the beekeepers and to offer beekeeping training for farmers and experts. Currently, different private organizations are also engaged in the production of beekeeping equipments.

Atsbi Wemberta is also one of the potential districts of Tigray Region for beekeeping development. According to the information from the District Agricultural and Rural Development Office, the District has 16,915 honeybee colonies. The existing figure of

honeybee colonies makes the District one of the potential areas for developing beekeeping sub sector in the region as well as in the country. All beekeepers of the distinct were only using traditional beehive eight years back, which is inconvenience to undertake internal inspection and feeding, and has no possibilities of supering to differentiate brood chamber and honey chamber. The annual crude honey yield per traditional beehive is 5-7kg. It is very low in quantity and quality compared to national average of improved box hive, which is 20-25kg.

As also noted by Crane (1990), box hives allow honeybee colony management and use of a higher-level technology, with larger colonies, and can give higher yield and quality honey. Improved box hive has components like brood chamber, super (honey chamber), inner and outer cover. Improved box hive has advantages over the others in that it gives high honey yield in quality and in quantity. The other advantages 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.

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 (Appendix 1a) in Atsbi Wemberta District. However, there was no adequate information on the determinants of the technology adoption, socio-economic and socio-psychological factors influencing adoption of beekeeping technology and the financial 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.

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 financial 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.

1.2 Objectives

The specific objectives of the study are:

- to identify determinants of improved box hive adoption by the beekeepers; and
- to analyze financial benefits of adopting improved box hive technology.

1.3 Significance of the study

Improved beekeeping practices have been introduced in Ethiopia since 1960`s. Holeta Bee Research Center (the then Holeta Beekeeping Demonstration Station) is the pioneer organization for the development of beekeeping sub sector in the country. Ministry of Agriculture and different Non-Governmental Organizations have also been playing a great role in disseminating improved box hives. Even though those organizations are contributing much in the dissemination of the technology, there was no adequate study on adoption of the technology. In addition to this, financial benefit of box hive was not adequately assessed so far.

There are various determinants that positively or negatively contribute towards adoption of the technology. Identification of the determinants are important for policy makers, researchers and organizations involved in beekeeping development programs to get enough information on the adoption status of improved box hive, which in turn would help them to suitably modify the strategies. Generally, the Government, Non-Government and individuals involved in beekeeping activity would get information on the determinants of adoption and financial benefit of the technology. Hence, the study would contribute much in generating appropriate information on determinants of adoption of improved box hive technology.

1.4. Scope and limitations of the study

The study dealt with 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.

1.5. 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

This chapter gives theoretical highlights for the study. It is organized into sub topics such as Definition and concept of adoption, background of adoption study, farmers' adoption decision, empirical studies on adoption, beekeeping situation of Ethiopia, and conceptual framework.

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 (1962) 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 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. Review of empirical studies on determinants of adoption

In Ethiopia, empirical studies on adoption of farm technology mainly concentrated on the investigation of crop, Soil and water conservation and dairy technologies (Itana, 1985; Getachew, 1993; Chilot *1994*, Lelisa, 1998; Shiferaw and Holden, 1998; Kidane, 2001; Berhanu, 2002; Endries, 2003; Habtemariam, 2004, Million and Belay, 2004). With regard to beekeeping technology adoption Melaku's (2005) is the only one to mention. It confirms

that study on beekeeping technology adoption is found at infant stage. How ever, related research materials to the selected explanatory variables for the study have been reviewed as follows.

Voh's (1982) research report on factors associated with the adoption of recommended farm practices in a Nigerian village also explained that extension contact, socio economic status, access to market, education, leadership role have positive relationship with the adoption of new technologies.

According to Feder *et al*., (1985) in their study of adoption of agricultural innovation in developing countries, factors that influence technology adoption are credit, farm size, risk, labor availability, and human capital and land tenure. The same authors stated that farmers' awareness about the technology can increase, if they have access to education. Education can also directly facilitate technology adoption, by increasing access to information about alternative market opportunities and technologies. Legesse (1992) revealed that extension contact, poor distribution of inputs and technical assistance, socio psychological variables such as farmers' ability, belief, habit and customs, and expectations affect the technology adoption.

Research study of Itana (1985) showed that literacy, farm size and adequacy of rainfall affect the adoption decision of farmers positively, while unavailability of cash for down payment and price of farm inputs affect farmer's adoption decision negatively. In the same study farmers' asset position, non-farm income and price of farm output also found to be affecting negatively the adoption decision of farmers on package of agricultural technologies in subsistence agriculture of two districts of Ethiopia.

Chilot (1994) in his study of factors influencing adoption of new wheat technology in selected district of Ethiopia, found that access to timely availability of fertilizer, perceived relative profitability of the improved variety, number of extension contact and wealth position had positively and significantly relation to new improved wheat variety adoption.

As of Van den Ban and Hawkins (1996) adoption of improved technologies is strongly affected by the policy environment like input supply, market, credit, price policies and improved supply system. Likewise, the effectiveness of extension service and other communication media as well as farmers educational level influence the use of improved technologies.

A study by Makokha *et al* (1999), confirmed that farmers characteristics such as participation in field days and demonstration, attendance at workshops and seminars contact with extension and leadership position have significant influence on perception and hence adoption decision of farmers. They also found that technological attributes such as supply (availability), economic and yield benefit and convenience had significant influence on adoption decision

Farmers with high number of livestock have an opportunity to bear the risk that may occur. As a result, it encourages adoption of in new agricultural technologies. In line of this, studies of Getahun *et al*. (2000), Endrias (2003) and Tesfaye *et al.* (2001) showed that the number of livestock owned, that is expressed by tropical livestock units (TLUs) significantly influence the probability of adoption of a farm technologies in their respective studies. Simeon and Nega (1997) also explained high cost, low return, inappropriateness of technologies, lack of credit facilities, the prevalence of animal diseases, absence of transport and marketing infrastructure as some of problems affecting diffusion of technologies.

Study of Kidane (2001) on adoption of new wheat and maize varieties in Tigray region, Ethiopia investigated that adoption of crop varieties were influenced by frequency of contact between the farmers and extension. The study also indicated that the higher contact time positively influenced the adoption decision of the farmers.

Berhanu (2002) observed that the availability off- farm incomes, extension contact, feed shortage, the total livestock owned, distance between residence and market, bull service are found to have a positive and significant influence the adoption decision of the farmers on crossbred dairy cows in the central highlands of Ethiopia.

Farmers with high levels of education are better adopters of improved farm practices than those with lower levels of education (EARO, 2002). Studies of Hassen *et al.* (1998) and Habtemariam (2004) identified that farmers' education had positive and significant influence on adoption.

Cramb (2003) inferred that a number of farm-household factors are typically associated with adoption, such as:

- Age, education and personal characteristics of the household head
- Size, location and tenure status of the farm
- Availability of cash or credit for farm investment
- Access to markets for farm produce; and so on

Determinants of technology adoption encompass characteristics of the technology, features of the farming system, market and policy environments as well as socio-economic characteristics of the decision- making unit (house hold, farmer) (Ehui *et al*. 2003).

Perception of technology attributes is treated as a composite variable computed by adding the difference between positive and negative psychological field forces or by aggregating the net perception scores of respondents on the attributes of each and every practice of the recommended technology package including perceived relative advantages and disadvantages of fertilizer, spot application of fertilizer, improved cultivars and line planting for maize and perceived relative advantage and disadvantage of recommended breeds, housing, medical and feeding practices for dairy (Habtemariam, 2004). The study which was conducted in Shashomene and Debrezeit districts of Ethiopia using the above methods, reported that perception was not found to be significantly associated with the production efficiency of both maize and dairy farmers in many of the practices incorporated into the package of the two commodities.

The study conducted by Million and Belay (2004) indicated that age had a weak and at the same time negative association with adoption. In contrary Omiti *et al*. (1997) investigated positive relationship between age and adoption behavior of farmers. Several factors, some of

which relate to the characteristics of the technology and others to the context do influence the speed of dissemination and adoption of technologies. The stimulant among these factors is the demonstrated value of such technologies especially the marketability and profitability of their products. Other factors such as the ease of application, access to support services and how the technology fits in the knowledge base of the production system also do significantly influence adoption (National Agricultural Research Organization, 2004).

Tesfaye's (2004) study on adoption of in organic fertilizer on maize in Amhara, Oromia, and southern regions, explains that farm experience, access to credit, use of improved crop varieties, use of farm yard manure, family size, level of education and total farm size significantly influencing adoption of chemical fertilizer

Tesfaye *et al.* (2001) in their adoption study of determinants of high yielding maize technology adoption show significant influence of family size on the adoption of decision of improved maize varieties**.**

Melaku (2005) in his study of adoption and profitability of KTB beekeeping technology in Ambasel district of Ethiopia, by using logit model found that household farm experience, perception of timely supply of the technology, extension contact, and visit to apiaries have a positive and significant effect on farmers' adoption of Kenya top bar hives.

Mesfin's (2005) research report revealed that farmers' perception on the yield superiority of triticale has positively and significantly affected adoption of triticale in Farta district of Ethiopia. The study further stated that distance to all weather road and market centers are negatively and significantly related to adoption of triticale. In addition, non-farm income and investment cost have influenced farmers' adoption decision of triticale positively and significantly. This implies that the higher the price of the input decreases the adoption of new technology.

From the given definition and explanation of adoption, it can be concluded that adoption decision takes time and needs continuous work to enable the users to reach on decision. The

user has to continue with technology by incorporating in his farming practice to say adoption has taken place.

A number of empirical studies on adoption of different technologies that have been carried out by different researchers considered explanatory variables such as personal, socio-economic, technological and institutional factors. The variables that are significant in some studies are not necessarily significant in other studies. This is mainly due to the difference between personal, socio-economics and socio cultural factors of the society. The study of Ehui *et al.* (2004) also revealed the difficulties of developing a universal model of the process of technology adoption with defined determinants and hypothesis that hold true everywhere. Hence, this study has considered important explanatory variables of the previous study and analytical tools used by different researchers to identify their influence on the adoption of improved box hive.

2.5. Financial benefit of farm technology

The probability of adoption of a new technology will depend on the difference in profitability between the new and old technologies, and the ability of the farmer to perceive the advantages and efficiently utilize the new technology (Schultz, 1995).

As noted by Gavaian and Gemechu (1996), high yields are not sufficient conditions to persuade farmers to adopt a technology. With technology application, farming must be basically profitable or at least more profitable than other alternatives.

Legesse (1992) in his study on analysis of factors influencing adoption and the impacts of wheat and maize technologies in Arsi Negele, Ethiopia, maize variety and fertilizer technologies increased farmers yields and net benefit.

Behera and Mahapatra (1999) in the study on income and employment generation for small and marginal farmers through integrated farming system which includes pisciculture, field and horticultural crop (agro forestry), poultry, mushroom, apiculture and biogas enterprises find out that apiculture produced the highest return (Rs 7.94 per rupee or 0.18 US dollar invested), followed by Pisciculture (Rs 5.46 per rupee or 0.12 US dollar invested).

Ambrosini *et al.* (2002) in their study on the therapeutic effects of propolis in livestock farming examine the role of beekeeping as a source of valuable food and off-farm income in rural areas of developing countries. Some of the valuable beekeeping products include honey, beeswax and propolis. This study discusses the potential of propolis as a therapeutic agent against human and poultry (particularly fowls) diseases, owing to its antibacterial, anti fungal, antiviral, anti protozoa, anti helmintic, antioxidant and immune-enhancing proprieties, as an antibiotic additive for cheese, and as a dietary supplement for humans and animals.

Leggesse *et al.* (2004) in their study on duration analysis of technological adoption in Ethiopian agriculture reveals that economic incentives are the most important determinants of the time farmers wait before adopting new technology. The authors further stated that other agricultural inputs (area of farm land, labor, credit), extension services and farmers` personal characteristics (education, gender, age) appear to have had little, if any, effect on adoption behavior.

Melaku (2005) using partial budgeting analysis indicated, when added cost (reduced return) and increased return (reduced cost) accounted for both the home made and institutionally prepared KTBH, it was found that both types of KTBH are beneficiary and remunerative According to Kerealem (2005) movable comb top bar hives result in higher net return per colony compared with local hives.

2.6 .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 effected 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)

Rural knowledge management that links various actors who have and seek knowledge to bring together their knowledge and experiences

2.7. Honeybee races of Ethiopia

Different scholars have studied identification of honeybee races of Ethiopia. As noted by Smith (1961) cited in Nuru (2002) *Apis mellifera monticola* was the first honeybee race reported to exist in the Ethiopian plateau.

Ayalew (1990) identified the existence of five honeybee races in Ethiopia. These are:-

1. *Apis mellifera adansanii* exists in south and western part of the country
2. *Apis mellifera jemenitica* founds in the low land areas of eastern Ethiopia
3. *Apis mellifera monticola* exists in Southeast Mountain of Bale- Dinsho
4. *Apis mellifera litorea* exists in southwest low lands
5. *Apis mellifera abyssinica* exists in highland area of central, west and southern parts of the country.

Amsalu (2002) and Nuru (2002) recent detail work revealed the presence of five honeybee races of Ethiopia, namely;

1. *Apis mellifera monticola*, which exists in northern high mountains part of the country
2. *Apis mellifera bandasii* founds in central highlands
3. *Apis mellifera scutellata* founds in west tropical forestlands
4. *Apis mellifera jementica* exists in eastern and western low lands areas
5. *Apis mellifera woyi –Gambela* founds in the extreme western and southern semi-arid to sub moist lowland areas.

The latest study did not come across with *Apis mellifera litorea* and *Apis mellifera Abyssinica.* This indicates that there is a difference among the studies on Ethiopian honeybee races. Therefore, it requires further investigation to clearly identify honeybee races of Ethiopia.

2.8. Honeybee races in the study area

As the study of Nuru (2002) in the north west of Ethiopia the Sudan border areas above Kumruk, west of Manbuk, west of Aykel up to Metema, west of lay Armacho (Angareb lowlands) in the north, the western Tigray (Humera and Shiraro), in east including Afar

lowland plains are dominated by *Apis mellifera jemenitica*. This honey bee race is characterized by yellow color but also consists black members; smaller than *bandasii*, *monticola*; has less tendency for reproductive swarms; its swarming is monophasic; has less migration tendency and aggressive than other races.

2. 9. Beekeeping activities in Ethiopia

The diversified agro climatic conditions of the country create environmental conditions conducive for the growth of over 7000 species of flowering plants of which most are bee plants (Nuru, 2002). Edwards (1976) also confirms that Ethiopia has various endemic species of flowering plants. According to Mammo (1976) in Ethiopia, about one million farmers are engaged in beekeeping. The favorable climate of the country allows having about 10 million honeybee colonies of which 7 million are kept in different man made hives and the balance exists as wild colonies (EMA, 1981). Beekeeping is a long lasting practice in Ethiopia. As a result, beekeepers have developed indigenous technical knowledge on traditional hive construction from different locally available materials, on honeybee management practices like honey season identification, swarm catching and attractant methods, swarm control method, honeybee enemy protection, traditional methods of sting protection and reduction of pain (Workneh , 2006)

According to Holeta Bee Research Center (2004), there are four different types of beekeeping practices in Ethiopia namely, traditional forest, traditional backyard, transitional and improved beekeeping.

Traditional forest beekeeping: - It 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 during honey harvesting period as the beekeeper drops down the hive from the tree, it damages the honeybee colony. It is also dangerous for the beekeeper to climb tall tree in night.

Traditional backyard beekeeping: - It 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; it does not also require skilled manpower; whereas its disadvantages are inconvenience to undertake internal inspection and feeding, in some places the size is too small and causes swarming, it has no possibilities of supering, there is no partition to differentiate brood chamber and honey chamber.

Transitional beekeeping: - It is one of improved methods of beekeeping practices. The types of hives are Kenya Top Bar Hive (KTBH) and Tanzania Top Bar Hive (TTBH). The hives can be constructed from timber, mud or locally available materials. Each hive carries 27-30 top bars on which honeybees attach their combs. The top bars have 3.2cm and 48.3cm width and length, respectively. Transitional (intermediate) beekeeping practice has different advantages such as, it can be opened easily and quickly, the bees are guided into building parallel combs by following the line of the top bars, the top bars are easily removable and this enables beekeepers to work fast, the top bars are easier to construct than frames, honeycombs can be removed from the hive for harvesting without disturbing combs containing broods, the hive can be suspended with wires or ropes and this gives protection against pests. Transitional beekeeping has its own disadvantages such as, top bar hives are relatively more expensive than traditional hives, combs suspended from the top bars are more apt to break off than combs which are building within frames.

Improved beekeeping practices: - It uses different types of frame hives. Zandar and Langstroth hives are the most common that exist in the country. Dadant, Modified Zandar, and foam hive are found rarely. These hives differ in number and size of frames. The most commonly used hive type in Ethiopia is Zandar type. Improved beekeeping hives have components like brood chamber, super (honey chamber), inner and outer cover. Improved box hive has advantages over the others in that it gives high honey yield in quality and in quantity. The other advantages 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.

2.9.1 Beekeeping practices in northern Ethiopia

Indigenous technical knowledge of beekeepers is different from region to region in the country. As a result, beekeepers' practices also show differences. According to Nuru (2002) farmer beekeepers of the region have well developed indigenous technical knowledge on beekeeping. They keep their bees in backyard either under separate shelter or around the house wall or even inside the house i.e. with domestic animals and family members without any problem. They hang their beehives inside their living rooms and provide entrances on the sides of the walls. The author further stated that in Tigray some beekeepers keep honeybee colonies inside living rooms and honeybees are sharing the same doors with members of the family. The beekeepers of the area construct beehives for different purposes; for instance, small hive to induce reproductive swarming and big hives for honey production. The beekeepers also practice feeding and moving their colonies to other places for searching bee forage.

2.9.2 Beekeeping practices in southern Ethiopia

As the other regions of the country, in this area beekeeping is one of the oldest agricultural practices. Traditional, transitional and improved beekeeping management are being practiced. As noted by Amsalu (2002) in the south western part of the region particularly (mash area) farmer beekeepers use natural forest only for beekeeping purposes. The forest is distributed among beekeepers and one cannot use for beekeeping without the permission of the forest owner (beekeeper). In some areas of the region as revealed by Nuru (2007) every family has its own forestland to use for traditional beekeeping, which is known as *kobo*. According to *kobo* system one cannot be allowed to cut a single stick or to hang hives in the forest which is not belonging to him.

Even though the practice is not contributing much for the productivity of beekeeping, its contribution is high for forest conservation in the area. Generally in the area, traditional forest beekeeping is predominant. A beekeeper can have 10-200 honeybee colonies. The beekeepers get honeybee colony mainly through trapping swarms. In relation to honeybee management, no attention is paid to honeybee colonies. Beekeepers visit their honeybee colonies during honey harvest. The honey harvesting practice is, climbing up the tree and

sending the hive with rope or dropping it then harvesting the honey with the mixtures of pollen and beeswax. There are mainly two types of honey; white and yellow or amber. White honey, which is harvested during April to May, has higher value than yellow honey in the surrounding, as it is perceived to be good quality. It is documented that yellow honey is also harvested during September to November. The beekeepers are mainly selling their honey to *tej* (local beverage) makers and to few honey collectors. The `*tej*` makers get multiple advantage i.e. selling the `*tej*` and preparing beeswax, which is sold to beeswax collectors.

