BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES GRADUATE PROGRAM

CHARACTERIZATION OF BEEKEEPING SYSTEM AND EVALUATION OF HONEY QUALITY IN TEHULEDERIE DISTRICT OF SOUTH WOLLO ZONE, AMHARA REGION, ETHIOPIA

M.Sc. Thesis

By

Abebe Mitikie

May, 2017

Bahir Dar, Ethiopia

Wisdom at the source of the Blue Nile

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Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science (MSc.) in Animal Production

May, 2017
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I

THESIS APPROVAL SHEET

As member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defense examination, we have read and evaluated this thesis prepared by Mr. Abebe Mitikie (ID. No. 000602074) entitled "Characterization of Beekeeping Systems and evaluation of Honey Quality in Tehulederie District of South Wollo Zone, Amhara Region, Ethiopia". We hereby certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in Animal Production.

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DECLARATION

This is to certify that this thesis entitled "**CHARACTERIZATION OF BEEKEEPING SYSTEMS AND EVALUATION OF HONEY QUALITY IN TEHULEDERIE DISTRICT OF SOUTH WOLLO ZONE, AMHARA REGION, ETHIOPIA.**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Animal Production**" to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mr. **Abebe Mitikie** (ID. No. 000602074) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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BIOGRAPHICAL SKETCH

The author was born in 1973, at Addis Zemen town, South Gondar zone, Amhara region, Ethiopia. He finished his junior and secondary school education at Addis Zemen and he got his diploma in Animal science from Jimma College of Agriculture in 1994. After his successful completion of his college education, he joined Simada district office of agriculture and worked as a development agent, district level expert and livestock development team leader for about 11 years. After attaining experience in livestock development, he joined Haramaya University and successfully finished and got his Bachelor of Science degree in Animal sciences. Then after, he joined south Gondar office of agriculture as zonal livestock expert and worked for 2 years. Currently, the author is employee of the regional livestock resources development and promotion agency and working as a regional senior livestock expert for the last 6 years. Now, he joined as M.Sc. student at College of Agriculture and Environmental Sciences, Bahir Dar University in 2015 specializing in Animal production.

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DEDICATION

This thesis is dedicated to the expected novel comer in the far-fetched gargantuan planet.

LIST OF ABBREVIATIONS

ARBOA	Amhara Region Bureau of Agriculture
ARBFED	Amhara Regional Bureau of Finance and Economic Development
ARLRDPA	Amhara Region Livestock Resource Development Promotion Agency
B.C.H.	Brocken Comb Honey
BOFED	Bureau of Finance and Economic Development
CSA	Central Statistics Agency
Co MESA	Common Market for Eastern and Southern Africa
EBA	Ethiopian Beekeepers Association
ECAE	Ethiopian Conformity Assessment Enterprise
ES	Ethiopian Honey Quality and Standard
FDRE	Federal Democratic Republic of Ethiopia
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HMF	Hydroxyl methyl furfural
IGAD	Inter-Governmental Authority on Development
Kg	kilogram
LDMPS	Livestock Development Master Plan Study
m.a.s.l	Meter Above Sea Level
m.eq	Mile Equivalent
MOA	Ministry of Agriculture
No	Number
SPSS	Statistical Package for Social Sciences
SE	Standard Error

“Characterization of Beekeeping System and Evaluation of Honey Quality in Tehulederie District of South Wollo Zone, Amhara Region, Ethiopia”

ABSTRACT

This study was conducted in Tehulederie district, Eastern part of Amhara National Reginal State to characterize the beekeeping system, analyze the potentials and constraints for beekeeping and suggest possible solutions for existing problems, identify major honeybee flora and their flowering periods, and evaluate the major honey quality in different agro-ecology of the study area . Data were collected from 120 beekeepers having bee colonies and living in three different agro-ecologies. The study had two parts: part one was data collection among beekeepers with a semi-structured questioner by single- visit-multiple-subject formal survey method. All the collected data was analyzed by using SPSS v-20 Duncan’s and one-way ANOVA method. From the total 120 sample beekeepers 92.5 % of them were male headed households, 95.8 % of them are married, mean age of the respondents was 48.97±11.03 years and they owned 105, 17 and 57 traditional, transitional and frame hived colonies respectively. The study result indicates that based on their level of technological advancement, three distinct types of beekeeping practices were used by the sample beekeepers in the area. These are traditional (local) hive based, transitional (Ethio-ribrab top bar) hive based and moveable frame (box) hive based beekeeping practices. Most of the beekeepers in the study area kept both traditional, transitional and frame beehives at their eave of the house, only 10.8% feed their colony at dearth, 95.5% of them increases colonies by catching the swarm colonies. The mean honey yield of traditional, transitional and framed type hives was 5.64, 12.7 and 16.9 kilogram per year, respectively and all of the respondents sell the unstrained honey directly to local market. Drought or rain dependent of the agriculture (76.7%), increased cost of production (75%), pests and predators (47.5%), application of pesticides and herbicides (43.3%) and lack of bee forages 32.5% are the major constraints to tackle the development of beekeeping in Tehulederie district. The second part of the study was the determination of honey quality produced in the study district. Twenty four honey samples were collected from crushed comb (traditional and transitional hive) honey and framed hive honey as two distinct groups from the represented 3

different agro-ecologies of the district directly from the apiary farm gates with tightly closed half a kilogram of plastic containers analyzed for eight honey quality parameters (moisture content, total reducing sugar, pH, acidity, diastase activity, sucrose content, HMF and mineral content) in the Food Chemistry and Analysis laboratory of School of Chemical and Food Engineering, Bahir Dar University, Ethiopia. The mean moisture content, mineral content, acidity, pH, HMF, diastase activity, sucrose content, and total reducing sugar, are 16.7%, 0.07%, 22.3 meq. acid/kg, 3.85±0.46, 37.7 mg/kg, 14.4 Goth scale, 4.04 % and 64.3meq/kg respectively. All the eight determined parameters showed that 100 % of the sample means were situated in the acceptable range of the world honey quality standard set by Codex Almentarious, 2001. Package designing for implementation of improved practices, gaining of efficient seasonal trainings, plantation of drought tolerant bee forages, establishment of diversified beekeeping products collection and processing centers, integrating the responsible crop scientists, animal science experts and other administration organizations for efficient utilization of agrochemicals and farther study are recommended to enhance the sector.

Key words: Amhara region, bee forage, beekeeping characterization, Honeybee, honey quality, Tehuledere district

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Chapter 1: INTRODUCTION

1.1 Background and Justification

Ethiopia has a huge natural resource base for honey production and other hive products (Admasu Adi *et al*., 2002). Its topography is also complex and altitude varies from the lowest point 126 m below sea level (Dankil depression) to the highest 4620 meters above sea level (mount Ras Dashen) (Amssalu Bezabeh *et al*., 2004). Moreover, Ethiopia has variable agro ecological zones which lead to a huge diversification in fauna and flora species. Its forests and woodlands contain diverse plant species that provide high amount of nectar and pollen for foraging bees (Girma Deffar 1998).

On the other hand, beekeeping is traditionally a well-established household activity in almost all parts of the country (Hailegebriel Tesfay, 2014). Furthermore, it is one of the ancient agricultural practices in Ethiopia. With this, Ethiopia is one of the few countries in the world with a long beekeeping tradition that gave an opportunity to supply honey and bees wax to the international markets (Yetimwork Gebremeskel, 2015). The sub-sector, still, is implemented with a minimum improvement specifically for the purpose of producing honey and some crude wax. However, the benefit from the sub sector to farmers, traders, processors and exporter is not satisfactory (Beyene Tadesse and David, 2007).

The country is estimated to have ten million bee colonies, which is the largest in Africa (Tessega Belie, 2009). It is believed that half of the colony numbers (5,885,263) are kept (hived) in three different hive types; traditional, transitional and frame hives. From this, the annual honey production of the country has been estimated to be 48,711,892 kilogram in 1.6 times average harvesting frequency per-hive (CSA, 2014/15). The volume (43,737 metric tons) accounts approximately 2.48% of the world and 21.73% of the African honey production (Girma Deffar, 1998). Even if the production looks large enough, only a small amount of this produce is delivered as an export market item. This is because; the country itself has a huge local market demand for the honey and bees wax produced. Accordingly, among its production, more than 70% is used for making local beer called “Tej” and only 10% of the produce is used as table honey (Tessega Belie, 2009). The share of this sub-sector to the national GDP has never been commensurate with the huge honey bee colony number and the country’s potential. However, today, many table honey processing plants are

flourishing and some has started to produce table honey for local and export markets. Hence, even if production technology is still far behind, hive products (honey and bees wax) are being well commercialized. In line with this, the ten year average annual estimated demand for hive products export in Ethiopia (2013-2022) is expected to reach 90,357 tons (ERCA, 2011).

Generally, it has been believed that households are consuming only less than 10% of their total harvest at home mainly for medicinal, ritual or cultural ceremonies, and the remaining is available for market (Ethiopian honey Bees, 2012). Even if, hive productivity and honey production is not as expected due to various reasons, honey has a long tradition and cultural values (such as an article of trade in old days, as an important ingredient for honey mead (the local beer called “Tej”). Beeswax is also used to produce candle for rural farmers’ especially in Orthodox churches. Recently, beekeeping activity is becoming a business developed for income generation.

Amhara region, as one of the potential regions in the country, has a huge bee colony resource potential. It contains 23% of the bee colonies and 22.8% of the total honey production in the country (CSA, 2014/15). The regional livestock resource development promotion agency is also giving due emphasis to the beekeeping sector based on its importance for watershed management, employment of rural youths as well as enhancing honey and wax production. Due to the fact that promotion of improved hives and introduction of new innovations have been done for the last 15 years, a number of honey bee colonies have been transferred into the transitional and frame hive technologies (Adebabay Kebede *et al.*, 2008). Currently, regardless of the efforts made in improving the beekeeping management and use of improved technologies, the three types of honey bee hives (traditional, transitional and frame) are being used by beekeepers in the region.

According to the regional livestock development promotion agency (2014/15) annual report , a total number of 1,162,872 honey bee colonies have been estimated to exist in the region, of which about 87%, 2.36% and 10.65% of the colonies are hived in traditional/local, transitional/Ethio-ribrab and frame hives, respectively, where North-Eastern part of the region is the most potential area. Even if the traditional beekeeping accounts for more than 75% of the honey and nearly all the beeswax produced in the region, the intermediate type of

(transitional or the Ethio-ribrab) bee hive has been considered as the most appropriate type of hive for the resource poor beekeepers. Furthermore, the average honey productivity per each of the hives is 8, 17 and 25 kg in traditional, transitional and frame hives respectively (ALRDPA, 2014/15).

The study district, Tehulederie one of the Eastern districts of the region, is located in the South Wollo zone. The area is known for better natural vegetation coverage, honey bee colony number and honey production. Beekeeping practice in the district has been believed to have an important contribution to the rural livelihood. Escalated income generation and important role plays to poverty reduction and livelihood improvement, of course, depends on the quality and quantity of hive products. This also relies on appropriate utilization of improved technologies and proper management of the honey bee colonies.

1.2. Significance of the Study

Analysis of competitiveness and comparative advantage of a given export commodity is very crucial for a progressive economic growth of a nation. However, with the exception of some case studies, the region at large and the study area in particular has little information about beekeeping production characteristics and quality of hive products in particular. Some specific studies were conducted in the region such as the quality of honey in Libo kemkem district by University of Gondar *(*Addis Getu & Malede Birhan, 2014*);* constraints and prospects for apiculture research and development in Amhara region (Kerealem Ejigu *et al*., 2009); honeybee production and marketing systems, constraints and opportunities in Burie district (Tessega Belie, 2009); and Physico-chemical properties of honey produced in Sekota district (Tewodros Alemu *et al.,* 2013). However, there was limited account illustrating aspects of the production characteristics and honey quality determination based on agro ecology and along different honey production practices in the North Eastern part of the region especially North Wollo and South Wollo zones.

The significance of this study was characterization of the beekeeping systems in the study area. The beekeepers' indigenous knowledge on the different beekeeping practices in the study area was identified and summarized. Moreover, the quality of honey produced in the district was evaluate which in turn will facilitate significantly to the marketing of quality

honey and increase income of beekeepers in the study area. The study is expected to provide basic information for policy makers and donor agencies in the economic competitiveness of the local honey in the international market. Furthermore, the study is providing first-hand information for private investors, who are engaged in honey processing. Similarly, the study could offer guidance to investment allocation to the resources in the area for its better exploitation and boosting outcomes. This study also helps to decide the recent and future market directions of the produce in order to encourage the use of appropriate market accesses. Generally, without assessing the competitiveness of the honey produced, it is difficult to boost the overall beekeeping production benefits and/or to utilize its potentials in the study area.

1.3 Objectives of the Study

The general objective of the study is to characterize the beekeeping system and evaluate the quality of honey produced in Tehuledere district of the Amhara region, Ethiopia with the following specific objectives.

- To characterize the beekeeping systems,
- To assess the potentials and constraints for beekeeping in the study area, and
- To evaluate the honey qualities in different agro ecologies of the study area.

1.4 Research Questions

The research was conducted to answer the following important questions:

- What are the characteristics of beekeeping system in the study area?
- What are the production potentials of the study area?
- How beekeeping is practiced in the study area?
- What are the possible dearth periods to supplement honey bees?
- What measures are being practiced in pre and post-harvest handling of honey?
- What is the position of honey quality at the farm gate levels based on Ethiopian and International quality standard parameters?

Chapter 2: LITERATURE REVIEW

2.1. Honey Bee Resources in Ethiopia

African bees are much more active in collecting nectar than temperate-zone bees (Ayalew Kassaye, 1990). Beekeeping is an appropriate and well-accepted farming practice and it is best suited to extensive range of ecosystems of tropical Africa (Amssalu Bezabeh *et al*., 2012). Bees produce wax readily to response their need to build new combs frequently in Africa.

Based on morphometric analyses, different researches have different and controversial findings about the origin of the honey bee species. The hieroglyphs of ancient Egypt refers to Abyssinia as the source of honey and beeswax. Based on this historical evidence it is assumed that beekeeping may started about 5000 years ago in the Northern Ethiopia along with the early settlement of the people(Ayalew Kasaye, 1990). So it has been a tradition since long before other farming systems practiced.

There are five honey bee races that are found in Ethiopia; *Apis mellifera jemenitica* in eastern lowlands, *A.m. monticola* in the southern mountains, *A.m. litorea* in the extreme western low lands, *A.m. adansonii* in the southern mid-altitude areas and *A.m. abyssinica* central plateau and southwestern parts of tropical forest (Ayalew Kasaye, 1990). Moreover, Radloff and Hepburn (1997) reported *A.m. jemenitica, A.m. bandasii* and *A.m. sudanensis* are the three which exists in Ethiopia as cited by Yetemwork G/meskel (2015).

According to Amssalu Bezabeh *et al.* (2004), morphometric characters of the Ethiopian honey bees revealed that five statistically discrete races of bee populations are existing and occupying in different ecologies of the country*: A.m. jemenitica,* in the northwest and eastern arid and semiarid lowlands, *A.m. scutellata* in the west, south and southwest humid midlands, *A.m. bandansii*, in the central moist highlands, *A.m. monticola* from the northern mountainous highlands and *"Woyi-gambela"* in south western semiarid to sub humid lowland parts of the country.

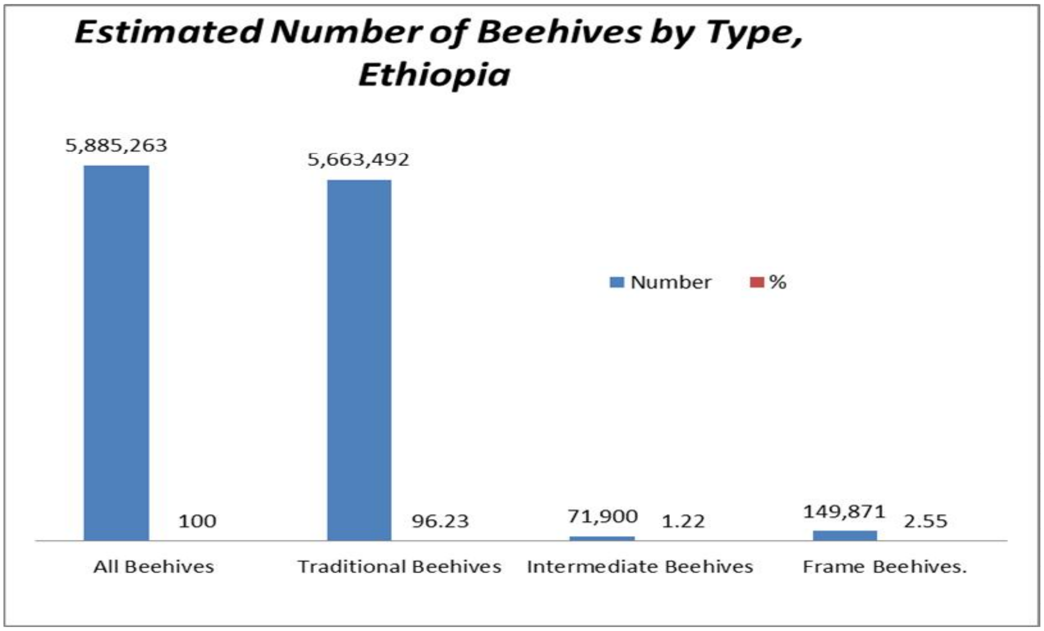
Research by Marina *et al*. (2011) brought a controversy idea about the different honey bee sub species of Ethiopia as cited by Yetemwork Gebremeskel (2015). The authors described a new subspecies, *Apis mellifera simensis,* on the basis of their morphometrical analyses. This indicated that there should be additional efforts need to characterize the different honey bee sub species of Ethiopia and to delineate the geographical distribution of these bee races.

