Dissertation Ref. No. 0011/05/015

Characterization of Beekeeping Systems and Honey Value Chain, and Effects of Storage Containers and Durations on Physico-Chemical Properties of Honey in Kilte Awlaelo District, Eastern Tigray, Ethiopia

PhD Dissertation

By

Yetimwork Gebremeskel Gebru

Addis Ababa University, College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

PhD Program in Animal Production

May, 2015

Debre Zeit, Ethiopia

CHARACTERIZATION OF BEEKEEPING SYSTEMS AND HONEY VALUE CHAIN, AND EFFECTS OF STORAGE CONTAINERS AND DURATIONS ON PHYSICO-CHEMICAL PROPERTIES OF HONEY IN KILTE AWLAELO DISTRICT, EASTERN TIGRAY, ETHIOPIA

A dissertation submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University for the fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Production

By

Yetimwork Gebremeskel Gebru

May, 2015

Debre Zeit,Ethiopia

Addis Ababa University

College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Yetimwork Gebremeskel Gebru

Titled: 'CHARACTERIZATION OF BEEKEEPING SYSTEMS AND HONEY VALUE CHAIN, AND EFFECTS OF STORAGE CONTAINERS AND DURATIONS ON PHYSICO-CHEMICAL PROPERTIES OF HONEY IN KILTE AWLAELO DISTRICT, EASTERN TIGRAY, ETHIOPIA'

and recommend that it be accepted as fulfilling the Dissertation requirement for the

Degree of Philosophy in Animal Production

Prof.Harpal Singh _____ _____

Chairman Signature Date

Amsalu Bezabih (PhD) _____ _____

External Examiner Signature Date

Gebeyehu Goshu (PhD, Assoc.prof) _____ _____

Internal Examiner Signature Date

Prof.Berhan Tamir (PhD) _____

Major advisor Signature Date

Desalegn Begna (PhD) _____

Co-advisor advisor Signature Date

Final approval and acceptance of the dissertation is contingent upon the submission of its corrected copy to the CGC through the concerned departmental graduate committee.

I hereby certify that I have read the revised version of this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Prof.Berhan Tamir (PhD) _____ _____

Dissertation advisor	Signature	Date
Prof.Berhan Tamir (PhD)	_____	_____
Department Chair	Signature	Date

STATEMENT OF THE AUTHOR

I first, declare that this dissertation is my bonafide work and that all sources of materials used for this dissertation have been duly acknowledged. This dissertation has been submitted to the requirements for PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University's Library to be made available to borrowers under rules of the Library. I solemnly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this dissertation are allowable without special permission provided that accurate acknowledgment of source is made. Requests for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the School of Graduate Studies when in his judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Yetimwork Gebremeskel Gebru Signature _____

College of Veterinary Medicine and Agriculture

Date of Submission: _____

BIOGRAPHICAL SKETCH

I, the author of this PhD Dissertation, was born in September 1980 in Tigray, Ethiopia. I attended my elementary and junior school education at Wallia Junior Secondary School and high school education at Keftegna 20 Secondary School in Addis Ababa. After a successful completion of my high school education, I joined Haramaya University in September 1997, where I studied Animal Sciences and graduated in 2001 with BSc degree. Soon after graduation, I was employed by the Agricultural Technical and Vocational Educational Training (ATVET) Department of the Ministry of Agriculture and Rural Development to teach at Wukro/Tigray/ATVET College as Junior Instructor. I then joined the school of graduate studies of Haramaya University in October 2004 to pursue Master of Science degree and graduated in January 2006 with MSc degree in Animal Production. I was then employed by Wukro St. Marry′s College as instructor. I have been working with Debre Berhan University as instructor since September 2009.

ACKNOWLEDGEMENTS

Above all, loving, kindness and faithfulness of the Almighty God in bestowing health, strength, patience and protection throughout the study period is highly appreciated.

The dissertation contents were the results of an on-farm survey in the district and different parts of the region and laboratory investigations conducted in Conformation Assessment Organization of Ethiopia. Undoubtedly, many people have contributed to this work. It is impossible to acknowledge all of you individually. In case I miss out your name, please know that I am very grateful to all who helped me.

Special thanks and heartfelt appreciation goes to my advisors Professor Berhan Tamir and Dr. Desalegn Begna for their unreserved advice to my research thesis writing through providing valuable comments and suggestions.

I greatly acknowledge the Kilte Awlaelo district Office of Agriculture and Rural Development (OoARD) especially Ato Atakilitiy, Alem and Ato Tesfamariyam. Without the support of the local extension staff and farmers the on-farm research wouldn't have been carried out and their contribution is gratefully acknowledged. I would also like to express my deep thanks to the staff of Kilte Awlaelo district Agricultural Offices, and the different tabias Agricultural Development Agents for their cooperation during the selection of sample farmers involved in the on farm study.

I would also like to express my earnest appreciation to the Addis Ababa University and the Ethiopian Conformity Assessment Enterprise (ECAE) for funding half of the laboratory cost. I am also grateful to Aba G/Ziher Yohans dean of Wukro St.Marry′s college their all rounded support and encouragement during my study.

Finally, my greatest appreciation goes to my husband Awet Estifanos and our daughter Rekik Awet, my sisters Berhan, Haymanot and Alganesh for their patience to the long

hectic time I was away. I find it hard to express in word of my family encouragement, assistance and tolerance. Special acknowledgment of gratitude and appreciation is directed to them. I owe all of them more than a simple expression of thanks.

LIST OF ABBREVIATIONS

ATVET	Agricultural Technical Vocational Education Training
BoARD	Bureau of Agriculture and Rural Development
BoANR	Bureau of Agriculture and Natural Resource
CSA	Central Statistics Authority
DAs	Developmental Agents
DCSI	Dedebit Credit and Saving Institution
ECAE	Ethiopian Conformity Assessment Enterprise
EHBPEA	Ethiopian Honey and Beeswax Producers and Exporters Association
EBA	Ethiopian Beekeepers Association
ETB	Ethiopian Birr (Currency)
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
GOV	Governmental
HBRC	Holleta Bee Research Center
HMF	Hydroxymethylfurfural
IFAD	International Fund for Agriculture
kg	Kilogram
KAD	Kilte Awlaelo District
KTB	Kenya Top Bar
MARD	Ministry of Agriculture and Rural Development
m.a.s.l	Meter above sea level
MoRAD	Ministry of Agriculture and Rural Development
NGO	Non-Governmental Organization
OoARD	Office of Agriculture and Rural Development
PA	Peasant Association
SNNPR	Southern Nations, Nationalities and People Regional State
SNV	Netherlands Development Organization
TAMPA	Tigray Agricultural Marketing Promotion Agency
VCA	Value Chain Analysis

DEDICATION

This dissertation is dedicated to my husband, **Awet Estifanos** and our daughter **Rekik Awet**

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDIX

CHARACTERIZATION OF BEEKEEPING SYSTEMS AND HONEY VALUE CHAIN, AND EFFECTS OF STORAGE CONTAINERS AND DURATIONS ON PHYSICO-CHEMICAL PROPERTIES OF HONEY IN KILTE AWLAELO DISTRICT, EASTERN TIGRAY, ETHIOPIA

Yetimwork G/Meskel

PhD thesis

Addis Ababa University (2015)

ABSTRACT

This study was conducted to evaluate the existing beekeeping system and honey production, identify major bee flora, honey storage methods, honey marketing and value chain actors, constraints of beekeeping and honey production, and honey quality as influenced by storage containers and durations in Kilte Awlaelo district of Eastern Tigray, Ethiopia. A semi-structured questionnaire interview and focus group discussion were the main tools used to gather primary data from the households and honey value chain actors. The household data were collected from 156 beekeepers in three tabias of the district. For the physico-chemical analysis, 20 kg of honey was harvested from frame beehive of a single farmer and stored in plastic pot, tin-can and glass for 0, 3 and 6 months and analyzed for moisture, ash, pH, acidity and HMF. Majority (95.5%) of the beekeepers owned frame beehives and only 4.5% of the beekeepers owned traditional beehives. The average beekeeping experience of the beekeepers was 9.48 years with the range varying from 1 to 34 years. The average honey yield per hive/harvest and per year was 7.66 and 16 kg for traditional beehive, 19.4 and 35 kg for frame beehive, respectively. Beekeepers identified Becium grandiflorum, Hypoestes forskaolii, Leucas abyssinica, Euclea schimperi, Cordia Africana, Eucalptus spp. and, Opuntia ficus-indica as the major bee forage. Honey badger, ants, wax moth, spider, birds, lizard and snake were identified as the major bee pests and predators in their order of importance. About 14.7%, 15.4% and 21.2% of the beekeepers store honey for 1-3, 4-6 and more than 6

months, respectively. Plastic pots (54.5%), tin-can (30.1%), glass (9.6%) and clay pots (5.8%) were identified as containers used to store honey. The results of the physico-chemical analysis indicated that all the samples (100%) are within the acceptable range of world and Ethiopian honey quality standards with moisture (17.25%), ash (0.14%), pH (3.86), acidity (17.57 meq/kg) and HMF (1.71 mg/kg). The honey quality analysis indicated that the honey from the study district to be of high quality and safe for local consumption and for export. From the value chain analysis, the distribution of frame beehives in the study district was increasing from 43 beehives in 1998 to 490 beehives per year in 2013 due to interventions by different governmental and nongovernmental organizations. From the enabling environment, it was observed that the different developmental polices and strategies of the government to be sufficient for practicing apiculture in small and commercial scales. From this study it was revealed that the quality of honey produced was high, and the potential for honeybee and quality honey production in the district is very high, which calls for proper intervention along the value chain components and actors, and involvement of huge investment in the development of honey production, processing and export. Also, a continued support with policies, strategies and programs at all levels will play a role for the sustainability of the sector.