2.9.3 Beekeeping practices in western Ethiopia

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. The honey harvesting method is similar with southern part of the country. 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.

2.9.4 Beekeeping practices in central highlands of Ethiopia

According to Amsalu (2002), in central and eastern highlands honeybees are kept in backyard and in the forest. Backyard beekeeping practice is more predominantly exercised

in the area. Traditional beehives are made up of pot, bamboo, locally available shrubs and trees. Workneh (2006) also reveals that traditional beehives used in the area are cylindrical in shape with the dimension of around one meter in length and a diameter of around 20 cm. It is made up of *Vernonia thomasoniana (Rejii)*, *Hagenia abyssinica* (*koso*), strawberry, climber, *Lippia adoensis* (*kusaye*), *Eucalyptus* sp., *Grewia ferruginea* (*Dhokonu*), *Myrsine africana (kachama*), clay hive, log, (*Rosa abyssinica* (*qaqawi*)**,** *Premna schimper* (*urgesa*) bamboo and other locally available materials. The internal parts of the hives are smoothened with mud and cow dung and the external part of the hives are covered with grass to protect from rain. The beekeepers attract swarms into the new hive by fumigating with '*Ejersa*' (*Olea europaea* subsp*. cuspidata*), '*sombo* (*Ekebergia capensis*) (its bark), *Tungit* (*Otostegia intergrifolia*), *kussayee* (*Lippia doensis*), *teji sar*, beeswax, *dokima* (*Syzygium guinneese*), *bessobila* (*Ocimum sanctum*), *tid* (*Juniperus procera*), perfume, *itan* (*Boswelia papifera*), *wanza* (*Cordia africana*). If two or more materials are found in their area, they fumigate by mixing together and it is powerful in attracting the bees. Method of fumigating the new hive is digging the hole and preparing the smoke and digging another hole adjacent to the first hole then connecting the two holes internally by producing small hole which helps to pass smoke and putting the new hive up down on the hole which has no fire. The new hive may be fumigated until the internal color of the hive gets brown.

Beekeeping management such as regular visiting of colonies, feeding, watering and protection from honeybee enemies are being undertaken in the area. Beekeepers also practice migratory beekeeping i.e. moving their colonies to places where plenty of bee forage are available. Beekeepers also use traditional queen cage mainly made of bamboo to prevent their colonies from absconding.

2.10. Improved beekeeping technology development

As stated in Holeta Bee Research Center (2004) the foundation of the whole of our modern beekeeping technology development can be traced back to the Langstroth`s practical application of the concept of the bee space in 1851. The rapid development of modern beekeeping can be attributed to four very important discoveries;

1. The construction of movable frame hives in 1806.

2. The application of `bee space` by Langstroth in 1851, and the subsequent development of the modern movable frame hive. Bee space which is 9.5mm air gap between the frames or combs and the hive walls and covers respected by bees. Bee space has high value in the development of improved box hive. If the bee space is wider, unwanted comb is built which makes it difficult to move frames freely.
3. The development of beeswax foundations press in 1857, which make sheets of beeswax with identification of the cell bases.
4. The discovery of centrifugal honey extractor in 1865. In the same year, queen excluder was invented. It helps to protect queen and drone from passing to the honey chamber i.e. the brood could be kept out of the honey stored frames.

Generally, the pattern of improved beekeeping was established in the half century between 1851 and 1900.

2.11. Relative advantage of beekeeping

Beekeeping is a sustainable form of agriculture that is beneficial to the environment and provides economic reasons for the retention of native habitats and potentially increases yield from food and forage crops (Jones, 1999).

As noted by Robinson (1980) beekeeping has various relative advantages and some of them are as follows:

a. Bees are cosmopolitant i.e. they adapt to wide range of environment. They can survive at altitude below 400 masl where cattle production may be severely constrained due to tsetse or other reasons.
b. 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.
c. Beekeeping does not compete for resources with other agricultural endeavors and can be run integrally with other agricultural activities. Man cannot harvest and utilize nectar and pollen in the absence of bees.
d. Bees' culture does not disturb ecological balance, as may cultivation of crops and practices of animal husbandry.
e. 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.

f. 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.
g. 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
h. The whole family can become involved since men, women, or elder children can do the work in most cases at home.
i. A beekeeper can develop knowledge and skill, which are rewarding and help to generate self-reliance
j. 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.
k. Apitheraphy i.e. medicine using bees products, all societies have a wealth of traditional knowledge concerning the healing properties of bee products.

2.12. 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.

The following conceptual model (Figure 1) serves the study as its framework.

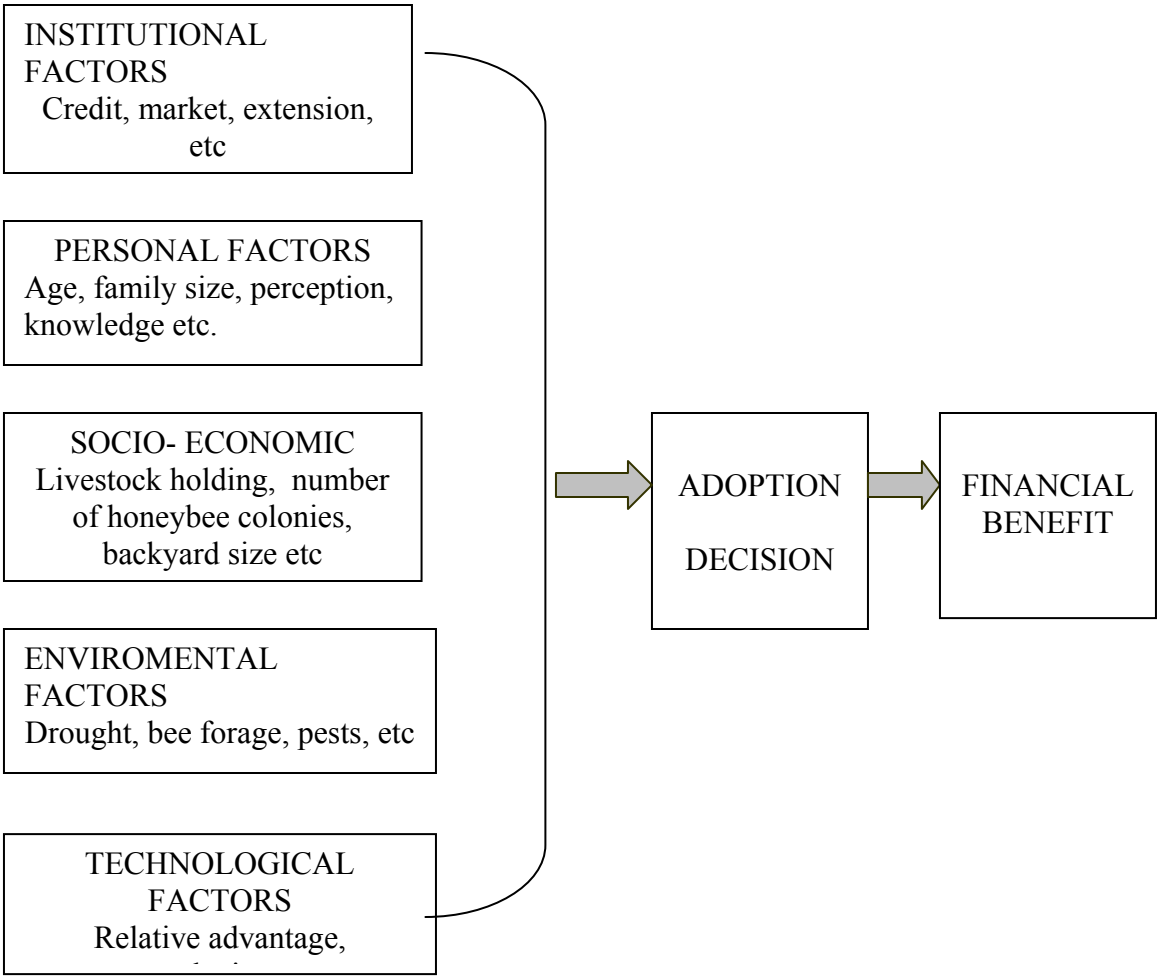


Figure 1. Determinants of improved box hive adoption

3. RESEARCH METHODOLOGY

Under this chapter, description of the study area, method of data collection, analysis, hypothesis and definition of variables are briefly explained.

Atsbi Wemberta district is purposively selected for this particular study. It is one of the Pilot Learning Sites of Improving Productivity and Marketing Success (IPMS) project of Ministry of Agricultural and Rural Development that is being implemented by International Livestock Research Institute (ILRI), which is funding this research project. The stakeholders in this district have identified apiculture as a priority sector.

3.1. Description of the study area

Atsbi Wemberta district is found in Eastern zone of Tigray Region at about 65km from Mekele regional city. It is located in the north east of the regional city at 13º 36``N and 39º 36``E. The District is bounded in the north by SaeseTsaedaemba District, in the south by Enderta District, in the east by Afar regional state and in the west by KilteAwuelalo District. It has an altitude at Dega (highland), which ranges from 2400 m to 3000 m and at weinadega (midland) ranging from 1800 m to 2400 m above sea level. The District has a total area of about 1223 sq. km. Generally the district has 70% and 30% Dega and Weina dega, respectively.

3.1.1. Climate

The climate of Atsbi Wemberta ranges from cool to warm. The average temperature of the area is 18^{o}c. Generally the climate of the area is characterized as highland and middle land. Rainfall is usually intense and short in duration, with an annual average of about 667.8 mm.

3.1.2. Population

According to the information from District Agricultural and Rural Development Office (2006), Atsbi Wemberta has a total population of 112,639 of which male and female are 55,359 and 57,280, respectively. Urban and rural population is 9609 and 103,030 respectively.

3.1.3. Economic activities

According to the information from Atsbi Wemberta District ARD planning office (2006) the dominant cereals crops of the area are barley, wheat, teff, maize and sorghum. Among the pulses, beans, field pea and lentil are the major dominant crops. There are also cattle, equines, sheep, goat, camel, and beekeeping (Table 1). Honeybee colony multiplication through over crowding and splitting method is practiced in the highland areas where as honey production is a common practice in middle altitude.

Table 1. Livestock population of the study area.

No.	Livestock type	Unit	Total
1	Ox	Number	21,908
2	Cow	‘’	30,588
3	Goat	‘’	15,431
4	Sheep	‘’	82,950
5	Donkey	,,	9,416
5	Mule	‘’	1,333
6	Horse	‘’	79
7	Camel	‘’	54
8	Poultry	‘’	47,265
9	Honeybee colony	Hive with honeybee colony	16,915

Source: Atsbi Wemberta ARD office (2006)

3.1.4. Infrastructure

The District has 32 schools at different levels i.e. 7 (1-8 grade), 2 (1-7 grade), 4 (1-6 grade), 3 (1-5 grade).15 (1-4 grade), and 1 (9-10 grade). The district has 14 health posts, 3 clinics and one health station. In addition, it has all weather roads, which connect all PAs with neighboring districts.

In the District and its neighboring districts, the forest coverage is large (Table 2). It is a good opportunity for beekeeping activities as it houses bee forage. In addition, it has 3,473 hectars of area enclosure that also has bee forage. In the area enclosure, it is possible to integrate bee forage like in Tigrigna `gribiya` (*Hypostus ariculata*) and `tebeb` (*Basium clandiforbium*) etc, which are contributing much to honey production of the area.

Table 2. Land allocation of the study area

No.	**Land type**	**Unit**	**Amount**
1	Cultivated land	hectare	14,535
2	Ready to be cultivated	‘’	35,305
3	Grazing land	“	8,742
4	Area enclosure	“	3,473
5	Forest (include the project areas of neighboring districts	“	89,185
Total			149,764.23

Source- combined from Atsbi ARD office report (2006)

3.1.5. Beekeeping activities in the study area

Improved box hive was introduced to the District in 1998. Improved and traditional beekeeping practices are mainly dominating in the area. Currently, beekeeping extension is working on both improved and traditional beekeeping practices. Highland areas are used for traditional beekeeping and the middle land is for improved beekeeping. According to the beekeepers and bee expert of the district, the highland is not suitable for improved box hive. The highland area is too cold and as a result the honeybees cannot resist the cold in the box hive. This results in low yield and high absconding of honeybees. The main activity of traditional beekeeping is to multiply honeybee colony to provide honeybee colonies for beekeepers engaged in improved beekeeping management. The current price of one honeybee colony is about 550.00 Birr.

The box hive and honeybee colony along with the necessary protective materials such as veil, glove, and smoker are provided on credit basis extension, without down payment. It also includes queen excluder and pure bees-wax. Providing all the necessary components of beekeeping materials to the user is important to increase hive products.

In the district, there are five beekeeping associations that were organized by district Agricultural and Rural Development office with the assistance of ILRI and World Vision. Three of them are organized for landless youth of Dibab Akorein, Bark Adisebiha and Hayelom PAs. They have 31, 18, and 10 members, respectively. Each member of the association gets three box hives on credit basis. The repayment of the credit is based on the hive product harvested. They are not enforced to repay their credit if they could not get the yield. The source of credit for these landless youth is from IPMS credit fund. Two associations were also organized including active beekeepers who can serve as a model to others. World Vision Ethiopia (an NGO) financed these associations. The main objective of these associations is to serve as demonstration site for other beekeepers in the district. The district cooperative office is responsible to distribute the hive and to manage the credit of all associations. The intention of providing the box hive as a credit is to use the money for similar purpose i.e. organizing similar associations in other PAs. The district Agricultural and Rural Development Office also provides honey extractor and casting mold for beekeepers free of service charge. The honey extractor is being provided through DA and foundation sheet making is done at district level.

In the district, there are 16 Farmer Training Centers (FTCs). Each FTC includes beekeeping training as a major component. In nine FTCs, there are 18 improved box hives, which serve for practical training. The remaining seven FTCs have 16 traditional hives, used for demonstrating colony multiplication. Honeybee colonies are increasing in the area due to colony multiplication, as honeybee colony is one of the income sources for the beekeepers. Honey yield is also increasing, except in 2004 due to drought occurrence in that year (Figure 2)

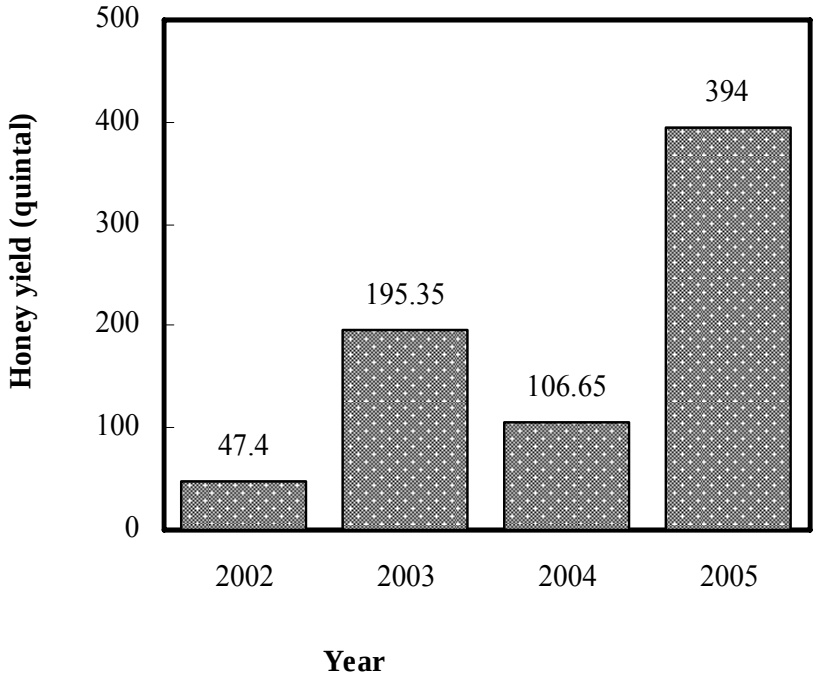


Figure 2: Honey production trends in the study area

Source: Atsbi Wemberta ARD office, (2006).

The maximum honey yield obtained per improved box hive and traditional hive is 60 kg and 12kg, respectively, where as the minimum honey yield from both beehives is 10kg and 2 kg, respectively. In relation to its price, the highest and minimum price for honey from box hive is 45 Birr/kg and 30 Birr/kg, respectively. Similarly the highest price for honey from traditional hive is 28 Birr/kg and the minimum is 10 Birr/kg (District Bee expert, personal communication).

Table 3.Types of beehives in the study area

S.No.	Hive type	Number
1	Dadant	12
2	Langstroth	12
3	Kenya Top Bar	5
4	Zandar	5716
5	Traditional	11,199
	Total	16,944

Source: Atsbi Wemberta ARD office (2006)

Among the introduced hives, the number of Zandar is the highest (Table 3). It was selected based on high yield obtained from each hive based on the study made for two consecutive years in the district by livestock unit of the district. According to the study report, the highest honey yield was recorded from Zandar type improved box hive, annually an average of 18.7kg pure honey (Table 4).

Table 4. Comparison of honey yield from different improved box hives

Hive type	Unit	Quantity
Dadant	Kg/hive/annum	8.9
Langstroth	‘’	13.2
Zandar	‘’	18.7

Source: compiled from Atsbi Wemberta ARD office report (2006)

3.6. Sampling techniques

For this study purposive sampling was employed to identify Peasant Associations in which improved box hive was promoted. Based upon their beekeeping potential, four Peasant Associations were selected purposively. Among the selected Peasant Associations, the beekeepers were stratified into adopters and non-adopters of improved box hives. According to Storck *et al*. (1991), the size of the sample depends on the available fund, time and other reasons and not necessarily on the total population. Hence, the total sample size for the study was 130 beekeepers. Based on their probability proportional to size principle, 45 adopters and 85 non-adopters were taken for the study through systematic sampling method (Table 5).

Adopters are those beekeepers who used improved box hive for two years and non-adopters are beekeepers who did not use improved box hives during the study period.

Table 5. Sample respondent selection across Peasant Associations.

No.	PA	AD	n	NAD	n	THH	Tn	%
1	Hayelom	400	18	512	22	912	40	30.8
2	Dibab-Akorein	85	4	345	15	430	19	14.6
3	Barka-Adisabiha	320	14	482	21	802	35	26.9
4	Michael -Emba	210	9	611	27	821	36	27.7
	Total	1015	45	1950	85	2965	130	100

Note: AD- adopter; n- sample; NAD-non adopter; THH-Total household head; Tn- total sample

3.7. Method of data collection

A full understanding of the complexities involved in the adoption of technologies and the impacts they have can only be achieved by mixing methods, such as surveys, qualitative interviews focus groups discussion (Dick *et al*., 2004). Accordingly, the data were collected from beekeepers and extension workers of the district. Structured interview schedule (Appendix 2) was prepared and pre-tested to include all quantitative data pertaining to the proposed study. For obtaining the relevant information, observations and personal interviews were conducted with beekeepers, extension workers and bee experts.