2.2. Overview of the Beekeeping Practices

Beekeeping is an appropriate and well-accepted farming practice and it is best suited to extensive range of ecosystems of tropical Africa. Ethiopia is a leading honey producer in Africa and one of the ten largest honey producing countries in the world. Beekeeping is an appropriate and well-accepted farming practice and it is best suited to extensive range of ecosystems of tropical Africa (Ayalew Kassaye, 2001).

Ethiopia is blessed with adequate water resources and various honeybee floras, which create fertile ground for the development of beekeeping. Honey hunting and beekeeping have been practiced in the country for the exploitation of honey. In places where wild colonies of bees living in hollow trees and caves are found, honey hunting is still a common practice in Ethiopia (Tessega Belie, 2009).

Based on the input used and their management, two types of beekeeping practices were mainly used in the district Kilte Awlaelo, Eastern Tigray. These were traditional and frame hive beekeeping (Yetemwork Gebremeskel, 2015). On the other hand, three distinct types of bee keeping practices used by the sample beekeeper farmers in Burie District of Amhara Region (Tessega Belie, 2009). Based on their level of technological advancement, there are three types of beehives used for honey production in Silti district of SNNP region. These are traditional, intermediate and movable frame beehives (Alemayehu Kebede, 2011). Generally speaking currently in Ethiopia beekeeping is practiced in three types of production practices namely; traditional, transitional and frame beehive beekeeping practices across the country except extreme hot areas of Afar and Somali region.



Source: CSA2014/15

Figure 1: Estimated number of bee colonies in different hive type, Ethiopia

Based on the result obtained by Tessega Belie (2009) around Bure of Amhara region, the average amount of honey harvested from traditional, top bar and frame hive were 8.94 kg, 10.66 kg and 15.56 kg per hive, respectively. Reported a 7.4 kg, 36 kg per hive of honey from traditional and frame hive beekeeping practice was recorded averagely in the district Kilte Awlaelo, Eastern Tigray during 2013 (Yetemwork G/meskel, 2015).

Table 1: Production of crude honey in Ethiopia

Hive Type	Yield (in Kg/hive)			Potential Yield
	Farmers (Average)	Research Center	National Production	
Traditional	3-5	Na	5	10
Transitional (Intermediate)	10-15	15-20	18	40
Box (Frame) Hive	15-20	20-30	15-20	60

Na= not available, Kg= kilogram, Source: Commercial farm based collection centers and integrated beekeeping, 2013/14.

Traditional beekeeping is the old practice widely used, by the people for thousands of years in Ethiopia. Traditional husbandry is practiced with many millions of fixed comb beehives made from locally available materials such as logs, mud, cow dung and ash particularly in the remote areas of the country. For the period until frame beehives are introduced, these fixed comb beehives can yield a modest amount of honey, and also about 8-10% of beeswax (Kerealem Ejigu, 2009). This harvest is achieved with minimal cost and labor, and it is valuable to people living in lower and comparatively modest level of the rural areas. Traditional bee hives have their own advantages. It is cheap and easy to establish with a minimum knowledge and capital. It also produces more propolis than other types of bee hives.

Among the disadvantages, it is not convenient for simplified beekeeping practices and honey harvesting activities; limitations during colony feeding at times of food shortage, internal inspection is destructive, less possibility to split colonies especially during artificial colony multiplication, selection for honey yield and behavior is not an easy task, excessive bee killing during honey harvesting even the queen, and judging ripeness of honey is very difficult and leads to excessive brood and store combs' damages.

Transitional beekeeping is an intermediate beekeeping system between traditional and frame hive beekeeping practices. Generally, top-bar (Ethio-ribrab) beehive is a single or double story long box with slopping side walls inward the bottom and covered with bars of fixed width; 32 mm for east African honey bees (Sysay Gobessa *et al.,* 2012).

Movable top-bar hives, with its relative advantages over traditional and frame hives could be alternative option in beekeeping sustainable development plans. It can be opened easily and quickly, easiness to internal inspection, the bees are guided to build parallel combs through a line of bees wax smeared beneath the top bars. The top bars are easier to construct than frames, honey combs can be removed from the beehive for harvesting without disturbing bees and combs containing broods. Transitional beekeeping has its own disadvantages such as, top bar beehives are relatively expensive than traditional beehives, and combs suspended from the top bars are more advantage to break off than combs which are building within frames. Transitional beekeeping started in Ethiopia since 1976 and the types of beehives used are:

Kenya top-bar beehive, Tanzania top-bar beehive and Mud- block beehives but now a day is Ethio-ribrab hive. Among these, Ethio-ribrab is widely known and commonly used in many parts of the country because the top bars are easier to construct than other type of top-bar hives, has also divisions in to chamber to increase or decrease the size according to the colony size.

The third type of the beekeeping practice is the frame hive beekeeping practice. The frame hive beekeeping methods aim to obtain the maximum honey crop, without harming bees. It uses different types of frame beehives. Zandar, Langstroth, Dadant, Modified Zandar, and foam beehives was existed in the country (Ayalew kassaye, 2001). Dadant, Modified Zandar, and foam beehives are found rarely. These beehives differ in number of frames and size of the hive. The most commonly used frame beehive type in Ethiopia is Zandar type. Modern movable- frame beehive consists of precisely made rectangular boxes superimposed one above the other. The number of boxes is varied seasonally according to the population size and activities of bees. When the season is active for bees the number of worker bees increases and needs enough space suppering is recommended; otherwise during dearth period reduction of additional box is vital. It has also possibilities to control swarming by suppering the boxes. Improved frame beehive has advantages over other types in that it gives high quality and quantity of honey yield. It is easy to transport the honeybees from place to place for searching honeybee flower and for pollination services.

There are disadvantages of frame hive beekeeping practice over other types, the equipment are not affordable to buy by those subsistence farmers because of expensiveness. It requires skilled manpower and the equipment needs very specific precaution to operate them. The average yield of pure honey from movable frame beehive is 15-25 kg/year, and the amount of beeswax produced is 1-2% of the honey yield. However, in potential areas, up to 50-60 kg harvest has been reported (HBRC, 1997).

2.3. Major Contribution of Beekeeping

2.3.1 Beekeeping for poverty alleviation

Despite the apparent importance of the apiculture sector to the rural poor, the economy and in food production terms generally, not much effort has been made to develop the sector. Beekeeping is one of the most important income-generating activities among animal productions specially and agriculture practices as a whole in the rural communities. Honey is mainly produced as a cash income. Honey has good domestic market all the year round with price different at market points and different season. Farmers diversify income sources like honey selling. Some farmer beekeepers of the region reported to earn about 20,000 Birr annually from honey selling only which contribute the largest portion of their annual incomes. These facts indicate the high potential of beekeeping as source of income and means of livelihood with diversification of income for the rural communities. Many resource poor farmers sell their honey to the local markets and use income to agricultural inputs, purchase livestock, food crops and other miscellaneous household items. Honeybees can also be sold to meet cash requirements (Tessega Belie, 2009).

Beekeeping is an inherited tradition in Ethiopia with an estimated 1 in 10 smallholders keeps bees (Ayalew Kassaye, 2001). Basically beekeeping practices support 300,000 households in Amhara region having an average of 5 house hold members with a total of 1.5 million individuals directly or indirectly supported by its income. There are also 55,000 emerging rural youths with in common interest groups form ten to twenty individual members in group around the water shed on honey and bees wax production since four years ago (ALRDPA, 2013/14). There is also a future bright situation when we see the natural resources with unemployed rural youths to participate in the sector when partners acting together. The role of the sub-sector for generation employment is huge.

Thousands of households are engaged in "*Tej*-making" in almost all urban areas. There are also ten cooperatives, one union and five individual processors emerging and some exporters are participated and engaged in the sector directly or indirectly (Kerealem Ejigu, 2005).

2.3.2 Beekeeping for economic growth

Beekeeping has been a tradition since long before other farming systems. Beekeeping is a very long-standing and deep-rooted practice in the rural communities of the country and around one million farmers are estimated to keep bees (Tessega Belie, 2009). Beekeeping has been and still plays a significant role in the national economy of the country as well as for the subsistence smallholder farmers. The contribution of bees and hive products is probably one of the most important small-scale income generating activities for hundred thousands of farmer beekeepers. Cumulatively, it has a good contribution for export market income earning from non-compatible but pollen and nectar source products called honey and wax.

2.3.3 Beekeeping for environmental protection

Bees provide numerous benefits to the natural environment and have a critical role in its sustainability. Beekeeping is a non-destructive activity that could be employed in the conservation of biodiversity in area protection. Households living adjacent these areas can support the conservation efforts of these resources by establishing apiaries within or at the boundary of these protected areas (National Bee keeping training and extension manual, 2012). Farmers realizing that vegetation is a source of forage for bees will guard against the destruction and be encouraged to plant more plants for supplying pollen and nectar. In the process many plants are conserved and protected from destruction (FAO, 2009).

2.3.4 Beekeeping for plant pollination and biodiversity conservation

The value of honeybees in crop pollination is under estimated in developing countries, it has a significant role in increasing national food production and regeneration of plant species. Honeybees are the primary pollinating agents in the world. Their service in pollination is estimated to be worth over 15 times the value of all hive products together, although it is much more difficult to quantify their benefit (Gichora M., 2003). Hackett (2004) estimated that the value of honeybee pollination in U.S. agriculture to be 14 billion U.S $ annually.

Their role is not readily recognized, even though bees are needed for the pollination of many cultivated crops and for maintaining biodiversity in non-cultivated areas (FAO, 2009).

Usually a honeybee can visit between 50 to 1000 flowers in one trip, which takes between 30 minutes to 4 hours. In Europe, a bee can make between 7 to 14 trips a day. A colony with 25 000 forager bees, each making 10 trips a day, is able to pollinate 250 million flowers (FAO, 2009).

Honeybee is also believed to play a significant role in the economy of Ethiopia through pollination services. Pollination is one of the most important factors that affect seed production in agricultural crops. In Ethiopia, an experiment was conducted to determine the effect of pollination on Niger (*Guizotia abyssinica*) and the result showed that honeybees increased the seed yield of Niger by about 43% (Admasu Adi and Nuru Adgaba, 2002) and Onion (*Allume Cepa*) by two fold (Admasu Adi *et al*, 2008).

2.4 Honey Production and Market Demand

The word honey indicates for the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature (COMESA, 002 2004).

Honey is one of the most marketable agricultural products in Ethiopia. The total honey production of Ethiopia is estimated up to 240,000 tons; only a small amount of this is marketed (Honey sector investment opportunity brief, 2013). The large majority of beekeepers in the country are still producing honey using traditional hives. Currently, one of the ten farmers performs the beekeeping activity with other agricultural practice all over the country (Ayalew Kassaye, 2001). The prevailing technological and capacity building problem to reach every beekeeper to produce with the small quantity of bee products available in the hands of the beekeeper remains to be a less effective to traders to be extensively engaged in bee products trading. As the report obtained by Abel Kebede (2012) from EEPD, 2006 that Honey export marketing in Ethiopia was started during the 1980`s. The total estimated honey production during 1976-1983 ranges from 19,400 to 21,000 tons per annum(Honey sector investment opportunity brief, 2013). However, a very small amount of this volume was

exported during the specified period. Furthermore, there has been an increased in volume of production of honey from 21.480 tons to 23,700 tons between the period 1984 and 1994. But only 3.05 tons per annum has been exported during the specified period. This production and export level of honey was increasing from time to time. During the year 2011 the annual export of honey amount reaches 729 tone and importing 3 tone at the same time. But the demand of honey is increasing to 1220 tone at the domestic and 90357 tone for export market within this year (Honey sector investment opportunity brief, 2013).

The average annual demand for honey products in Ethiopia in ten years (2013-2022) is expected to reach at 90,357 tons. This is as a result of the current high population and future growth trends, a growing number of urban centers and urbanized lifestyles, and finally the economic growth rates registered by the country and visible increased income levels of the population. Basically the honey produced in Ethiopia has not yet captured a significant market share in the export market due to the traditional way of production, which hardly meets the quality standards of exotic markets, as well as the uncompetitive offering price (Honey sector investment opportunity brief, 2013).

2.5. The Honey Quality and Major Determinant Factors

Honey is a semi liquid product, which contains a complex mixture of carbohydrates, mainly glucose and fructose. Honey contained from honeybees had a complex mixture of components should be consider as parameter; moisture content, apparent sucrose content, pH, acidity, diastase activity, reducing sugar content, HMF and mineral content (ES 1202 : 2005).

Chemical composition of honey mainly depends on the vegetation sources from which it derives. The properties of Ethiopian honey are reported by different researchers. External factors like climate, harvesting conditions and storage can also influence it as Crane (1980) indicated and Tessega Belie (2009) sited. Inappropriate materials used for honey handling, Careless storage conditions of honey leads to reduce its quality (Yetemwork G/meskel, 2015). The quality and properties of honey are also related to honey maturity, the production methods, climatic conditions, processing and storage conditions as well as nectar sources of the honey (Sisay Gobessa *et al*., 2012). High levels of Hydroxymethylfurfural (HMF), loss of

enzymatic activity, changes in flavor, color change/darkening and microbial growth are also factors for quality reduction of honey (Yetemwork G/meskel, 2015).

1)Moisture content

Moisture content not more than 20% is one of the most commonly monitored parameters as international quality standards for honey (Codex Alimentarius Commission, 2001 and Ethiopian Quality Standard Authority, 2005). Those honey samples produced in relatively high humid areas like South and South West part of the country found to be consists high moisture than honey produced from low humid areas of the country. The moisture content of honey in Burie district of Amhara Region had mean of 18.83 (Tessega Belie, 2009). The moisture content of the honey of Libo Kemkem district ranged from 15.60 - 21.20% (Addis Getu & Malede Birhan, 2014). Those all results shown that the honey obtained from Amhara Region had in good condition based on the indication of moisture contents. Other parameters also show similar results to the moisture contents.

2) HMF content

HMF (5-hydroxymethylfurfuraldehyde) measurement is used to evaluate the quality of honey; generally not present in fresh honey, its content increases during conditioning and storage such as heat processing both to reduce viscosity, and to prevent crystallization or fermentation in air ventilated chambers, immersion of honey drums in hot water leads to deferent HMF levels in honey (Biochrom, 2013).

3) Diastase activity

Diastase is an enzyme that facilitates conversion of starch to maltose and is added by bees during honey production (Addisu Getu and Malede Birhan, 2014). Although natural levels of the diastase presentation in honey are variable in honeys depending on floral sources. The activity of diastase in honey is affected by storage and is sensitive to temperature increase and can thus be used as an indicator of storage time/freshness and controls during processing of the honey. The reduction of diastase activity from a given honey sample is expected as a useful quality indicator.

Legislation has set a minimum level for diastase activity; it should not be less than 8 DN units, where 1DN unit hydrolyses 1ml of 1% starch using 1g of honey for 1 hour at 37°C. The reference equation from the International Honey Commission gives a definition of diastase number as: Diastase number, DN = (28.2 x absorbance change at 620nm after 10 minutes) + 2.64.

4) Sugar contents

Analyses of different sugars can yield valuable information about source and floral origins of the honey (Alemayehu Kebede, 2011). The apparent sucrose content and the reducing sugar content are measured by the fehling method. The apparent reducing sugar accounts roughly to the sum of the main honey sugars (glucose and fructose) with some minor disaccharides.

5) Free acidity

The free acidity of honey may be explained by taking into account the presence of organic acids in equilibrium with their corresponding lactones, or internal esters, and some inorganic ions, such as phosphate. High acidity can be indicative of fermentation of sugars into organic acids (Yetimwork Gebremeskel,2015).

Table 2: The National and International honey quality standards

		Standards	
Characteristics tested	World	FAO/WHO	National
Moisture content, % by mass	18 – 23	21 – 23	21max.
Total ash, % by mass	0.25 – 1	0.6 – 1	0.60max.
Total reducing sugar	60 – 70	65 min	65 min.
Sucrose content, % by mass	3 – 10	5 – 10	5max.
Acidity, milli equiv. acid/kg	5 – 54	40/kg	40/kg
Hydrixymethylfurfural mg/100g	40 -80	80 max	40max.
Diastase	3-10	-	3 min.
pH	3.2 - 4.5	-	-

Source: Quality and Standards Authority of Ethiopia (2005)

2.6. Challenges and Opportunities for Beekeeping in Ethiopia

2.6.1 Challenges for beekeeping in Ethiopia

As other livestock sector programs, beekeeping has faced many challenges which, one way or the other, we couldn't tackle them efficiently so far. Absence of rural credit service, high price of improved beekeeping technologies, drought and deforestation of natural vegetation, poor post-harvest management of beehive products, absence or poor marketing chains, indiscriminate application of agrochemicals, no insurance to finance beekeepers, the unpleasant behaviors of bees, honeybee diseases, pests and predators, absence of coordination between research, extension and farmers and shortage of records and up-to- date information are major constraints which need special attentions.

1) Limitation of rural credit service

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

2) High price of improved beekeeping technologies

The improved beekeeping frame hives require different technological imputes like centrifuge honey extractor, hive tool, queen excluder and others are obtained from imported from abroad with foreign currency. The frame hives with its accessories can be produced in the region but their price is continuously increasing time to time and currently reaching to a price of birr 1500. For example, let us assume that someone needs to start beekeeping with 5 frame hives, then he/she needs a to invest the amount of money reaching up to 20,000 birr which is believed to be unaffordable for the resource poor farmer. So the Amhara regional livestock development promotion agency advises those participants to use transitional beehive first then understanding the technology practice, they afford frame hive beekeeping system (ALRDPA, 2013/14). Please rewrite this paragraph!!

3) Drought and deforestation of natural vegetation

Deforestation and overgrazing has nearly depleted the bee forage availability, ultimately resulting in low honey and beeswax production, cause colony migration. However, there is still the potential to increase honey production and to improve the livelihood of the beekeepers (Beyene Tadese& David P., 2007).