Key words: Bee forage, honeybee, honey quality, honey storage, Kilte Awlaelo district, production system

1. INTRODUCTION

Beekeeping has a long history in Ethiopia. However, beekeeping research and development activities were initiated in 1965 with the establishment of the then Holleta Beekeeping and Demonstration Station, now Holleta Bee Research Center, with the aim of improving the productivity of the subsector. Properly planned extension activities, nonetheless were started in 1978 (EBA, 2005). According to (Ayalew and Gezahegn, 1991), there is a huge potential for honey production in the country and the subsector is an important livelihood activity in almost all regions owing to the prevailing ecological and floral diversity. It is an environmentally safe venture contributing much to the improvement of the livelihood of beekeepers. It is also an important integral part of the economic activity that created job opportunity to more than 2 million people (CSA, 2011).

Ethiopia is top honey producing country in Africa and one of the ten largest honey producing countries in the world (Ayalew, 1990). The country is also one of the four largest beeswax producing countries and this commodity is one of the major exportable products and in 2010/2011, about 620,101 kg of honey was exported (CSA, 2011). It has been reported that annually an average of 420 million Ethiopian Birr is obtained from the sale of honey (Gidey and Kibrom, 2010). The total number or population of honeybee colonies of the country is estimated to be about 10 million, of which about 7.5 million are confined in beehives and the remaining exist as feral colonies in the forest (SNV, 2005). Contextually, Ethiopia has the potential to produce 500,000 tons of honey and 50,000 tons of beeswax per annum, but currently production is limited to 54,000 tons of honey and 5,000 tons of beeswax (MoA, 2012). Meanwhile, there is large and growing demand for honey and other bee products worldwide since it has nutritional and/or medicinal values (Gizachew, 2011).

However, significant proportion of honey produced in the country is used for domestic consumption mainly for making a local drink known as *Tej* (Hartmann, 2004). Moreover, evidences indicate that the amount of honey exported is comparatively low and less than 1% of the total produced (SNV, 2005; Beyene and David, 2007; CSA, 2012).

The north-western, south-western and western regions of Ethiopia are known for their immense potential for honey production (Gezahegn, 2001). A study conducted by SNV (2005) showed that Oromia region produces about 41% of total honey produced by the country, followed by SNNPR and Amhara regions with a respective share of 22% and 21%. The Tigray region contributes close to 5% and all rest regions contribute 11%.

Although the annual production of both honey and beeswax in Ethiopia was reported to be large by African standard, the honey production system is generally traditional. The traditional beekeeping system accounts for more than 90% of the honey and beeswax produced nationally. According to Ayalew and Gezehegn (1991), under these traditional systems, the productivity of honeybees was reported to be exceedingly low and only an average of 8-15 kg of honey could be harvested/beehive/year. In situations where improved beekeeping technologies are used, it has been reported that an average of 15-20 kg/beehive/year could be harvested. This is indicative of the vital role that improved honey production interventions could play in guaranteeing high levels of honeybee productivity and quality. Nevertheless, before technological interventions are planned and strategies are devised for certain production setting, characterizing the prevailing honey production and bee management system and identifying the inherent production constraints is very important so that effective targeting of interventions would be possible.

Moreover, there are diverse set of partakers involved in various activities along the production-marketing-consumption chains of honey. First hand observations point out the poor functioning of honey value chains at many areas across Tigray regional state in general and the study district in particular. It is noticeable that inaccessibility to market is one of the factors that hold back the success of producers by inducing low farm-gate prices, reducing returns to labor and capital, and increasing input and transaction costs. The consequence is that there would be a reduction in incentives to participate in economic transactions and discourages development of market-oriented honey production systems.

Like the rests of the country, beekeeping has a long-standing tradition in Tigray region, dating back to ancient times during the kingdom of Abyssinia. Currently the practice has strong growing end markets making it viable enterprise for women and landless youth (USAID, 2008). The number of bee colonies in the region is estimated to be 206,040, of which 63% and 37% were for traditional and modern beehives, respectively (BoARD, 2010). According to Meaza (2010), one season honey production for the year 2009/10 was 25,454 quintals and 2008/09 annual production was 31,000 quintal. Though, beekeeping practice in recent years is improving, the contribution of honey production of the region to national honey production is still low (about 5%).

Under the prevailing reality of Tigray region, where the population is sparsely settled and seasonality of honey production and the nature of the product on the one hand and lack of organized marketing system on the other (Taddele and Nejdan, 2008), it is likely that the high transport cost and other physical barriers abate access to market. Furthermore, lack of negotiating skills and the absence of collective actions and market information are important impediments to the prevailing honey value chain. It is thus vital that an efficient, integrated and responsive honey marketing system is established for stimulating the honey producers and improve their economic gain from the venture. It is also hypothesized that high levels of gain of honey productivity and enhancing technological interventions could be realized when favorable marketing conditions are established. Moreover, honey marketing is affected by quality which is affected by many factors as: its origin, processing methods, storage condition and the time from harvesting until it is sold for human consumptions (Iuliana *et al*., 2007).

With the exception of some case studies like constraints assessment to improve the livelihood of beekeepers (Gidey and Mekonin, 2010), beekeeping and honey production (Taddele and Nejdan, 2008), physicochemical analysis of Tigray honey: an attempt to determine major quality markers of honey (Kebede *et al*.,2012), there is limited and/or no comprehensive account illustrating aspects of regional honey production system. In particular, honey production system honey value chain, plants species majorly

contributing to honey production and the effect of storage containers and durations on the different honey quality parameters in Kilte Awlaelo district remain obscure..

However, Kilte Awlaelo district is one of the district in the region with high potential for beekeeping. In the district, the long (*kiremti*) rain take place from June through mid-September. This period is followed by heavy flowering and vegetation which characterizes the peak production and harvesting season is in late September to December (USAID, 2008). Minor harvesting also takes place between May-June. According to USAID (2008) traditional beehives produce approximately 5-6 kg per year, while frame beehive production averages 15-25 kg per year. While using frame beehive has a dramatic increase in both quality and quantity of honey production, the majority of farmers in the district still apply traditional beekeeping using traditional basket beehives. Furthermore, low quality characterizes the honey produced in the region as a whole which hinder the contribution of these commodities to domestic consumption and foreign exchange earnings (Beyene and David, 2007; SNV, 2005). The low quality honey and beeswax production can be attributed to traditional beekeeping and honey containers prevailing in the study area. Honey has a long shelf life, and can be stored in clay jars on-farm or packed in plastic bottles and airtight transparent glasses in varying sizes.

Honey is derived from the diverse species of bushes and trees, which in Kilte Awlaelo includes Tebeb, girbiya, Sukakerni, Hohot, and Eucalyptus. Red, yellow, and white are the principal colors or varieties of honey produced, with white comprising 90% of production and the highest in demand. White honey can be produced in both liquid and cream form, and is characterized by a strong aroma, low moisture content, consistent texture, and bright color (USAID, 2008).

As stated at the outset, the low quality of honey produced is one of the factors hindering the contribution of this commodity to domestic consumption demand and foreign exchange earnings (Beyene and David, 2007; SNV, 2005). This justifies research initiatives spearheading to analysis and mapping of a production-marketing-consumption value chain of this commodity in Tigray region. This analysis is vital as it allows for

pinpointing the challenges and opportunities along the value chain and facilitates planning for potential remedial strategies to offset the identified constraints. This PhD research work contribute to the prevailing information gap regarding the challenges and opportunities of the system through analyzing the region's honey value chain.

The quality of honey is normally assessed by a physico-chemical test of its ingredients. These ingredients have substantial insinuation on honey industry as they influence the storage quality, granulation, texture, flavors and the nutritional and medicinal values of the product. Internationally, certain constituents were therefore proposed as quality criteria for honey (Bogdanov *et al*., 1999), and these include, but not limited to, moisture level, electrical conductivity, reducing sugars, amount of fructose and glucose, concentration of sucrose, free acidity, total acidity, hydroxymethylfurfurale (HMF) and proline content. The magnitude of these physico-chemical properties of honey could be influenced, among others, by the type of storage container used (Jonathan, 1994). In this regard, it is assumed that the physico-chemical properties of honey can change with time and kinds of storage containers. Therefore, this study was conducted with the following objectives:

General objective

- Characterize honey production system, honey yield, constraints of honey production, analyze honey value chain and determine the physico-chemical properties of honey as influenced by type of storage containers and durations.