Qualitative methods such as observation and focus group discussion were also used to collect information on marketing problem, general view of the respondents on the technology and management practices of their apiary.

The enumerators who have know how on beekeeping were recruited to collect the data using the interview method, under the supervision of the researcher. Training was also provided to the enumerators on data collection. The researcher monitored each enumerator while they were collecting the data. Secondary data were also collected from different sources such as books, research publications, journals, office reports, Internet etc.

For partial budgeting, the data such as price of improved box hive, pure bees–wax and accessories were collected from the District ARD office. Honey yield price, feed cost, Labour cost and traditional hive cost were taken from sample respondents.

3.8. Data analysis

The tools for data analysis were descriptive statistics such as percentages, frequencies, mean and standard deviations; t-test and χ^2 were also employed to test the continuous and discrete variables, respectively. SPSS version 12 was used to analyze quantitative data. Any item that cannot be captured through quantitative analysis was analyzed qualitatively based upon interview and group discussion with extension workers and beekeepers. For identifying financial benefit of adopting improved box hive partial budgeting was employed. A partial budget is a technique for assessing the benefits and costs of a practice relative to not using the practices. It takes into account only those changes in costs and returns that result directly from using a new practice. As noted by Upton (1987), Partial budgets are useful to evaluate changes such as:

- Adopting a new technology
- Expanding an enterprise
- Alternative enterprises
- Different production practices
- Hiring a custom operation rather than purchasing equipment
- Making a capital improvement

Partial budgeting is based on the principle that a change in the organization of a farm or ranch business will have one or more of the following effects:
Eliminate or reduce some costs.
Eliminate or reduce some returns.
Cause additional costs to be incurred.
Cause additional returns to be received.

Analytical model selected for this study is binary logit model, which significantly identifies the influences of determinants of improved box hive adoption. It is also possible to analysis adoption behavior of farmers using simple correlation, linear probability functions etc.

However, these models have their own limitations such as t- ratios are incorrect, exhibit hetroscedasticity, non normality; their estimated probabilities (Pi) may be greater than one or below zero and assume pi increases linearity with X (Maddala, 1983, Gujarati, 1995). The Logit and Probit models overcome such drawbacks as both are based on a commutative distribution function. It is also true that various adoption studies so far done on crop, livestock, soil conservation etc. have used Probit and Logit models for identifying the impact of independent variables on dependent variables. However, as of Aldrich and Nelson, (1984), the outputs of Probit and logit models are usually similar. Even though their outputs are similar the logit model is easier in estimation. It is also appropriate to express the probability of adoption and the intensity of use after technology adoption. Due to this fact, selecting binary logit model is thought to be appropriate for this study.

Model specification

Following Maddala (1983), Aldrich and Nelson (1984), Green (1991) and Gujarati (1995) the logistic distribution for the adoption decision of improved box hives can be specified as:

$$Pi = \frac{1}{(1+e^{-zi})} \qquad \text{Equation ---------- 1}$$

Where, Pi is a probability of adoption of improved box hive for the i^{th} farmer

e- represents the base of natural logarithms

Zi - is the function of a vector of n explanatory variables which is expressed as

$$Zi = Po + \sum_{I=1}^{m} Pixi + ui$$

Z - is an underlying and unobserved stimulus index for the i^{th} farmer

i- are observation on variables for the adoption model

Po- is the constant term

Pi - are the unknown parameters to be estimated

Ui- the disturbance term

m- the number of explanatory variables identified for the study

If pi is the probability of adopting improved box hive their 1-Pi represents the probability of not adopting the technology and expressed as

$$1-Pi = 1 - \frac{1}{(1+e^{-zi})} = \frac{e^{-zi}}{(1+e^{-zi})} = \frac{1}{(1+e^{zi})} \quad \text{Equation ------- 2}$$

Then, the odd ratio of the equation 1 and 2 is expressed as

$$\frac{Pi}{1-pi} = \frac{1+e^{zi}}{(1+e^{-zi})} = e^{zi} \quad \text{Equation ------ 3}$$

Equation 3, $\frac{Pi}{1-Pi}$ defines the probability of adoption of improved box hive to non adoption of the technology. Finally, the logit model is expressed as follows by taking the natural logarism of odd ratio

$$Li = \ln\left[\frac{Pi}{1-Pi}\right] = \ln e^{Po+\sum Pixi} = zi = Po + \sum_{i=1} Pixi \quad \text{Equation----- 4}$$

Where li= log of the odds ratio in favor of improved box hive adoption, which is not only linear in xi but also linear in the parameters.

Thus, if the stochastic disturbance term (ui) is introduced the logit model becomes

$$Zi = Po + P1xu + B2x2 + \text{--------} + Bnxi + ui \quad \text{Equation---------- 5}$$

Estimation procedure

Before using the model, multicollinearity was checked to exclude one of the highly correlated explanatory variables. With this particular study, there is no serious multicollinearity problem (Appendix 3 and 4). As to Gujarati (1995) there are various indicators of multicollinearity and no single diagnostic will give us a complete handle over the collinearity problem. Accordingly, Variance Inflation Factor (VIF) and condition index (CI) were used for continues variables.

If there is larger value of VIF_i, there is more troublesome. As a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if R_i^2 exceeds 0.95), that variable is said to be highly collinear (Gujarati, 1995). Following Gujarati (1995), the VIF_j is given as:

$$VIF\ (X_j) = \frac{1}{1 - R_j^{\ 2}}$$

Where, R_j^2 is the coefficient of determination when the variable X_j is regressed on the other explanatory variables.

There may also be interaction between qualitative variables, which can lead to the problem of multicollinearity. To detect this problem, coefficients of contingency were compounded. The contingency coefficient was compounded as follows:

$$C = \sqrt{\frac{\chi^2}{n + \chi^2}}$$

Where, C is coefficient of contingency

$\chi 2$ is chi-square test and

n = total sample size.

The iterative maximum likelihood (ML) estimation procedure was used to estimate the parameters of the models. Maximum likelihood is the most efficient (and sometimes the only) way to estimate the parameters of specifications that involve limited dependent variables. In very general sense, the method of ML yields values for the unknown parameters, which maximize the probability of obtaining the observed set of data (Liao, 1994).

3.9. Hypotheses and definition of variables

Hypothesis

Adoption of improved box hive technology is significantly influenced by personal, environmental, and socio-economic factors.

The variables of the study

Adoption of improved box hive technology is the dependent variable of the study. It is represented by 1 if the beekeepers adopt the box hive and 0, other wise.

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:

Age (AGE): It is a continuous variable and measured using completed years of life. Literature reveals that young people are more flexible in deciding for change than aged people (Motamed and Singh, 2003). Therefore, it was anticipated that young people adopt the improved box hive more than elders.

Experience in beekeeping (BKEXPER): It was measured in years since the respondent engaged in beekeeping activities. Farmers who practice traditional beekeeping have experience in beekeeping and they also know the advantage of beekeeping. Experience helps an individual to think in a better way and makes a person more mature to take right decision (Rahman, 2007). Hence, it was hypothesized that farmers with more experience in beekeeping would adopt the technology more.

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

Education of household head (EDUCATI): Improved box hive technology utilization involves technical applicability; Feder *et al.* (1985) noted that education improve the decision making process and thereby influence the level and/or composition of anther inputs. Hence education would increase the understanding of the technology and anticipated to increase adoption. This variable was measured based upon formal years of schooling attended by the respondents.

Size of backyard (SIZESITE): Beekeepers keep their bees in the backyard. The beekeepers who have large sized backyard have more chances to adopt the technology. Therefore, it was hypothesized that backyard size and adoption of the technology have positive relationship. This variable was measured in meter.

Livestock holding of household (LIVESTOCK): Number of livestock is an important proxy for indicating wealth status of the respondent in the study area. Farmers with high number of livestock have an opportunity to bear the risk that may occur (Getahun *et al*. (2000), Endrias (2003) and Tesfaye *et al.* (2001). Therefore, it was hypothesized that there

would be a positive relationship between farmers with high livestock and adoption of the technology. Number of livestock was measured in Tropical Livestock Unit (Appendix 5).

Total number of honeybee colonies (BEECOLON): It is a continuous variable and was measured taking total number of honeybee colonies. It was anticipated that beekeepers who have honeybee colonies could adopt the technology as it is the matter of transferring the honeybee colonies from traditional hive to improved box hive

Availability of accessories (casting mold, honey extractor) **(AVACSOR)**: 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). Casting mold is very important to make foundation sheet on which the bees develop the cells. Honey extractor is also required for extracting the honey. It is dummy variable and will be measured using 1 if the accessories are available and 0, otherwise. Therefore, it was hypothesized that availability of accessories in the area facilitates adoption of the technology.

Honeybee pests (PESTPRBLM): It is dummy variable and was measured using 1 if the problems do not 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 was hypothesized that the adoption of beekeeping technology would be adversely affected by the existence of honeybee disease, pests and predators in the study area.

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 box hive technology, it was expected that receiving credit and adoption of the technology has positive relationship.

Extension contact (EXTCONTA): Feder *et al.* (1985) noted that extension efforts increase the probably of new technology by increasing the stock of information pertaining to modern production increment. It is dummy variable and was measured using 1 if the beekeeper has contact with extension agent and 0, otherwise. Effective utilization of improved box hive technology requires close follow up of the extension workers. So, it was hypothesized as beekeepers who have contact with extension agent would adopt the technology more.

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.

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.

Beekeeping training (BKTRAIN): It is dummy variable and was measured using 1 if the respondent has got beekeeping training and 0, otherwise. Training is very important to create awareness on the technology as well as to make the beneficiary more productive. Rahman, (2007) also stated that training might have inculcated technical competency, more exposure to the subject matter and convinced to adopt the improved technologies in the farms. It was hypothesized that obtaining training on the technology has positive influence on the adoption of the technology.

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.

Knowledge of the technology: As noted by Rogers (1983) Knowledge is the function in which an individual is exposed to the innovation's existence and gains some understanding of how it performs .Having knowledge of the technology is crucial for effective and efficient utilization of the technology. So, it was hypothesized that beekeepers who have sufficient knowledge of the technology adopt the improved box hive more. This variable was measured by inquiring the respondents, five practical questions of improved box hive.

4. RESULTS AND DISCUSSION

4.1. Demographic Characteristics of the respondents

The mean age of household head for adopters and non-adopters is 42.2 and 47.2 years, respectively. It has significant mean difference at P<0.01 and the result is provided in Table 7. The result shows that the adopters' mean age is smaller than non adopters. It is negatively correlated at P=0.010. It implies that beekeepers are reluctant to new technology as they get older. The result agrees with Yohannis (1992) and; Shiferaw and Holden (1998) who also indicated that age of the household head negatively influenced adoption.

Similarly, it was found that 48.9% of the adopters were in the age category of 28-40 years (Appendix 6a). The remaining 35.6% and 15.6% of the adopters were found in the age groups of 41-53 and 54- 66 years old, respectively. Appendix 6a shows that as the age of respondents increase, adoption of improved box hive decreases. The total families of the respondents consist equally 50% male and female. Among the respondents of adopters and non-adopters 97.8% and 91.8%, respectively are male. The balance 2.2% and 8.2% are female in that order (Table 6). Similar to other parts of Ethiopia, male-headed households dominate the area. Female-headed household included in the sample are those of widows. With regard to marital status of the respondents 93.1% are married and the remaining 6.2% and 0.8 % are widow and widower, respectively (Table 6).

Table 6. Sex and martial status distribution of household head

(n= 130)

No.	Sex of household head	Non-adopter n=85	Adopter n=45
1	Female	7(8.2)	1(2.2)
2	Male	78(91.8)	44(97.8)
	Total	85(100)	45(100)
	Marital status		
1	Married	77 (90.6)	44 (97.8)
2	Widow	8 (9.4)	--
3	Widower	--	1 (2.2)
	Total	85 (100)	45 (100)

( ) percent

The respondents mean family size is 6.6 and 5.9 for adopters and non-adopters, respectively. It ranges from two to ten members of the family. The finding on the mean difference of both categories is provided in Table 7. The result shows that the mean family sizes of adopters are greater than non adopters. There is also significant mean difference between adopters and non adopters at P<0.05. This indicates that beekeepers with large family size opt more for technology adoption. This in turn implies technology adoption increases hive products which contribute to satisfy the need of their family. It is also positively associated with improved box hive adoption.

Table 7. Mean distribution of sample respondents by personal related variables

n=130

Variables	Adopter (n=45)	Non-adopter (n=85)	T-value	r_s	P
Age	M= 42.2 SD=8	M=47.2 SD=6	2.621***	-.226***	0.010
Family size	M= 6.6 SD=1.6	M=5.9 SD=1.6	2.043**	.178**	0.043
Beekeeping experience	M= 10.7 SD=8	M=9.5 SD=6	0.941Ns	0.083Ns	.348
Education	M= 2.7 SD=2.3	M=1.1 SD=1.9	4.239***	.351***	0.000

M=mean, SD= Standard Deviation, Ns, **, ***, non significant, significant at P<0.05 and P<.01

4.2. Beekeeping experience

Farm experience helps the farmer to get more understanding of management practices of the farm activities. In relation to beekeeping, as indicated in Table 7, there is no statistically significant mean difference between adopters and non-adopters.

The mean year of the respondents experience in beekeeping for adopter and non-adopters is 10.7 and 9.5 years, respectively. The result indicates that the mean years of beekeeping experience of both categories are nearly equal. Beekeeping experience alone cannot draw the beekeeper to adopt the technology.

4.3. Education of household head

It was found that 33.8% of the respondents cannot read and write. The remaining 38.5 % and 27.7% of the respondents attended formal education up to the level of 1-4 and 5-8 years of schooling respectively (Table 8). With regard to non-adopters 35.3 % of them did not attend any formal education. The remaining 35.3 % and 29.4% of the non-adopters had an educational level of 1-4 and 5-8 years of schooling, in the same order. Where as in relation to adopters 31.2 % of respondents cannot read and write, the balance 44.4 % and 24.4 % had an educational level of 1-4 and 5-8 grade, respectively (Table 8).

Table 8. Education level of respondents

(n=130)

No.	Education level	Non –Adopter (n=85)	Adopter (n=45)	Total
1	No grade	30 (35.3)	14 (31.2)	44 (33.8)
2	1-4	30 (35.3)	20(44.4)	50 (38.5)
3	5-8	25 (29.4)	11 (24.4)	36 (27.7)
	Total	85 (100)	45 (100)	130 (100)

( ) –percent

On the other hand, comparison was done between adopter and non-adopter in relation to their mean educational level (Table 7). It has statistically significant mean difference at $P<0.01$. This shows that the education level of adopters of improved box hive is higher than

non-adopters of the technology, implying the influence of the variable in making adoption decisions. The variable is also positively associated with adoption of improved box hive.

4.3. Socio- economics characteristics of the respondents

4.3.2. Farm size

Farm size was thought to be a good proxy indicator of wealth. The size of land distribution between adopters and non-adopters is on average 0.55 ha and 0.59 ha for adopters and non-adopters, respectively (Table 9). The respondents have the land size which ranges from zero to three hectare with the mean of 0.58 ha. It is below national average land size, which is 1.5ha. It could not indicate significant mean difference between both categories. The result shows that both categories have nearly equal size of land and implying that small farm size can not affect adoption of improved box hive in the study area.

Table 9. Mean distribution of sample respondents by socio economic related variables

n=130

Variables	Adopter (n=45)	Non-adopter (n=85)	T-value
Farm size	M= 0.55 SD=0.45	M=0.59 SD=0.35	0.465Ns
Apiary Size	M= 26.8 SD=5.2	M=19.01 SD=2.9	1.388Ns
Livestock holding	M= 4.4 SD=2.6	M=3.9 SD=1.8	0.615Ns
Honeybee colony holding	M= 3.2 SD=1.5	M=2.4 SD=1.3	1.590Ns

M=mean, SD= Standard Deviation, Ns=non significant,

4.3.3. Apiary Size

Apiary is the place where honeybee colonies are kept. The apiary size holding of the respondents ranges from 6 m^2 to 100 m^2 with the mean of 26.8 m^2 and 19.01 m^2 for adopters and non-adopters, respectively. It has no significant mean difference (Table 9).

This indicates that beekeeping activity can be undertaken on small land size. One of the relative advantages of beekeeping activity is also that it does not require fertile land and uncultivated area is also suitable for beekeeping. Hence, for landless farmers having apiary site is sufficient for engaging in the activity. Beekeeping needs relatively small apiary size and this implies that apiary size can not influence adoption of improved box hive.

4.3.4. Livestock holding

Livestock holding was thought to be a good proxy indicator for wealth. The major livestock reared in the area are cattle (ox, cow), sheep, goat, poultry, and donkey. Mean comparison was made between adopters and non-adopters using t-test and the result is provided in Table 9. The total livestock holding of the respondents was 529 TLU, ranging from 0 to 13.65. The mean livestock holding for adopters and non-adopters is 4.4 and 3.9, respectively. It has no significant mean difference. It reveals that there is no significant difference in the wealth status of both categories measured by livestock holding.

4.3.5. Honeybee colony holding

Honeybee colony is one of the prerequisite to decide adoption of improved box hive. In the study area, the price of one honeybee colony is about 550.00 Birr. It is too high compared to other areas of the country due to high demand and limited supply. The adopters and non-adopters on average had 1.4 and 2.4 honeybee colonies in traditional hives in their bee farm, respectively.

The over all honeybee colony holding of the area was 3.2 and 2.4 honeybee colonies for adopters and non-adopters, respectively (Table 9). Honeybee colony was also thought to be proxy indicator of wealth in the study area. However, the difference is not statistically

significant as the respondents had more or less equal number of honeybee colonies. In other words, having more or less number of honeybee colonies did not affect use of improved box hive. Participant observation also confirmed that there were beekeepers who decided to adopt the technology though they did not have honeybee colonies as it is possible to start beekeeping by purchasing honeybee colonies.

4.4. Perception of beekeepers about improved box hive

It was found important to identify perceived relative advantage of improved box hive and its relative disadvantage so as to get the general perception of beekeepers about improved box hive.

Table 10. Perception of respondents towards improved box hives

(n=130)

No.	Adopter (n=45)	Non-adopter (n=85)	T-value	r_s	P
1	M= 16.4 SD=2.6	M=13.8 SD=3.9	4.008***	.199**	0.023

M=mean, SD= Standard Deviation, ***, **- significant at P<0.01, P<0.05

High yield, ease for inspection, ease of harvesting of products, quality honey are the major relative advantages of improved box 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 improved box 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 box hive (Table 10), where as relative disadvantage and adoption of box hive was not correlated (Appendix 6b).