4) Poor post-harvest management of bee products

Due to some technical errors like impurities added during harvesting the quality of honey is seriously affected. Died bees, local hive plastering materials like cow dung, bee brood, pollen and even the wax are found mixed with the honey. Smoking beyond the required level was found to have an effect on the flavor of honey which makes unacceptable by the consumer.

5) The defensive behaviors of bees

The species of bees are all *Apis mellifera* that has a very defensive and attacking behavior. This special defensive nature is a risk full practice both for the beekeepers as well as the extension workers. To this both the beekeepers and extension workers need the protective clothes for safe practices. But the entire protective materials price is more than 1500 birr as high as beyond their pocket. In addition the development agents ask insurance for their risk full beekeeping practices otherwise they can't cop up the mechanism of bees defense.

6) Absence of business insurance

Beekeeping is sensitive business practice that can be risked easily by drought due to either shortage of feed or water supply for the bees. The beekeeper may lose all the colonies within a month. Farmers are susceptible to disaster that can't tolerate the risk even with a minimum loss of their livelihoods. They can't mitigate the problem easily to cop up the risk and it leads to fear of the technology acceptance at all.

7) Indiscriminate application of agro-chemicals

Ethiopia has chemical utilization and movement of bees and bee products proclamation since 2010. But has no implementation strategy. So it is not applied at the grass root level. The uses of Agrochemicals and pesticides have a huge influence on bee's health specially those areas of highly crop producers the real possibility of damaging the colony, as well as the contamination of hive products. Of the various kinds of chemicals, insecticides and herbicides are now major problems to the beekeepers (Kerealem Ejigu, 2010). Insecticides are the main destructive chemical than other pesticides. What do you mean by saying this???

Poisoning of honeybees by agrochemical has been increased from time to time. Some beekeepers lost their colonies totally due to agrochemicals. So, it needs special attention from the government to solve the problems by coordinating and integrating the responsible crop scientists, animal science experts and others bodies.

8) Honeybee disease, pest and predators

Pests and predators cause devastating damage on honeybee colonies within short period of time and even overnight. Ants, honey badger, bee-eater birds, wax moth, varoa mit, spider and beetles were the most harmful pests and predators in order of decreasing importance (Hailegebriel Tesfay, 2014). Some studies indicate that the region in particular and the country at large appears to be free from various honeybee brood diseases and at the same time at low level of adult bee diseases incidences (Hailegebriel Tesfay, 2014). A major category of diseases which cause economic loss comprises amoeba, nosema and chalk brood (Kerealem Ejigu, 2009).

2.6.2. Opportunities for beekeeping in Ethiopia

1) Potential resources for beekeeping practices

Ethiopia has huge bee colony numbers which are adapt to live in different environmental situations. As a result, Ethiopia is home to most diverse flora and fauna in Africa. Its forests and woodlands contain diverse plant species that provide surplus nectar and pollen to foraging bees (Kangave Alice *et al*.,2012). There are over 7,000 species of flowering plants existing in

the country; of which most are honeybee flora comprising natural trees, forage plants, horticultural and cultivated crops (Livestock Development Master Plan Study- Phase I, 2007). These resources coupled with variable climate, huge water resources and other favorable ecological factors enable the country to sustain ten million bee colonies (Alemayehu Kebede, 2011).

2) Good policy and extension service structure of the country

Considerable changes have been made to improve apiculture production through training. Introduction of new technologies, production and distribution of equipment and institutional capacity building was implemented for the last ten years. Great attention has also been given to training of extension workers and farmers in apiculture so that they could acquire better beekeeping knowledge and develop skills enabling them to improve the traditional and increase the production of honey and beeswax.

The reorganization of the livestock extension services to access the grass root level of implementers for well performing of the services. The Amhara Region Bureau of Agriculture redesigned such activity of the beekeeping improvement plan including implementation proceeded for the last five years. The main objective of the development plan was to improve the quantity and quality of honey and beeswax produced in the region. This goal was attained implemented with a set of extension packages, which include, technology supplementation, training of beekeepers, follow up in matters related to honey and wax production and extraction, introducing modern production technologies and facilitating beekeepers to be organized in service cooperatives so that they can collectively have adequate volume of marketable bee products, develop marketing strength and have easy access to inputs required for the production of honey and beeswax. Now a day revision of growth and transformation plan1 was taking place by the higher regional officials and preparation of the plan for the coming five year GTP2 is ongoing.

3) Positive market opportunities and promising demand for beekeeping products

Ethiopia has a Good export market opportunity for bee products like honey and bees wax. There is a high production potential of the country that can be achieved best results when the

sector problems are addressed. There are entrants of new chain private organizations at different level to the honey as well as the wax sector. Demands of bee products are enormously increasing from time to time at an alarming rate. The healthy condition of bees and production of organic honey are the basic criteria to attract the market of hone demands.

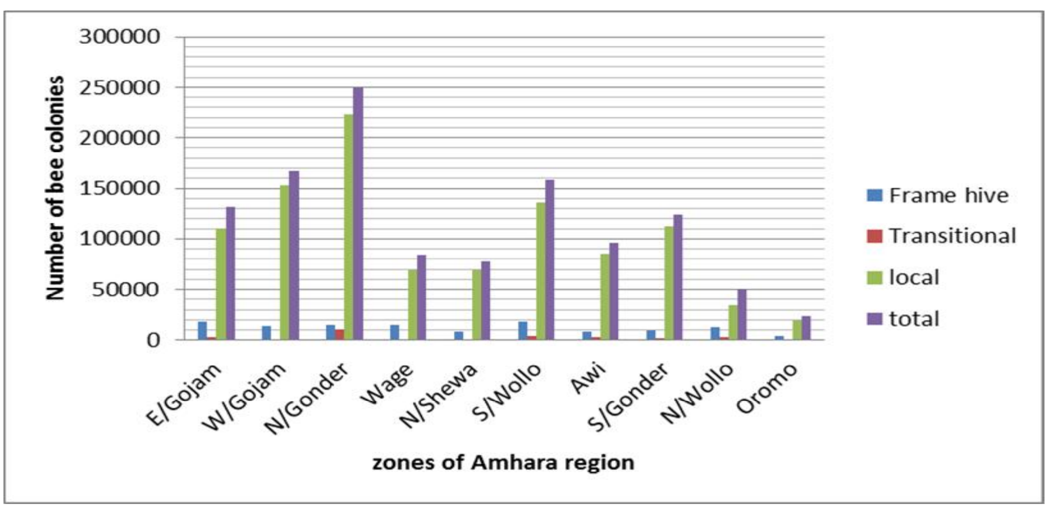
Chapter 3: MATERIALS AND METHODS

3.1. Descriptions of the Study Area

The Amhara National Regional State located at 9°-13°45'N Latitude and $36^{0}.4;^{0}$ $3;^{1}$ E longitude found in the Northern Tigray, Southern Oromia, Eastern Afar, South west Benishangul Gumuz National Regional State and in the West to Sudan . The region is the most intensively cultivated part of the highland Ethiopia, which is endowed with different bee forage plants .Some of these plants are available throughout the year.

The region has 161,239 km square area comprising of 11 administrative zones including Bahir Dar special zone (CSA, 1993). Zones are also divided in to 128 rural and 28 urban districts. Those districts are divided into 3170 rural and 358 urban with a total of 3525 kebeles/sub districts (BOFED, 2013/14). The Region has a higher potential and conducive environment for beekeeping activities. Now a day, there are huge numbers of bee colonies in the region in different hive types. The region has a total of 1,162,872 bee colonies of which 1,011,323 (86.96%) are found in local hive and the rest 27,505 (2.36%) in transitional hive and 124,044 (10.66%) in frame hives (ALRDPA, 2014).

When we compare the region with our country Ethiopia 20% of the colony number and 27.31% of the honey production is obtained in Amhara region. The region has 230,000 Bee Keepers that practice with and without other agricultural activities (ALRDPA, 2014/15).



Source: ALRDPA, 2014. Annual report

Figure 2: Number of bee colony in different zones of Amhara region

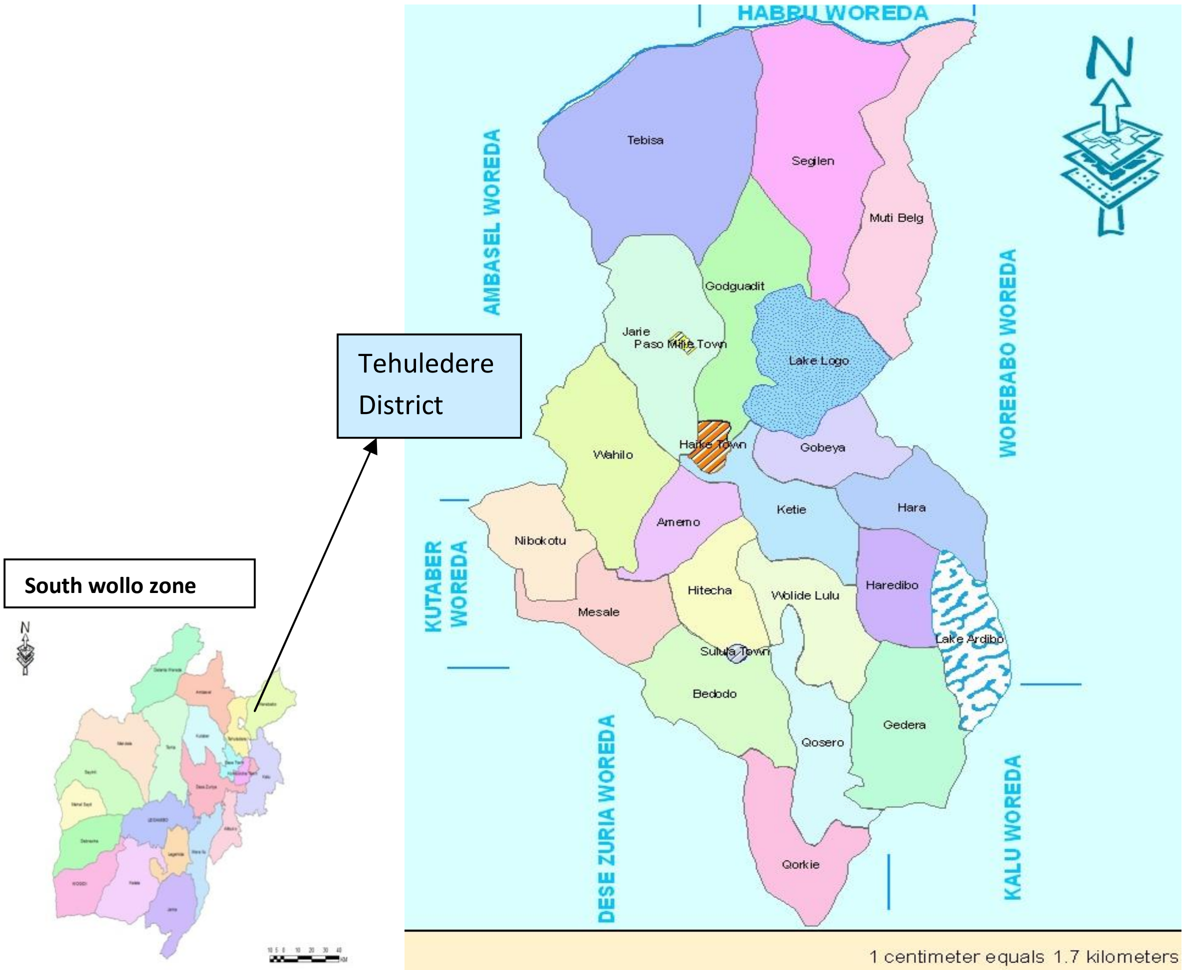
From the total honey produced in the country, the house hold consumption and the saleable amount was found to be 41% and 54%, respectively. Amhara region and the research zone of South Wollo also uses their production for house hold consumption and to sale by 39.7% and 57.44% and 52.3% and 45%, respectively (ELCA, 2011).

The study was conducted in Tehulederie district, South wollo zone of the Amhara National Regional state, EthiopiaThe capital of the district Haik, located at a distance of about 430 km North of Addis Ababa through Addis-Woldia rout and at a distance of about 450 km East of Bahir Dar through Bahir Dar Dessie rout. According to the Tehulederie district office of Agriculture report (Put the year here please), the district is geographically bordered by Werebabo in the East, Ambassel and kutaber in the West, Ambassel and Habru in the North and Dessie zuria and Kallu districts in the South (Figure 3). Tehuledere district covers an area of 446.7 km square comprising 19 rural administrative kebeles. Based on agro climatic condition, the district is classified in to mid-altitude (72%), low land (15%) and the rest are high land (13%) (Tehuledere district office of Agriculture, 2014).

Topography of the district is composed of plain (13.3%), mountainous (26.4%), gorge (12.3%), undulating and water body (39.36%) and others (8.64%) (Tehulederie district office of agriculture, 2014). The annual rain fall (which is bi-modal in nature) is 1,030 mm per annum which occurs between June to September and February to April. The minimum and maximum temperatures ranged from 5 to 30^{o}C and the altitude of the area ranged from 1,000 to 2,800 meters above sea level.

The district has a total population of 108,993 people with 97% living in the rural areas engaged in agricultural activities including beekeeping. From the total 3,568 beekeeping households in the district, 547 were female headed households. The agro-ecological distribution of these beekeeper households were (313) in the highland, (1458) in the lowland and (1797) in the mid highland areas. Furthermore, about 57% of the total populations have between 15 to 64 years of age being engaged in different jobs.

Tehulederie district is among the intervention areas of LIVES (Livestock, Irrigation Value Chain for Small holders in Ethiopia) collaboration with International Livestock Research Institute (ILRI) targeting to contribute in enhancing livestock production system (including beekeeping) for the development of the country in general and sustainable livelihood to the rural population in particular.



Source: Tehuledere woreda office of Agriculture

Figure 3: Map of the study area

3.2. Sampling Technique and Frame

In this study, a multistage sampling procedure was used. In this case, the district was classified into three different agro-ecologies (lowland, mid altitude and highland) represented by 5, 11 and 3 kebeles, respectively. Then after, representative kebeles were selected using proportional sampling technique. As a result, a total of 4 kebeles were selected (1 kebele each

from highland and lowland and 2 kebeles were randomly selected from mid altitude agro-ecologies..

The sampling frame in this study was focusing on the households who owned honeybee colonies in different hive types. Hence, the beekeepers were purposively selected from the respective kebeles. A total of 120 respondents beekeepers were selected (30 each from highland and lowland and 60 from mid-altitude) from the list of beekeepers using a simple random sampling technique for the survey. Generally, 5% sampling error was used as a standard.

In this study, 24 honey samples (crushed comb honey from traditional and transitional bee hives and extracted honey from frame hives as distinct groups), 8 honey samples (4 crushed and 4 frame hive honeys) from each of the representative agro ecologies, were collected using food graded 500 gm plastic containers from representative apiaries. Then after, honey samples, after clearing from different debris, dead bees and other unwanted materials, were prepared according to the "COMESA 002 (2004) Standard for Honey" protocol for the quality analysis.

3.3. Data Sources

Both primary and secondary data sources were used. Prior to data collection, checklist preparation, selected study site observation, questionnaire pre-testing with key informants and understanding the livelihood status and styles of the beekeepers was conducted.

Accordingly, primary data were collected from sampled respondents from each of the representative kebeles through a semi-structured questionnaire. Furthermore, honey samples were collected from freshly harvested crushed and extracted honey, as explained above (write the sub title, where the idea is present). On the other hand, secondary data were collected from various sources like, previous research findings, reports of Ministry of Agriculture (MOA), Regional Livestock Resource Development Promotion Agency, district Livestock Resource Development Office and other governmental and non-governmental organizations).

3.4. Methods of Data Collection

The study has two parts: part one is a survey work that was conducted among beekeepers with a semi-structured questioner. While part two was the determination of the qualities of honey produced in the area. (This paragraph should come at the beginning of material and methods part)

3.4.1. Survey

Information was collected using semi-structured questionnaire with trained enumerators under the supervision of the researcher. For the survey work, the method of data collection was through a single- visit-multiple-subject survey (ILCA, 1990). Before the actual survey the questionnaires were pre-tested. The actual data collected during the survey work include:

1) Household characteristics: - social: sex, age, family size, education level and economic status: land holding, livestock, honeybee colonies, off-farm activities.

2) Honey production systems: these include the past and present number of hives owned, type of hives used and cost of hives, beekeeping equipments, active season and dearth period, amount of honey and crude beeswax harvested, cost of production of honey and crude beeswax, honey marketing situation and market prices.

3) Farmers' indigenous knowledge and practices: place of keeping hives (site), hive inspection, methods of swarm control, swarm catching experiences, methods of colony multiplication, harvesting time and methods, honey storage facilities and post harvest management of honey.

4) Potentials and constraints of apiculture in the study areas: vegetation cover, potential honey plants and flowering time, poisonous plants, water resources availability, honeybee pests and predators, insecticides and others chemicals application.

3.4.2. Honey sampling and quality analysis

3.4.2.1 Sampling of honey:

The honey samples used in the study were collected directly from the farm gates using tightly closed, chemical free plastic containers having the capacity of half kilo gram. The samples were made free from foreign maters like dead bees, insects, debris, brood, and particles of the comb (Pavelkova A., 2013).

Figure 4 : Honey sample collection at farm gate

3.4.2.2 Methods of honey quality analysis

Honey quality parameters like moisture content, total reducing sugar, pH, acidity, diastase activity, sucrose content, HMF and mineral contents were tested in the Food Chemistry and Analysis laboratory of School of Chemical and Food Engineering, Bahir Dar University, Ethiopia. Samples of honey were analyzed for different honey quality parameters according to the procedures described by International Honey Commission (2009) for the determination of honey quality parameters as follows:

1) Moisture Content

Prepared sample were homogenized and put in a flask. The flasks were closed and placed in a water bath at a temperature of 50°C (±0.2) until all the sugar crystals were dissolved. The solutions were cooled to room temperature and stirred again with checking that the flask were air tight.