Specific objectives

- To characterized beekeeping systems and to identify major bee flora species,
- To map and analyze honey value chain and identify the actors and their roles across the chain,
- To analyze the challenges and opportunities of beekeeping and honey value chain,
- To determine the effect of storage containers and storage durations on physico-chemical properties of honey

2. LITERATURE REVIEW

2.1. Bees and Beekeeping in the World

Human experience of beekeeping started 5 million years ago from the earliest times in which presumably the honeybees coming to existence. The object of exploitation for their product by the ancestors of mankind who appeared 1.8 million years ago, in a manner similar to the one by which chimpanzees today lick honey of tree twigs by inserting them into wild bee beehives (Jun, 2009). The same writer stated that later development with higher levels of technology by putting the honey in containers for transportation and storage would eventually complete the so-called honey-hunting. From evidences such as rock paintings of the stone aged caves depicting honey hunting, it is certain that such types of honey hunting were in those days practiced widely across the old world where honeybees were distributed. Africa has many rock paintings about honey hunting than any other continent and some of the countries, which can be mentioned, are South Africa (Natal), Zimbabwe, Morocco, Libya and Tanzania (HBRC, 1997).

Bees and beekeeping contribute to peoples' livelihoods in almost every country on earth. Honey, and the other products obtained from bees have long been known by every society: perhaps it is only intuit societies that have evolved without the possibility – in arctic conditions – to exploit bees for sweet honey and other products. Even though the honeybee is of the same species in temperate climate Europe and tropical Africa, *Apis mellifer,* and appears to be similar, the practiced beekeeping is very different. In fact, their biology and behavior differ significantly. Adjare (1990) also noted that except in the severe cold of the Polar Regions the honeybee is well distributed over the globe. It has been known that bees can be kept in the desert or in urban areas such as Addis Ababa, capital city of Ethiopia for example, there are many beekeepers that benefited from evergreen eucalyptus dominated vegetation in the town (Tessega, 2009) and even been done in a New York City as roof garden.

2.2. Role of Beekeeping in Environment Global Warming Mitigation

The interdependent relationship between bees and trees started millions years ago. Thus, bees are a precious world resource: they are essential for sustaining the environment because they pollinate flowering plants. Bees also keep our agriculture to be sustainable by pollinating crops and thereby increase yields and quality of seeds and fruits, and they provide us with honey, beeswax and other products which are valuable sources of food and income (Nicola, 2009). According to this writer Pollinators strongly influence ecological relationships, ecosystem conservation and stability, genetic variation in the plant community, floral diversity, specialization and evolution. As one of the best pollinators' bees play an important role, but little recognized in most terrestrial ecosystems.

It is clear that in areas where the acquisition of honeybees depends on wild colonies and the nectar sources depend on natural vegetation, the basic elements of apiculture derive from the richness of the nature that provides two resources (nectar and pollen). Therefore the closer the relationship between life and apiculture becomes, the much higher the consciousness of conservation of forest and natural vegetation is raised. In most parts of Ethiopia since the past few years it has been observed such type of traditional efforts toward the conservation of natural vegetation through beekeeping (Hartmann, 2004). Hence, the apiculture development has made it possible to raise awareness of the natural environment and to leads to engage in the conservation activities parallel to the beekeeping. Generally, bees have a high degree of adaptation to different environment, are important parts of farming systems, and do not cause land degradation and ecological imbalances.

The best example for this is, in Ethiopia forest management for beekeeping has been an ancient practice (Girma, 1998). It involves colony management, beehive management, forest productivity improvement and regulatory issues to sustain forest utilization for beekeeping products. The interaction of bee and forest management in the forest of south west Ethiopia has passed through several phases of beekeeping technology development.

And this intricate relationship has continued even in contemporary intermediate and high beekeeping technologies (Hartmann, 2004).

Generally, forests provide an essential environment for bees, protect beehives and provide materials for beehive construction. Trees are also major sources of pollen, nectar and plant tissue (Svensson, 1991; Momose et al, 1998; Kato and Kawakita, 2004). Similarly bees pollinate forest and improve ecosystem productivity which has great contribution to minimize the global warming.

2.3. Overview of Beekeeping in Ethiopia

There is no well-documented evidence that indicates when and where beekeeping practice started in Ethiopia. However, according to Ayalew (1978) as cited by Giday and Kibrom, 2010) beekeeping had started in the country between 3500-3000 B.C. Among all countries of the world; probably no country has a longer tradition of beekeeping than Ethiopia (Hartmann, 2004). In Ethiopia except for some places in Afar and Somalia regions honeybees are fairly distributed in the country adapting varying degree of weather conditions. They all produce honey, the nutritious natural food good for both man and animals (FAO, 1990).

Although the number of farmers engaged in honey production is not well known, but is estimated that around 1.8 million households are actively involved in honey production (MoA, 2012). According to this researcher the moderate climate of Ethiopia makes one of the most successful countries in the tropics in box beehive utilization. Historically, Ethiopia has been an important honey and beeswax producing country dominated by local consumption. Thus, the Hieroglyphs of ancient Egypt refer to Abyssinia (ancient name of Ethiopia), as source of honey and beeswax and Abyssinia has been known for its beeswax export to Egypt for centuries when other items were not exported (Gezahegn, 2001). However, in modern times Ethiopia lost its charm as honey exporter and produced largely to serve the demands of local markets and those in neighboring countries (Sreejith *et al.,* 2011).

Traditionally honey is consumed in the form of *Tej* (honey wine) and *birz (non-alcholic)* and some for medicinal use (Ayalew and Gezahegn, 1991). The report by MoA (2012) stated that annual honey consumption nearly equals annual crude honey production, currently estimated at 54,000 tones. In the country, beekeeping is an integral part of the life style of the farming communities, and except for a few extreme areas, it is a common practice in every place where humankind has settled. In addition, Ethiopia has probably the longest tradition of all the African countries in beeswax and honey marketing. Plentiful forage availability coupled with favorable and diversified agro-climatic conditions of Ethiopia create environmental conditions conducive for the growth of over 7000 species of flowering plants which has supported the existence of large number of local honeybee colonies (*Apis mellifera*) in Ethiopia (Girma,1998).

The density of beehives occupied by the honeybees on the land may be the highest, at the present moment, of any country in the African continent (Ayalew and Gezahegn, 1991). The total number of beehive and honey production by the different regions of Ethiopia is summarized in Table 1 (CSA, 2012). Generally, in Ethiopia there are three types of beekeeping practices: traditional forest beekeeping, traditional back yard beekeeping, transitional beekeeping and improved (modern) beekeeping. According to Amssalu *et al*. (2004), about 90 % of beekeeping that farmers practice in Ethiopia is traditional.

Table 1. Total number beehives and honey production by region in 2011/2012

Geographical area	All types of beehive		Traditional		Intermediate beehive		Modern bee hive	
	No. of beehive	Annual honey production (kg)	No. of hive	Annual honey production	No. of beehive	Annual honey production	No. of bee hive	Annual honey production
Ethiopia	4,993,815	39,891,459	4,772,537	36,487,937	81,596	475,855	139,682	2,927,667
Tigray	219,036	2,432,652	169,048	1,649,966	2,171	40,117	47,817	742,570
Afar	-	-	-	-	-	-	-	-
Amhara	965,293	8,684,393	898,863	7,891,333	23,802	139,914	42,628	653,146
Oromia	2,738,127	18,520,532	2,654,266	16,903,546	43,499	207,309	40,362	*
Somalie	*	*	*	*	-	-	-	-
Benshangul-Gumuz	230,241	1,079,157	228,430	1,062,721	*	*	*	*
SNNP	779,235	8,077,588	760,342	7,885,526	11,162	82,196	7,730	109,866
Gambella	58,402	1,090,386	58,299	1,088,355	11,162	82,196	7,730	109,866
Harari	928	4,215	869	4,215	*	*	-	-
DireDawa	756	1,697	646	1,436	*	*	*	*

Source: CSA (2012)

2.3.1. Honeybees and their distribution in Ethiopia

The topography of Ethiopia is complex and the altitude varies from the lowest point blow 126 m to the highest on Ras Dashen about 4620 meters above sea level (Amssalu *et al*., 2001). These variable agro ecological zones lead to huge diversification in species of fauna and flora. Its forests and woodlands contain diverse plant species that provide high amount of nectar and pollen to foraging bees (Girma, 1998). These potential makes the country the largest honey producer in Africa. Also considerable amount of wax is produced in the country. Regardless of the potential Ethiopia is fourth in beeswax and tenth in honey production at global level (Girma, 1998).