This implies that the beekeepers in the study area positively perceived about improved box hive which is a good opportunity for beekeeping extension intervention. Similarly,

statistically it is significantly different at P<0.01 with t-value=4.008 (Table 10). The result reveals that beekeepers who had positive perception of the technology adopt the technology more. 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.

4.5. Availability of accessories of improved box hive

Improved box hives requires accessories like casting mold and honey extractor. In the study area both equipments were used at group level. Honey extractors are found at PA level where as casting mold are found at district level. Effective utilization of those equipments enhance adoption of improved box hive. It was observed that foundation sheet service was provided for beekeepers at district level. The beekeepers were provided foundation sheets for both base and supers at the same time. Interview results with bee expert of the district had also coincided with the observation. This implies that fresh foundation sheet was not offered during supering (adding box) time. Such practice may decrease the acceptance of the foundation sheet by the honeybees. It can also be the harbor of wax moth unless it is stored in aired area. One of the beekeepers during key informant interview said, “I suspect the quality of the beeswax, its acceptance by the honeybees is very low.” The perception of the beekeeper is acceptable. As the foundation sheets stay for a long time in store, it looses its freshness, which attracts the honeybees. As indicated in Table 11 there is no significant different between adopters and non-adopters. It indicates that accessories were not the barriers for using improved box hive.

Table 11. Availability of accessories

(n=130)

Response	NAD n=85	AD n=45	χ^2
No	25 (14.4)	12 (26.7)	0.109Ns
Yes	60 (70.6)	33 (73.3)	
Total	85 (100)	45 (100)	

NAD- non-adopter, AD- adopter, ( )-percent, Ns= Non significant

The other accessories required for effective management of beekeeping are 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). Among the adopters of the box hive, 82.2 %, 84.5% and 51.1% have smokers, veil and glove, respectively, where as, 4.8%, 5.9% and 2.4% of the non-adopters were using smoker, veil and glove, respectively (Table 12).

Table 12. Distribution of protective materials

(n=130)

Accessories	Response	NAD n=85	AD n=45
Smoker	No	81 (95.2)	8 (17.8)
	Yes	4 (4.8)	37 (82.2)
Veil	No	80 (94.1)	7 (15.5)
	Yes	5 (5.9)	38 (84.5)
Glove	No	83 (97.6)	22 (48.9)
	Yes	2 (2.4)	23 (51.1)

( )- percent, NAD- non adopter, AD adopter

As indicated in Table 13, among the adopters the reason for not having protective materials were unavailability, expensiveness and using traditional materials which accounts for 36.4%, 45.5% and 18.1%, respectively. On the other hand 7.9%, 2.6% and 89.5% of non-adopters replied similar reason for not having protective materials in that order. Among the adopters, 5.6%, 77.8%, 11.1% and 5.5% also discontinued smoker; gloves; smoker, veil, glove; and smoker, glove in accordance of their order. According to the respondents 11.8%, 11.8% and

76.4 of causes for discontinuance were expensiveness of the material, unavailability, both expensive and unavailable, respectively.

Table 13. Protective materials utilization status of the respondents

(n=130)

Description	Reasons	NAD (n=76)	AD (n=11-18)	Total
Reasons for not using protective materials	Not found	6(7.9)	4 (36.4)	10(11.5)
	Expensive	2(2.6)	5(45.5)	7(8)
	Use traditional	68(89.5)	2(18.1)	70(80.5)
Protective materials discontinued	Smoker	-	1 (5.6)	1 (5.6)
	Glove	-	14 (77.8)	14 (77.8)
	Smoker, veil, glove	-	2 (11.1)	2 (11.1)
	Smoker, glove	-	1 (5.5)	1 (5.5)
Reasons for discontinuing	Expensive	-	2 (11.8)	2 (11.8)
	Unavailable	-	2 (11.8)	2 (11.8)
	Expensive and unavailable	-	13 (76.4)	13 (76.4)

NAD- non-adopter, AD- adopter, ( )-percent

4.6. Honeybee pest problems

The existences of honeybee pests can create obstacle for adopting improved box hives as they attack honeybees and hive products. The occurrence of honeybee pests for both adopters and non-adopters were similar. Table 14 summarizes that among the respondents, 100% of adopters and 95.3% of non-adopters replied the existence of pest problem in their bee farm. Hence, pest problem is a common problem in the study area for both categories.

Table 14. Honeybee pest problem occurrence by sample respondents

(n=130)

Response	NAD n=85	AD n=45	Total
No	4 (4.7)	---	4 (3.1)
Yes	81 (95.3)	45 (100)	126 (96.9)
Total	85 (100)	45 (100)	130 (100)

NAD- non-adopter, AD- adopter, ()-percent,

The major honeybees` pests exist in the study area were identified and prioritized by the respondents based upon the damage they cause on the honeybees and hive products (Table 15). According to the prioritization result, even though ant causes a serious problem, 21.1% of respondents were using improved ant protection method (Table 23). The non-adopters used traditional ant protection method i.e. adding ash under the hive stand. As a result, the over all number of respondents that used improved ant protection was minimal.

Table 15. Ranks of honeybee enemies

(n=130)

No.	Honeybee enemies	Frequency	%	Rank
1	Ant	45	34.4	1st
2	Wax moth	37	28.5	2nd
3	Honey badger	22	16.9	3rd
4	Birds	11	8.5	4th
5	Spider	10	7.7	5th
6	Hive beetle	4	3.1	6th
7	Lizard	1	0.7	7th

4.7. Institutional factors

Under this sub topic major institutional factors such as credit, extension, and market situation of hive products are discussed.

4.7.1. Credit

Credit programs may enable farmers to purchase inputs or acquire physical capital, needed for technology adoption (Feder *et al.*, 1985). 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, Dedebit Credit and Saving Institution (DCSI) provides to the maximum of 5000.00 Birr for farmer who requires credit. The interest rate for regular extension and package was 15% and 9% respectively. The interest rate of regular extension is high due to transaction cost and risk of repayment. With regard to package, ARD supports in facilitating credit and its repayment. As a result, its interest rate is minimal compared to regular extension. The loan has to be repaid within five years. However, credit alone by itself is not guarantee for technology adoption. It was found that 46.5% of the respondents were not the beneficiaries of the existing credit opportunity. This was mainly to avoid risk of repaying the loan from other sources, if expected amount of honey from improved box hive is not obtained (Table 16). The remaining 27.6%, 25.9% of the respondents have not used the credit due to unavailability and high interest rate respectively.

In relation to this, during group discussion, one of the participants said "there is no guarantee to receive credit and engage in beekeeping because if absconding occurs no yield is obtained to repay the loan and one is enforced to repay the loan from other sources". This implies that the beekeeper lacks confidence in the technology and skill in bee management. Once the beekeeper is equipped with skill in improved beekeeping management, it is possible for the beekeeper to manage absconding problem and other beekeeping management practices. Among the adopters, 21.6% were repaying their loan by selling the hive products; the balance 67.6 % and 10.8% of the respondents were repaying their loan from hive product or other sources; and other sources, in the same order (Table 16). It was observed that there was no fungiblility problem as the beekeepers used the credit for the intended purpose.

Table 16. Constraints of credit and means of loan repayment

(n=95)

No.	Constraints	NAD (n=58)	AD (n=37)
1	Unavailable	16 (27.6)	--
2	High interest rate	15 (25.9)	--
3	Risk aversion	27 (46.5)	--
	Total	58 (100)	
	Loan Repayment		
1	Hive product	-	8 (21.6)
2	Other sources	--	4 (10.8)
3	Hive product and other source	-	25 (67.6)
	Total		37 (100)

( )-percent ,NAD- non adopter, AD-adopter

With regard to receiving credit, the adopters have more used the credit (Table 17). It is also found that it is significantly different at $P<0.01$. In the study area promotion of the technology is accompanied by credit, as the fact the beekeepers who decide to adopt the technology can get credit.

Table 17. Credit using status of sample respondents

(n=130)

Response	Non adopter (n=85)	Adopter (n=45)	χ^2
No	62 (72.9)	5(11.1)	45.036***
Yes	23 (27.1)	40 (88.9)	
Total	85 (100)	45(100)	

( ) percentage , *** significant at $P<0.01$

4.7.2. Extension contact

Extension plays a great role in promoting improved beekeeping technologies. In beekeeping to offer effective extension service, the extension workers themselves need to be well equipped in skill in the technology. Based on the interview result with district bee expert and observations made, the beekeepers had directly got technical assistance from the bee expert

of the district. This indicates that the involvement of DA in providing technical assistance to the beekeepers was minimal. As shown in Table 18, 84.4 % of the adopters contacted with extension agent. This assists the beekeepers to know more about the technology, which in turn help them to utilize at the technology effectively. The difference is statistically significant at P<0.01. This shows that the beekeepers who frequently visit extension agent get more acquaintance with technology and tends to decide adoption of the technology.

Table 18. Status of extension contacts of the respondents

(n=130)

Response	Non adopter (n=85)	Adopter (n=45)	χ^2
No	49 (57.6)	7 (15.6)	21 .259***
Yes	36 (42.4)	38 (84.4)	
Total	85 (100)	45 (100)	

( ) percentage *** significant at P<0.01

4.7.3. Apiary visit

Visiting the apiary helps the beekeeper to learn more about the technology. It also motivates the beekeepers towards adopting the technology. Among the respondents, 29.4 % and 71.1 % of non-adopters and adopters respectively, had got an opportunity to attend apiary visit which was organized by extension (Table 19). It is statistically significantly different at P<0.01. This shows that the beekeepers that got an opportunity of visiting the apiary adopt more the technology. During visiting 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 findings of Melaku (2005), which explains that there is significant association between adoption and apiary visit by farmers.

Table 19. Apiary visit status of the respondents

(n=130)

Response	Non adopter (n=85)	Adopter (45)	χ^2
No	60(70.6)	13 (28.9)	20.780***
Yes	25 (29.4)	32 (71.1)	
Total	85 (100)	45 (100)	

( ) percentage *** significant at P<0.01

4.8. Knowledge on improved box hive

Improved beekeeping technology requires knowledge on its practical activities. The knowledge source could be farm experience, research, extension and NGOs. Five practical questions were provided for beekeepers to identify their level of knowledge on improved beekeeping practices. The mean score of adopters and non-adopters were found to be 4.7 and 3.3, respectively (Table 20). It is significantly different at P<0.01. It is also positively corralled with adoption of technology at (r=0.472, P=000). This shows that having knowledge of the technology assists adoption of improved box hive. The result is in line with Yadav (1992) who found that adoption of improved paddy cultivation practices had a highly significant and positive correlation with knowledge of farmers. The finding also agrees with Degnet and Belay (2001) who found that farmers' knowledge of fertilizer use and its application rate positively influenced adoption of high yielding maize varieties.

Table 20. Knowledge of respondents on box hive management

(n=130)

Adopter (n=45)	Non-adopter (n=85)	T-value	r_s	P
M= 4.7 SD=0.6	M=3.3 SD=1.4	6.054***	.472***	0.000

M=mean, SD= Standard Deviation, ***- significant at P<0.01

4.9. Hive product marketing

The availability of market for the hive products enhances the adoption of improved box hive. In the study area, 21.2 % of non-adopters and 75.6% of adopters replied that there was market for their honey (Table 21). However, there was no ready market that absorbs the honey produced in sustainable way (Box 1). It was observed that the respondents were supplying their honey to market in nearby towns (Atsbi and Wukro). In the study area, the following honey marketing channel was also observed.

1. Producer--------consumer
2. Producer-------honey collector------consumer
3. Producer-----honey collector---processing ---consumer

During the study period, there were few honey collectors that did not purely engaged in honey collection activities. As observed, the collectors are those individuals engaged in trading consumer goods. The activity of honey collection was few parts of their major role. The first channel was the dominant activity in the study area, where as, the second honey marketing channel was weak due to inefficient and few number of participants i.e. they do not collect honey in large quantity and supply to other areas. The third honey marketing channel was at initial stage and this can be strong when fully operated.

Table 21**.** Responses of sample respondents on Market availability

(n=130)

Response	Non adopter (n=85)	Adopter (n=45)	χ^2
No	67 (78.8)	11(24.4)	36.253***
Yes	18(21.2)	34 (75.6)	
Total	85 (100)	45 (100)	

( ) percentage *** significant at P<0.01

As indicated in Table 21, it is significantly different at P<0.01. The result indicates that adopters have more market for their product. This is mainly due to honey produced in improved box hive has quality and as a result has high demand. It is free of pollen, bees-wax, brood and debris.

Group discussion was also held to strengthen the result of the quantitative part (Box 1). It was undertaken with five beekeepers consisting both improved box hive users and non users. The importance of making the discussion with two groups helped to get fully information on market problem of pure honey and crude honey.

Box 1. Group discussion on honey marketing

The group discussion was made at Dibab Akorein PA with five beekeepers. The discussion was focused on honey marketing situation of the area. Ato Abraha Girmay, one of the participants expressed about honey marketing as "so far, we are selling our honey on individual bases and we do not have bargaining power" the price is determined based on the existing demand during the market day. It was also observed that there was no strong honey collector. This indicates that even though the district has high honey production, there was no ready market that attracts the beekeepers. The beginning of Dimma enterprise in establishing honey-processing plant at Adigrat would be a potential market for honey production in the area. The honey processing plant would be a constant receiver of honey production and needs frequent supply of honey. To fulfill the demand of the honey processing plant, honey production should be maximized. Ato Tesfaye Tadesse, one of the beekeepers during the group discussion also said, "Dimma enterprise is beginning honey collection from the area. It is a good opportunity for us to get market for our honey production". During the study period, Dimma honey processing plant was testing its machine efficiency and for this purpose, it collected 200kg honey from Atsbi. Dimma purchases honey from beekeepers at market price of the area. The beekeepers get an advantage of sustainable market for their product. Dimma also makes moisture content testing and physical assessment on the quality of honey during honey collection. This leads the beekeepers to produce quality honey to get market for their product. To utilize the opportunity organizing beekeepers is desirable. As an initial step, organizing informal groups which can engage in collective marketing would be a good start. By realizing the benefits of collective marketing, well organized formal co-operatives can develop in due course. Once the beekeepers are organized, the PA can support them in providing apiary site; from financial organization they can get credit and other technical support. They can also get bargaining power and sell their honey at attractive price.

4.10. Beekeeping training

Beekeeping training develops the beekeepers' self-confidence in the technology. It also increases the productivity of the beekeepers. In the study area, Agricultural and Rural Development and Non- Governmental Organization organized beekeeping training. The trainings were offered on bee management, hive product and colony multiplication. The result is summarized in Table 22.

Table 22. Responses of sample respondents on beekeeping training

(n=130)

Response	Non adopter (n=85)	Adopter (n=45)	Total	χ^2
No	80 (94.1)	11(24.4)	91 (70)	68.014***
Yes	5(5.9)	34 (75.6)	39 (30)	
Total	85 (100)	45 (100)	130 (100)	

( ) percentage *** significant at P<0.01

Among the respondents 30% of them got the training. The remaining 70% of the respondents did not get the training. This indicates that the training coverage was low. As a result, the majority of the beekeepers were using their indigenous knowledge. Need based beekeeping training could back promotion of beekeeping technology so as to obtain the intended amount of hive products. It is significantly different at P<0.01, which implies developing the skill of beekeeper through beekeeping training enhanced adoption of improved box hive. It was also observed that 24.4% of the adopters did not get training on improved beekeeping practices (Table 22). In the other ways, they were provided only the box hives. Under such situation, the beekeeper cannot be the beneficiary of the technology, as it requires skill. Those respondents who got beekeeping training found the training to be useful. This indicates that the beekeepers were well acquainted with effective utilization of improved box hive along with its management practices.

4.11. Improved box hive adoption

Improved box hive was introduced to Ethiopia in 1960`s when different beekeeping stations were established in the country. There are different types of improved box hives such as Zandar, Langstroth, Foam, and modified Zandar etc. In the study area, improved box hives have been introduced after 30 years of its introduction to the country. Even though the duration of its introduction to the district is short the promotion of the technology is encouraging. During the study period, the district had 5716 improved box hives, which is Zandar in type. Among the respondents, 34.6% of them were adopting the technology. It is nearly equal to the secondary data obtained from the District ARD, i.e. 33.8%. As also noted by EEA (2005) at the regional level, 31.23 % of beekeepers have received improved box hive from extension agents. The existing beekeeping extension of the study area is to address all the beekeepers with improved box hives.

The respondents of adopter's category had the total number of 170-box hives. The average number of box hive per adopter was 3.7; where as, the average number of improved box hive per adopter of the district was 2.3. The beekeepers have interest in improved box hive. They have understood its advantage over traditional beekeeping management. However, the cost of the technology and honeybee colony is too high according to their perception. The result of group discussion (Box 2) clearly indicates the general picture of the technology in the view of the beneficiaries.

Box 2. Group discussion on improved beekeeping practices

A group discussion has been held with some beekeepers of Michael Emba PA on improved beekeeping activities. They were six in number. Among the group, Ato Gebreegizaber Haftu said "we are aware about the advantages of improved box hive compared to traditional beekeeping. Adding to this, improved beekeeping practice offers high quality and quantity of honey. It is also suitable for hive inspection, feeding, supering and harvesting." The other participant also expressed regarding the area's honey quality as "the color of our honey is white and it is preferable by the consumer to any other colors in the area." Beekeepers give high value for beekeeping and they express the value of beekeeping in *Tigringa*: - "*»{¼#y»P#Ä ªÕ#W »°#[¤;#y»P#ýA«##ŧLx@#[¤;#y»P#»X#p /V#[¤*" Which is translated as "he is the owner of white honey; he is the owner of strong colony. His honey is the best for '*Teji*' production which is a local drink". It is noticed that beekeeping has high value among the beekeepers and it paves the way for beekeeping extension intervention. It is obvious that improved box hive is introduced to the district eight years ago. Even though the duration is short compared to the inception of improved beekeeping practices in the country, which is in 1965, because of the beekeepers readiness and eagerness for change improved box hive promotion is encouraging and can be a good exemplar. The other participants also agreed with their colleagues view but they stressed on the high cost of the box hive. Based up on the observation and discussion made on the area, beekeepers were using one super but they received two supers. Hence, there is an opportunity to reduce the price of the hive if the beekeepers are provided with one super (Appendix 1a) instead of two supers. In addition, beekeepers can make hive stand from locally available materials. As observed the hive stand of box hive is made up of metal, which also increases the cost of the hive. So, with the reduction of these two items, the price of the hive can be reduced. Another issue raised by Ato Leul Ayalew is that about the problem of `*imodia*` (rust) which affect the flower, as a result the honeybee cannot get nectar and pollen. This requires further investigation to search for appropriate solution.

4.12. Major beekeeping practices by sample respondents

The beekeepers of the study area have developed different beekeeping practices using their Indigenous Technical Knowledge (ITK) and beekeeping training. Under this sub topic, major practices such as feeding, bee forage planting, colony multiplication etc. have been discussed

4.12.1. Honeybee feeding and bee forage planting practices

Honeybees store honey for their own consumption during dearth period. Beekeepers are harvesting honey, which the honeybees stored for themselves. As a result, honeybees face starvation due to lack of feed. To overcome the problem, supplementary feed is required for the honeybees. In this study, it was found that 80% and 69.4% of the respondent provided supplementary feed from adopter and non-adopter categories respectively (Table 23).