The cleanness and dryness of the prism of Refractometer were ensured first. After homogenization, the surface of the prism was evenly covered with the sample directly. , . After 2 minutes (Abbe refractometer), the refractive index was read. Each honey was measured twice and the average values were recorded. The corresponding moisture content was read from the table and the prism was carefully cleaned after use. The honey and water contents were calculated from the RI measured by applying the equation of Wedmore (1955): WWed (%) = [−0.2681−log (RI−1)]/0.002243.

2) Mineral (ash) Content

Ash content was determined after the sample was burnt in an electric muffle furnace (Lenton Thermal Designs, England). First the ash dish was cleaned and heated in the electrical furnace at ashing temperature, subsequently cooled in desiccators to room temperature and weighed to 0.001g (M_2). Then, 5g of honey sample was weighed to the nearest 0. 001g (M_0) and put in the prepared ash dish and two drops of olive oil was added to prevent frothing. Then, water was removed and commences ashing without loss (by foaming and overflowing) at a low heat rising to 350 - 400^{o}C by using electrical device. Hot plate was used to char the sample before inserting into the furnace. After the preliminary ashing with hot plate, the dish was transfer to the preheated muffle furnace adjusted at a temperature of 550^{o}C) and heated for 1 hour. The ash dish was cooled in the desiccators and weighted. The ashing procedure was continued until constant weight is reached (M_1). Percent ash in g/100g honey was calculated using the formula:

$$\text{Ash \%} = \frac{M_1 - M_2}{M_0} \times 100$$

Where, M_0 = weight of honey taken, M_1 = weight of dish + ash and, M_2 = weight of dish.

3) pH and Free Acidity:

Ten gram of the honey samples were dissolved in 75 ml of carbon dioxide-free water (distilled water) in 250 ml beaker and stirred with the magnetic stirrer. Then the pH was measured with pH meter (Inolab, Germany), calibrated at pH 4.0 and 7.0. The solution was further titrated with 0.1M sodium hydroxide (NaOH) solution to pH 8.30 (a steady reading was obtained within 2 minutes of starting the titration) (Appendix 7.4). For precision the reading to the nearest 0.2 ml using a 10 ml burette was recorded. Free acidity, expressed as milliequivalents or millimoles of acid/kg honey = ml of 0.1M NaOH x 10, and the result expressed to one place of decimal point.

Acidity =10V Where,

V = the volume of 0.1N NaOH in 10 g honey

4) Hydroxy methyl furfural (HMF)

The determination of the hydroxy methyl furfural (HMF) content is based on the determination of UV absorbance of HMF at 284 nm. In order to avoid the interference of other components at this wavelength, the difference between the absorbance of a clear aqueous honey solution and the same solution after addition of bisulphite was determined. The HMF content was calculated after subtraction of the background absorbance at 336 nm. Spectrophotometer operating in a wavelength range including 284 and 336 nm used.

Accurately, weigh 5 g of honey in small beaker and transfer with total of 25 ml distilled water to 50 ml volumetric flask. 0.50 Carrez solution I, mix, was added to 0.50 ml Carrez solution II (Appendix 7.4), mix, and diluted to volume with distilled water and drop of alcohol was added to suppress foam. It was filtered through filter paper and the first 10 ml filtrate was discarded. 5 ml filtrate was pipette into each of two 18 X 150 mm test tubes. 5.0 ml distilled water was added to one tube (sample) and 5.0 ml $NaHSO_3$ solution to other. Mixed well by using Vortex mixer and determined. When absorbance is greater than 0.6, sample solution was diluted with water and reference solution with 0.1% $NaHSO_3$ solution to correct absorbance for dilution.

The absorbance of the sample solution against the reference solution at 284 and 336 nm in 10 mm quartz cells within one hour was determined. When the absorbance at 284 nm exceeds a value of about 0.6, the sample solution diluted with water and the reference solution with sodium bisulphite solution in order to obtain a sample absorbance low enough for accuracy. When dilution is necessary,

The dilution, D = final volume of sample solution 10

Calculation and expression of result

HMF in mg/kg = (A284 - A336) x 149.7 x 5 x D/W, Where:-

A284 = absorbance at 284 nm

A336 = absorbance at 336 nm

5) Diastase Activity

The unit of Diastase Activity, the Gothe unit, is defined as that amount of enzyme which will convert 0.01 gram of starch to the prescribed end-point in one hour at 40^{o}C under the conditions of test. Results are expressed in Gothe units (or Schade units) per gram of honey. Filter or spectrophotometer with small band interference filter set at 660 nm is used. 10.0 g of honey prepared for sampling into a beaker and dissolved completely in approximately 15 ml of water and 5 ml of acetate buffer without heating. The solution was transferred quantitatively to a 50 ml volumetric flask containing 3 ml of sodium chloride solution and adjusts the volume to the mark with water (sample solution). The time from the addition of the diluted starch solution to the determination of the absorbance was as constant as much as possible in the calibration as well as in determining the diastase activity because the color intensity is time dependent.

10 ml of honey solution was pipette into a 50 ml flask and placed in the 40°C water bath with a second flask containing about 10 ml of starch solution. After 15 minutes, 5 ml starch solution (Appendix fig 7:5) was pipette into the honey solution, mixed and started the timer. At periodic intervals, for the first time after 5 minutes, 0.5 ml aliquots removed and added rapidly to 5 ml of diluted iodine solution. Water (as determined in "Calibration of the starch

solution"), is added and mixed well and immediately was read. The diastase activity is calculated as diastase number (DN).

6) Reducing Sugar

This method is a modification of the Lane and Eynon (1923) procedure, involving the reduction of Soxhlet's modification of Fehling's solution by titration at boiling point against a solution of reducing sugars in honey using methylene blue as an internal indicator (Appendix 7.4). The difference in concentrations of invert sugar was multiplied by 0.95 to give the apparent sucrose content. This method is based on the original method of Lane and Eynon (1923) and is also used in the Codex Alimentarius standard (2001).

The amount of water added bring the total volume of the reactants at the completion of the titration to 35 ml was calculated by subtracting the preliminary titration (X ml) from 25 ml. Pipette 5 ml Fehling's solution A was pipette into 250 ml Erlenmeyer flask and approximately 5 ml Fehling's solution B was added (Appendix 7.4). Add (25-X) ml distilled water, a little powdered pumice or other suitable antidumping agent and, from a burette, all but 1.5 ml of the diluted honey solution volume determined in the preliminary titration. The cold mixture was heated to boiling over wire gauze and maintains moderate ebullition for 2 minutes. 1 ml 0.2 % methylene blue solution was added whilst still boiling and the titration was completed within a total boiling time of 3 minutes by repeated small additions of diluted honey solution until the indicator was decolorized.

Calculation and expression of result: $C=25/W_2 x\ 1000/Y_2$

Where C = g invert sugar per 100 g honey

W_2 = weight (g) of honey sample

Y_2 = volumes (ml) of diluted honey solution

7) Apparent Sucrose

The honey solution (50 ml) was placed in a graduated flask, together with 25 ml distilled water, heated to 65^{o}C over a boiling water bath. The flask is then removed from the heated

bath and 10 ml of hydrochloric acid was added (Appendix 7.4). The solution was allowed to cool naturally for 15 minutes, and then brought to 20^{o}C and neutralized with sodium hydroxide (Appendix 7.4), using litmus paper as indicator, cooled again, and the volume adjusted to 100 ml (diluted honey solution). Then the procedure of determining reducing sugar continued.

Apparent sucrose content = (invert sugar content after inversion - invert sugar content before inversion) x0.95. The result is expressed as g apparent sucrose per 100 g honey.

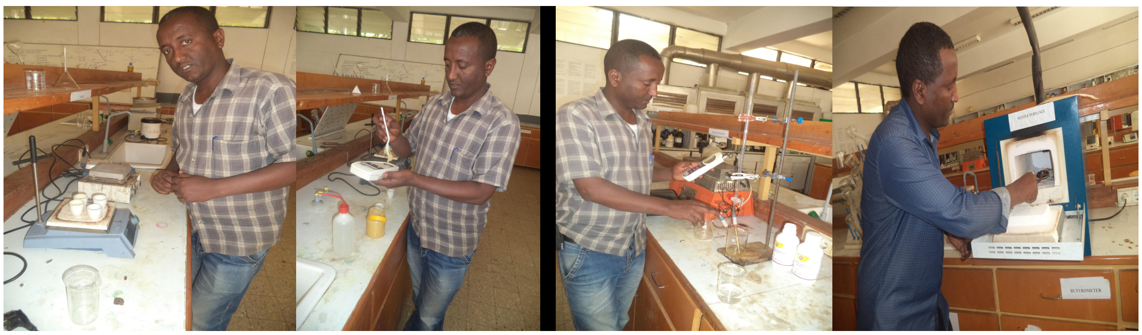


Figure 5: Laboratory analysis of the honey sample

3.4 Data Management and Statistical Analysis

Collected data from both primary and secondary sources have been documented, organized, analyzed and summarized using MS excel and SPSS version 20 for descriptive statistics. The survey data were coded and tabulated for analysis using SPSS statistical package version 20. As descriptive statistics variability measures the degree to which the scores are spread out or clustered together in a distribution from the sample was mainly applied for analysis of means and frequencies.

The physico-chemical honey quality parameters (moisture content, total reducing sugar, pH, acidity, diastase activity, sucrose content, HMF and mineral content) from both crushed comb and extracted honey were analyzed.

The statistical analysis was run to determine differences in composition of honey between agro ecology and hive types by using Duncan's t-test and One-way analysis of variance respectively. Significant differences ($p < 0.05$) were observed in moisture content of honey samples in the district with agro-ecology and hive type when compared based on factors between groups.

Chapter 4: RESULTS AND DISCUSION

Data for the survey work were collected from a total of 120 households selected from the three agro ecologies. The households in the three agro ecologies were found to have 105, 17 and 57 honeybee colonies in traditional, transitional and frame hives, respectively. This indicated that the development of modern beekeeping system (transitional and frame hive beekeeping) in the study area being lower compared with other districts. This result in the current study was supported by the study conducted in Kilte Awlaelo district, Eastern Tigray during 2015 which showed that among the sampled beekeepers (156), 95.5% had honeybee colonies in frame hives with a mean of 6.39 and a maximum of 100 colonies(Yetemwork G/meskel, 2015).

4.1. Household Socio-Economic Characteristics

4.1.1 Household characteristics

The current study confirmed that 92.5% of total sampled households (120) were male headed households while the rest were female headed (Table 3). This table doesn't contain the percentage of female headed household be keepers) According to the results shown, low numbers of female headed beekeepers doesn't explain that their participation in beekeeping in the study area is minimal. However, as described by Tessega Belie (2009) beekeeping has been considered as an activity carried out by men, we have found that women participation is not significant in the district.

With regard to marital status, 95.8% of total interviewed households were married while 0.8%, 1.7% and 1.7% were single, widowed and divorced, respectively (Table 3). Based on this result, we understood that married participants are significantly engaged in beekeeping than others grouped under other marital status. This could explain that beekeeping requires stability and married couples are using different options for asset building. When we come to religion of survey participants, 92.5% of interviewed participants were Muslims while the rest falls into Christianity (Table 4).

Our data demonstrated that 4.32± 1.24 people were an average family size per household with a maximum of 8 and a minimum of 2 people. However, the statistical analysis demonstrated that there was no significant difference among participant beekeepers in family size. Regarding average beekeeping experience, the result showed that sample respondents do have 13.98 years (with a range of 1 to 40 years) of continued involvement (experience) in beekeeping (Table 4). In addition, we have understood that women (wife), young boys and girls of the family are also involved in different beekeeping activities to help the head of the family (household). Interestingly, respondents have explained that those young boys and girls who were acquiring experience in beekeeping with their family have become independent beekeepers through time when they got the chance to have a colony.

Table 3: Family size, experience and age of respondents in Tehulederie district

Description	N	Minimum	Maximum	Mean	SD
Family size in No	120	2	8	4.32	1.24
Experience years in b/k	120	1	40	13.98	9.34
Age of respondents in years	120	28	80	48.97	11.03
Total land holding in hectare	120	0	1.38	0.597	0.27

N= number of observation, SD= standard deviation

Mean age of respondents in the study area was 48.97±11.03 years (ranging from 28 to 80 years). This could explain that beekeeping is an activity which can be carried out at different age groups and, in most cases, people at younger and old ages are actively engaged in beekeeping (Table 3).

Regarding to level of education, 26.4%, 37.2%, 10% and 7.2% of the respondents have attended basic education, Grade 1-4, Grade 5-8 and Grade 9-12, respectively (Table 4). However, in Amhara Region about 19.2% of the respondents were Illiterate. From the total respondents 51.9% were literate and the remaining was illiterate (Sisay Yehuala *et al.*, 2013). The result of this study indicated beekeeping is being practiced by literate beekeepers who can understand the majority of training packages and different advises which has been described by their colony management skills and productivity of their colonies (Table 4).

Table 4: Educational and religious status of the respondent in Tehulederie district

Educational Status	N	%
Illiterate	23	19.2
Basic education	32	26.4
Grade 1-4	45	37.2
Grade 5-8	12	10
Grade 9-12	8	7.2
Religious Status		
Muslim	111	92.5
Christian	9	7.5

4.1.2 Land holdings

The average land holding was about 0.6 hectares (with a range from 0 to 1.38 hectares) (Table 5). The data has described that the average land holding in the study area is below the national average (1.5 ha). More specifically, 10% of total respondents had less than 0.25 hectares of land which was mainly used for crop production (Table 5). This shows that beekeeping could be practiced with people who have very small plot of land in their mixed farming system.

Table 5: Household land holding system in hectare

Land holding type	N	Minimum	Maximum	Mean	Std. Deviation
Total land holding	120	0.0	1.38	0.59	0.2723
Farm land	119	0.04	1.20	0.42	0.2185
Forest land	88	0.03	0.50	0.12	0.0846
Private grazing land	78	0.04	0.70	0.13	0.0943
Other land coverage	1	0.04	0.04	0.04	0.00

N= number of respondents

4.1.3 Major crop production problems encountered

Respondents' reported that cereals are the most commonly grown crops in the study area. More specifically, Barley *(Hordeum vulgare L.)* followed by Sorghum (*Sorghum bicolor*),

Maize *(Zea mays L.)*, Teff *(Eragrostis teff)* and Wheat *(Triiticum)* are the most commonly grown crops. With regard to perennial crops, the respondents explained that chat to be the most important cash crop in the study district. They also explained that the dominance of cereal crops in the area is due to the feeding habits of the local community and the production potential of the agro-ecologies in the district. Respondents also indicated that cereal crops are the major sources of pollen and nectar for honey bees during flowering season. Thus, season of crop production is one of the major determinant factors for honey production in the study district.

Interviews indicated that the major constraints of crop production in the three different agro-ecologies are similar. Shortage of farm land and drought (erratic rain fall) are the major problems that faces repeatedly and affects the crop production (Table 6). On top of that, soil fertility loss, disease, shortage of oxen and prevalence of rodents are also challenges to crop production potential of the district (Table: 6).

Table 6: Crop production problems in Tehulederie district.

Agro-ecology	Constraints	Frequency	Percent
Highland	Shortage of farm land	18	60.0
	Drought	11	36.7
	Soil fertility loss	1	3.3
	Total	30	100.0
Mid altitude	Shortage of farm land	34	56.7
	Shortage of oxen	1	1.7
	Drought	24	40.0
	Rodents	1	1.7
	Total	60	100.0
Low land	Shortage of farm land	16	53.3
	Shortage of oxen	1	3.3
	Drought	9	30.0
	Soil fertility loss	2	6.7
	Diseases	2	6.7
	Total	30	100.0

4.1.4 Major livestock production constraints

With regard to livestock production constraints respondents reported that shortage of animal feeds (85.8%), diseases (65.8 %) and shortage of improved breeds (59.2), and low productivity of local animals are major constraints which affect the livestock production and productivity (Table 7).

Furthermore, 54.2 % of the respondents confirmed that shortage of grazing land is one of the main problems (Table 7). The average (0.13 hectares) of unimproved private grazing land with minimal productivity and communal off farm lands in the district have been explained to be small enough for animal feed production (Table 4). Seasonal variation in feed resources in terms of quantity and quality has been also explained by sampled respondents. Respondents who own animals have showed that they have been feeding their animals with weeds, grasses harvested from farm strips and boundaries, crop aftermath, crop residues and communal grazing lands at different seasons of the year.

The data described that lack of drinking water (20%) and shelter (10.8) had also their own negative contribution to livestock production (Table 7). Thus, organized and integrated technical and institutional interventions are very essential to enhance the livestock sector in the study area.

Table 7: Livestock production constraints

Livestock constraints	Frequency	Percent
Shortage of feed	103	85.8
Shortage of grazing land	65	54.2
Shelter and housing	13	10.8
Lack of drinking water	24	20
Disease	79	65.8
Low productivity/breed	71	59.2

4.2 Beekeeping Activities and Honey Production

The source of colonies under different hive types, the hives source and foundation stock availability are described under this section. Similarly the beekeeping production practices, their distribution and advantages, type of equipment used for honey harvesting, honey production trend and honey harvesting frequency of the district are also discussed.

4.2.1 Foundation source of colonies and equipment

According to the survey result, 48.1% and 34.9% of the respondents reported that the source of their foundation stalks is traditional hive colonies from parents and catching the swarm colonies, respectively. Majority of the respondents (68.8%) reported that the source of their transitional and (48.3%) frame hive colonies are through catching the swarms during the swarming season. It shows that swarming of bees is still a source of foundation stock and the starter for most of the beekeepers especially in modern (transitional and frame hive) beekeeping production system (Table 8). Other source of the foundation colony was buying from neighbors which had colonies before. 17%, 25% and 20.7% of the foundation stock of the respondent's traditional, transitional and frame hive colonies respectively, were obtained by purchasing. The rest of the other colony sources were gift from parents. Please re-write the paragraph, it is not written in a good manner and it is not palatable!!!