Based on morphometric analyses, different researchers have different and controversial findings about the origin of the bee species, *Apis melifera.* Smith (1961) reported the existence of *Apis Mellifera monticola* from the Ethiopian plateaus, and later Ruttner (1975) also reported the presence of *A.m. scutellata* and *A.m. jemenitica*. The existence of five honeybee races: *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) also suggested (Ayalew, 1990). Moreover, Radloff and Hepburn (1997) reported *A.m. jemenitica, A.m. bandasii* and *A.m. sudanensis* from Ethiopia.

According to Amssalu *et al*. (2004), the multivariate analysis of the morphometric characters revealed the existence of five statistically discrete populations occupying different ecologies in 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. They described a new subspecies, Apis mellifera simensis,

on the basis of morphometrical analyses. The Ethiopian bees are clearly distinct and statistically separable from honeybees belonging to neighboring subspecies in eastern Africa. Considerable variation of morphological characters in relation to altitude is present in the samples under analysis, but there are no statistically separable subgroups within this population. There is no indication for the presence of more than one subspecies of honey bee in Ethiopia. This indicated that there should be additional efforts to delineate the geographical distribution of the bee races.

2.3.2. Role of beekeeping in Ethiopian economy

Beekeeping is an important component of agriculture and rural development program in many countries. The role of beekeeping in providing nutritional, economic and ecological security to rural communities at the household level and is an additional income generating activity in the country economy. This, being a non-land-based activity, does not compete with other resource demanding components of farming systems (FAO, 1990).

In Ethiopia Beekeeping is a promising non-farm activity for the rural households. It contributes to the incomes of households and the economy of the nation. The direct contribution of beekeeping includes the value of the outputs produced such as honey, bee wax, queen and bee colonies, and other products such as pollen, royal jelly, bee venom, and propolis in cosmetics and medicine (Gezahegn, 2001).

It also provides an employment opportunity in the sector. The exact number of people engaged in the honey sub-sector in Ethiopia is not well known. However, it is estimated that more than one million farm households are involved in beekeeping business using the traditional, intermediate and frame beehives (Gidey and Mekonen, 2010). It could also be observed that a large number of people (intermediaries and traders) participate in honey collection and retailing (at village, district and zonal levels), and thousands of households are engaged in *Tej*-making in almost all urban areas, also hundreds of processors are emerging and exporters are also flourishing (Beyene and David, 2007).

Moreover, honey and beeswax also play a big role in the cultural and religious life of the people of Ethiopia (Gidey and Mekonen, 2010). According to Nuru (2007), beekeeping has high social and economic value in the country. The number of honeybee colonies and beehives owned serves as a major wealth ranking in some societies.

Ethiopia is among the leading honey producers in Africa and has the natural resources to further increase its production. Most of the honey produced is consumed locally, and the export quantity compared to total production is very low. However, the level of table honey is gradually increasing, though still very low, due to the expansion of modern beehives and private sector involvement in setting up industrial honey processing resulting in obtaining good quality table honey that meets export requirements. The trend of honey exports from the country is shown in the Table 2 (SNV, 2009).

Table 2. Honey export value from Ethiopia in the year 2003-2009

Year	Quantity (tons)	Value		Unit price	
		Birr	US$	Birr/kg	US$/kg
2003/4	8	1 22,240.00	13,582.22	15.28	1.70
2004/5	15	4 59,150.00	51,016.67	30.61	3.40
2005/6	28	7 89,880.00	87,764.44	28.21	3.13
2006/7	406	1 1,790,240.00	1,310,026.67	29.04	3.23
2007/8	242	6 ,449,300.00	7 16,588.89	26.65	2.96
2008/9	210	7 ,363,662.53	6 99,264.93	35.10	3.33

Source: Global Development Solutions, LLC as cited by SNV, 2009.

Moreover, in the country, many people are engaged in honey trading at different levels and also in production and selling of honey beer "*tej*". Honey beer or "*tej* "has been a popular drink throughout the country since ancient time. In every town, "*tej* "production is a big business and it is even served in some big bars and hotels as special cultural drinks. In the country it is estimated that more than 15,000 honey "*tej* "breweries are

operating in the different parts of the country. "*Tej"* brewing, besides serving as family labor employment creates job opportunities for large number of citizens (Nuru, 2007).

The same author stated that in this time beeswax is one of the most important agricultural export products and is contributing in the earning of foreign currency. The annual average value of beeswax produced in the country is about Ethiopian Birr, 125 million. The country is the leading beeswax producer and exporter in Africa and fourth in the world overall. The amount of beeswax being exported is, however, very low compared to the quantity being produced. The introduction and efforts to expand the transitional beehives is believed to increase the productivity as well as the potential for export through channeling beeswax to wax processors (SNV, 2009). Table 3 shows that beeswax export from the country in the last five years.

Table 3. Beeswax export value from Ethiopia in the year 2004-2009

Year	Quantity (tons)	Value			Unit price
		ETBirr	US$	Birr/kg	US$/kg
2004/5	525	2,501,000	1,389,000	2 3.81	2.65
2005/6	400	1 0,593,000	1,177,000	2 6.48	2.94
2006/7	353	1 3,644,000	1,516,000	3 8.65	4.29
2007/8	415	1 6,425,000	1,825,000	3 9.58	4.40
2008/9	341	1 6,606,932	1,431,179	4 8.63	4.19

Source: Global Development Solutions, LLC as cited by SNV, 2009.

Beekeeping also plays a significant role in the country's food production through honeybee pollination services of major cultivated crops. The role it plays in enhancing food security, poverty reduction and food production through pollination of crops has become substantial in the recent years (EHBPEA, 2010). About one third of all plants or plant products eaten by humans depend directly or indirectly on bees for their pollination (FAO, 2009). The yield of plants pollinated by honeybees can be increased in quality and quantity. According to Crane (1990), honeybees can increase the yield of *Citrus sinensis* by 30%, watermelon by 100% and tomatoes by 25%. Adimasu *et al.* (2004) also reported that onion yields had been increased by 94% due to honeybee's pollination.

2.4. Beekeeping Systems in Ethiopia

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 (Tessga, 2009). According to Ayalew (2008), currently in Ethiopia beekeeping is practiced in three types of production systems namely; traditional, transitional and frame beehive beekeeping.

2.4.1. Traditional beekeeping

Traditional beekeeping is the oldest and the richest practice, which has been carried out by the people for thousands of years in Ethiopia. This beekeeping practice is extensive and closely tied to swarm management: beehives are hung up in trees to catch swarms and are then transferred to the ground. Often, such beehives are placed in a kind of bee house that protects the beehives from the heat and rain.

Traditional beehives are crafted by creating a tube shaped structure using branches, straw, cow dung and clay. Beehives are typically 30-40 cm across and 1 m long. Sometimes they can be carved from a soft log, such as from a cactus tree (Gallmann and Thomas, 2012). Several million bee colonies are managed with the same old traditional beekeeping methods in almost all parts of the country (Fichtl and Admasu, 1994). This beekeeping practice different based on the resource in the area for the beekeeping activities. Thus, two types of traditional beekeeping is found in the country: forest beekeeping and backyard beekeeping. In some places, especially in the western and southern parts of the country, forest beekeeping by hanging a number of traditional beehives on trees is widely practiced. In other most parts of the country backyard beekeeping with relatively better management is common (Nuru, 2002, Gallmann and Thomas, 2012). The beekeepers that are experienced and skillful in using these beehives

could do many operations with less facility (Tessega, 2009). However, traditional bee beehive has its own disadvantage on the beekeeping practice and honey harvesting activities (Table 4).

Table 4. Disadvantages of traditional beehives

Beekeeping	No possibility to inspect comb for brood diseases
	Work with open beehives must be performed in complete darkness at night
	No possibility to split the colony for artificial colony reproduction
	No selection for honey yield and behavior
	No possibility to feed a colony during times of food shortage
Honey harvesting	High chance that the colony (queen) is killed during harvesting
	Very difficult to judge the maturity / ripeness of honey before harvesting
	Brood and honey combs are harvested together because separation of the two is laborious and difficult

Source: Gallmann and Thomas, 2012

This production system is characterized by a very low honey production, where under Ethiopian farmers' management condition; the average amount of crude honey produced from traditional beehive is estimated to be on average only about of 8 to 15 kg honey per harvest/beehive/year (Beyene and David, 2007).

Traditional husbandry is practiced with many millions of fixed comb beehives 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 its weight is beeswax. This harvest is achieved with minimal cost and labor, and it is valuable to people living a marginal existence (Tessega, 2009).

2.4.2. Transitional beekeeping system

Transitional system is a type of beekeeping intermediate between traditional and modern beekeeping methods. Generally, top-bar beehive is a single story long box with slopping

sidewalls inward toward the bottom (forming an angle of 115^{o} with the floor) and covered with bars of fixed width, 32 mm for east African honeybees (Segeren, 1995).