The supplementary feed includes sugar, barley flour, peas and beans flour. Both adopters and non-adopters were providing supplementary feed to their honeybee colonies. In addition to supplementary feeding, planting bee forage is also required to get the intended honey yield.

Bee forage determines the amount of honey yield obtained. The existence of more bee forage results in high honey production provided that other factors are suitable for honey production. In the study area, there was no improved bee forage promotion. However, there was an extension activity, which encourages beekeepers to grow indigenous bee forage such as (in *Tigrigna*) `*gribiya*` (*Hypostus ariculata*) and `*tebeb*` (*Basium clandiforbium*). These plants are herbaceous and contribute high in honey production of the area. The beekeepers also grow different bee forages. Accordingly, 84.4% of the adopters and 36.1% of the non adopters were growing different indigenous bee forage (Table 23).

Table 23. Beekeeping practices of sample respondents

(n=130)

No	Practices	Non adopter	Adopter	Total
1	Hive shading			
	no	21 (24.7)	1 (2.2)	22 (16.9)
	yes	64 (75.3)	44 (97.8)	108 (83.1)
2	Supplementary feed			
	no	26 (30.6)	9 (20)	35 (26.9)
	yes	59 (69.4)	36 (80)	95 (73.1)
3	Bee forage			
	no	53 (63.9)	7 (15.6)	60 (46.2)
	yes	30 (36.1)	38 (84.4)	68 (53.8)
4	Improved ant protection			
	no	81 (97.6)	20 (44.4)	101 (78.9)
	yes	2 (2.4)	25 (55.6)	27 (21.1)
5	Honeybee colony multiplication			
	no	39 (45.9)	21 (46.7)	60 (46.2)
	yes	46(54.1)	24 (53.3)	70 (53.8)
6	Post harvest handling			
	no	50 (73.1)	---	50 (38.5)
	yes	35 (26.9)	45 (100)	80 (61.5)

( ) indicates percentage

4.12.2. Hive shading construction and ant protection practices

Hive shading is one of the practices that is recommended to protect the honeybees from high temperature, wind and rain. Among the users of improved box hive 97.8% were adopting the practice whereas 75.3% of non-adopters were constructing hive shade (Table 23).

In the study area, ant causes a serious damage on honeybees and hive products. According to respondents' prioritization result, ant stood in the first rank among honeybee pests (Table 15). Among the beekeepers who adopt improved box hive, 55.6% used improved ant protection method. On the other hand, 97.6% of non-adopters were not using improved ant protection method (Table 23).There are different ant protection methods. All types of ant protection methods were used only by adopters. Table 24 summarizes that 56% of the respondents used cone shaped metal sheet and the balance 40% and 4% used cone shaped

used inner tube of rubber and used engine oil, respectively. The beekeepers who did not adopt improved box hive protect their honeybees using traditional methods of ant protection, which is mainly adding ash under the hive stand.

Table 24. Uses of different ant protection methods by sample respondents

No.	Ant protection materials	NAD	AD (n=31)	Total
1	cone shaped metal sheet	-	14 (56)	14 (56)
2	used engine oil	--	1 (4)	1 (4)
3	cone shaped used inner tube of rubber	-	10 (40)	10 (40)
	Total	-	25 (100)	25 (100)

( )-percent, NAD- non adopter, AD-adopter

In addition to aforementioned practices, the respondents were also practicing colony multiplication. It serves for two purposes. These are to increase the number of honeybee colonies and to earn additional income by selling honeybee colonies. It was found that 53.3% of the adopters and 54.1% of the non adopters used colony multiplication practices (Table 23). They were using different colony multiplication techniques among which over crowding were the dominant practice

The effectiveness of the practices depends on the quality of the products. Hence, Importance of sanitation is unquestionable in hive products so as to keep the quality of honey and to be competent in the market. Honey is a food item, which is mostly consumed directly. Hence, the honey should be unadulterated and uncontaminated during harvesting, extracting, and storing. Traditionally beekeepers store the honey in clay pot, gourd (made of cucumber), small '*tasa*', plastic bag (sack of fertilizer), and bags made of animal skin etc. These equipments decrease the quality of the honey. In the study area, all the adopters were storing their honey in plastic bucket, which is the recommended material to maintain the quality of honey (Table 23). The beekeepers who decided to adopt improved box hive more incorporated appropriate post harvest handling of hive products.

Generally, the success of effective utilization of improved box hive depends on incorporation of other improved beekeeping practices. These improved practices are hive

shade construction, supplementary feed, colony multiplication, appropriate post harvest handling of hive products, bee forage planting; and improved ant protection methods. Only 26.7 % of the adopters were using all types of practices (Table 25). The beekeepers who adopt improved box hive relatively more integrated other improved beekeeping practices to their bee farm. However, other combinations of components were used mainly by the non-adopters (Table 25). Beekeeping extension was also addressing non-adopters so as to incorporate improved beekeeping practices in their bee farm. In all combination of practices almost post harvest handling practice exists. The beekeepers are paying due attention to hive product quality and enables them to be competent in hive product marketing. The result of participant observation also confirmed that the beekeepers were storing the honey using plastic jar, in moisture free area. This gives extra value to their honey, which is white and preferable by the consumer.

Table 25. Combination of beekeeping practices

(n=130)

Practices in combination	**Response**	**Adopter** (n=45)	**Non adopter** (n=85)	**Total**
Shade, feed, post harvest handling	No Yes	44 (97.8) 1 (2.2)	74 (87.1) 4 (12.9)	118 (95.9) 5 (4.1)
Shade, feed, colony multiplication,	No Yes	44 (97.8) 1 (2.2)	64 (75.3) 21 (24.7)	108 (83.1) 22 (16.9)
Shade, feed, flora, colony multiplication	No Yes	38 (84.4) 7 (15.7)	74 (87.1) 11 (12.9)	112 (86.2) 18 (13.8)
Shade, feed, flora, post harvest handling	No Yes	44 (97.8) 1 (2.2)	71 (83.5) 14 (16.5)	115 (88.5) 15 (11.5)
shade, feed, colony multiplication , post harvest handling	No Yes	30 (66.7) 15 (33.3)	7 (8.2) 78 (98.8)	37 (28.5 93 (71.5)
Shade, colony, post harvest handling	No Yes	45 (100)	84 (98.8) 1 (1.2)	129 (99.2) 1 (0.8)
Feeding, bee forage, colony multiplication, ant protection, hive shading, post harvest handling (all practices)	No Yes	33 (73.3) 12 (26.7)	85 (100) -	118 (90.8) 12 (9.2)
Feeding, bee forage, ant protection, hive shading	No Yes	39 (86.7) 6 (13.3)	85 (100) --	124 (95.4) 6 (4.5)
Shade, feed, ant protection	No Yes	41 (95.3) 2 (4.7)	85 (100) --	126 (98.4) 2 (1.6)

( ) Percent

4.13. Absconding of honeybees

Absconding is the total movement of honeybee colony by leaving the hive. Absconding can happen due to different reasons. Lack of feed, honey bee pests and drought are the main problems that may cause absconding. During group discussion and observation, it was found that there was absconding problem for both adopters and non-adopters. This implies that absconding is the common problems of both adopters and non- adopters. The main causes of absconding from the hives were lack of feed, which accounts 42.2%. Honeybee enemies, honeybee disease and indiscriminate agrochemical application accounts for 34.3%, 7.8%, and 15.7%, respectively (Table 26).

Table 26. Main causes and control methods of absconding

(n=102)

No.	Causes of absconding	NAD (n=71)	AD (n=31)	Total
1	Honeybee enemies	19 (26.8)	16(51.6)	35 (34.3)
2	Lack of feed	40 (56.3)	3 (9.7)	43 (42.2)
3	Honeybee disease	5 (7)	3 (9.7)	8 (7.8)
4	Agro chemical	7 (9.9)	9 (29)	16 (15.7)
	Total	71 (100)	31 (100)	102 (100)
	Means of absconding control			
1	Using queen cage	---	10 (32.3)	10 (9.8)
2	Cutting wing's of queen	42 (59.2)	14 (45.2)	56 (54.9)
3	Fixing piece of queen excluder on hive entrance	----	2 (6.5)	2 (2)
4	Protecting honeybee from enemy	29 (40.8)	5 (16)	34 (33.3)
5	Total	71 (100)	31 (100)	102 (100)

( )-percent, NAD- Non Adopter, AD-adopter

As indicated in Table 26, beekeepers use different mechanisms to strengthen the acceptance of their hives by honeybees. Accordingly, 54.9% of the respondents were exercising cutting

the wing of the queen. The remaining 9.8%, 2%, 33.3% of the respondents were using queen cage, fixing piece of queen excluder on the entrance of the hive, protecting from honeybee enemies, respectively. According to the respondents they used different means to substitute the absconded colony such as through purchasing, catching the swarm and multiplying the colony.

4.14. Means of engaging in beekeeping

Farmers can start beekeeping using different methods. The majority of the beekeepers started beekeeping with purchased honeybee colony (Table 27). HBRC beekeeping training manual (2004) also recommends the beginners to start with purchased colony, as it is strong and well established. Beekeepers can start beekeeping activities by catching the swarm, purchasing or through inheritance. According to the respondents 58.8 % of them started beekeeping by purchasing the honeybee colony the remaining 22.5 %, 3.1%, 14%, 1.6% started by catching the swarm; through inheritance; catching and purchasing; catching and inheritance in that of order (Table 27). The result indicates that both adopters and non-adopters engaged in beekeeping activity with similar situation in all ways of starting beekeeping.

In relation to apiary site, in the study area 46.2%, 0.7%, 4.6%, 48.5% of the respondents were keeping their bees in backyard, in forest, under roof, and in the house respectively (Table 27). Forest beekeeping is highly minimized in the area, which was very difficult to use improved beekeeping practices. The majority of the respondents were keeping their bees in backyard and in the house, which accounts 46.2% and 48.5% respectively. Such apiary sites are appropriate for daily activities of beekeeping. Beekeepers have accumulated indigenous knowledge on beekeeping as they were making follow up to their bees in their nearby areas. This in turn helped them to practice improved beekeeping practices.

Table 27. Means of getting honeybee colony and apiary site of the sample respondents (n=130)

No.	Means of colony getting	NAD (n=85)	AD (n=45)	Total
1	Catching the swarm	24 (28.3)	5 (11.1)	29 (22.5)
2	Purchasing	45 (52.9)	31 (68.9)	76 (58.8)
3	Inheritance	3 (3.5)	1 (2.2)	4 (3.1)
4	Catching or purchasing	10 (11.8)	8 (17.8)	18 (14)
5	Catching or inheritance	3 (3.5))	--	3 (1.6)
	Total	85 (100)	45 (100)	130 (100)
	Apiary site			
1	Backyard	40 (47.1)	20 (44.4)	60 (46.2)
2	In forest	1 (1.2)	--	1 (0.7)
3	Under the roof	6 (7.1)	--	6 (4.6)
4	In the house	38 (44.7)	25 (55.6)	63 (48.5)
5	Total	85 (100)	45 (100)	130 (100)

( )-percent, NAD- non adopter, AD- adopter

4.15. Family responsibility in different beekeeping activities

As noted by Robinson (1980), among the relative advantages of beekeeping one is that whole family can involve in beekeeping activities since men, women or elder children can do the work at home. Accordingly, there are different beekeeping activities such as swarm catching, transferring, hive inspection, honeybee feeding, honey harvesting, honey extracting and honey selling. The members of the family have their own contribution in undertaking the activities. Identifying the responsibility of the household assists for appropriate target group selection. Figure 3 depicted the involvement of the family in different beekeeping activities. Husband alone undertook 46% of beekeeping activities. The others were wife; children; husband and wife; husband, wife and children undertook 18.5%, 2.2%, 27.2%, and 5.7 % of beekeeping activities in that order.

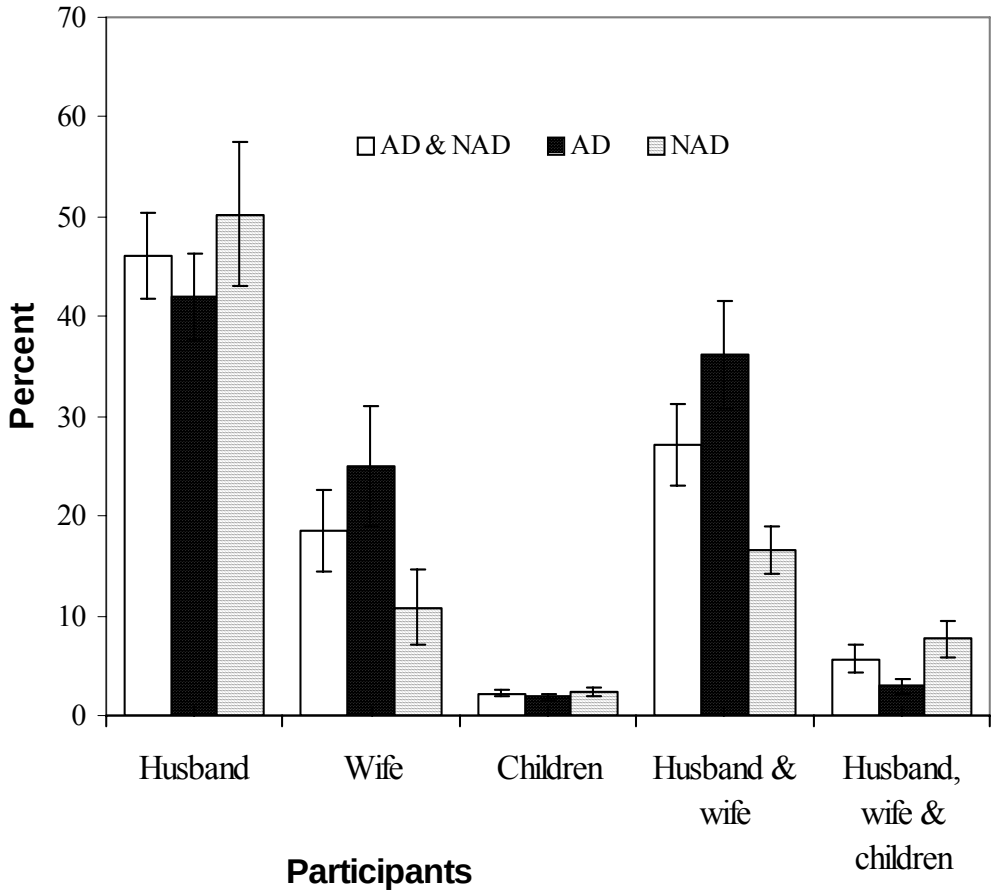


Figure 3**:** Family participation in beekeeping activities.

AD- Adopter, NAD- non-adopter. Bars indicate ±SE (n= 73 to 129 individuals).

Husbands from adopter and non-adopter households undertook 42% and 50 % of beekeeping activities respectively (Figure 3). It is not statistically significantly different. The result indicates that nearly equal numbers of husbands from both categories were participating in beekeeping activities. The participation of wife in beekeeping activities was high in adopter category and the difference is significant at $P<0.1$. This indicates that improved beekeeping activities are convenient for participating women. In the other way, adoption of improved box hive increases the labor share of women. It does not need hanging the hive in the tree or under the roof as that of traditional hives, which is difficult for women to climb. Improved beekeeping activities can not overload the women as the activities (honey extraction, harvesting, transferring etc.) are carried out during off time i.e. during night and it is not done regularly. For instance, transferring can be done once unless to add more hives or to replace the absconded honeybee colony and honey extraction can be done

twice a year in the study area. As realized in group discussion, the sale of honey in most cases is undertaken by women and there is an opportunity to increase their benefit from hive product selling due to adopting improved box hive.

The participation of husband and wife (in combination) in beekeeping activities was also significantly higher at $P<0.01$, in adopter category. The result reveals that women can equally participate in improved beekeeping activities, if they are addressed by beekeeping extension.

4.16. Determinants of Adoption of Improved box hive

Explanatory variables that are selected for econometric model would be discussed based upon the model output. Accordingly, as indicated in Table 28, 90 % of the total variation for the improved box hive is explained by logistic model. The χ^2 result also shows that the parameters are significantly different from zero at $P<0.01$ for the adoption of improved box hive. The model correctly predicted sample size of 84.4 % and 92.9% for adopters and non-adopters, respectively. The explanatory variables that fit the model, credit, Knowledge, education level of household head, perception and visit demonstration were found to be significant as hypothesized. Age, family size, extension contact, market availability and beekeeping training were insignificant. The result implies that there is no variation between adopters and non-adopters in mean age and family size. The other explanatory variables such as beekeeping training, extension contact and availability of market were also insignificant. Probably, their less influence in the regression is due to other factors such as high cost of the technology and honeybee colony which more affect the technology adoption. The result of group discussion coincides with the out put as it identified the high cost of improved box hive and honeybee colony.

Table 28. Logistic regression for factors influencing improved box hive adoption

Variables	B	S.E.	Wald	Sig .	Exp(B)
AGE	-.017	.045	.150	.699	.983
FAMLSIZ	.382	.257	2.211	.137	1.466
EDUCATI	.446	.172	6.729	.009***	1.562
PERCEPTION	.252	.134	3.523	.061*	1.287
CREDIT	2.607	.968	7.251	.007***	13.555
EXTCONTA	.805	.628	1.643	.200	2.237
VISTDEM	2.262	.905	6.247	.012**	9.598
KNOWLED	1.656	.603	7.549	.006***	5.239
MKTAVAIL	1.257	.789	2.538	.111	3.515
BKTRAIN	.144	.413	.122	.727	1.155
Constant	-15.465	4.362	12.570	000	000

-2 log likelihood 59.852
χ^2 107.857***
Predicted adopter 84.4 %
Non-adopter 92.9%
Over all 90%
*, **, *** significant at p<0.1, p<0.05, and p<0.01

The explanatory variables that were significantly influencing adoption of improved box hive are discussed as follows;

Credit – In the study area, improved box 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 P<0.01, the odds in favor of adopting improved box hive increased by a factor of 13.6 for beekeepers who had received credit. The result reveals that the availability of credit and receiving enhances beekeepers adoption decision on improved box 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 improved inputs.

Knowledge – Improved beekeeping technology require knowledge on its practical activities. It is statistically significant at P<0.01, the odds in favor of adopting improved box hive increased by a factor of 5.24 for beekeepers who had better skill on improved beekeeping practices. The result is in line with Yadav (1992) who finds that adoption of improved paddy cultivation practices was a highly significant and positive correlation with knowledge of farmers. The finding is also agrees with Degnet and Belay (2001) study that shows farmers knowledge of fertilizer use and its application rate positively influenced adoption of high yielding maize varieties.