According to the survey result, 87.6% and 82.4% of the respondents replied that they constructed traditional and transitional beehive, respectively. Majority (63.8%) of the respondents got frame beehive from government with credit (Table 9). Also, non government organizations had little (5.2%) contribution in the distribution of frame beehive with credit in the district. Other 27.6% of the respondents reported that they purchased the framed beehive from the local market sold by other farmers.

Table 8: Foundation sources of colony in Tehulederie district

Source of colony	Traditional hive colony sources		Transitional hive colony sources		Frame hive colony sources	
	Frequency	%	Frequency	%	Frequency	%
From parent	51	48.1	1	6.3	18	31.0
By catching swarm	37	34.9	11	68.8	28	48.3
Buying	18	17.0	4	25.0	12	20.7
Total	106	100	16	100.0	58	100.0

Table 9: Foundation hive sources in Tehulederie district

Source of hives	Traditional hive sources		Transitional hive sources		Frame hive sources	
	Frequency	%	Frequency	%	Frequency	%
Constructed by him self	92	87.6	13	82.4	-	-
Constructed locally and bought	9	8.6	-	-	-	-
Bought from market	5	3.8	1	5.9	16	27.6
Supplied by GO with Credit	-	-	-	-	37	63.8
Supplied by GO with free	-	-	-	-	2	3.4
Supplied by NGO with Credit	-	-	-		3	5.2
Supplied by NGO with free	-	-	2	11.8		-
Total	106	100	16	100	58	100

The price of different hives was determined by respondents as follows; the mean value of traditional, transitional and frame hives price were 35.8+5.7, 217.8+36.6 and 860.7+216.1 respectively (Table 10). Frame hives bought from market had lower price than hives bought from government and non government organizations. Those suppliers for local markets were obtained their framed hives from GO's and NGO's with credit in different years. But they don't use it efficiently due to knowledge gap and unavailability of other modern hive equipments and they sold it with a minimum cost to their neighbors.

Respondents determine the mean service year of traditional, transitional and frame hives were 6.3, 7.6 and 12.6 years respectively (Table 10). They have elaborated that the service year of the hives mainly determined by the construction material.

4.2.2 Beekeeping practices

The survey result shows that depending on the technological advancement, beekeeping in the study area had taking place in three different production practices. Those are the traditional hive beekeeping practice owned by 105 participants with 180 colonies in traditional or local hive, the second transitional hive beekeeping practice which is owned by 17 participants with 20 colonies of top bar hives and the third frame hive beekeeping practice that owned by 57 participants with 99 frame hived (box hive) colonies. Though beekeepers had practiced either of the beekeeping systems based on the availability of resources like equipments, trainings (knowledge) and initial capital.

Table 10: Number of colonies owned per individual respondent, price and service year of different hive types

Activities	N	Minimum	Maximum	Mean	SD
Number of colonies in traditional hive per respondent	106	1	7	1.71	0.829
Number of colonies in transitional hive per respondent	16	1	4	1.18	0.728
Number of colonies in frame hive Per respondent	58	1	4	1.74	1.078
Price of one traditional hive	63	25.00	50.00	35.8254	5.737
Price of one transitional hive	9	150.00	250.00	217.7778	36.666
Price of one frame hive	58	450.00	1200.00	860.7143	216.104
Service year of traditional hive	99	4.00	10.00	6.3434	1.363
Service year of transitional hive	16	5.00	10.00	7.6250	1.408
Service year of frame hive	58	8.00	15.00	12.6071	2.024

N= number of owned respondents, SD= standard deviation from the mean

The result obtained from the respondents showed the mean number of traditional, transitional and frame hived colonies owned by 106, 16 and 58 beekeepers were 1.71, 1.18 and 1.18 colonies respectively (Table 10). It indicated that the minimum utilization of advanced beekeeping materials are practiced in the district. This is due to the high cost of initial capital requirement of the technology (training and improved beekeeping accessories) which should be given due attention, low rural credit access for beekeepers, high price of the colony due to non of the application of queen rearing techniques, adoption of transitional bee hive is minimum due to minimum extension services. Similarly disseminations of moveable frame bee hive is attributed to many factors like weak extension services, initial high costs, demand for its own seasonal management techniques and other accessory equipments, poor economic background of the beekeepers, lack of knowhow on improved technologies, and the like.

4.2.3 The comparison of different hive beekeeping practices

Interviews reported that traditional hive beekeeping practices has advantages because the hive construction material is available locally (100%) and can be constructed simply with traditional beekeepers knowledge (Table 11). The main inputs are local knowledge and local materials, rather than improved technology and advanced knowledge. Fixed comb hives are usually cylindrical in shape, made from bamboo, cow dung and mud. They have been used in the district for generations. Most of the honey is harvested from fixed comb hives. The disadvantages of traditional hive system are more swarming frequency (96.7%) than transitional (58.3%) and frame hives (25.8%) (Table11). It is less durable (100%), produces less quality (100%) and quantity of honey, low temperature maintenance ability (86.7%) for the bees and not suitable for harvesting (97.5%) of honey crop. The result of the study indicates that traditional hive is a fixed comb the hollowed out hives makes difficult for internal hive inspection.

The transitional beekeeping practices had also its advantages that it can be constructed with locally available (97.5%) materials, the top bar is movable and suitable for harvesting (100%) of the ripened honey, more honey produce than traditional hives(Table11). Top-bar hives are particularly suitable for beginner beekeepers because it is often easier to learn how to manage

and harvest from a top-bar hive than from a fixed comb hive. Transitional (Top-bar hives) are cylindrical boxes with a series of bars arranged side by side along the top. Bees are encouraged to construct their combs from the undersides of these top-bars. Top-bars enable the beekeeper to lift individual combs out of the hive. Combs containing unripe honey or brood can be placed and those containing ripe honey can be removed for harvest. Harvesting honey and beeswax from top-bar hives is simple and can be achieved with minimum damage to the colony. Its disadvantages are less quality and amount (94.2%) of honey production than frame type hive.

As the respondents indicated, the frame hive beekeeping practice advantages are suitability of harvesting the honey (100%), producing quality and high quantity(100%) of honey, good for temperature maintenance (94.2%), less swarming frequency (74.2%) and durable (100%) for long period use (Table11). But it is not convenience to construct (100%) by local beekeepers knowledge and needs special training to construct, construction materials are not available simply and locally (100%). This type of hive is appropriate but is expensive to buy and maintain, machinery is required to extract the honey. Beeswax yield from frame hives are low compared to fixed comb hives.

Table 11: The advantages and disadvantages of different beehives in Tehulederie district

Criteria	Traditional%		Transitional%		Moveable-frame%	
	Yes	No	Yes	No	Yes	No
Material availability	100	-	97.5	2.5	-	100
Suitability of harvest	2.5	97.5	100	-	100	-
Quality and quantity of honey	-	100	5.8	94.2	100	-
Temperature maintenance	13.3	86.7	25.8	74.2	94.2	5.8
More swarming frequency	96.7	3.3	58.3	41.7	25.8	74.2
Convenience to construct	100	-	14.2	85.8	-	100
Durability		100	-	100	100	-

4.2.4 Equipment used for honey harvesting

For traditional beekeeping system 14.6%, 9.5%, 100% and 2.9% of beekeepers, for transitional beekeeping 5.6%, 35.3%, 38.9%, 100%, 5.9%, 16.7% of beekeepers and for frame hive beekeeping 5.4%, 33.3%, 22.8%, 100%, 5.4%, 5.3 % of beekeepers used smoker, bee brush, knife and water sprayer, respectively (Table 12). It indicated that most of the beekeepers used knife as a chisel and honey harvesting tool in all of the three beekeeping practices. However, majority of the beekeepers lack protective cloth, smoker, bee brush, honey extracting tools and chisel. Success of beekeeping is determined by the utilization of appropriate hive tools and protective materials. Tessega Belie (2009) also agrees that the adoption of improved beekeeping practices also relies on the supply of these basic materials.

The moveable frame hives are demanding more additional beekeeping equipment than traditional and transitional hives. Traditional hive beekeeping requires some basic materials to carry out their activities; those materials are protective cloths, smoker, knife, bee brush, water sprayer and honey presser. Top bar hive beekeeping practices also requires chisel additionally than traditional beekeeping tools. The moveable frame hive beekeeping practice requires casting mould, honey extractor and queen excluder in addition to those above tools. And it also requires better knowledge of implementation as compared to other beekeeping practitioners.

Table 12: Equipment utilization percentage for honey harvesting in Tehulederie district

Hive type	Protection cloth	Smoker	Bee brush	Knife	Water spryer	Chisel
Traditional	0.9	14.6	9.5	100	2.9	0
Transitional	5.6	35.3	38.9	100	5.9	16.7
Frame	5.4	33.3	22.8	100	5.4	5.3

4.2.5 Productivity, honey harvesting frequency and features of honey bees

Interviews reported that the mean honey yield of three different types of hives (traditional, transitional and framed type hives) were 5.64, 12.7 and 16.9 kilogram per year, respectively (Table 13). The amount of honey produced from one bee hive per year varies from places to places. Productivity of the different beekeeping practices were different due to the availability of plenty of pollen and nectar source plants, input applied differences, management of the beekeepers and the environmental situation of the district. The maximum amount of honey harvested from traditional, top bar and frame hive were 11, 20 kg and 30 kg, respectively and the minimum were 3 kg, 7 kg and 6 kg, respectively (Table 13). These results are indicators of the existence of room for increasing performances of these beehives through good management practices to make favorable beekeeping environment. This also notes us that we are still bellow the line of productivity what the beekeeping industry can gain the potential.

Although the price of one colony has strong difference between the minimum 200 and maximum 1200 birr value, and the mean price of one colony is 816.53 ± 192.35 birr (Table 13). There is no official market in the district to sell the honey bee colony and people sell their colony only for neighbors who know present colony price to determine only by seller and buyer agreement.

Table 13: Honey yield and price of different hive colonies in Tehulederie district

Parameters	N	Min	Max.	Mean	SD
Honey yield (traditional hive)	105	3.00	11.00	5.6429	1.42727
Honey yield (transitional hive)	17	7.00	20.00	12.7059	3.80402
Honey yield (framed hive)	57	6.00	30.00	16.9386	6.88300
Price of colony (birr/colony)	95	200	1200	816.53	192.353

The main feature of the honey bees was expressed by the respondents based on their local perception. The district honeybees have aggressive (95.8%) behavior, red (58.3%) and somehow black (37.5%) in color, and medium (79.2%) and somehow small (20.8%) sized in nature (Figure 5).

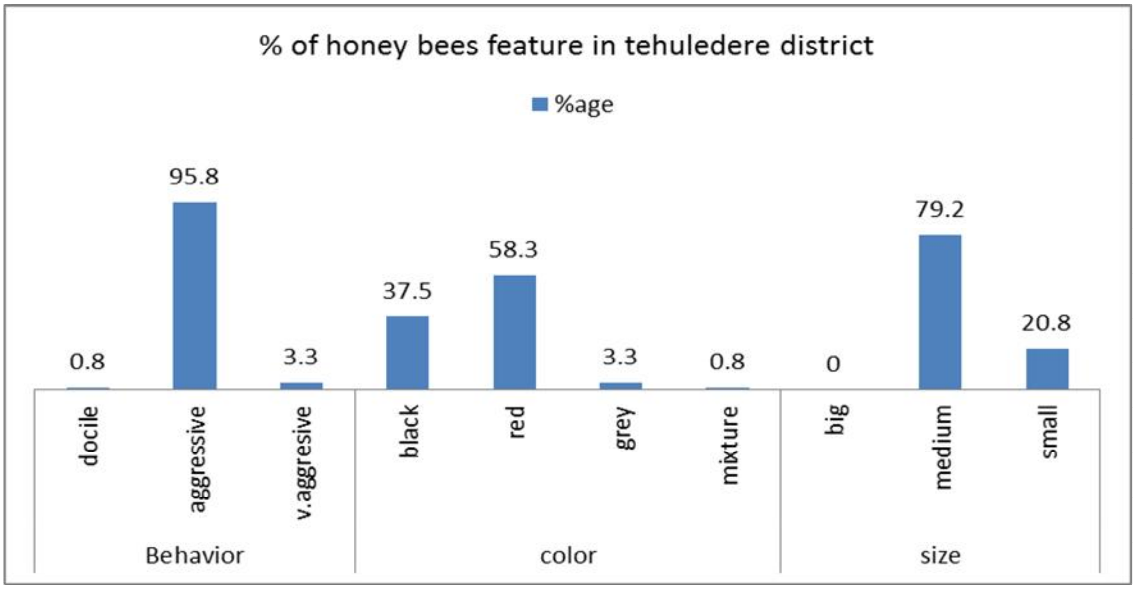


Figure 6: Features of honey bees in Tehulederie district

The two distinct harvesting seasons in a year are the first major harvesting period during October to December and the second harvesting during April to Jun (Table 14). Based on the respondent's interview results of the study, honey was harvested once or twice due to the chance of availability of the binary rains for bee forages.

Table 14: Honey harvesting period in Tehulederie district

1st Harvesting period			2nd harvesting period		
Season	N	%	Season	N	%
Oct – Dec	119	99.2	App - Jun	115	95.8
Jan – Mar	1	0.8	Jul -sep	5	4.2
Total	120	100.0	Total	120	100.0

N= number of respondent %= percent of respondent

4.3 Farmers practices and colony management

The portion finds out the indigenous knowledge of beekeepers on placement of their colonies, service years of the colonies, seasonal management practices and colony inspection practice in the district.

4.3.1 Placement and service years of the colony

Most of the beekeepers in the study area kept traditional, transitional and frame beehives at their eave of the house to prevent from rain and extreme sunbeam. Some of the respondents reported that they keep their hives at backyard (Table 15). However, there are youths of common interest groups that place their frame beehive colonies in the rehabilitated water shed closure areas. According to the beekeepers, the main reasons for beehive placement or apiary selection are close supervision, controlling from theft, and availability of bee flora. Similar observations were reported by different researchers in different areas of the country (Tessega Belie, 2009; Yetemwerk G/meskel, 2015). Regarding to the beehive placement Deborah and Devid (2008) sited by Yetemwerk G/meskel, (2015) recommended that groups of 4-8 beehives should be placed at a distance of 152.4 m in order to allow the bees to take advantage of the early morning bloom time. An apiary can accommodate up to 20 hives depending on the availability of flowering trees and bee forages up to 3 km from the apiary (Kangave Alice *et al,* 2012). It is also important the direction of the hive entrance along the sunlight to encourage bees for early foraging if the wind direction is not a problem.

Table15: Placement of the bee colony in Tehulederie district

Placement of bee colonies	Traditional (%)	Intermediate (%)	Modern (%)
Back yard	20.6	29.4	34.5
Under the eave	77.6	70.6	65.5
Inside the house	1.9		
Total	100	100	100

According to the result of the survey, the maximum service year of traditional, transitional and frame hives are 15, 17 and 25 years and the minimum service year is 8, 8 and 12 years, respectively (Table 16). The difference of service years is caused by the materials that the hive built exposure of the hive for external environmental factors and constructing efficiency of the hives. Mainly the traditional and transitional hives are made from locally available materials than frame hive.

Table 16: Service years of different bee hive types

	N	Minimum	Maximum	Mean	SD
Service year of traditional hive	106	8	15	12.4340	1.79957
Service year of transitional hive	16	8	17	12.3125	2.67628
Service year of frame hive	58	12	25	16.4912	3.09448

N=number of respondents SD= standard deviation from the mean

4.3.2 Honeybee colony inspection

The result obtained from the respondents showed the frequency of internal and external honeybee colonies inspection. Most of beekeepers sometimes inspect externally and rarely inspect their colonies internally (Table 17). Moreover only 5.8% of the respondents frequently inspecting their colonies externally but the rest 79.2% and 15% of them were inspecting sometimes and rarely, respectively. Internal inspection was takes place sometimes by only 18.3% of the respondents and the other 81.7% of them are inspecting rarely. Though, colony and apiary inspection is very crucial to maintain honeybee colonies from different natural risks and enemies such as pests, predators, diseases and chemical poisoning.

Experiences show that external colony inspection can be done frequently at any time; however, circumspection should be conducted during internal colony inspection. Efficient and continues training and follow up for beekeepers should be considered necessary.

Table 17: Frequency of internal and external hive inspection by beekeepers

Inspection frequency	Type of inspection	
	External (%)	Internal (%)
Frequently	5.8	
Sometimes	79.2	18.3
Rarely	15.0	81.7
Total	100	100

4.3.3 Occurrence of seasonal activities

According to the respondents, different activities were performed in different seasons. The main seasons for the yearly first hive suppering period, the brood raring period and swarming

of the colonies are during July to September. The first honey harvesting period, and some super redaction taking place during October to December. Yearly second hive suppering, some supper reduction and swarming is made during January to March (Table 18). When the season has no rain and drought occurrence, the secondary production season will be postponed and colony migration and absconding occurs as mitigation reaction of the bees due to shortage of pollen and nectar. Instead during April to Jun if the season has good rain condition to bloom the bee plants the second hive suppering, second honey harvesting and second supper reduction takes place. Even if the dearth period is so long too hard to cop-up by the bees themselves, colony feeding is practiced only by 9 persons (10.8%) from the total 120 respondents.

During the honey flow season honeybees store honey for their own consumption for dearth periods feeding. Bees do not need feeding as other livestock does. However, human beings exploitation of honey leads the bees to feed scarcity and faced them to starvation. Though supplementary or emergency feeding was required during long dry periods, heavy raining periods, and when colonies used for other manipulation like royal jelly production, artificial queen rearing and during pollination services.