Transitional (intermediate) beekeeping practice has different advantages such as, it can be opened easily and quickly, the bees are guided into building parallel combs by following the line of the top bars, the top bars are easily removable and this enables beekeepers to work fast, the top bars are easier to construct than frames, honeycombs can be removed from the beehive for harvesting without disturbing combs containing broods, the beehive can be suspended with wires or ropes and this gives protection against pests. Transitional beekeeping has its own disadvantages such as, top bar beehives are relatively more expensive than traditional beehives, and combs suspended from the top bars are more apt to break off than combs which are building within frames (HBRC, 2004). According to this, center 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. Among these, KTB is widely known and commonly used in many parts of the country (HBRC, 1997). The top bars are easier to construct than frames, honeycombs can be removed from the beehive for harvesting without disturbing combs containing broods, the beehive can be suspended with wires or ropes and this gives protection against pests. However, as compared to traditional beehives relatively it is expensive in price.

2.4.3. Frame beehive beekeeping system

The modern beekeeping methods aim to obtain the maximum honey crop, season after season, without harming bees (Nicola, 2002). It uses different types of frame beehives. Zandar and Langstroth beehives are the most common that exist in the country. Dadant, Modified Zandar, and foam beehive are found rarely. These beehives differ in number and size of frames. The most commonly used beehive type in Ethiopia is Zandar type. Modern movable- frame beehive consists of precisely made rectangular box beehives (beehive bodies) superimposed one above the other in a tier. The number of boxes is varied seasonally according to the population size and activities of bees.

Improved box beehive has advantages over the others in that it gives high honey yield in quality and in quantity. The other advantages of improved box beehive are its possibilities to control swarming by supering and it is easy to transport the honeybees from place to place for searching honeybee flower and for pollination services. On the other hand, its disadvantages are- the equipment are relatively expensive, requires skilled manpower and the equipment needs very specific precaution.

Generally, about 4,601,806 beehives exist in Ethiopia, out of which about 95.5% were traditional, 4.3% transitional and 0.2% frame beehives (Beyene and Davide, 2007). Based on the national estimate, the average yield of pure honey from movable frame beehive is 15-20 kg/year, and the amount of beeswax produced is 1-2% of the honey yield (Gezahegn, 2001). However, in potential areas, up to 50-60 kg harvest has been reported (HBRC, 1997).

2.5. Overview of Beekeeping in Tigray

Extreme environmental degradation has occurred throughout the region on all land types as evidenced by soil erosion, loss of trees, grasses and general biodiversity. Much of the original woody vegetation and grasses have been removed from cultivated land and from unprotected hillsides which historically have been used for grazing and wood extraction (Tony, 2010). However in the past two decades as the government give more attention on the rehabilitation of degraded areas in the region and this situation created a favorable condition for beekeeping development.

The success of the honey promotion program; however, is inextricably linked with the success of enclosure areas in re-habilitating vegetation on a large scale. Vast areas of land are now covered in flowering plants such as Tebeb, Gerbia and akacha which provide bee fodder (Tony, 2010). Moreover, the landless youth have got benefits from these enclosed areas through beekeeping activity. Therefore, transforming enclosure or watershed in to apiary is just one example of a possible “win-win situation” for poverty alleviation (Jacobs *et al.*, 2006). The same authors recommend the integration of the apiculture

sector into overall land management strategies and farming systems, so as to ensure abundant nectar and pollen for a good and successful apiculture development.

In Tigray region, apiculture is a good source of income for smallholder farmers, as both honey and bee colonies are in high demand. To increase the yield and improve the quality of honeybee resources in the region, the Tigray Regional Government has been introducing framed beehives and accessories (Gidey and Mekonen, 2010). However, because this equipment is relatively expensive to buy, most smallholders could not increase their income as expected. Some innovative beekeepers started to use alternative equipment and practices to manage their bee resources and to improve the quality of the products (Hailu *et al*., 2007).

In the region during the past two decades promotion of modern beehive management and equipment, queen rearing by farmers, bee forage development and market development has resulted in honey production increasing from 130 quintals to 31,100 quintals and productivity increased from 10 kg/ beehive to 35 kg/beehive (Gizachew, 2011). According to MoARD (2007), the potential for an expanded honey industry is simply enormous, and there are more than 200,000 honeybee colonies in Tigray region, of which only 53,282 have modern beehives. The majority of the colonies with frame beehives were recently established (MoARD, 2008). According to CSA (2012), there is a difference in total bee beehives number and honey production potential of the different zones of Tigray region (Table 5).

Table 5. Number of beehives and honey production in different zones of Tigray

Geographical area	**Beehive**	**Honey production(Qt.)**
Tigray	219,036	2,432,652
North West Tigray	38,325	569,301
Central Tigray	77,525	951,597
Eastern Tigray	42,411	366,347
Southern Tigray	43,706	278,183
Western Tigray	17,068	267,224

2.6.Value Added Beekeeping Products

Many people easily put beekeeping on par with honey production. Moreover, they often consider honey merely as a sweetener. But there are other important bee products and honey has a much diversified use. Beekeeping is more than a honey and beeswax enterprise. It can create valuable income for the rural and urban poor (Jacobs *et al*., 2006). Even though, the best known primary beekeeping products in Ethiopia are honey and wax, but pollen, propolis, royal jelly, honeybee venom, queen, honeybee colonies and their larvae are also marketable primary beekeeping products in worldwide (Rainer, 1996).

2.6.1. Honey

Honey is the most important primary products of beekeeping both from a quantitative and an economic point of view. It was also the first bee product used by human kind in ancient times (Rainer, 1996). Honey is the natural sweet substance produced by honeybees from the nectar of blossoms or from the excretions of plant-sucking insects living on parts of plants, which the honeybees collect, transform by combining with specific substances of their own, store and leave in the honeycomb to ripen and mature (Codex, 2001).

In Ethiopia the largest part of the honey is used to brew *tej*, a local kind of honey-wine. Also different kinds of honey-beers can be brewed. For those who prefer non-alcoholic drinks, honey is a tasteful sweetener of juices, cocktails and teas. Ethiopians´ make a popular soft drink made out of honey is '*birz',* which is consumed as a delicacy during religious festivities (Jacobs *et al*., 2006). Honey's main features depend on the floral origin or the nectar source foraged by the honeybees. The composition and quality of honey also depends on environmental and other factors associated with production, such as weather, humidity inside the beehive, nectar conditions, and treatment of honey during extraction and storage (Tchoumboue *et al*., 2007). Moreover, honey is exportable crop. According to Nicola (2004), most developed countries import honey to meet such demand.

This requirement can provide developing countries with useful source of foreign exchange from honey exports.

2.6.2. Bees wax

Beeswax is the material that bees use to build their nest. It is manly produced by young honey bees that secrets wax from their wax glands. According to its purity and color valued for different functions. Light colored wax is more highly valued than dark colored wax which is likely to have been contaminated or overheated.

Wax is useful primarily for comb foundation making, cosmetic industries, candle making, ointment and cream, varnishes and polishes, creating special forms and surfaces for artistic sculptures and for queen cups preparation to be used for queen rearing to develop and multiply bee colonies. In Ethiopia, beeswax is largely collected from traditional beehives rather than the moveable frame beehives. The wax yield from traditional beehives is estimated to be 8–10 % of the honey yield, compared to 0.5 % – 2 % from frame beehives (MoARD, 2006). However, in the different regions of the country, beeswax collection is not significant and the beeswax produced by bees, which could be harvested by beekeepers, is wasted. The wax is mostly left or thrown away (Fichtl and Admasu, 1994) and the people do not know the beeswax is generating attractive money. Even so, the yearly beeswax production is estimated to 5000 t. This makes Ethiopia the fourth largest beeswax producing country in the world after China, Mexico and Turkey (Moa, 2012). Hartmann stated that this product mainly exported to Japan, Germany, the Netherlands and the USA. Like honey, beeswax is also a multipurpose natural bee product, which is used in the manufacture of more than 300 commodities. Moreover, beeswax is used in manufacture of electronic components, in modeling, casting for industry, in polishes for shoes, furniture, floors and in specialized industrial lubricants (Nicola, 2004). Honey and beeswax also play a big role in the cultural and religious life of the people of Ethiopia (Tessega, 2009).

2.7. Physical and Chemical Characteristics of Honey

2.7.1. Viscosity

Freshly extracted honey is a viscous liquid. Its viscosity depends on a large variety of substances and therefore varies with its composition and particularly with its water content. Viscosity is an important technical parameter during honey processing, because it reduces honey flow during extraction, pumping, settling, filtration, mixing and bottling. Raising the temperature of honey lowers its viscosity a phenomenon widely exploited during industrial honey processing (Rainer, 1996).