Education – Education increases the knowledge of beekeepers on improved box hive as they get more access to information. It also increases the understanding of the technology which, in turn, helps to easily apply the technology. As hypothesized, education influences adoption of improved box hive positively and significantly at P<0.01 %. The odds in favor of adopting improved box hive increased by a factor of 1.56 for beekeepers who had more education level. The result is also supported by earlier studies of Voh (1982), Feder *et al*. (1985) and Cramb (2003).

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 at P<0.05. The odds in favor of adopting improved box hive increased by a factor of 9.6 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

Perception – Positive perception of beekeepers about the technology increases adoption decision and it influences adoption of improved box hive positively and significantly at P<0.1. The odds in favor of adopting improved box hive increased by a factor of 1.28 for beekeepers who positively perceived the technology. The result reveals that beekeepers who had positive perception of the technology adopt the technology more. 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.

4.17. Major constraints of beekeeping sub sector in the study area

In order to utilize the beekeeping sub sector, identifying the existing constraints and searching for solutions are of paramount importance. During data collection, group discussion was held with representative respondents. The objective of group discussion was to identify the existing constraints of beekeeping sub sector. Accordingly, the participants identified ten major constraints. All problems cannot be solved at once because of time and capital shortage. As a result, prioritization of the problems was made to identify the most important constraints that hinder the development of beekeeping sub sector in the study area. The constraints can also hinder adoption of improved box hives (Table 29).

Table 29. Ranking of beekeeping constraints in the study area

No.	Constraints	Frequency	Rank
1	Drought	41	1st
2	Absconding of Honeybees	39	2nd
3	Disease and pest	15	3rd
4	Lack of beekeeping material	10	4th
5	Death of colony	6	5th
6	Lack of Extension support	5	6th
7	Marketing problem	4	7th
8	Shortage of bee forage	3	8th
9	Lack of beekeeping skill	2	9th
10	Reduction of honeybee colony	1	10th

Source-own data computation

As indicated in Table 29, drought is the primary constraint in beekeeping sub sector in the study area. It affects their feed sources (bee forage and water). As a consequence, the honeybee colony absconds to areas where resources are available for their survival. The existence of honeybees' disease and pests affect the honeybees' life which, in turn, also leads them to absconding. The remaining constraints prioritized above affect the hive products of the study area, though their degree of influence is different.

4.18. Honey harvesting season of the study area

Understanding the honey-harvesting season of the area assists for different extension activities such as provision of technical assistance, beekeeping training on pre harvest and post harvest, arrangement of market, arrangement of beekeeping equipment especially which serves for group (casting mold and honey extractor in the context of the study area) etc. This, in turn, facilitates adoption of improved box hive as the beekeepers can get assistance from technology introduction to marketing of the output. In the study area, Honey harvesting starts in August and completes in December (Figure 4). The peak honey-harvesting season

of the area is September to November. During one harvesting season there is an opportunity of harvesting honey 2-3 times per hive.

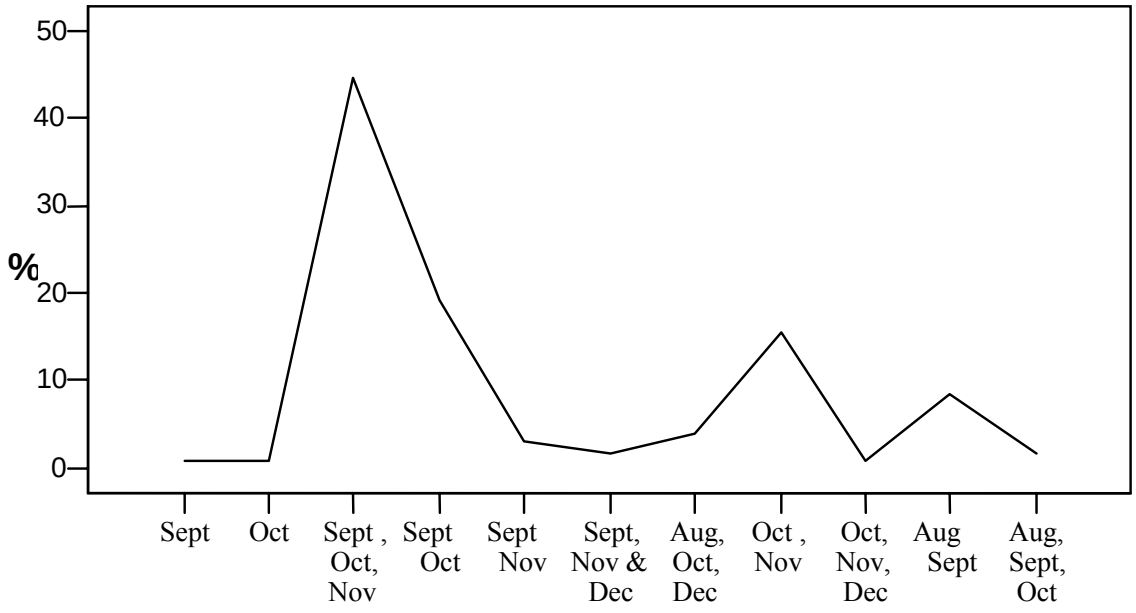


Figure 4: Honey harvesting season of the study area

Generally, September to December are active season and others month are dearth periods for beekeeping activity. With this information, in the study area appropriate seasonal honeybee colony management (for active and dearth period) can be undertaken.

4.19. Financial benefit

Yield is an important determinant factor in adopting the technology. The higher the yield obtained from the introduced technology easier it is to convince the farmers to adopt the technology. In the study area the minimum and maximum honey yield per annum for improved box hive is 8 kg and 64kg, respectively. The mean annual honey yield is 27kg. It is above the national honey yield average, which is about 20-25kg/hive/annum. The price of one kg pure honey was 35.00 Birr at farm gate and 50.00 Birr at nearby regional town. Hence, a beekeeper could get 945.00 - 1350.00 Birr gross benefit per hive/annum.

4.20. Financial loss

There was financial loss due to absconding of honeybees from improved box hive and traditional hive in the study area**.** Among the adopters, there was 53 empty improved box hives (Table 30). On average a box hive can yield 27kg/annum. Hence, annually there was a loss of 50,085.00 Birr assuming that the price was 35.00 Birr/kg. There was also 57 empty traditional hives among the respondents during 2005/6-production year. The average honey yield from a traditional hive (Appendix 1c) was 10kg crude honey and with the price of 25.00 Birr/kg the annual loss could be 14,250.00 Birr. Totally, from both types of hives there was annul loss of 64,335.00 Birr.

In addition to this, bees-wax, which has different advantages such as foundation sheet making, candle making, shoe cream etc has not been utilized in the study area. It is possible to harvest from a box hive 1% pure bees-wax of the harvested honey per annum (Nuru, senior bee researcher, personal communication). With this reality from 117 box hives, which yields on average 3159kg annually, 31.59 kg pure bees-wax could be obtained. On the other hand, from a traditional hive 5% pure bees-wax of the harvested honey can be harvested annually. The sample respondents had 229 traditional hives which yields on average 2290 kg crude honey annually. It could be possible to get 114.5kg pure bees wax from traditional hive. Totally, it is possible to harvest 146.09 kg pure bees-wax from both hives. In the study area, a kg of beeswax costs 41.05 Birr. It is possible to conclude that from the existing 117 improved box hives and 229 traditional hives, it would be possible to earn 5997.00 Birr annually from a sale of bees-wax.

Table 30. Honeybee colonies occupation rate in different hives

No.	Hive type	With bees	Without bees	Occupation rate
1	Improved box hive	117	53	68.8%
2	Traditional hive	229	57	80%
	Total	346	110	76%

The occupation rate of improved box hive by honeybees is too low compared to traditional hive. This implies that there was high absconding rate from improved box hive probably due to beekeepers` shortage of skill in beekeeping management practices. The average honey yield from both hives indicates that the area has potential for beekeeping.

The respondents had 170 box hives and 286 traditional hives. Among the total number of both types of hives 24% was not serving for hive products as 110 hives were without honeybees. In addition other hive products such as bees-wax, pollen, royal jelly, propolis and bee venom are not yet used. Hence, when the annual loss is considered, in the area, beekeeping sub sector was not exploited to its maximum.

Table 31. Partial budget for improved box hive and traditional hive

(n=45)

Column 1			Column 2		
Added cost (Birr)	improved box hive	traditional hive	Additional return (Birr)	improved box hive	traditional hive
Transport	12.55	--	Honey yield	945	250
Accessories service charge	19	--	Total added return	945	250
Interest	23.65	0.26			
Feed cost	26.5	8.70			
Pure bees -wax	123.15	--			
Labor cost	15	5	Reduced cost	--	--
Total added cost	219.85	13.96	Total reduced cost	--	--
Reduced return	--	--			
Total reduced	--	--			
Total negative	219.85	13.96	Total positive	945	250

Net income from improved box hive (945-219.85=725.15 Birr)

Net income from traditional hive (250-13.96=236.04 Birr)

Incremental net benefit of improved box hive is (725.15-236.04=489.11 Birr)

The partial budgeting result reveals that the beekeepers are profitable due to adopting improved box hive or due to adding the technology to their bee farm. Table 31 also summarizes that the incremental net benefit of improved box hive is 489.11 Birr. This shows that the beekeeper can increase his/her benefit from improved box hive by more than twice compared to traditional hive. Melaku (2005) also came with similar conclusion in his study using partial budgeting analysis that both the homemade and institutionally made KTBH (Appendix 1d) were beneficial and remunerative. As noted by the author, movable top bar hives results in higher net return per colony compared with traditional hives. The national average of KTBH is 10-15kg crude honey/hive/annum, which is below the national average of improved box hive (20-25kg pure honey/annum). The comparison of KTBH financial benefit was not included in this study, as it was not practiced in the study area. It is also in line with the study of Legesse (1992) on analysis of factors influencing adoption and the impacts of wheat and maize technologies in Arsi Negele, Ethiopia, which explains that maize variety and fertilizer technologies increased farmers' yields and net benefit. The result further supported by Behera and Mahapatra (1999) who found out that apiculture produced the highest return (Rs 7.94 per rupee or 0.18 US dollar invested), followed by Pisciculture (Rs 5.46 per rupee or 0.12 US dollar invested). Ebrahim (2006) also reached on similar conclusion that adoption of crossbred dairy cows with recommended management practices changes the profit of dairy farmers by 2865.47 Birr per cow per year.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and conclusion

The study was conducted in Atsbi Wemberta district of eastern zone, Tigray region at about 65km from Mekele regional town. It is located at 13º 36``N and 39º 36``E. The district is bounded in the north by SaeseTsaedaemba district, in the south by Enderta district, in the east by Afar regional state and in the west by Kilte Awuelalo district. The district is organized into 16 PAs. It has a total population of 108,700 of which male and female accounts 50, 478 and 58, 222, respectively. It has an altitude of which ranges from 918m to 3069m above sea level. The highest and the lowest of temperature in the area is 8^{o}c and 28 ^{o}c , respectively. The average annual rainfall is 667.8mm. The area is characterized by mixed farming i.e. livestock and crop farming.

Apiculture is the most important source of household income. For instance in 2005, the beekeepers of the district have got 394 quintal of honey that worth 1,182,000.00 Birr, with the price of 30.00 Birr/kg. The beekeepers engaged in colony multiplication are using over crowding and splitting method, which is rarely observed in other areas. Currently, there are about 16,915 honeybee colonies out of which 5,716 are improved box hive. Improved box hive coverage is 33.8% that is by far above the national improved box hive coverage that is about 1 %. The price of one colony is 550.00 Birr in the study area. The pure honey and crude honey costs 35.00 Birr and 25.00 Birr per kg respectively. As a result, the income of household that adopt colony multiplication and improved box hive can be improved significantly.

The objectives of the study were to identify determinants of improved box hive adoption by the beekeepers; and to analyze financial benefits of adopting improved box 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 45 adopters and 85 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 data were analyzed using descriptive statistics such as percentages, frequencies, mean, and standard deviates. T- test and χ^2 have also been employed to test the continuous and discrete variables that influence the adoption of improved box hives. Financial benefit of adopting improved box hive was analyzed using partial budgeting. A binary logit model was also selected for identifying the determinants of box hive.

Beekeeping plays an important role in income generation for beekeepers in the study area. Beekeepers do not only get income from hive products but also from honeybee colony selling. The demand of the honey is high as its white color is preferable by the consumers to any other colors of honey.

In relation to demographic characteristics of the study area, they were 91.8% and 97.8% male headed from non adopters and adopters, respectively. It has no significant mean difference, which implies that in both adopter and non-adopter male-headed household were dominating nearly in, equal proportional. The mean family size was 6.6 and 5.9 for adopters and non-adopters in the same order. Statistically, it has significant mean difference at $P<0.05$, which confirms that beekeepers who had large family size more tends to adopt improved box hive, to satisfy the need of their family.

With regard to socio-economics characteristics of the study area, education level was the factor that brought significant difference at $P<0.01$, in adoption decision of the beekeepers. Similarly, farm size was thought to be a good proxy indicator of wealth assuming that the owner of the larger farm size is wealthier and able to take risky in case of technology failure. As the land distribution among adopters and non-adopters were similar in size, there is no significant mean difference between them. Livestock holding is another proxy indicator for wealth. However, it also has no significant mean difference as both categories had nearly equal number of livestock.

Beekeeping holding was assumed to be another determinant of adopting improved box hive. However, as the respondents had more or less on average equal number of honeybee colonies, no significant mean difference could be observed between adopters and non-adopters in the study area.

Beekeepers can engage in beekeeping activities by different means such as catching the swarm, purchasing, and through inheritance. The majority of the beekeepers started beekeeping with purchased honeybee colony.

With reference to comparison made on the perception of relative advantage and disadvantage of improved box hive, it was found that beekeepers have positive perception about improved box hive, which is a good opportunity for beekeeping extension intervention program.

Adoption of improved box hive alone cannot assist to increase hive products. It is mandatory to be accompanied by adoption of accessories (casting mold, honey extractors); protective materials (smoker, veil, and glove); supplementary feeding practices, growing bee forage, colony multiplication, using improved ant protection methods, hive shading and appropriate handling of post harvest practices. Combination of all improved beekeeping practices were more used by adopters.

Ant, wax moth, honey badger, birds, spider, hive beetle, and lizards are the major honeybee enemies in the area, which affected both adopters and non-adopters. The result of prioritization depicted that ant stood in the first rank in causing damage on hive products. However, only 21.1% of the respondents were adopting improved ant protection methods. The non adopters used traditional ant protection method i.e. adding ash under the hive stand. As a result, the over all number of respondents that used improved ant protection was minimal.

Absconding was also another problem, which affected honey production of the area. It was investigated that 42.2% of absconding was caused due to lack of feed, which implied the need of promotion of more feeding and growing bee forage. The remaining 34.3%, 7.8% and 15.7% occurred due to honey honeybee enemies, honey bee disease and indiscriminate agrochemical application in the same order.

The logit model revealed that use of credit, Knowledge, educational level of household head, perception and apiary visit were found to be positively and significantly influencing

adoption of improved box hive. On the other hand, age, family size, extension contact, beekeeping training and market availability were not significantly influencing adoption of improved box hive.

Concerning financial benefit, partial budgeting result reveals that the beekeepers are financially benefited owing to deciding to adopt improved box hive. The total benefit found from improved box hives exceeds the benefit from traditional hive by more than twice.

Major problems of beekeeping sub sector were identified in the study area. Based upon the ranking result, drought; honeybee pests, disease; lack of beekeeping materials; death of colony; lack of extension support; marketing problem; shortage of bee forage; lack of beekeeping skill and reduction of honeybee colonies were found to be the major constraints in the beekeeping development of the districts, in their order of sequence.

5.2. Recommendations

Astbi Wemberta is one of the districts that has potential in beekeeping among the districts of Tigray region. The promotions of improved box hives along with its improved practices have been introduced to the study area since 1998. The Agricultural and Rural Development, and NGOs have been attempting to popularize the technology. Even though, the dissemination of the technology is encouraging its effectiveness is not found as desired. Hence, the following recommendations are provided to utilize the technology effectively and efficiently.

The beekeepers did not increase significant number of improved box hive. They were almost with improved box hive they initially received. The main constraint is the cost of the technology. Researchers and development workers have to search other alternatives like the modifications of the technology using locally available materials to reduce the cost of the technology.

The beekeepers are provided the hive with two supers including foundation sheet. The majority of them are using one super of which the two supers they received. One super with foundation sheet is out of use through out the production season. Similarly, the hive stand is made from metal, which also increases the cost of the technology. The beekeepers can also prepare the hive stand from the locally available materials. For supplying the technology, it needs identification of the area that needs two and one super. Generally, if the beekeeping extension makes arrangement with the suppliers of the improved box hives to reduce one super and hive stand, the cost of the technology can be considerably reduced for those beekeepers who are not using two supers during adding box.

Absconding is the common problem of beekeepers in the area. It was mainly caused due to lack of feed, honeybee enemies, and indiscriminate agrochemical application. These problems can be managed by organizing beekeeping training via beekeeping extension, NGOs and private sectors involved in beekeeping development, which addresses honeybee protection and honeybee management, including feeding practice and growing more bee forage. Particularly, promoting ant protection methods such as cone shaped metal sheet, cone

shaped used inner tube of rubber and used engine oil is an urgent need to overcome the existing ant problems in the study area.

Improved box hive can be more effective if it is accompanied by the promotion of hive shading, supplementary feed, bee forage, improved and protection, honeybee colony multiplication and post harvest handling practices. Hence, beekeeping extension, NGOs and private sectors involved in beekeeping development can do more on the promotion of improved beekeeping practices so as to increase the honey production and improve its quality and market value. Honeybee colony multiplication started by Dimma enterprise can fill the gap of honeybee colony demand and supply of the district. Extension and NGOs can assist the enterprise in demonstrating their reared honeybee colony to the surrounding beekeepers and other similar areas.

Bee forage is one of the important factors that play a pivotal role in the increment of honey yield. In the study area, there was no promotion work on bee forage. Hence, it is an urgent need for an integration work for Beekeeping extension, Research, Beekeepers, NGOs and Private sectors engaged in beekeeping development to introduce improved bee forage by searching suitable bee forage to the area. Similarly, the existing indigenous bee forages such as in *Tigrigna* `*gribiya*` (*Hypostus ariculata*) and `*tebeb*` (*Basium clandiforbium*) etc, which flower even in summer season (which is dearth period for honeybees) should be promoted and also incorporated in area enclosures. Further investigation on pollen analysis of the indigenous bee forages including its quality can be done to identify its contribution for white color honey production of the area. There was also "*imodia*" (rust) problem on the bee forages and requires further investigation to search for appropriate solution.

Provision of foundation sheet at the same time for the base and super of the hive decreases the acceptance of the hive by the honeybees. Hence, foundation sheet should be made for super during adding box (supering). Casting mold management at district level is not the efficient way to provide the fresh foundation sheet to the beekeepers. The District Agricultural and Rural Development Office has to decentralize its management at PAs level. ARD can organize landless youth at each PA in groups and they can provide foundation sheet and honey extraction service at reasonable price to beekeepers. In this way, for the land

less youth job opportunity can created. The group can also engage in honey and crude wax collection. NGOs and credit institution can also assist the group in providing initial capital for working office and equipment.