Table18: Major seasonal activities occurrences

Activities	Season(s)				Not act at all	Total
	Jul -Sep	Oct-Dec	Jan-Mar	Apr-Jun		
Brood rearing period	86.7		13.3			100
First hive suppering	100					100
Second hive suppering period			96.6	3.4		100
First honey harvesting		99.2	0.8			100
Second honey harvesting period			4.2	95.8		100
Super reduction		33.8	38	18.3	9.9	100
Absconding	1.7		25	18	55	100
Swarming	83.3		15.8	0.8		100
Colony migration			61.7	24.2	14.2	100
Dearth period		1.7	98.3			100
Colony feeding			0.8	10	89.2	100

4.3.4 Dearth period colony feeding

From the total 120 interviewers 111 of the respondents 92.5% do not feed their colonies at all. According to the interviewers respond only 9 farmers did the bee's supplementary feeding included besso and shiro (locally prepared food items). From the nine respondent 8 persons feed besso and only one person feed shiro. Besso and shiro is made from pulse with some amount of paper and locally used spices. This feeding practice mainly from January to February (11.1%), March to April (55.5%) and May to Jun (33.3%) (Table19). In most cases they feed colonies external of the hive. This approach can be practice when the colony is not much weak to compute with other colonies, other ways weak colonies need to be feed internally of the hive. The supplementary feeds which are available in the locality include *besso, shiro*, sugar syrup, grinded sugarcane, honey and water mixtures should be supplemented during the dearth period to protect the harsh condition of the colony. The best feed is to leave adequate honey during harvesting or provide sugar syrup or pollen substitute (pea, bean, chick pea, Soya bean flour). In addition to supplementary feeding, planting bee forage is also required to get the intended honey yield. The major determinant factor of the honey yield obtained in a given colony is availability of bee forages.

Table19: Season of colony feeding in percent in Tehulederie district

Measurement	Sep- Oct	Nov- Dec	Jan- Feb	Mar- Apr	May- Jun	Jul-Aug
Frequency	0	1	0	5	3	0
Percentage	0	11.1	0	55.6	33.3	0

4.3.5 Reproductive swarm capturing, swarm controlling practices

Reproductive swarming is a common phenomenon in honeybee colonies during colony reproduction period. From the total respondents about 43,2 % of them replied that there was practicing swarm control in different techniques. The most frequently ways of controlling reproductive swarm by the respondent beekeeper 65.4% and 34.6% were controlling the swarm by increasing the hive size or suppering and by removing the developed queen cells, respectively. About, 95% of the sample respondents have experience of catching the reproductive swarm and transfer to different hives. They are using different techniques to

capture those reproductive swarm; these are 55% of the respondents using dispersing dust onto swarming colony, 27.9% of them using spraying water onto swarming colony and 16.3% using hanging hive on branches of a tree (Table 20).

Swarming of bees is accepted by all of the interviewed beekeepers. Because it is a means of simple colony multiplication they know in their local knowledge is capturing of the swarm colony and the price of colony is very expensive as determined from the above section (4.2.1).

Table 20: Method of increasing colony number, swarm capturing and controlling

Method of colony no to increase	% used	Technique of swarm capturing	% used	Swarm control technique	% used
By swarm catching;	95	Dispersing dust onto swarming colony	55.8	Increasing the hive size/suppering	65.4
By simple splitting techniques;	5	Spraying water onto swarming colony	27.9	Removing developed queen cell	34.6
By grafting		Hanging hive on branches of a tree	16.3	Splitting the colony	

4.3.6 Honey straining practices and price of honey

Only two persons from the total respondents strain their honey before marketing. They strained the honey obtained from traditional and frame hive why they stained honey from frame hive by simple decantation method and sell in the local market with a better price (150birr).

From the total respondents about, 45.8%, 22.5%, 13.3% and 18.3% were caused to unstrained the honey due to the amount of honey will be reduced, consumer do not prefer strained honey, lack of knowledge how to strain it and lack of materials to strain the honey, respectively (Table 21). However straining of honey separates the honey from bees wax efficiently and sells separately each the honey as well as the wax had gain better price than unstrained honey.

It requires awareness creation and efficient follow up for producers repeatedly to adopt the techniques.

All other respondents sell the unstrained honey directly to local market with a minimum of 70 and a maximum of 150 birr per kilogram (Table 22). The mean price of one kilogram honey is 114.62 birr. The price of honey is determined by agreement between suppliers and consumers. Fluctuation of price at different season is common due to seasonality honey production in the district.

Table 21: Causes of unstrainning of honey

Causes	Frequency	Percent
Lack of materials	22	18.3
Lack of knowledge how to strain	16	13.3
Consumer do not prefer strained honey	27	22.5
The amount of honey will be reduced if strain	55	45.8
Total	120	100.0

Table 22: Price of honey

	N	Minimum	Maximum	Mean	SD
Price of one kg of strained honey	2	150.00	150.00	150.0000	0.0
Price of one kg unstrained honey	120	70.00	150.00	114.6250	16.917

SD= standard deviation from the mean, N= number of observation

4.3.7 Storage practices of honey

When market has plenty of honey at harvesting time unless the beekeeper is at critical financial problems, honey is stored for long period to get better price. The respondents kept their honey for different period of time. Some 41.7% of the interview say I don’t store, I will sale immediately after harvest or it will be consumed during harvesting, other 46.7 % of them said that they kept for 1-6 months (Table 23).

Figure 7: Honey marketing and storage materials in the study area, Tehuledere district

Traditionally beekeepers used different storage containers for different storage duration. 94.2% and 5.8% of the respondent used commonly plastic jar and clay pots, respectively. According to Gichora (2003) sited by Kerealem Ejigu (2005) plastic container is the ideal storage material for the quality of honey. But the clay pot may pass and absorb the moisture and bad smell from the atmosphere due to the hygroscopic nature of the honey. According to the Ethiopian honey quality standard (ES1202:2005) storage containers made of improper material shall be coated completely with bees wax or food grade plastic lines to avoid any direct contact between honey and the container.

Table 23: Honey storage duration and containers used in Tehulederie district

Storage duration of honey	Frequency	%	Container	Frequency	%
I don’t store, I will sale or it will be consumed during harvesting	50	41.7	plastic jar	113	94.2
1-6month	56	46.7	Clay	7	5.8
7-12 month	3	2.5	Total		100
1-2 years	5	4.2			
More than 2 years	6	5.0			
Total	120	100.0			

4.4 Potentials and Constraints of Beekeeping in the Area

4.4.1 Major honey bee plant species and water resources

According to the research 66.6 % of beekeepers grow different plants that help as bee forage for nectar and pollen source in different seasons. Accordingly the major field crops grown in the district cereals of sorghum *(Sorghum bicolor)*, maize *(Zea mays)*, Teff (Eragrostic abicinicus), barley (*Hordeum vulgare*), Wheat (*Triticum aestivum*) oil seeds of nuge *(Guitozia abyssinica)*, Gomenezer (*Brassica Spp)* pulses of vetch *(Lathyrus sativa),* Shembera *(Cicer artietinum)* and Lentil (*Lens culiaris*) are the main source of pollen and nectar during the honey flow season.

The pollen and nectar source variability influences the honey flavor and determines its commercial quality (Ofelia A. *et al.*, 2010). Honeys from certain areas are preferred by consumers due to their sensory characteristics. It is mainly related to floral origin of the honey.

Availability of more seasonal bee forages results in high honey production provided that other environmental factors are suitable for bees (Ofelia A. *et al.*, 2010). In Tehulederie district, there was limited improvement of bee forages development except with the water shed biological soil and water conservation practices. However, there was an extension structure to producers at grass root level, poor linkage between them results minimum development of the sector. Although the followings are the major bee plants of the tree and shrub species which are available in the study area with flowering periods as respondents indicated.

Table 24: Bee flora (Trees, Shrubs and Herb species), and flowering time in Tehulederie district

Local name	Scientific name	Plant type	Honey color	Flowering period												
				Source	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Wanza	*Cordia africana*	T	Y	N&P												
Key bahir zaf	*Eucalyptus spp.*	T	R	N&P												
Bisana	*Croton macrostachyus*	T	B	N&P												
Girar	*Acacia bussei*	T	Y	N&P												
Girar	*Acacia albida*	T	Y	N&P												
Kulkual	*Euphorbia abyssinica*	S	W	N&P												
Sensel	*Justicia schimperiana*	S	Y	N&P												
Tid	*Juniperus procera*	T		p												
Sasebaniya	*Sesbania sesban*	S		N&P												
Weira	*Olea africana*	T		N&P												
Kega	*Rosa abyssinica*	T		N&P												
Kentefa	*Entada abyssinica*	T	Y-W	N&P												
Kinchib	*Euphorbia tirucalli*	S		N												
Eret	*Aloe vera*	S	W	N&P												
Grevila	*Grevillea robusta*	T	NI													
Gumero	*Capparis tomentosa*	S	Y	N&P												
Agam	*Carissa spinarum*	T	Y	N&P												
Chat	*Catha edulis*	T		N&P												

Tree lucern	*Chamaecytisus proliferus*	T		N&P												
Kitkita	*Dadonaea viscosa*	T	Y													
Digita	*Sennasiamea*	T														
Qurqura	*Ziziphus spinachristi*	T														
Atat	*Maytenus arbutifolif/ obscura*	S		N&P												
Embacho	*Rumex nervosus*	S		N&P												
Endod	*Phytolacca dodecandra*	S		N&P												
Maget	*Trifolium steudneri/acaule*	H	Y	N												
Meche	*Guizotia scabra*	H	Y	N&P												
Shinkurt	*Allium cepa*	H														
Telba	*Linum vsitatissiumum*	H														
Zikakibe	*Ocmum basilicum*	H		N												
Wajma	*Medicago polymorpha*	H	Y	N												
Tenadame	*Ruta chalepensis*	H		N												
Besobela	*Ocimum basilicum*	H														
Adeyabeba	*Biden spp*	H	Y	N&P												
Azo Harege	*Clematis hirusta*	S														
Embuay	*Solanium indicum*	S														
Cheba	*Acacia nilotica*	S														

Note: Y=yellow, W= white, R= red B=black N= nectar, P= pollen T= tree, S= shrub, H=herb NI= not identified

Before plantation of trees and shrubs long strategic plan should be design about purpose of utilization of them. Before cultivation of the available plant species integration of the concerned organizations is require. All agricultural development plans should be consider beekeeping for mutual benefits in different development strategies at different agro-ecologies of the area.

According to the respondents, honeybees collect water from streams (45%), rivers (20.8%), spring (28.3%) and the rest (5.8%) from water harvesting sources (Table 25). If suitable drinking water is not available in the immediate surroundings with in 500 m from the apiary, provision of water is required. In many literatures, water is equally important as bee forage to the honey bees (Tesega Belie, 2009; Alemayehu kebede, 2011).

Bees rarely store water in the hive, but bring it in as needed, so it is vital to provide fresh water to them continuously. Bees use water for different purposes like evaporative cooling to control the humidity of the colony, to dilute the crystallized stored honey, to feed the developing larvae, and to digest and metabolize of their food as do most living organisms.

Table 25: Water resource availability for bees in Tehulederie district

Source of water	Frequency	Percent
Stream	54	45.0
River	25	20.8
Water harvestings	7	5.8
Spring	34	28.3
Total	120	100.0

4.4.2 Major beekeeping constraints

From the different choices of beekeeping constraints, the respondent beekeepers raised drought or rain dependent of the agriculture (76.7%), increased cost of production (75%), pests and predators (47.5%), application of pesticides and herbicides (43.3%) and lack of bee forages 32.5% are the major constraints face the production potential of the beekeeping sector

(Table 26). Similarly reported at Selte wereda of Ethiopa results indicated beehives and beekeeping equipment/materials shortages, prevalence of pests and predators, pesticide poisoning and declining bee forage are major constraints for beekeeping production respectively (Alemayehu kebede, 2011).

Researchers identified similar constraints in beekeeping sector in different parts of the country (Kerealem Ejegu, 2005; Abiyu Zewde, 2011; Yetemwork Gebremeskel, 2015). The first challenge of beekeeping around Enebse Sar Midir Wereda of Amhara Region and Amaro special Wereda of Southern Nations, Nationalities and Peoples Region was frequent occurrence of drought (Kerealem Ejegu, 2005). Like other agricultural activities beekeeping is mainly affected by drought all over the country; because Agricultural practices are more depend on natural rain fed than other water sources. Though the bee forages as well as the water sources are mainly affected by seasonal condition of the rain fall. People should consider the different water sources like water harvesting structures and development of springs. Plantation of drought resistance bee forages and supplementation of water during dry period shall be strictly applied.

The second constraint which was reported by respondents was high cost of production for the purchase of colony for foundation stock as well as the high cost of improved technologies. Beekeepers had no knowhow about the colony multiplication techniques. Similarly the cost of frame hive and its accessories are increasing from time to time that is not affordable to buy by rural poor farmers. Therefore training of the beekeepers about colony multiplication techniques and expansion of the rural credit services with a vital insurance should be considered for future expansion of the sector along with the efficient utilization of the district capacity..

Other constraints reported by interviews was the existence of pests and predators like ants and wax moths, application of pesticides and herbicides, and lack of bee forages should be considered in extension services beekeepers must react to tackle for future development of the sector.

Table 26: Major constraints of beekeeping and pest/predator in Tehulederie

Major constraints	N	%	Primary Pest/predator of the district	N	%
Lack of bee forage	39	32.5	Ants(*formicidea*)	56	47.5
Drought/rain fall	92	76.4	Wax moth (*Galleria mellonella)*	42	35.6
Pests and predators	57	47.5	Lice(*Phthirus pubis*)	6	5.1
Pesticide and herbicide application	52	43.3	Spider(*Loxosceles recluse)*	3	2.5
Increased cost of production	90	75	Bird(*Merops apiaster*)	6	5.1
			Honey badger (*Mellivora capensis*)	5	4.2
			Total	118	100

N= number of respondents

4.4.3 Prevalence of pests and predators

The respondents agreed that on the most important enemies of bees around the district are Ants (*Dorylus fulvus*) (47.5%) and wax moth (35.6%) (Table 26). Ants are most wearisome to honey bees and bee keeping sector. Ants were reported to feed on honey, brood, and bees' wax and pollen after all honey and the broods are depleted (Hailegebriel Tesfay, 2014). The indigenous knowledge applied to prevent ants by those respondents are applying ash under the hive stands, clean the underneath of the hives & keep their apiary hygienic, break leaves of eucalyptus and spread beneath the hive stand & plantation of tomatoes around the apiary sight and smearing of burnet motor oil on the hive stand.

Wax moth is also one of important honey bee enemies and causing a serious problem especially in frame hives. In the five regional states of Ethiopia including Amhara region wax moths ranked among the disastrous pests of honey bees by bee keepers (Hailegebriel Tesfaye, 2014). Controlling of the hive space that is timely reduction of the additional space during honey flow season, keep apiary sight clean, remove old comb, and strengthen the colony during dearth period are the indicated measures taken Other bee lice (5%), birds (5%), honey badger (4.2%) and spider (3%) are significantly affected honey bees and their productivity as interviewers indicated. The present study is in line with Kerealem Ejigu (2005) who reported ants, honey badger, bee-eater birds, wax-moth and spiders as the major honeybee pests and enemies in Enebse Sar Midir and Amaro districts in Ethiopia. Also the study in conducted in Silti wereda was ranking, ants were number one predators (27.6%) followed by wax moth (20.6%), bee eater birds (18.3%), spider (16%) and wall lizard (12.4%) but honeybadger was the other minor predatory in the area (Alemayehu Kebede 2011).

4.4.4 Prevalence of poisons plants and chemical poisoning of honey bees

Results obtained from the respondents indicated that Susbania species and Sensel (*Justitia schemperina*) were toxic to honey bees and causes toxicity for the product honey. Susbania species was reported to be toxic to the bees themselves and those in which the honey produced from its nectar become toxic to humans consumption (Hailegebriel Tesfaye, 2014). Sensel (*Justitia schemperina*) is also described by the respondents to affect the honey quality by causing diarrhea to consumers. Yet, these call for attentions confirmed by research.

The respondent beekeepers indicated also whether their bees have an effect on prevalence of chemical poisoning or not. Vertualy70.8% of them says yes their colonies are victims for different chemicals used in the district. The beekeepers and their neighbors used chemicals without restriction for pest control, for weed control and for malaria control, 56.7%, 50.8% and 46.7% near to the apiary sits, respectively (Table 27). Commonly used agro chemicals such as Thionex 35ec,Fyfanon 50% Ethiozinon60%ec, Endosulfa35%, Decis 2.5%ec, Dicopur 720sc, Agro-thoate 40%ec, Agro 2,4-D amin 720 A, were tested for toxicity effect on honeybees under laboratory condition. The results indicated that all agro chemicals except Agro 2,4-D amin 720A caused significant mortality on honeybees when ingested with food.

Fyfanon 50%, Ethiozinon60%ec and Desis 2.5%ec are also significantly toxic to honeybees through vapor. Results of the field experiments also supported the result of laboratory that all agro chemicals tested under field condition have caused significant deaths except Agro2, 4-D amin 720A, E (Amsalu Bezabeh *et al*., 2012). Strategies for utilization of chemicals should be set by the regional government with integration of concerned crop scientists, animal experts, legal entities and environmentalists.

Table 27: Utilization of chemicals in Tehulederie district

Chemicals used in the district	**yes**	**no**	**Total**
Chemicals for pest control			
Frequency	68	52	120
Percentage	56.7	43.3	100
Chemicals for weed control			
Frequency	61	59	120
Percentage	50.8	49.2	100
Chemicals for malaria control			
Frequency	56	64	120
Percentage	46.7	53.3	100

4.5 Honey Production Purposes, Place of Product to Sale and Market Information

According to the result from interview the mean utilization of honey produced by respondents 76% ±15.7% for marketing and 24% ±15.7% for home consumption (Table 28). Unlike many other agricultural products of the district farmers, honey is primarily market product. As SOS-Sahel (2006) indicated, it is estimated that over 90% of the total honey produced in the country is for market sale and very little is consumed at home (Beyene Tadesse, 2007).