2.7.2. Density

Another physical characteristic of practical importance is density. Honey density, expressed as specific gravity, is greater than water density, but it also depends on the water content of the honey. Because of the variation in density it is sometimes possible to observe distinct stratification of honey in large storage tanks. The high water content (less dense) honey settles above the denser, drier honey.

2.7.3. Hygroscopicity

The strong hygroscopic character of honey is important both in processing, storage and for final use. Because of this character it easily absorbs moisture from the air. Thus, in areas with a very high humidity it can be difficult to produce good quality honey of sufficiently low water content, which can be measured using a gadget called refractometer. Different researches show that normal honey with a water content of less than 18.3 % or less will absorb moisture from the air if a relative humidity is above 60% (Rainer, 1996).The moisture content of honey should not be more than 20% (CODEX, 2001).

2.7.4. Color

The other physical characteristics is color and in liquid honey it varies from clear and colorless (like water) to dark amber or black categories which do not really have any bearing on quality. While it is not an indicator of honey quality and there are exceptions to the rule, generally speaking, the darker color the honey, the higher its mineral contents, the pH readings, and the aroma/flavor levels. Minerals such as potassium, chlorine, sulfur, iron, manganese, magnesium, and sodium have been found to be much higher in darker honeys (http://www.benefits-of-honey.com, 2013).

2.7.5. Crystallization

According to Rainer (1996), crystallization is another important characteristic for honey marketing, though not for price determination. In temperate climates most honeys crystallize at normal storage temperatures. This is due to the fact that honey is an oversaturated sugar solution, *i.e.* it contains more sugar than can remain in solution. Many consumers still think that if honey has crystallized it has gone bad or has been adulterated with sugar. The crystallization results from the formation of monohydrate glucose crystals, which vary in number, shape, dimension and quality with the honey composition and storage conditions. The lower the water and the higher the glucose content of honey, the faster the crystallization. Temperature is important, since above 25°C and below 5°C virtually no crystallization occurs. Around 14°C is the optimum temperature for fast crystallization, but also the presence of solid particles (e.g. pollen grains) and slow stirring result in quicker crystallization.

2.7.6. Hydroxyl-methyl-furfural (HMF)

Hydroxyl-methyl-furfural is a break-down product of fructose (one of the main sugars in honey) formed slowly during storage and very quickly when honey is heated. The amount of HMF present in honey is therefore used as a guide to storage guide to storage length and the amount of heating which has taken place (Crane, 1980, Rainer, 1996, http://www.benefits-of-honey.com) Virtually HMF absent in newly produced honey; it is a byproduct of fructose decay, formed during storage or during heating. Thus, its presence is considered the main indicator of honey deterioration.

2.7.7. pH and Free Acidity

Honey pH depends on both the ionized acids of this food and mineral elements and influences microorganism's development, enzymatic activity and texture, among other properties .Honey typically has a pH in the range of 3.3–5.6. The natural acidity of honey inhibits growth of many pathogenic bacteria whose minimum tolerated pH is in the range of 4.0–4.5 (Patricia et al, 2010). These two properties of honey can influence honey stability and its storage conditions and also they give some information on honey origin (Nombré et al., 2010). The high acidity of honey is an indication of the fermentation of sugars present in the honey into organic acid particularly the gluconic acid and the inorganic ions such as phosphate and chloride (Ouchemoukh et al., 2007). According to Bogdanov *et al.* (2008) these honey fermentation results are responsible for two important characteristics of honey: flavor and stability against microbial spoilage. The acidity of honey developed due to the presence of organic acids. The value of honeys acidity, lower than 50 meq/kg of honey, means that honeys will not be fermented.

Generally, Chemical composition of honey mainly depends on the vegetation sources from which it derives, though external factors like climate, harvesting conditions and storage can also influence it (Crane, 1980). Careless handling of honey can reduce its quality. Amongst the factors that most influence quality are high temperature, length of storage and moisture content greater than 21%. They lead to fermentation, high levels of HMF, loss of enzymatic activity, changes in flavor, darkening and microbial growth (Moguel *et al*, 2005).

2.8. Concept of Value Chain

A value chain (VC) can be defined as the full range of activities that are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services); delivery to final customers; and final disposal after use (Bammann, 2007). According to Issa (2010), in the context of food production, these activities include farm

production, trade and support to get food commodities to the end consumer (e.g. transport, processing).

Business dictionary also defined value chain as linked value adding activities that convert inputs into outputs which, in turn, add to the bottom-line and help create competitive advantage. Agricultural value chains can include three or more of the following: producers, processors, distributors, brokers, wholesalers, retailers and consumers (Bammann, 2007).

Moreover, the value chain concept has proven particularly useful for the identification and formulation of projects as well as in the development of strategies for improved agricultural and rural development. A value chain is the full range of activities required to bring a product from conception, through the different phases of production and transformation, and delivery to final consumer (Kaplinsky and Morris, 2001). As stated by Mengistu (2010), without having well established coordination among the value chain actors and convenient marketing systems, the potential increment in productivity, rural incomes and foreign exchange earnings resulting from dispersed efforts and introduction of improved production technologies alone could not be effective. Thus, a well-established bee product marketing system would be a very valuable tool for producers, collectors and processors to plan and take advantage of the products´ seasonal flow (Mengistu, 2010). An improvement in marketing efficiency, thus, attracts the attention of many governmental and NGOs and viewed as an important national development strategy.

2.9. Constraints of Beekeeping in Ethiopia

Ethiopia has enormous untapped potential for promoting beekeeping; both for local use and for export purpose. Ethiopia is one of the countries of the continent that has the largest honey bee population and owns a big potential of honey production owing to its varied ecological and climatic conditions. Moreover, beekeeping is an appropriate and well-accepted farming technology and is best suited to extensive range of ecosystems of tropical Africa (Chala *et al.,* 2012). However, like any other livestock sector, this sub

sector has been ceased by complicated constraints (Tessega, 2009). According to this author, the potentiality of apiculture could be backed up by research and the beekeepers' indigenous knowledge which should be assessed. In this regard it is important and right time to conduct apicultural research in order to assess the situation at the grass-root level: to identify the opportunities, challenges, socio-economic importance, attitudes and analyze the performance of the existing beekeeping situation before any development program interventions.

The major constraints in the beekeeping sub-sector are: the unpleasant behavior of bees (aggressiveness, swarming tendency, and absconding behaviors); lack of skilled manpower and training institutions; low level of technology used; high price of improved beekeeping technologies; drought and deforestation of natural vegetation; poor post-harvest management of beehive products and marketing constraints; indiscriminate application of agrochemicals; honeybee disease, pest and predators; poor extension services; absence of coordination between research, extension and farmers; absence of policy in apiculture; shortage of records and up-to- date information; and inadequate research institutions to address the problems. But all these problems may not be a constraint to all parts of the country and may not be equally pressing to every place. So, it requires characterizing the constraints in their respective places to take an appropriate development measure (HBRC, 1997; Ayalew, 2001; Edessa, 2002). According to Gidey and Mekonen (2010), lack of adequate bee forages, poor market, lack of trained development agents, inadequate government support, bee pests, predators and inadequate training are mainly the problems facing the honey sub-sector in Tigray region.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Kilte Awlaelo district (KAD), one of the districts in Eastern Zone of Tigray regional state, Ethiopia. The district was selected based on the potential for beekeeping and honey production, honey type and accessibility.

Kilte Awlaelo district is geographically located between 39^{o} 30' E – 39^{o} 45' E and 13^{o} 45' N -14^{o} 00' N located in the eastern part of Tigray at a distance of 45 km from Mekelle, It borders with Hawzien and Sease Tsadaemba in the North, Atsbi Womberta in the East, Douga Tembien in the West and Mekelle in the South. The district currently encompasses a total of 15 tabias and 64 kebeles. The district is classified as weyna-dega (mid-highland). The altitude of the district ranges from 1980 to 2500 m a.s.l. The average daily air temperature ranges from 15^{o}_{C} and 30^{o}_{C}. The mean annual rainfall is about 558 mm.

The total population of Kilte Awlaelo district is about 106,733; Out of which 51,767 is male and 54,966 is female. The total number of household's head is 27,049 and average family size is 5 (BoANR, 2013). In the district alone, approximately 8,540 farmers are engaged in honey production with an annual output of 234.61 MTs of both traditional and frame beehive (USAID, 2008). The long rainy season (*kiremti*) takes place from June to mid-September. This period is followed by heavy flowering and vegetation which characterizes the peak production and harvesting season (late September – mid December). Minor harvesting also takes place between May-June. Traditional beehives produce approximately 5-6 kg per year, while honey yield from frame beehives on average ranges from 15-25 kg per year.