Drought is the major problem in beekeeping development of the area. To overcome the problem, it is crucial to integrate beekeeping activities with water harvesting to secure their livelihood. The Research can select moisture stress tolerant perennial bee forage suitable to the area and beekeeping extension, NGOs, and Private Sectors can also participate in the selection of bee forage and its promotion.

It was found that credit is strongly influencing adoption of improved box hives. Non-adopters were not using the existing credit in the area due to the occurrences of honeybees` absconding. The research, beekeeping extension, NGOs, and Private Sectors can develop the skill of beekeepers on the management of absconding through organizing on spot beekeeping training, which, in turn, enable them to develop confidence in the technology.

Currently, the beekeepers in the study area are using only honey and Honeybee colonies for income generation. However, other hive products particularly bees-wax which is important for foundation sheet making is not yet utilized in the area. Therefore, the beekeeping extension, NGOs and Private Sectors can do more to utilize the existing beeswax of the area through provision of training on collection of the crude bees -wax and extraction of it.

Apiary visit was found to be significantly influencing adoption of improved box 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.

It needs collaboration among the cooperative office of the district, ARD and NGOs to strengthen the existing beekeepers cooperative as they can be a learning environment for similar areas. Organizing them in enclosure areas has multi advantage i.e. apiary can be established in the area and they can also protect and conserve it by planting different bee forages.

Education level of house hold head and practical knowledge of the technology were found to be positively and significantly influencing adoption decision of improved box hive. The educated beekeepers can easily understand the basic management practices of beekeeping and they also know the advantage that is obtained from improved beekeeping by comparing with traditional beekeeping. Hence, it is appropriate for research, beekeeping extension and NGOs to target them during on-farm research and improved beekeeping technology promotion as they can easily understand about the technology which, in turn, helps for convincing the others to adopt the technology. The Research can also identify and document the existing Indigenous Technical Knowledge of beekeepers to integrate valuable ITK into improved beekeeping practices.

.

6. REFERENCES

Adimasu Adi, Gizaw Ebsa, Amsalu Bezabih, and Debisa Lemessa, 2004. Effect of honeybee pollination on seed *Allium cepa*. Holeta Bee Research Center, Holeta

Aldrich, J.H. and Nelson, F.D., 1984. Linear probability, logit and probit model: quantitative application in the social science-sera miller McCun, sage pub.Inc, University of Minnesota and Iola, London.

Ambrosini, F., Diop, C.T., Oliveros, O., Cianci, D., 2002. The therapeutic effects of propolis in the livestock farming. Journal of agriculture and environment for international development. V.96(1/2), p.13-22.

Amsalu Bezabih, 2002. Multvairate morphometric analysis and behaviour of honeybees (Apis mellifera L.) in the southern region of Ethiopia. PhD dissertation, Rhodes University, South Africa.

Aregay Waketola, 1980. Assessment of the Diffusion and Adoption of Agricultural Technologies in *Chilalo*. *Ethiopian Journal of Agricultural Systems*. 1(2): 50-67.

Atsbi Wemberta district ARD ofiice, 2006. Planning document. Atsbi, Tigray region.

Ayalew Kassaye, 1978. Beekeeping Extension in Ethiopia. Unpublished.
Holeta Bee Research Center, Holeta

Ayalew Kassaye, 1990. The honeybees (Apis Mellifera) of Ethiopia. A morphometric study . M.Sc. thesis, Agricultural University of Norway, Norway

Ban, A.W, Van den and H.S Hawkins, 1996. Agricultural Extension Black well Science Ltd, UK

Behera, U.K. and Mahapatra, I.C., 1999. Income and employment generation for small and marginal farmers through integrated farming systems. Indian Journal of Agronomy.,V.44(3), p.431-439

Berhanu Bedasa, 2002. Analysis of factors affecting the adoption of cross bred dairy cows in the central highlands of Ethiopia: The case of two districts in North Show zone. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

BSE, 2004. Modernizing Agriculture: A way out of food insecurity? Proceedings of a National Workshop, Feb.19-20,2004, Biological Society of Ethiopia, Addis Ababa.

Chilot Yirga, 1994. Factors influencing adoption of new wheat technologies. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Cramb, R.A. 2003. Processes Affecting the Successful Adoption of New Technologies by Smallholders. *In:* Hacker, B. (ed). Working with Farmers: The Key to the Adoption of Forage Technologies, pp.11-22. ACIAR Proceedings No. 95. Canberra: Australian Centre for International Agricultural Research

Crane, E., 1990. Bees and beekeeping: Science, practice and world resources. Comstock publishing associates (cornell university press), Ithaca, New York.

Dasgupta, S., 1989. Diffusion of Agricultural Innovations in Village India, Department of Sociology and Anthropology, University of Prince Edward Island, Canada

Degnet Abebaw and Belay Kassa, 2001. Factors influencing adoption of high yielding maize varieties in south western Ethiopia: An an application of logit.
Quart.J.interna.Agric.40(2):149-167).

Dick R., Adato M., Haddad L., and Hazell P., 2004. Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research. International Food Policy Research Institute, Washington, D.C.

Doss, C., W. Mwangi, H. Verkuijl, and H. de Groote. 2003. Adoption of Maize and Wheat Technologies in Eastern Africa: A Synthesis of the Findings of 22 Case Studies. CIMMYT Economics Working Paper 03-01. Mexico, D.F.: CIMMYT.

EBA., 2005. Ethiopia Beekeeping Association, fourth annual conference proceedings. Addis Ababa.

Ebrahim Jemal, 2006. Adoption dairy innovations: its income and gender implications in adami tulu district. Unpublished M.Sc. Thesis, Haramaya University, Haramaya.

Edwards, S., 1976. Some wild flowering plants of Ethiopia. Addis Ababa University press. Addis Ababa , Ethiopia

EEA (Ethiopian Economic Association), 2005. Study of the Ethiopian agricultural extension program. Ethiopian Economic Policy Research Institute, Addis Ababa, Ethiopia.

Ehui S.K., Ahmed M.M., Berhanu Gebremedhin, Benin S.E., Nin-Pratt A. and Lapar Ma.L., 2003. Ten years of livestock policy analysis. Policies for improving productivity, competitiveness and sustainable livelihoods of smallholder livestock products. ILRI, Nairobi, Kenya.

Ehui S.K., Lynam J. and Okike I. (eds). 2004. Adapting social science to the changing focus of international agricultural research. Proceedings of a Rockefeller Foundation. ILCA social science research fellows workshop held at ILCA, Addis Ababa, Ethiopia, 14-18 November 1994. ILCA, Addis Ababa, Ethiopia.

Endrias Geta, 2003. Adoption of Improved Sweet Potato Varieties in Boloso Sore Woreda, Southern Ethiopia. An M. Sc. Thesis Presented to the School of Graduate Studies of Alemaya University.

Ethiopian Agricultural Research Organization (EARO) / ARTP, 1999. Research Extension Farmers Linkage, Project Implementation Manual. Addis Ababa, Ethiopia. 57-61.

Ethiopian Mapping Agency (EMA), 1981. National atlas of Ethiopia. EMA, Addis Ababa, Ethiopia.

Feder, L., R.E., Just and O. Zilberman, 1985. Adoption of Agricultural Innovationin Developing Countries:"A Survey" Economic Development and Cultural Change, 32(2): 255-298.

Hassen Rashid, M. and Kiarie Njoroge, 1998. Adoption and Performance of Improved Maize in Kenya. Maize Technology Development and Transfer. Londen.59pp.

Gavaian, S. and Gemechu Degefa, 1996. The profitability of wheat production in Ethiopia. The case of Tiyo area in Arsi zone. Ethiopia journal of agricultural economics 1:38-62.

Getachew Olana, 1993. Farmers response to new coffee development technologies and factors influence it: The case of small farmers in Ghimbi CIPA,Wollega, Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Getahun Degu, M. Mwangi, H. Verkuijil and A. Wondimu, 2000. An Assessment of the Adoption of Seed and Fertilizer Packages and the Role of Credit in Smallholder Maize Production in Sidama and North Omo Zones, Ethiopia. EARO, CIMMYT, November 2000. P.24.

Gollin, D., Moris, M., and Byerlee, D., 2005. Technology adoption in intensive post Green Revolution systems. *Amer. J.Agr. Eco.87 (number 5,2005):1310-1316. American agricultural economics association.*

Green H. William, 1991. Econometrics analysis. New York University, Macmillan publishing company, New York.

Gujarati, D.N., 1995. Basic Economics, 3rd edition.McGraw-Hill,Inc: Newyork.

Habtemariam Abate, 2004. The comparative influence of intervening variables in the adoption behaviour of maize and dairy farmers in Shashomene and Debrezeit, Ethiopia. PhD Thesis, University of Pretoria.

Hagmann,J., E.Moyo, E.Chuma, K.Murwira, J.Ramaru and P.Ficarelli, 2003. Learning about developing competence to facilate rural extension process. In Wettasinha, C., L.Van Veldhuizen and A.Waters-Bayer (Eds), Advancing participatory technology development: case studies on integration in to agricultural research, extension and education. Silang, Cavite, Phillipines:IIRR/ETC ECOCULTURE/ CTA, pp21-38.

Holeta Bee Research Center, 2004. Beekeeping training manual. Holeta, Ethiopia.

Itana Ayana, 1985. An analysis of factors affecting the adoption and diffusion patterns of packages of agricultural technologies in subsistence agriculture. A case study in two extension districts of Ethiopia. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Jones, R., 1999. Beekeeping as a business. Commonwealth Secretariat, London.

Kerealem Ejigu, 2005. Honeybee production system, opportunities and challenges in Enebse sar midir woreda (Amahara region) and Amaro special woreda(SNNPR),Ethiopia. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Kidane Gebremariam, 2001. Factor influencing the adoption of new wheat and maize varieties in Tigray, Ethiopia:the case of Hawzien woreda. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Langyintuo A. and Mulugeta Mekuria, 2005. Modelling Agricultural technology adoption using soft ware stata, International Maize and Wheat Improvement Center IMMYT).Harare, Zimbabuwe

Legesse Dadi, 1992. Analysis of factors influencing adoption and the impact of wheat and maize technologies in Arsi Negele area, Ethiopia. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Legesse Dadi, Burton, M., and Ozanne, A., 2004. Duration analysis of technological adoption in Ethiopia agriculture . Journal of agricultural economics-Volume 55, Number 3 Nov. 2004, pages 613-631.

Lelisa Chalichisa, 1998. The determinants of adoption, intensity and profitability of fertilizer use: The case of Ejere district, West Shewa zone. An M.Sc. thesis presented to the School of Graduate Studies of Addis Ababa University, Ethiopia.

Liao, T.F., 1994. Interpreting Probability Models: Logit, Probit, and Other Generalized Linear Models. Sage University Paper Series on Qualitative Applications in the Social Sciences. Thousand Oaks.CA:Sage

Lionberger, H.F., 1960. Adoption of new ideas and practices. Ames, Iowa: The Iowa state university press.

Maddala, G.S., 1983. Limited dependent and qualitative variables in econometrics. Cambridge university press.

Makokha, M., H. Odera, II.K.Martim, J.R. Okelabo and D.M.Iruria,1999. Farmers' Perception and Adoption of Soil Management Technologies in Western Kenya. AFrican Crop Science Journal, Vol.7 (4)

Mammo Gebreyesus**,** 1976. Practical aspects of bee management in Ethiopia. Proceedings of the first international conference on apiculture in tropical climates, London UK, pp 69-78.

Melaku Gorfu, 2005. Adoption and profitability of Kenyan top bar hive beekeeping technology: A study in Ambasel woreda of Ethiopia. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Mesfin Astatkie, 2005. Analysis of factors influencing adoption of trititicale (X-triticosecale wittmack) and its impact: The case of Forta woreda. Unpublished M.Sc. Thesis, Alemaya University, Alemaya.

Million Taddesse and Belay Kassa, 2004. Factors influencing adoption of soil conservation measures in south Ethiopia: The case of Gununo area. *J.Agric.and Rur.devel.in the Tropics and sub tropics. 105(1):49-62.*

Motamed M. K and Singh B., 2003. Correlation of Adoption of Improved Sericulture Practices. Indian Journal of Extension Education XXXIX (1 and 2):51-57.

National Agricultural Research Organization, 2004. The effect of technology dissemination on adoption, technical report. Uganda.

Nuru Adigaba, 2002. Geographical races of the honeybees (Apis mellifera L) of the northern regions of Ethiopia. PhD dissertation, Rhodes University, South Africa.

Nuru Adigaba, 2007. Atlas of pollen grains of major bee flora of Ethiopia, ESAP. Addis Ababa, Ethiopia

Omiti, J.M., Partan K.A. Senden, J.A,and Ehui, S.K., 1997. Economic Contribution of Livestock to the Subsistence Economy of Rural Households. The Case of Ethiopia.

Rahman S., 2007. Adoption of improved technologies by the pig farmers of Aizawl district of Mizoram, India.

Ray, G. L., 2001. Extension Communication and Management. Naya Prokash, Calcutta.145-162pp.

Robinson, G., 1980. The potential for apiculture development in the third world. *American bee journal* 120 (5) : 389-400.

Rogers, E.M., 1962. Diffusion of Innovation. The Free Press of Glencone.

Rogers, E.M., 1981. Diffusion of Innovation. New York: Free Press

Rogers, E.M., 1983. Diffusion of Innovation. 3rd ed. New York: Free Press

Rogers, E.M, 1995. Diffusion of Innovation. New York: Free Press.

Rogers, E. M. and F.F. Shoemaker, 1971.Communication of Innovation:
A Cross- cultural Approach, Second Edition. The Free Press, New York.

Ruttner, F., 1988. Biogeography and taxonomy of honebees. Springer-verlag, Berlin, Germany.

Salim, M., 1986. Rural innovation in agriculture. Chugh Publications, New Delhi.

Schultz , T.W., 1995. The value of the ability to deal with disequilibrium.
J.Econ.Liter.13:827-846.

Shiferaw, B. and Holden, S.T., 1998. Resource degradation and adoption of land conservation technologies by small holders in the Ethiopian highlands. Agricultural economics 18:233-247.

Simeon, k, Ehui and Nega G/silassie, 1999. The Contribution Of Livestock To The Sustainability Of Technology And Policy Issues. Proceedings Of The 3rd Conference Of The Society Of Agricultural Economics of Ethiopia, 2-3 October, 1997, AA, Ethiopia pp. 37-55

Storck, H., Bezabih Emana, Berhanu Adenew, Borowieck, A., Shimelis W/Hawariat, 1991. Farming systems and farm management practices of small holders in the Hararge high lands. Farming systems and resource economics in the tropics, vol.11.Wissenschaft surlang vauk,kiel, Germany.

Tesfaye Zegeye, 2004.Adoption of Inorganic Fertilizer on Maize in Amhara, Oromiya and Southern Regions. In Abebe Kirub (edt.), Agricultural technology evaluation, adoption and marketing Part 2.EARO, Addis Ababa, Ethiopia

Tesfaye Zegeye, Bedassa Taddesse and Shiferaw Tesfaye, 2001. Determinants of Adoption of Improved Maize Technologies in Major Growing Region of Ethiopia. Second National Maize Workshop of Ethiopia. 12-16 November, 2001. P. 125-136.

Upton, M., 1987. African farm management. Cambridge University press, Cambridge.

Voh, J.P., 1982. A study of factors associated with the adoption of recommended farm practices in a Nigerian village. Agricultural administration, 9 (1), 17-27

Workneh Abebe, 2006. Identification and documentation of indigenous knowledge of beekeeping practice. Proceedings of the 14th Ethiopian Society of Animal Production, ESAP. Addis Ababa.

Yadav, J.s., 1992. Evaluation of agricultural extension. New Delhi: Concept publishing company.

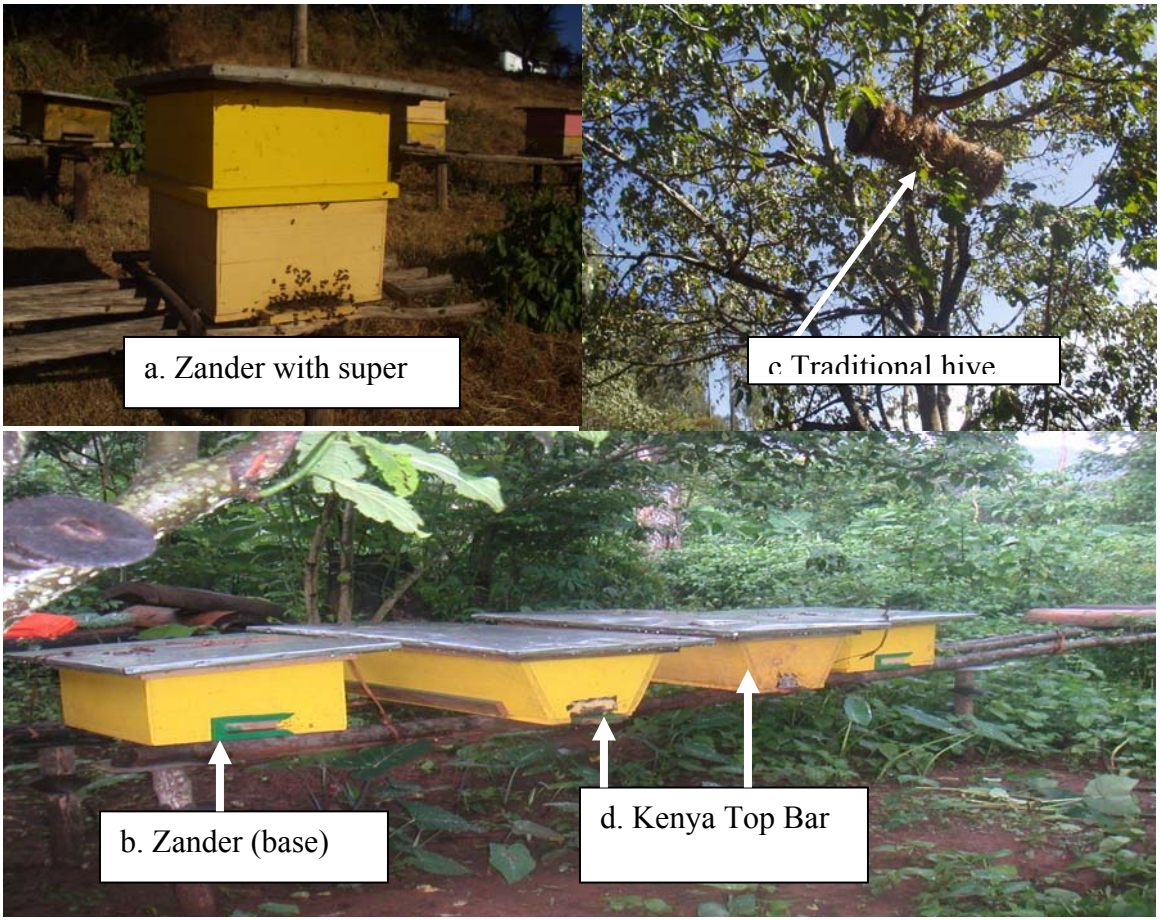
Yapa, L. and C. Mayfeld, 1978. Non-adoption of Innovations: evidence from discriminate analysis. Economic Geography. 54(2). 145-156.