Honey produced by the respondent beekeepers was directly sold at local market and some 12.5% of them are sold at their farm gates (Table 28). Based on the results of this study, there was no beekeeper that bases their income only from beekeeping.Though the district

beekeeping practice is carried out as a sideline activity to other income sources. There are no any market information sources about seasonal price and place of the products to sell. Actually it is very necessary to feed those beekeepers to gain fair price at the correct marketing time. The regional cooperative agency and Bureau of Trade should considered it as soon as possible.

Table 28: Utilization and marketing of honey in Tehulederie district

Purpose of production	N	%age utilization of honey				Place of product to sell		
		Min	Max	Mean	SD		Freq.	%
Honey produced for marketing	120	30	95	76	15.71	Farm gate	15	12.5
						Local market	105	87.5
Honey produce for home consumption	120	5.00	70.00	24	15.71	Total	120	100

Min: minimum, Max: maximum, SD: standard deviation from the mean

4.6 Honey Quality

The chemical properties of honey play an important role in determining the honey quality and affect international honey business. Unlikely other honey quality studied by different researchers in the country, this study focused only honey that collects directly from the hive.

4.6.1 Moisture Content

Moisture content is one of the most important parameters to be considered in the quality of honey since it affects storage life and processing characteristics. The moisture content of honey in this study ranges from 14.2 to 19.3 with the mean of 16.7 (Table 29). All of the honey samples in the study had moisture content within the accepted range of both the world as well as the national standard level. The results indicated that honey produced from the highland agro-ecology is comparatively higher moisture content than honey produced from low land areas. Similarly the results of the study conducted at Libokemkem wereda of Amhara Region showed that none of the honey samples exceeding the limit allowed by the

Codex and Council of the European Union (EU) of < 21% (Addis Getu and Malede Birhan, 2015*)*. Honey samples produced in relatively high humid areas like South and South West part of the country found to consist high moisture than honey produced from low humid areas of the country. Frame hive honey has higher moisture content than broken comb hive (top-bar hive and local hive) honey. Moreover, there was significant ($p < 0.05$) difference of the moisture content between groups based on the difference both in agro-ecology and hive type. Generally speaking the results revealed that the honey produced agro-ecology of the area and the hive type had an effect on the moisture content of honey, where the moisture content of the sampled honey increased with the altitude increase and modernizing of the hive type.

4.6.2. Ash Content

When the altitude of the agro-ecology increases the mineral content of the honey relatively increases. The mineral (ash) content of the samples from the current study ranged from 0.05 to 0.11% with a mean of 0.07%. The ash content of the honey samples obtained from Libokemkem wereda of Amhara region ranged from 0.014-0.31g with a mean value of 0.17 (Addis Getu and Malede Birhan, 2015). The accepted mineral content should be less than 0.6% (Table 27). In this result the mineral content of honey samples is within the Ethiopian accepted national standard quality level (Table 29). The results indicated that honey produced from the highland agro-ecology had moderately higher mineral content than honey produced from low land areas (Yetimwork Gebremeskel, 2015). But there is no reasonable difference of the ash amount in the sample honey based on hive types. Dark honeys, particularly honeydew honeys are the richest in minerals.

4.6.3. Acidity

The other quality criterion of the honey is acidity of the honey. Acidity of the samples honey analyzed for this study ranged from 19.5 to 25.5meq acid/kg with mean of 22.3 meq. acid/kg (Table 29). In this result the acidity of honey samples fulfilled within the World and the Ethiopian accepted national standard quality level (less than 40 meq. acid/kg of honey). The results indicated that honey produced from the highland agro-ecology is slightly higher acidic nature than honey produced from low land areas. There is no reasonable difference of the acidity in the sample honey based on hive types. Though, there is no significant difference

between groups of the sample acidity ($P>0.05$). Variation in free acidity among different honeys can be attributed to floral origin or to variation in the harvest season (Alemayehu Kebede, 2011). Acidity of the honey is one of its merits for its antimicrobial property. When the acidity becomes high, the honey becomes sour.

4.6.4. The PH value

The PH values of honey obtained in this study ranged from 3.1 to 4.7 with mean value of 3.85±0.46. The pH value of honey observed in this study is similar to the study result of Selte wereda ranged from 4.13 to 5.02 (Alemayehu Kebede, 2011). Similarly reported pH of 3.49 to 5.58 from Burie wereda, Ethiopia (Tesega Belie, 2009). Published reports indicated that acceptable pH of honey to be between 3.2 and 4.5 (Codex almentarius commission, 2001). This result is also within the quality regulation level proposed by Codex (1993) and EU (1974). The pH of honey should be between 3.2 and 4.5 (Bogdanov s., *et al.,* 1997). In this study 87.5% of the samples fall with the accepted standard quality (Table 29). The honey pH had significantly difference ($p<0.05$) by hive type groups of the sample honey. This indicates that the honey was fairly acidic and this could be in part responsible for the excellent stability of honey against fermentation and natural flavor (Gebregziabher Gebremedhin *et al.,* 2013). The variations in pH might mainly be resulted due to different acids found in different floral types.

4.6.5 Hydroxyl-Methyl-Furfural (HMF)

Hydroxyl-Methyl-Furfural (HMF) is one of the most important parameters for determination of the honey quality. The HMF values of honey obtained in this study ranged from 21.26 to 66.7 mg/kg with mean value of 37.7 mg/kg (Table 29). The acceptable HMF value of honey is between 40 and 80 mg/kg (Codex almentarius commission, 2001). It is higher in low land agro-ecology and broken comb hive type of the honey samples. However there is no significant difference between groups of the honey sample either the hive types or the agro-ecologies which is in the international acceptable pH value of honey.

Virtually absent in newly produced honey, hydroxvmethylfurfural (HMF) is a byproduct of fructose decay, formed during storage or during heating (Bogdanov s., *et al.,* 1997). Thus, its presence is considered the main indicator of honey over heated, aged or adulterated with invert sugar (hydrolyzed sucrose (FAO. 1996).

4.6.6. Diastase Activity

Diastase activity is a quality factor influenced by honey storage and heating. There is a large natural variation of the Diastase activity in honey. The acceptable Diastase activity of honey is between 3 and 10 Goth scale (Codex Almentarius Commission, 2001). The Diastase activities of honey obtained in this study ranged from 8.28 to 18.2 Goth scale with mean value of 14.4 Goth scale (Table 29). Like HMF it is higher in low land agro-ecology and broken comb hive type of this honey samples. There is a significant difference ($p>0.05$) of the diastase activity between the hive types. It is higher in Brocken comb hive type than frame hive.

4.6.7. Apparent sucrose content

The contents of apparent sucrose (non reducing sugar), samples vary from 0.99– 6.47% with the mean of 4.04 %. Although there is no significant difference between groups of the sample both in agro-ecologically and hive types. The world standard quality of apparent sucrose is determined to be 3 to 10 %. The result showed that 100 % of the samples were in the acceptable range (Table 29).

4.6.8. The reducing sugar content

The reducing sugar composition of honey samples collected in Tehuledere district vary from 58.8 to 68.9 meq/kg with the mean of 64.3 meq/kg positioned with in recommended range 60% to 70% by Codex Almentarious commission, (2001). It has significant difference of the reducing sugar ($p> 0.05\%$) between groups of the hive types. Similarly results in reducing sugar by (Gebreegziabher Gebremedhin *et al.,* 2013) in Tigray region honey which accounted about 70.95% on an average.

Generally the PH value, Diastase activity and reducing sugar contents had also significant differences between groups of hive types. Although the ash content of the honey samples had significant different based on agro ecology groupings. But no significance difference is observed in other parameters with in hive type and agro ecology groups. Generally the result all the eight parameters determined under those analyses showed that 100 % of the sample means were situated in the acceptable range of the world honey quality standard set by Codex Almentarious, 2001. Similar results was found at the acceptable range of quality around Gonder (Addisu Getu and Malede Birhan,2014).

Table29: Chemical analysis results of the honey samples in Tehulederie district

Variable	N	Moisture (%)		Ash (%)		Acidity (meq/kg)		pH	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Agro ecology based									
Highland	8	16.3– 19.3	17.89 ±1.12*	0.06– 0.10	0.083 ±0.01	21.0 – 24.0	22.8 ±1.2	3.1 - 4.7	3.6 ±0.57
Mid altitude	8	14.4 – 17.8	16.4 ±1.38*	0.06– 0.11	0.08 ±0.01	20.5– 25.5	22.7 ±1.8	3.2 – 3.9	3.61 ±0.25
Low land	8	14.2 – 16.6	15.7 ±0.8*	0.04– 0.08	0.06 ±0.01	19.5– 23.0	21.4 ±1.3	3.3 – 4.6	4.05 ±0.47
Mean	24	14.2– 19.3	16.7 ±1.42	0.05– 0.11	0.07 ±0.02	19.5– 25.5	22.33 ±1.55	3.1 – 4.7	3.85 ±0.46
Honey source based									
Framed hive honey	12	15.8– 19.3	17.55 ±1.115*	0.05– 0.10	0.075 ±0.016	19.5– 24	22.17 ±1.47	3.1 – 4.1	3.6 ±0.36*
Brocken comb honey	12	14.2– 17.7	15.87 1.2*	0.05– 0.11	0.074 ± 0.02	20.0– 25.5	22.5 ±1.68	3.5 – 4.7	4.1 ±0.41*
Mean		14.2– 19.3	16.7 ±1.42	0.05– 0.11	0.07 ±0.01	19.5– 25.5	22.3 ±1.55	3.1 – 4.7	3.85 ±0.46

Variable	N	HMF (mg/kg)		Diastase (Goth scale)		Reducing sugar(meq/kg)		Apparent sucrose (%)	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean± SD
Agro ecology based									
Highland	8	27.09– 45.51	35.76±6.47	8.3 –18.1	13.28 ±3.53	62.5 – 68.9	65.6 ±2.6	3.76– 6.06	4.69 ±0.8
Mid altitude	8	21.26– 40.72	31.08 ±7.08	9.1 – 18.1	14.4 ±3.4	58.8 – 68.9	62.9 ±3.7	1.78– 6.07	3.96 ±1.63
Low land	8	25.60– 66.47	46.20±18.05	14.4 – 16.8	15.5 ±0.89	62.4 - 68.9	64.6 ±2.8	0.99– 6.47	3.44 ±1.92
Mean	24	21.26– 66.46	37.68 ±12.99	8.3 – 18.2	14.4 ±2.9	58.8 – 68.9	64.4 ±3.2	0.99– 6.47	4.03 ±1.55
Honey source based									
Framed hive honey	12	25.60– 40.72	32.62 ±4.99	8.3 – 16.8	12.92 ±3.14*	62.5 – 68.9	66.0 ±2.5 *	2.49– 6.07	4.09 ±0.97
Brocken comb honey	12	21.26 – 66.47	42.7 ±16.50	13.5– 18.2	15.89 ±1.7*	58.8– 88.8	65.3 ±7.9 *	0.99 – 6.47	3.98 ±2.0
Mean	24	21.2– 66.5	37.7 ±13.0	8.28 – 18.2	14.4 ±2.9	58.8– 68.9	64.3 ±3.2	0.99– 6.47	4.04 ±1.55

*There is a significant difference at $P<0.05$ or at 95% confidence.

Source: Laboratory analysis result from collected honey samples

Table 30: Results of honey in the study areas, National and International standard

	Standards			Study Area Result
Characteristics tested	World	FAO/WHO	National	(Mean)
Moisture content, % by mass	18 – 23	21 – 23	21max.	16.7
Total ash, % by mass	0.25 – 1	0.6 – 1	0.60 max.	0.07
Total reducing sugar	60 – 70	65 min	65 min.	64.3
Sucrose content, % by mass	3 – 10	5 – 10	5 max.	4.04
Acidity, milli equiv. acid/kg	5 – 54	40/kg	40/kg	22.3
Hydrixymethylfurfural mg/100g	40 -80	80 max	40 max.	37.7
Diastase	3-10	-	3 min.	14.4
pH	3.2 - 4.5	-	-	3.85

Source: Quality and Standards Authority of Ethiopia (2005) and the study results

4.6.9 Correlation between the chemical properties of honey

Different honey quality parameters had different correlation results between each other in the study district (Table 31). The moisture content has positively and significantly correlated with apparent sucrose content (P<0.01), negatively and significantly correlated with diastase activity (P<0.01) and the pH value (P<0.05). However, there was no correlation between moisture content with free acidity, ash, HMF and Reducing sugar content. Moreover, the free acidity and ash content of the honey had no correlation with other pre-determined parameters. The PH value was highly significant (P<0.01) and positively correlated with HMF but no correlation with other pre-determined parameters except with the moisture content. However, diastase activity of honey was negatively correlated (P<0.05) with reducing sugar content but no correlation with other pre-determined parameters except with the moisture content. Apparent sucrose content was no correlation with all other pre-determined parameters except with the moisture content. Moreover, reducing sugar content was no correlation with all other pre-determined parameters except with diastase activity.

Table31. Correlation results between different chemical properties of sample honey

	Moisture content	Free acidity	PH	Ash	HMF	Diastase activity	%apparent sucrose	Reducing sugar
Moisture content	1							
Free acidity	.135	1						
PH	-.431*	.176	1					
Ash	.298	-.017	-.158	1				
HMF	-.330	-.096	.542**	-.37	1			
Diastase activity	-.524**	-.148	.336	-.117	-.113	1		
%apparent sucrose	.530**	.136	-.075	.113	-.035	-.202	1	
Reducing sugar	.401	.117	-.084	-.137	.084	-.423*	-.004	1

*Correlation is significant at (P<0.05) (2-tailed)
**Correlation is significant at (P<0.01) (2tailed)

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

This section concludes the relevant piece of findings available both from the survey as well as the laboratory analysis of the honey quality situation from the researcher cram. Appropriate possible suggestions are forwarded and indicated, recommendations for different level of actors set to enhance the sector.

5.1. Conclusion

The district Tehulederie has a long tradition of beekeeping practice as a sideline activity with other income sources. Based on their level of technological advancement, three distinct types of beekeeping practices are used by the sample beekeepers (120) in the area. These are traditional (local) hive based (105), transitional (Ethio-ribrab top bar) hive based (17) and moveable frame (box) hive based (57) beekeeping practices. However, the adoption of extension to modern beekeeping system (transitional and frame hive beekeeping) was exercised through generation with little development of technologies that contributes below the potential of the district.

The amount of honey produced from one bee hive per year varies from technology to technology and among geographical. The maximum amount of honey harvested was 30 kg recorded from frame hive. The difference was mainly due to the input applied differences, management of the beekeepers and the environmental situation of the district.

Even if the honeybee queen rearing center is established around the district, swarming of bees is still a source of foundation stock for most of the beekeepers. It is also concluded that they are using their own traditional knowledge only for queen rearing practices by using beehives constructed from locally available materials.

Despite all the challenges currently facing the beekeeping subsector, Tehulederie district has still enormous opportunities and a huge potential for modern beekeeping practice to boost the production and improve the quality of honey products. This can be expressed

by results obtained from some frame hive participants in the district produces comparatively high quality and quantity of honey from limited number of colonies, availability of diverse honeybee floras in most part of the district during the different season, availability of different water resources in and around the district, experience of the beekeepers leads to ease them to use the modern type technologies through training and good market demand of the product honey and bees wax.

Based on the result of this study, most of the beekeepers cannot gain training about colony multiplication techniques, construction of transitional bee hives, frame hive beekeeping system and its material utilization, about seasonal colony management practice and transferring of colonies in to modern hives.

5.2 Recommendations

Tehulederie has a huge potential and bright future for beekeeping practices. Therefore, government and non government organizations should act together to change the life of rural people and to gain cumulative benefit from beekeeping. Based on the result of this study issues that require consideration by concerned development organizations are recommended below:

- Designating of the package, identification of the local participants according to their enthusiasm, capacitating them through trainings and provision of technologies with full package with continuous follow up.

- Provision of continues trainings on different colony multiplication techniques, seasonal activities and transferring of colonies to modern hives and transitional (Ethio-ribrab) beekeeping production system that can implement with minimum cost which can be affordable by the rural poor households and land less youths.

- Plantation of drought tolerant bee forages around the apiary and natural resource rehabilitation of water shed areas, conservation of existing vegetations, exploitation

of crops as bee forage should be considered. Utilization of the available water resources during the drought period for watering of bee forages for supplementation of bees.

- Intensification of the existing beekeepers, youth groups, cooperatives and establishment of union to strengthen and creating a link between producers and processors to produce products which can fulfill international market standards.

- Establishment of diversified bee product collection, processing and marketing centers by capacitating the inputs suppliers, the landless rural interested youths, female household heads and other interested individuals.

- Poisoning of honeybees by the indiscriminate use of agricultural chemicals increased from time to time. As a result, a considerable number of beekeepers totally lost their colonies. Therefore, there is a need for the government to give special attention to solve these problems through coordinating and integrating the concerned bodies like crop scientists, animal science experts and other government organizations to make the already existing proclamation into effective.