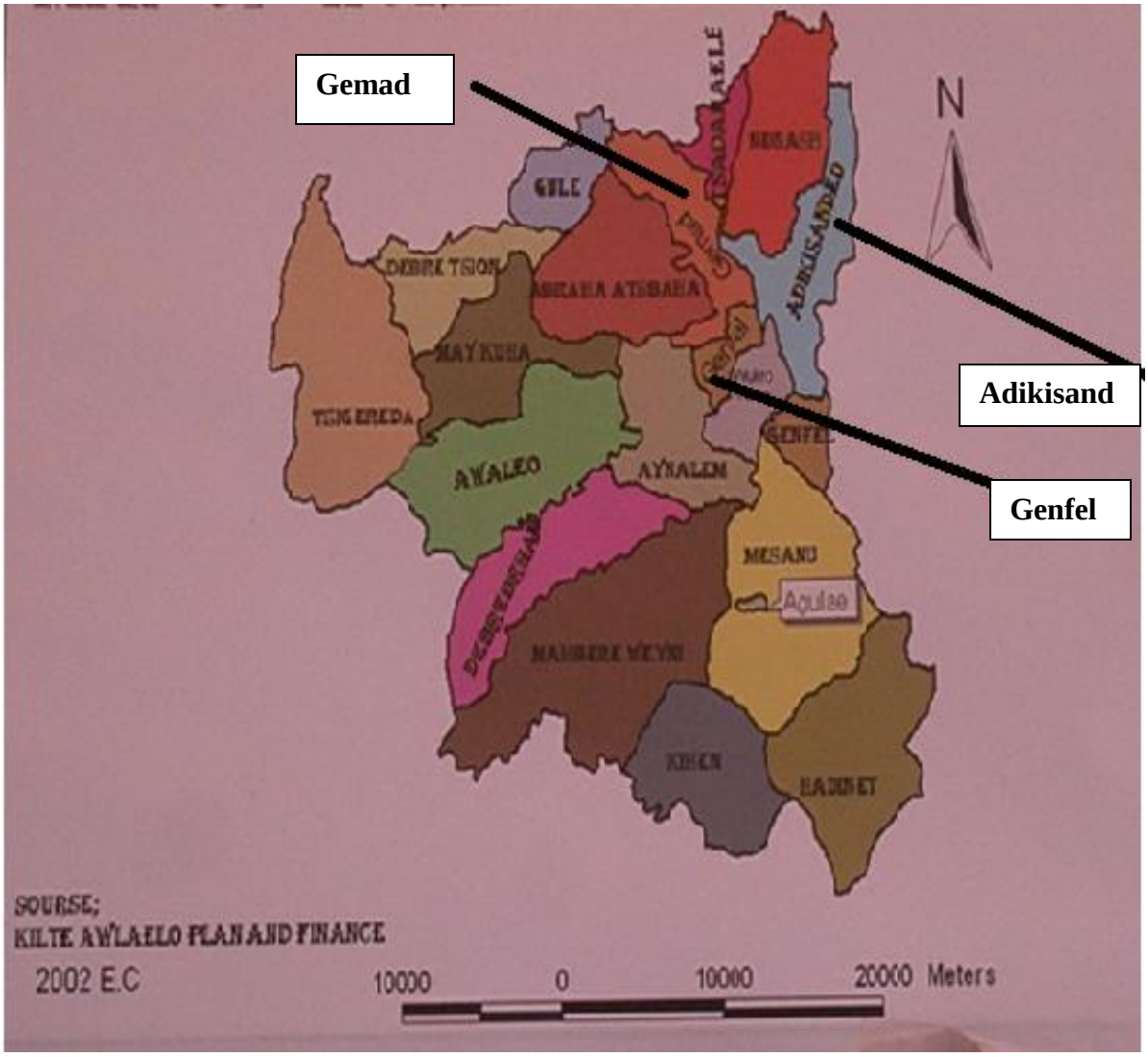

Figure 1. Map of the study district and sites

3.2. Sampling Procedure

Beekeeping in Kilte Awlaelo district is practiced as a sideline to other agricultural activities. About 48.3% by the male headed farmers, 10.4% women headed farmers and 41.4% by youth (BoARD, 2014).

The study was conducted in three randomly selected tabias of the district (Adikisandid, Gemad and Genfel). A total of 156 bee keepers were randomly selected and approached for interview. The sample size (N) was determined using the formula recommended by Arsham (2005) as $N = 0.25/SE^2$, where N is sample size, and SE is the standard error.

3.3. Data Collection

Data relevant to the study were collected through formal survey, secondary sources, focus group discussions, key-informants interviews and field observations.

Relevant information was further collected through discussions with the district OARD experts, DAs, PA administrators, Non-Governmental Organizations (NGOs), key informants and from other relevant institutions that play significant role in beekeeping activities of the district. During the survey, types of storage containers used and the average maximum honey storage period was identified and used as a base for the honey quality analysis study.

3.3.1. Formal survey

A formal survey was conducted using structured questionnaire, with open-ended and closed-ended questions with the help of trained enumerators. A structured questionnaire was prepared and pre-tested before administration and some re-arrangements, reframing and corrections in accordance with respondents' perception were made. The questionnaire was administered to the randomly selected household heads by enumerators recruited and trained for this purpose with close supervision by the researcher. The questionnaire was designed to capture information such as: household demographics

including sex, marital status and age of the respondent; beekeeping and/or management practices, honey production, honey yield, honey storage container types, honey storage duration, constraints of beekeeping. The survey considered the following major issues.

Household characteristics: The farm households are assumed to be the main caretakers of the colony. In this component, household attributes like sex, age, educational level, family size, and resource endowment related variables like honeybee colonies, livestock ownership, landholding, crop production was collected.

Honey production system: Number and type of beehive, cost of beehive and bee colonies, the different bee equipment, honey production and harvesting time, wax source and harvesting, honey and wax price were gathered. Different indigenous practices like apiary selection beehive management (inspection, swarm control and catching), method and time of honey harvesting, honey storage duration and storage containers and dry season colony management were collected.

Constraints and opportunities of beekeeping in the area: Information on major constraints and opportunities of beekeeping in the area, such as related with the availability of bee forages and water resources, agro-chemical and poisonous plants and honeybee pests and predators, extension linkage in beekeeping was gathered.

3.3.2. Secondary sources

Previous studies, guidelines, manuals and literature and documented data were reviewed to characterize beekeeping system constraints of beekeeping and the honey value chain actors. The secondary data pertaining to the investigation were collected from governmental organizations, non-governmental organizations, PA administration and various stockholders.

3.3.3. Focus group discussion

In each study tabias, discussions had been made with agricultural development agents, elders, village leaders and individuals who have knowledge about the beekeeping practices, management systems, bee flora, and constraints of beekeeping in the area. Focus group discussions consisting of 9 knowledgeable individuals were made per tabia to complement the survey work and the researcher facilitated the discussions at all sites. Individuals for focus group discussions were selected by the help of agricultural extension workers considering their age and experience with beekeeping activity, knowledge about the major bee flora, beehive types, honey storage, honey utilization and major constraints of beekeeping.

3.3.4. Field observation

Field observation was made to enrich the data on beekeeping and management practices, bee flora, beehive types, watering, and honeybee pests and predators, honey storage, honey marketing and utilization and any events pertaining to investigations were observed to strengthen the information obtained.

3.3.5. Key informants interview

Primary data were also generated by informal interview of extension workers in addition to beekeepers, direct field observations and focus group discussion with the intent of gathering information related to beekeeping systems, bee management practices and constraints of beekeeping etc. to strengthen data generated using different method.

3.3.6. Honey quality analysis

The honey quality, which is expressed by physico-chemical properties of the honey was studied using 3 most commonly and widely used container types (plastic, tin-can and glass containers) and 3 storage durations (immediately after harvest, 3 and 6 months of

storage durations) in 3 x 3 factorial arrangement replicated thrice. The honey quality was analyzed by taking honey samples that were stored in different containers for varied times in the Chemical Analysis Laboratory of Ethiopian Conformity Assessment Enterprise (ECAE), Addis Ababa, Ethiopia. Types of honey storage containers and honey storage durations were based on the questionnaire survey. After having identified the honey storage container types and storage durations, a bulk of honey, 20 kg freshly harvested honey from frame beehive was taken from a single farmer (so that heterogeneity related to origin, bee forage, beehive type, farmer practice etc. can be minimized), and stored in tin-can, glass and plastic container types for 0, 3 and 6 months, whereas plastic container in addition to storage was used as a control to store freshly collected honey samples until samples were analyzed in the lab within a day. Honey samples were taken from storage types and storage durations and analyzed for moisture, HMF, pH, acidity and ash contents according to the Harmonized Methods of the International Honey Commission (Bogdanov, 2002). Due to the laboratory is work on these parameters only the work is limited to these parameters. Laboratorial procedures of all parameters are given in Appendix 8.9.

3.3.7. Honey value chain assessment

In this component, the honey value chain activities and the actors across the chain, and their roles were assessed by applying a value chain analysis framework. The framework enables the mapping and characterization of the actors and patterns of their interactions through exploring value creation activities; and prevailing market opportunities and linkages among the chain actors. The approach also facilitates the analysis of actors and activities from production to consumption (Rich *et al.*, 2011). To this end, information available at different levels of the district was collected through discussions with key informants from the BoARD and other concerned stakeholders. Relevant qualitative and quantitative information along the value chain was gathered by interviews with the different actors in the chain.