Yenealem Kassa, 2006. Gender disparities in adoption of improved maize varieties between male headed and female headed households *in Kuni woreda*, western Hararghe zone, Ethiopia Unpublished M.Sc. Thesis, Haramaya University, Haramaya.

Yohannis Gebremedhin, 1992. The effect of conservation on production in the Andit-Tid area, Ethiopia; in: soil conservation for survival, edited by Kebede, T. and Hurni, H. Lowa state university press.

7. APPENDICES

Appendix 1. Different beehives



Appendix 2. Interview schedule

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 the interview
3. Be patient during the interview and express yourself in understandable way to the respondents.
4. Reliable information leads to right generalization. Hence, please write the beekeepers own response properly for each question.

Date of interview_____

Peasant association_____

Code_____

1. Personal Information

1.1 . Name of enumerator_____

1.2 . Name of household head_____

1.3. Sex_____Age_____

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

1.5. Have you attended formal education Yes ☐ No ☐

1.5.1 If yes, what is the highest grade attended? _____grade

1.5.2. If no, a. Can not read and write b. read and write

1.6. Details of household

No.	Name	age	Sex		Education (grade)
			M	F	
1					
2					
3					
	Total	-----			------

1.7. Total family size _____

2. Land utilization

2.1 Do you own land? Yes ☐ No ☐

2.1.1 If yes, what is the allocation (fill in table)

No.	Land allocation		Size in timad (any local measurement)								Total	
			Own		Hired in		Hired out		Crop sharing			
			Irrigated	Non-irrigated	irrigated	nonirregated	irrigated	Non Rrigated	irrigated	Non-irrigated	irrigated	nonirrigated
1	Cultivated land	Plot 1										
		Plot 2										
		Plot 3										
		Total										
2	Grazing land	Plot 1										
		Plot 2										
		Total										
3	Forest											
4	Uncultivated (hilly, rock)											
	Total farm size											

3. What are the major crops you grow during the cropping season (2006)?

No.	Crop type	Yield in quintal					Price/quintal		Size in timad) (Only for own)
		own	hired	Crop sharing	Total yield	Total sold	Harvest time	Off season	
1	Teff								
2	Sorghum								
3	Maize								
4	Beans								
5	Lentils								
6	Peas								
7	Vegetable								
8	Barley								
9	Wheat								
	Others(specify)								

4. Do you own livestock? Yes ☐ No ☐

4.1 If yes, what is the number of Livestock you own currently?

No.	Livestock type	Total number	Total number of sold	Total income in Birr
1	Oxen			
2	Cows			
3	Young bulls			
4	Calves			
5	Heifers			
6	Goats			
7	Goat young*			
8	Sheep			
9	Sheep young*			
10	Camel			
11	Horse			
12	Mule			
13	Donkey			
14	Donkey young*			
15	Poultry			
	Grand total			
16	Honeybee colonies (in hive)			

* Under the age of reproduction stage

5**. Beekeeping**

5.1. Do you keep bees? Yes ☐ No ☐

5.2. When did you start beekeeping? _____Years

5.3. How did you start beekeeping?

1. By catching the swarm
2. By purchasing the honeybee colony
3. Through inheritance
4. Any other (specify)_____

5.4. Where do you keep your honeybees?

1. Backyard
2. In forest
3. Under the roof
4. In the house
5. Any other (specify)_____

5.4.1. If you keep at backyard, what is the size of your backyard? _____timad.

5.5. Are you aware of improved box hive? Yes ☐ No ☐

5.5.1. If yes, from whom you hear about it?

1. Extension agent
2. Radio
3. Field day
4. Neighbor
5. Chart and poster
6. Any other (specify)_____

5.6. Have you ever used improved box hive? Yes ☐ No ☐

5.6.1 If yes, are you using improved box hive? Yes ☐ No ☐

5.6.2 If yes, when did you start utilizing box hive? _____ E.C

5.6.3. If yes, what type of improved box hive do you have?

1. Zandar
2. Langstroth
3. Foam
4. Any other_____

5.6.4. If no, why did you not use improved box hive?

1. It is expensive
2. It is not available
3. It needs skill
4. Lack of awareness
5. Any other (specify)_____

5.7. Can you buy improved box hive whenever you want to buy? Yes ☐ No ☐

5.7.1 If yes, if you have one or two improved beehives why did you not increase?

1 It is expensive
2. It is not available
3. It needs skill
4. No bee forage
5. Lack of land
6. Satisfaction with the existing number
7. Any other (specify)_____

5.8. Do you have protective materials? Yes ☐ No ☐

5.8.1 If yes, show the available materials using ` √ `

Smoker	Suit	Veil	Glove	Boot

5.8.2 If no, why?

1. Not found
2. Expensive
3. I use traditional
4. Any other_____

5.9. Do you get accessories (honey extractor, casting mold) to hire in your vicinity?

Yes ☐ No ☐

5.10. Is there any bee-keeping equipment that you discontinued using Yes ☐ No ☐

5.10.1. If yes, which is it? (one or more answer is possible)

1. Improved beehives
2. Honey extractor
3. Honey presser

4. Smoker

5. Veil

6. Glove

7.Any other_____

5.10.2. If yes, what are the reasons for discontinuing?

1. It is expensive

2. It is unavailable

3. It is not profitable

4. Its utilization is complex

5. Culturally not accepted

6. Any other_____

5.11. Have you constructed hive shading? Yes ☐ No ☐

5.11.1 If no, why did you not construct hive shading?

1. Lack of wood 3. Any other _____

2. The temperature is not hot

5.12 Do you provide supplementary feed to your honeybee during dearth period?

Yes ☐ No ☐

5.12.1 If yes, what do you feed your honeybees?

1. Sugar
2. Barely flour (beso)
3. Shiro
4. Honey
5. Any other _____

5.13. Do you plant bee forage? Yes ☐ No ☐

5.13.1 If yes, please list the name of the plants

No.	Name of bee forage	Total in ha (number of seedling)
1		
2		
3		
4		

5.14. Are there any pests of honeybees in your apiary? Yes ☐ No ☐

5.14.1. If yes, what are the major pests found in your apiary? Rank the pest causing the highest damages as 1

No.	Pests	Rank	No.	Pests	Rank
1	Ant		6	Honey badger	
2	Wax moth		7	Hive beetle	
3	Spider		8		
4	Lizard		9		
5	Birds		10		

5.15.2. If there are ants, do you use improved ant protection method?

Yes ☐ No ☐

5.15.2.1. If yes, what types of ant protection methods you use?

1. Cone shape lamera
2. Cone shape plastic
3. Burned oil
4. Any other_____

5.16 Do you practice colony multiplication? Yes ☐ No ☐

5.16.1. If yes, what type of colony multiplication methods do you practice?

1. Over crowding
2. Splitting
3. Any other_____

5.17. Do you get pure beeswax? Yes ☐ No ☐

5.17.1 If yes, how do you get?

1. by purchasing
2. Extracting crude beeswax
3. Any other (specify)_____

5.18. How do you handle your honey?

1. By storing in the recommended equipment (plastic jar)
2. By storing in moisture free area
3. By extracting and purifying properly
4. By using all the methods mentioned above
5. Any other (specify)_____

5.19. Is there any absconding from your box hive? Yes ☐ No ☐

5.19.1. If yes, what are the reasons for absconding?

1.Lack of feed

2.Honeybee enemies

3.Honeybee disease

4.Indiscriminate agrochemical application

5.Any other (specify)_____

5.19.2. If yes, what is the mechanism do you use to stay the honeybee colonies in the new hive?

1. Using queen cage

2. Cutting the wing of the queen

3. Fixing the queen excluder on the entrance of the hive

4. Any other (specify)_____

5.19.3. If yes, how many colonies did you lose this year? _____colonies.

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

1. By caching the swarm

2. By purchasing

3. Multiplying the colony

4. From family

5. Any other (specify)_____

5.21. How many honeybee colonies (hives with bees) do you own? (Fill in table)

Status	Traditional	Intermediate (Kenya top bar, Tanzania top bar, Mud hive)	Improved box hive	Total
With Honeybee colony				
Without honeybee colony				

5.22. Who often undertake beekeeping activities? Show in table using ` √ `

No.	Activities	Person undertakes the activities			
		Husband	Wife	Children	Hired labor
1	Swarm catching				
2	Transferring				
3	Inspection				
4	Feeding				
5	Honey harvesting				
6	Honey extracting				
7	Hive product selling				

6. Beekeeping extension

6.1 Do you have contact with extension agent? Yes ☐ No ☐

6.1.1 If yes, how many times do you contact per month? _____per month

6.2. Who assisted you for utilizing improved box hive? Show in rank

No	Category	Rank in terms of providing		
		Box hive and accessories	Advisory service	Technical assistance
1	Agricultural and Rural development			
2	Non-Governmental Organization			
3	Research Center			
4	Neighbor			
5	Relatives			

6.3. Which extension media helped you most to learn about box hive?

No	Category	Rank
1	Extension agent	
2	Radio	
3	Field day	
4	Television	
5	Printing materials	

6.4. What kind of hive products did you produce before using box hive?

1. Crude Honey
2. Crude Beeswax
3. Crude honey & beeswax
4. Any other (specify)_____

6.5 What kind of hive products did you produce after using box hive?

1. Pure Honey
2. Pure Beeswax
3. Queen rearing
4. Pure honey and beeswax
5. All products mentioned above

6.6 Did you ever get beekeeping training? Yes ☐ No ☐

6.6.1 If yes, from where did you got the training

1. Research center
2. Agricultural and rural development
3. Non Governmental Organization (NGO)
4. Any other (specify)_____

6.6.2. If yes, on what area did you get training?

1. Colony multiplication
2. Bee management
3. Hive products
4. Marketing

6.6.3. If yes, what methods were employed during training?

1. Lecture
2. Demonstration
3. Group discussion
4. Combination of all
5. Any other_____

6.6.4. If yes, did you find the training useful? Yes ☐ No ☐

6.6.4.1 What changes in the training would have made it more useful?

1. Understanding effective way of using box hive
2. Understanding improved beekeeping management (feeding, inspecting, supering etc.) 3. Any other (specify)_____

6.6.4.2. If yes, can you undertake transferring of honeybee colony from traditional to box hives? Yes ☐ No ☐

6.6.4.3. If yes, can you undertake honey extraction using honey extractor? Yes ☐ No ☐

6.6.4.4. If yes, can you make foundation sheet using casting mold? Yes ☐ No ☐

6.6.4.5. If no, what was wrong with the training?

1. It focuses only on theory
2. The training duration is too short
4. Lack of experienced trainer
5. It was not based on my need
6. Any other (specify)_____

6.6.5. How many times did you get beekeeping training? _____ times.

6.6.5.1. If you got the training two or more times, how did you find it?

1. It was repeated on the same topic and not useful 3. Any other (specify)_____
2. It was organized on different topic and I got more skill

6.7. Have you ever visited beekeeping demonstration site? Yes ☐ No ☐

6.7.1.If yes, where did you visit?

1. Neighbor apiary site
2. Agricultural and Rural Development demonstration site
3. Research center
4. Non governmental organization demonstration site
5. Any other (specify)_____

6.7.2. If yes, who organized the visit?

1. Agricultural and rural development
2. NGO
3. Research center
4. Personal 5. Any other_____

6.7.3. If yes, what new things you learn during the visit?

1. Appropriate site selection
2. Appropriate apiary management

3. Any other (specify) _____

6.7.4. Do you make experience sharing with beekeepers using box hives? Yes ☐ No ☐

6.7.4.1 If yes, on what occasion do you undertake?

1. During formal PA meeting
2. During beekeeping training
3. During `idir` meeting
4. Any other_____

7. Honey yield

7.1 How many times do you harvest honey per annum? _____,_____,_____months

7.1 When is the peak honey production period? _____ month

7.2. What is the amount of hive products you get from the following hive per annum?

No.	Unit	Traditional			Transitional			Improved box hive		
		Season 1	Season 2	total	Season 1	Season 2	total	Season 1	Season 2	total
Pure honey	Kg/hive									
Crude honey	Kg/hive									
Pure beeswax	Kg/hive									

8. Credit

8.1 Have you ever used credit for beekeeping? Yes ☐ No ☐

8.1.1. If yes, from where did you get the credit?

1. From government
2. From non government
3. From friends
4. Any other (specify)_____

8.1.2. If yes, how many times did you get during the last five years? _____times

8.1.3. If yes, what amount of loan did you get in the last five years? _____Birr

8.1.4 If no, what was the reason?

1. Not available
2. Interest rate is high
3. Lack of collateral
4. Any other (specify)_____

8.2. What is the repayment period of your credit?

1. One year
2. Two years
3. Three years
4. Four years
5. Five years

8.3. How did you repay your credit?

1. By selling the hive product
2. From other sources
3. Any other (specify)_____

8.4. Did you use the credit offered for beekeeping to other purposes? Yes ☐ No ☐

8.4.1. If yes, for what purpose did you use?

1. For educating children
2. For purchasing cloth
3. For purchasing seed, fertilizer
5. For purchasing goat or sheep 6. Any other (specify)_____

9. **Market**

9.1 Is there ready market for your hive products Yes ☐ No ☐

9.1.1 If yes, where do you sell your honey?

1. At market found in near by town
2. At farm gate
3. Cooperative
4. Tej house
5. Any other (specify)_____

9.1.2. If yes, can the market absorb all the quantity you need to sell?

Yes ☐ No ☐

10. Perception of advantage

10.1. Indicate by rating the following relative advantages of improved box hives using √`

Advantages	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
High yield					
Easy for inspection					
Easy for harvesting					
Produce quality honey					

10.2 Indicate by rating the following disadvantages of improved box hives using ` √`

Disadvantages	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
High cost					
Needs high skill					
Needs accessories					
Unavailable					

11. Knowledge

11.1 When do you undertake transferring? 1. Correct 0. Incorrect

a. During flowering period

b. After flowering period

c. Before flowering period

11.1.1 If not using recommended practice, why are you not using?

1. Lack of manpower during flowering period

2. Misunderstanding of the recommended practice 3.any other_____

11.2. What are the activities do you undertake during colony transferring from traditional to improved box hive 1.Correct 0. Incorrect

a. Bringing the traditional hive to the transferring area

b. Preparing the box hive

c. Arranging the frames and wiring

d. Making foundation sheet and attaching to the frames

e. Smoking then opening the traditional hive and cutting combs

f. Catching the queen and putting in the queen cage

g. Attaching 2 or 3 brood combs to the frames

h. Moving the colonies into the new hive **i.** All

11.2.1. If not using recommended practice, why are you not using?

1. Misunderstanding the recommended practice

2. Transferring is undertaken by bee expert 3. Any other _____

11..3. How do you identify exact honey harvesting time? 1. Correct 0, Incorrect

a. By internal inspection of the hive

b. By external inspection of the hive

c. By observing the honeybees symptom

11.3.1. If not using recommended practice, why are you not using?

1. Lack of bee suit
2. Misunderstanding the recommended practice
3. Honey harvesting is done by experts
4. Any other_____

11.4. How do you control swarming? 1. Correct 0. Incorrect

a. By removing the queen cell

b. By adding box (giving space)

c. a and b

11.4.1. If not using recommended practice, why are you not using?

1. Misunderstanding the recommended practice
2. Not practicing swarm control
3. The activity is done by bee expert
4. Any other _____

11.5 What is the importance of queen excluder? 1. Correct 0, Incorrect

a. To protect the queen from the honey chamber

b. For allowing the queen to the honey chamber

11. 5. 1 If not using recommended practice, why are you not using?

a. Misunderstanding the recommended practice

b. Not using queen excluder

c. The activity is done by bee expert d. Any other _____

11.6 Total score correct ☐

Very high very low

5	4	3	2	1

12. Financial

12.1 Expense during the cropping season

No.	Items	Price					
		Box hive		Transitional hive		Traditional hive	
		1997	1998	1997	1998	1997	1998
1	Hive						
2	Transport cost						
3	Opportunity cost of capital						
4	Labor cost						
5	Service charge for accessory (casting mold, honey extractor)						
6	Pure Beeswax						
7	Feed cost						

12.2 Benefit during the cropping season

No.	Items	Unit	Yield/hive						Unit price (Birr)						Total price					
			Box hive		Transitional.		Traditional.		Box hive		Transitional.		Traditional		Box hive		Transitional		Trad.	
			1997	1998	1997	1998	1997	98	1997	1998	1997	1998	97	98	97	98	97	98	97	98
1	Honey	Kg.																		
2	Bees wax	Kg.																		
3	Honey bee colony	Hive																		
4																				

13. What are the major problems for under taking improved beekeeping practices?

No	Problems	Rank
1	Lack of beekeeping materials	
2	Disease, pest and predators	
3	Reduction of number of honeybee colonies	
4	Shortage of bee forage	
5	Indiscriminate application of agro chemicals	
6	Lack of extension support	
7	Absconding	
8	Death of colony	
9	Drought	
10	Marketing	
11	Beekeeping skill	

Appendix 3. Variables inflation factor for Continuous explanatory variables

Variables	VIF	CI
Age	1.104	3.025
Education	1.197	3.455
Family size	1.166	4.094
Knowledge	1.331	8.591
Perception	1.100	10.768

Appendix 4 . Contingency coefficient for dummy variables

Variables	1	2	3	4	5
Apiary visit	1				
Market availability	0.291	1			
Extension contact	0.407	0.378	1		
Credit availability	0.260	0.559	0.401	1	
Beekeeping training	0.237	0.196	0.033	0.236	1

Appendix 5. Conversion factors to compute tropical livestock unit equivalents

Animal Category	TLU
Calf	0.25
Weaned Calf	0.34
Heifer	0.75
Cow and Ox	1.00
Horse	1.10
Donkey (adult)	0.70
Donkey (young)	0.35
Camel	1.25
Sheep and Goat (adult)	0.13
Sheep and Goat (young)	0.06
Chicken	0.013

Source: Storck *et at.* (1991)

Appendix 6. Different descriptive statistics

a. Age category of respondents

n=130

S.No.	Age category	Non adopter (n=85)	Adopter (n=45)
1	28-40	26 (30.6)	22 (48.9)
2	41-53	34 (40.0)	16 (35.6)
3	54-66	18 (21.2)	7 (15.6)
4	65-78	7 (8.2)	--
	Total	85 (100)	45 (100)

( ) percent

b. correlation between perception and box hive adoption

Variables	r_s	P
Relative advantage (Positive)	0.334***	0.000
Relative Disadvantages (Negative)	0.025Ns	0.775
Total attribute	0.199**	0.025

***, ** Significant at P<0.01, P<0.05, Ns= Non significant