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APPENDICES

Appendix Tables

Appendix Table7: 1. Relationship of water content of honey to refractive index

Refractive index (20^{o}c)	Moisture content (%)	Refractive index (20^{o}c)	Moisture content (%	Refractive index (20^{o}c)	Moisture content (%
1.5044	13.0	1.4935	17.2	1.4830	21.4
1.5038	13.2	1.4930	17.4	1.4825	21.6
1.5033	13.4	1.4925	17.6	1.4820	21.8
1.5028	13.6	1.4920	17.8	1.4815	22.0
1.5023	13.8	1.4915	18.0	1.4810	22.2
1.5018	14.0	1.4910	18.2	1.4805	22.4
1.5012	14.2	1.4905	18.4	1.4800	22.6
1.5007	14.4	1.4900	18.6	1.4795	22.8
1.5002	14.6	1.4895	18.8	1.4790	23.0
1.4997	14.8	1.4890	19.0	1.4785	23.2
1.4992	15.0	1.4885	19.2	1.4780	23.4
1.4987	15.2	1.4880	19.4	1.4775	23.6
1.4982	15.4	1.4875	19.6	1.4770	23.8
1.4976	15.6	1.4870	19.8	1.4765	24.0
1.4971	15.8	1.4865	20.0	1.4760	24.2
1.4966	16.0	1.4860	20.2	1.4755	24.4
1.4961	16.2	1.4855	20.4	1.4750	24.6
1.4956	16.4	1.4850	20.6	1.4745	25.0
1.4951	16.6	1.4845	20.8	1.4740	25.8
1.4946	16.8	1.4840	21.0		
1.4940	17.0	1.4835	21.2		

Appendix Table7: 2: Honey quality Ethiopian standard ES 1202:2005

Ser.No	Characteristics	Requirements
1	Apparent reducing sugar (as invert sugar), % by mass min.	65
2	Apparent sucrose content % by mass, max.	10
3	Water insoluble solids contents % by mass max.	0.1
4	Mineral content (ash), % by mass max.	0.6
5	Acidity mill equivalents acid per kg	40
6	Diastase activity, 1% starch solution hydrolyzed by the enzyme in 1 gram of honey in 1 hour at 40°C, min.	3
7	Hydroxymethyl furfural content mg/kg	40

Appendix figures:

Appendix figure7:1: Laboratory analysis of the sample honey

Appendix figure7:2: The three beekeeping hive types around Tehuledere district

Apendix figure7:3 Part of beekeeping and honey production in Amhara region

Apendix figure7:4 Part of the study district

Appendix figure7:5. Reagents preparation procedures for laboratory determination

Soxhlet's modification of Fehling's solution:

- Solution A: Dissolve 34.64 g copper sulphate pent hydrate ($CuSO_4.5H_20$) with distilled water to 500 ml. Keep one day before titration.
- Solution B: Dissolve 173 g sodium potassium tartar ate (C_4H_4 K $NaO_6.4H_2O$) and 50g sodium hydroxide (NaOH) with distilled water to 500 ml. Filter through inert material.

Standard Invert Sugar Solution (10 g/L) :

- Weigh accurately 9.5 g pure sucrose, add 5 ml hydrochloric acid ca. 36.5 percent w/w pure HCI) and dilute with water to about 100 ml, store this acidified solution for several days at room temperature (ca. 7 days at 12^{o}C to 15^{o}C,or 3 days at 20^{o}C to 25^{o}C), and then dilute to I liter.

methylene Blue Solution. Dissolve 2 g in distilled water and dilute to 1 litter.

Alumina Cream : Prepare cold saturated solution of alum ($K_2SO_4A1_2$ (SO_4) $_3$.24H2O) in water. Add ammonium hydroxide with constant

Phenolphthalein indicator: I percent (m/v) in ethanol, neutralized.

Distilled Water : made carbon dioxide free by boiling and subsequent cooling

Iodine stock solution : Dissolve 8.8 g of iodine analytical grade, in 30-40 ml water containing 22 g potassium iodide, analytical grade, and dilute to I litre with water.

Iodine solution 0.0007 N: Dissolve 20 g potassium iodine, analytical grade, in 30-40 ml water in a 500-mL volumetric flask Add 5.0 ml iodine stock solution and make up to volume. Make up a fresh solution every second day.

Acetate buffer - pH 5.3 (1.59.M) : Dissolve 87 g sodium acetate in 400 ml water, add about 10.5 ml glacial acetic acid in a little water and make up to 500 ml. Adjust the pH to 5. 3 with sodium acetate or acetic acid as necessary using a pH meter.

Sodium Chloride Solution 0.5M: Dissolve 14.5 g sodium chloride, analytical grade, in boiled-out distilled water and make up to 500ml The keeping time is limited by mould growth..

Starch solution: Preparation of soluble starch. In a conical flask immersed in a water-bath and fitted with a reflux condenser, boil 20 g of potato starch for one hour in the

presence of a n fixture of 100 ml of 95 percent ethanol and 7 ml of 1M hydrochloric acid. Cool, filter through a filtering crucible (pore size 90 - 150 -µm) and wash with water until the wash/water ceases to give any chloride reaction. Drain thoroughly and dry the starch in air at 35 ^{0}C the soluble starch must be stored in a well stoppered flask

Carrez solution I: Dissolve 15 g $K_4Fe(CN)_6.3H_20$ and dilute to 100 ml with distilled water.

Carrez solutionII: Dissolve 30 g Zn acitate and dilute to 100 ml with distilled water.

Sodium bisulfate solution: 0.20%. Dissolve 0.20 g $NaHSO_3$ and dilute to 100 ml with distilled water dilute 1+ 1 for reference if necessary Prepare fresh daily.

0.025 M sulpheric acid solution: Pipate 0.68ml of concentrated sulpheric acid and dilute it to 500ml with distilled water

0.05M NaOH solution: Accurately weigh 1gm of NaOH and dilute it to 500ml with distilled water

Appendix Table 7.3: Questionnaire used in the study

Questionnaire on characterizing the beekeeping system and honey quality in Tehuledere district of------------ kebele-----------village.

1. House hold characteristics

1.1 Name of respondent and responsibility ------------------------1.2 sex-----1.3 age------1.4 Number of years lived in the area ---------------- 1.5 Educational status: Read and write --------- grade (1-4)----------- grade (5-8)--------------- grade (9-12)----------- (higher level)-------------1.6 Religion----------------- 1.7 Marital status: Married---------- Single --------------- widowed------ Divorced---- 1.8 Responsibilities in the community (1. Political leader 2. Spiritual leader 3. Elder 4. Other (specify))

1.9. Family member and their educational level

No	Name	Relation	Sex	Age*	Education**

* 1. Below 14; 2. 14-60; 3. Above

**1. Illiterate; 2. Basic education; 3. Grade 1-4; 4. Grade 5-8; 5. Grade 9-12.

1.10. Division of work including off-farm activities according to age group

Sex	Age			
	8-15	16-28	29-45	46-60
Male				
Female				
Total				

1.11. Landholding (ha): 1.1 Total land holding ____1.2 Farmland _____1.3 Forest land _____ 1.4 Grazing land _____1.5 Others ____

1.12. Major crops grown

No.	Crop type	Area (ha)	Yield (qt)	Purpose				
				Household consumption	Seed sale for income	Cover wages in kind	Animal Feed	Others

1.13. What are the major crop production problems you encountered? 1. Shortage of farm land; 2. Shortage of oxen; 3. Drought; 4. Soil fertility loss; 5. Inputs (seed, fertilizer) shortage; 6. Weeds; 7. Insects; 8. Diseases; 9. Rodents; 10. Others (specify): ___________

1.14. What are the major livestock production constraints to you?

1. Shortage of feed; 2. Shortage of grazing land; 3. Shelter and housing; 4. Lack of drinking water; 5. Parasites; 6. Diseases; 7. Low productivity; 8. Market; 9. Others (specify): ____________

1.15. Do you and your family have an off-farm practice? 1. Yes; 2. No.

1.16 .If yes what off-farm activities you implement?

No	Off-farm activity	No. of family member participating	Total annual income in birr
`			

1.17 Do you keep honey bees? 1. Yes 2.No

1.18. If yes when did you start bee keeping? .... year(s) before.

2. Beekeeping activities and honey 'crop' production

2.1. How you start beekeeping?

No.	Sources	Total	Traditional	Transitional	Movable-frame
1	From parents				
2	Catching swarms				
3	Buying				
4	Others (specify)				

2.2. If the answer for question 2.1 is buying, is there a sale of bee colony in your locality?

1. Yes 2. No

2.3. If yes what is the price of one colony? ....ETB.

2.4. How many honey bee colonies you owned?

Ser. No.	Years	Traditional		Transitional		Moveable-frame		Remark
		No.	Product (kg)	No.	Product (kg)	No.	Product (kg)	
1	2011							
2	2012							
3	2013							
4	2014							
5	2015							

2.5. What are the features of your honey bees?

Behavior: 1. Docile 2. Aggressive 3. Very aggressive

Color: 1. Black 2. Red 3. Grey 4. Yellow 5. Mixture

Size 1. Big 2. Medium 3. Small

2.6. Which bees are with more production potential?

Behavior: 1. Docile 2. Aggressive 3. Very aggressive

Color: 1. Black 2. Red 3. Grey 4. Yellow 5. Mixture

Size 1. Big 2. Medium 3. Small

2.7. What are the sources and costs of the bee hives you are using?

No.	Items	Unit	Traditional	Transitional	Moveable-frame

1	Constructed by himself/herself	No			
2	Constructed locally & bought	No			
3	Bought from market	No			
4	Supplied by governments				
	-3 On credit bases	No			
	-4 Free of charge	No			
5	Supplied by NGOs				
	-5 On credit bases	No			
	-6 Free of charge	No			
6	Price of one hive	(ETB)			
7	Service years	years			

2.8. What are the major materials used for hive construction in the study area?

a. from bark of tree b. from clay

c. from mud d. from straw made e. others

2.9. What are the major advantages of your different bee hives?

No.	Criteria	Traditional		Transitional		Moveable-frame	
		Yes	No	Yes	No	Yes	No
1	Material availability						
2	Suitability of harvest						
3	Quality of honey						
4	Temperature maintenance						
5	More swarming frequency						
6	Convenience to construct						
7	Durability						
8	Cost effective						
9	Others (specify)						

2.10. Which equipment you are using for honey harvesting? (Mark one or more)

Hive type	Protection cloth	Smoker	Bee brush	Knife	Water spryer	Chisel	Others (specify)…
For traditional							
For transitional							
For modern							

2.11. Mention months of the dearth period and active season?

a. dearth period, -------------- to -----------------------

b. active season, -------------- to-----------------------

2.12. How much Kg of honey do you harvest from one hive per year?

No	Hive type	Average	Max	Min

2.13. How many times do you harvest honey per year? a) 1; b) 1.25; c)1.5; d)1.75; e) 2; f) 3; g) 4

3. Farmers practices and colony management

3.1. Where did you keep your colonies?

No.	Site or placement of hive	Traditional	Transitional	Moveable-frame
1	Back yard			
2	Under the eaves of the house			
3	Inside the house			
4	Hanging on trees near homestead			
5	Hanging on trees in forests			
6	Water shed forests land			
7	Others (specify)			

3.2. For how many years your colony remains or stays in the hive (didn't swarm)? Is that to mean absconding?? Because swarming is a normal procedure!!

1. Traditional: Minimum ______year (s) Maximum ______years
2. Intermediate: Minimum ______year (s) Maximum ______years
3. Movable-frame: Minimum ______year (s) Maximum ______years

3.3. The major types of tree species preferred for hive hanging during swarm catching

No.	Scientific name	Local name	Reason of preference
1			
2			
3			
4			

3.4. How could you increase your colony number? a) By swarm catching; b) By simple multiplication techniques; c) by grafting; d) others -----

3.5. If the answer is b or c, how many new colonies you got from one colony per a single multiplication? Max----, minimum-----

3.6. What type of techniques is used to capture swarming colony?

By dispersing dust onto swarming colony

By spraying water onto swarming colony

By hanging hives on branches of a tree

others (specify)……

3.7. Do you practice swarm control /prevention/? A) Yes b) No

3.8. If the answer is yes, what methods you used? a) Increasing the hive size; b) removing developed queen cells c) splitting the colony d) other (specify) -------

3.9. Is swarming advantageous to you? 1. Yes 2. No

3.10. If yes describe the reason(s)

a. To increase my number of colony b. To sale and income

c. To replace non- productive bee colonies d. others (Specify)

3.11. What method/s do you use to control swarming?
a. Removal of queen cell b. cutting of honey comb
c. Cutting drown comb d. supering
e. using large volume hive f. other specify ………………
3.12. Do you inspect your colonies? 1. Yes 2. No
3.13. If yes which type of inspection you perform?
a. external hive inspection
b. internal inspection c. both
3.14. Frequency of inspection
external hive inspection (circle one or more)
i. Frequently ii. Sometimes iii. Rarely
internal hive inspection (circle one or more)
Frequently ii. Sometimes iii. Rarely
3.15. When the following major activities occur in your locality?

No.	Activities	Season(s)				
		Aug -Oct	Nov-Jan	Feb-App	May-Jul	other
1	Brood raring period					
2	Hive suppering /spacing/					
3	Honey harvesting					
4	Super reduction					
5	Absconding					
6	Swarming					
7	Colony migration					
8	Dearth period					
9	Colony feeding					

3.16. Do you strain your honey? a. Yes b. No
3.17. Which honey do you separate/strain from beeswax and other debris before marketing? a) Honey from traditional hives b) honey from transitional hives c) honey from movable frame hives d) all e) not at all
3.18. If yes, what materials do you use for straining? a. Honey b. Honey presser c. Cloth d. Sieve e. Decantation f. Using hand
3.19. If you strain, what is the price of 1 kg strained honey? -------- ETB
3.20. If you don't strain your honey why? (Circle one or more). a. Lack of materials b. Lack of knowledge how to strain c. Consumer do not prefer strained honey d. The amount of honey will be reduced if strained e. Others specify: ____________________
3.21. If you do not strain, what is the price of 1 kg non strained honey? -------- ETB
3.22. For how long do you store your honey? (Circle one or more). a. I don't store, I will sale / it will be consumed during harvesting b. One to six months c. Seven to twelve months d. One year to two years 5. More than two years
3.23. For what reason do you store honey? a. due to price b. to increase medicinal value c. others (explain)----------------
3.24. What types of containers are used for honey collection and storage?
a. Plastic barrel/jar b. clay jar c. metallic container d. other specify…

3.25. If your honey is granulated or crystallized, did you change it to viscous honey? 1. Yes 2. No

3.26. If yes what methods do you use? a. Direct heating using fire b. putting in boiled water c. using sun light d. others………………..

3.27. How do you rate the quality of your Honey?

a. by color b. smelling c. by its odor d. by testing e. by its thickness f. other (specify)

3.28. What type of other bee products do you produce?

a. Bees wax b. propolis c. royal jelly d. Bee venom e. pollen f. Bee brood

3.29. Do you feed honey bee colonies? 1. Yes 2. No

3.30. If yes when do you feed your honey bee colonies (months)…………

3.31. What kind of feed you offer to your bees?

No	Type of feed	Amount offered/season/colony	Cost per kg(ETB)
1	Besso		
2	Shiro		
3	Sugar		
4	Honey		
5	Other (Specify)		

4. Potential and constraints of apiculture in the area

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

No	Types of beehives	Numbers (increasing/decreasing) trend	Reasons
1	Traditional		
2	Transitional		
3	Movable frame		

4.2. If there is an increase in trend in the number of bee colonies and honey yield over the years, what are the reasons? a) Good market price; b. Added more bee colonies; c. Use of new technologies; d. Others (specify) ___________

4.3. If there is a decrease in trend in the number of bee colonies and honey yields over the year, what are the causes and measures in order of importance?

No	Causes	Rank	Season of occurrence	Measures taken
1	Lack of bee forage			
2	Lack of water			
3	Drought (lack of rainfall)			
4	Migration			
5	Absconding			
6	Pests and predators			
7	Diseases			
8	Pesticides and herbicides application			
9	Death of colony			
10	Luck of credit			
11	Increased cost of production			

12	Others (specify)			

4.4. What is the major honey Bee plant species found in the study area?

No	Plant type	Scientific Name	Local Name	Flowering period	Color of honey Produced from
1					
2					
3					
4					
5					
6					
7					

4.5. Which types of plant species are more visited by honey bees? (Choose No from 4.4)

a.------ b. ------- c.--------- d. ----------- e -------

4.6. The honey from which plant species are more preferred among consumers?

a.------ b. ------- c.--------- d. ----------- e -------

4.7. Is there any plant species which are toxic for bees in the study area?

a. Yes b. No

4.8. If yes mention some of them

Scientific Name Local Name

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4.9. Does water available for your honey bees at all the time? 1. Yes 2. No

4.10. If yes, where do your honey bees get water? (Circle one or more)

a. stream b. rivers c. lakes d. ponds e. water harvesting f. others

4.11. If your response is No, how do you provide water to your bee colonies? ------------------------
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4.12. If there is any bee diseases in the study area what are they? ------------------------------------

4.13. In which category of hives your colonies do more likely affected by the disease?

a. traditional b. transitional c. movable-frame

4.14. What are the major pests & predators found in the area that threat your colonies? List in order of importance

No	Pest/predator	Rank	Local control methods
1	Ants		
2	Wax moth		
3	Bee lice		
4	Spiders		
5	Wasps		
7	Toads/frog		
8	Lizard		
9	Snake		

10	Monkey		
11	Birds		
12	Hama got/shelemetmat		
13	Others (specify)		

4.15. Do you use agrochemicals/chemicals in your locality? 1. Yes 2. No

4.16. IF yes, why do you apply agrochemical/chemicals?

a. crop pest control b. weeds control c. malaria control

d. tsetse fly control e. others (specify)-------------------------------------

4.17. When do you use agrochemicals/chemicals (months)? -----------------------------------

4.18. What type of agrochemicals/chemicals are you using? --

4.19. Do agrochemicals/chemicals affect your honey bees? 1. Yes 2. No

4.20. What is the estimated honey you lose due to the application of agrochemicals/chemicals? ---
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5. Market information

5.1. Purpose of honey produced

No	Purpose of honey produced	Percentage (%)
	For marketing	
	For self consumption	

5.2. Output selling by place of product sale

Product sale	Percentage (%)
Farm gate	
Local markets	
cooperatives	
National markets	

Compiler Name ---------------------------------signature----------------------

Date---------------Time------------Duration: Starting time ----------Ending time------------