3.4. Data Management and Statistical Analysis

The survey data were coded and tabulated for analysis. All the information to be generated from the production system study and value chain assessment was systematically categorized, tabulated and summarized using SPSS version 20. This was mainly applied for analysis of mean and frequency. Data related to honey quality were analyzed using GLM of SAS software (SAS, 2002).

The statistical model used for analysis of the data collected from the honey quality assessment is given below:

$Y_{ijk} = \mu + C_i + T_j + CT_{ij} + e_{ijk} + R$, where:

Y_{ijk} = Observed honey quality parameter

μ = Overall mean

C_i = Effect attributable to storage container type

T_j = Time effect

CT_{ij}= Container and time interaction effect

e_{ijk} = Random error

R = Replication effect

Whenever statically significant difference was observed ($P<0.05$, $P<0.001$) Least Significant Difference (LSD) tests were used to separate the means.

4. RESULTS

In this section, the results of questionnaire survey, honey value chain and honey quality assessment are presented and described from a total of 156 interviewed households, who possessed a total of 903 different types of beehives.

4.1. Household Socio-Economic Characteristics

From the total of 156 sample households interviewed, about 88.5% and 11.5% were male and female headed household, respectively. The mean age of the respondents was 47.62±12.04 years that ranged from 20 to 80 years (Table 6). The result showed that beekeeping can be performed by different age groups and in most cases people at younger and older ages are more engaged in beekeeping. The average family size was 6.83 persons, with minimum and maximum family size of 1 and 12 persons, respectively (Table 6). The average beekeeping experience of the sample beekeepers was 9.48 years with the range varying from 1 to 34 years of continued engagement in beekeeping. Young boys are involved in helping their families in different beekeeping activities and gradually they become independent beekeepers when they obtain their own beehives.

Table 6. Family size, experience, age, and landholding of household heads (N = 156)

Socio-economic characteristics	Minimum	Maximum	Mean	SD
Family size	1	12	6.83	2.18
Experience in beekeeping (yrs.)	1	34	9.48	6.84
Age of household head (yrs.)	20	80	47.62	12.04
Landholding (ha)	0.13	2.00	0.77	0.47

The average landholding during the study year was 0.77 hectares with minimum and maximum holding of 0.13 and 2.0 hectares, respectively. The average landholding of the area was below the national average landholding of 1.5 ha.

From the total beekeepers, 89.1% were married while 10.3% and 0.6% were single and divorced, respectively (Table7). Based on the study result, beekeeping activities could be performed by every social class of the community regardless of their marital status. Majority of the respondents were literate from primary education to secondary education. Among them 29.5%, 21.8% and 5.8% had attended primary, junior and secondary school education, respectively. About 25.6% could read and write while 17.3% were illiterate.

The survey result showed that all the beekeepers in the area are using both traditional and frame beehives. Majority (81.4%) of the beekeepers own frame beehive only. From the beekeepers 4.5% own only traditional beehive and 14.1% beekeepers possess both traditional and frame beehive.

Table 7. Marital status, educational level and beehive ownership (N =156)

Socio-economic characters	Number of respondents	%
Marital status		
Married	139	89.1
Single	16	10.3
Divorced	1	0.6
Educational level		
Illiterate	27	17.3
Can read and write	40	25.6
Primary education	46	29.5
Junior	34	21.8
Secondary education	9	5.8
Beehive ownership		
Traditional only	7	4.5
Frame beehive only	127	81.4
Traditional and frame	22	14.1

4.2. Livestock Production

The major livestock species reared in the area were cattle, sheep, goats, donkeys, poultry and honeybee colonies. The mean livestock holding is indicated in Table 8. The farming system of the area was crop-livestock system, where crop and livestock are integrated to the production of food and feed. As an integral part of the mixed farming system, livestock production plays a substantial role in the household food security. The primary purpose of cattle production in the crop–livestock mixed farming systems of the district was draft power. Farmers also explained about the advantages of the different species of livestock in their day to day life. Livestock were used as insurance at times of crop failure, ploughing of farmland, transportation, source of food, as immediate source of finance, loan repayment, fuel source and as a source of manure to maintain soil fertility. About 8.3% households did not own oxen, 5.1% owned an ox and 86.4% owned two and more than two oxen. For transportation of goods, water and other farm commodities the farmers used donkeys and about 82.1% of the farmers owned donkey. The mean honeybee colony holding (frame, traditional or both frame and traditional beehives) was 5.79 colonies.

Table 8. Livestock and honeybee colony holdings of sample respondents (N =156)

Species	Minimum	Maximum	Mean	SD
Cattle	00.00	15.00	4.00	2.4
Small ruminant	00.00	38.00	3.70	5.4
Equines	00.00	5.00	1.40	.95
Chicken	00.00	30.00	4.10	3.9
Bee colony*	1.00	100	5.80	9.9

* indicate the two types of beehives

Regarding livestock feeding system 78.8%, 28.8% and 42.3% of cattle, shoat and equine, respectively, were fed tethered (Table 9). Furthermore, regional policy enforces zero grazing to control land degradation and to increase the productivity of livestock. The above result shows the level of farmers' engagement to rehabilitate degraded area. Thus,

this practice is also important and advantageous to the development of different bee forages. It is also mentioned that there is a seasonal variation in the quantity and quality of feed. They fed their animals mostly with weeds, and green grasses from farm strip and bunds, crop aftermath, crop residues and range lands. Feed shortage due to grazing land shortage, different internal and external parasites and diseases were the major constraints limiting livestock production and productivity in their order of importance. Technical and institutional interventions would be very essential to improve the existing constraints to livestock production in the study area.

Table 9. Livestock feeding practices of the district (N = 156)

Livestock Species	Respondent (%)									
	Feeding practice									
	Tethering		Free grazing/browsing		Free ranging		Semi-intensive		Intensive	
	N	%	N	%	N	%	N	%	N	%
Cattle	123	78.8	19	12.2	-	-	-	-	--	-
Shoat*	45	28.8	30	19.2	-	-	-	-	-	-
Equine	66	42.3	65	41.7	-	-	-	-	-	-
Chicken	-	-	-	-	33	21.2	87	55.8	3	1.9

*Sheep and goats

4.3. Crop Production

Farmers practice a cereal dominated cropping system with wheat (Triiticum) as the most important crop, followed by teff (*Eragrostis teff*), barley (*Hordeum vulgare L.*), maize (*Zea mays L.*), millet and sorghum (*Sorghum bicolor*) and from pulses field pea (*Pisum sativa*) and chick pea (*Cicer arietinum*) were the major annual crops. Gesho (*Rhamnus priniides*), orange (*Citirus sinensis*), guava (*Psidium guajava*), avocado (*Persea Americana*), cactus (*Oputia ficus-indica*) and papaya (*Carica papaya*) were the major perennial crops or fruits in the district. The main purposes of annual crops cultivation was

for home consumption while cash income was generated mainly from the perennial crops.

According to their degree of importance, rodents, weed, farmland shortage, pests and shortage of rain or water were the problems related to crop production. Accordingly, these all could have direct or indirect effect on the productivity and quality of honey and bee colonies.

4.4. Honey Production System

Under this section beekeeping practices, colony placement and beehive preference, bee flora condition and water availability, honey or beehive product harvesting, colony management and characteristics, beekeeping potential and constraints, beehive product marketing and the overall beekeeping activities in the honey production systems of the study area will be described. From the study results except for few landless youths, there were no farmers that merely depend on beekeeping. Based on the input used and their management practices, two types of beekeeping practices were mainly used in the district. These were traditional and frame beehive beekeeping.

4.4.1. Traditional beekeeping

According to the survey result, the mean number of traditional beehives owned per household was 1.76 with minimum and maximum beehives being 1 and 4, respectively (Table 10).

The productivity of the beehive was different due to differences in management and environment. This was mainly due to difference in availability of bee forage. The mean honey production of traditional beehive was 7.66 kg/beehive/harvest with 3 kg minimum and 20 kg maximum. As far as the harvesting frequency of honey was concerned, 61.5%, 36.5 and 1.9% of the respondents harvested once, twice and three times a year, respectively.

Table 10. Number of colony, beehive condition and productivity

Parameters	N	Min.	Max.	Mean	SD
Number of traditional colony (owned/HH)	29	1	4	1.76	0.87
Number of framed hive colony (owned/HH)	149	1	100	6.39	12.67
Honey yield (traditional hive) kg/harvest	29	3	20	7.66	4.03
Honey yield (framed hive) kg/harvest	149	3	60	19.49	11.38
Number of empty traditional hive (owned/HH)	6	1	7	3.3	2.25
Number of empty frame hive (owned/HH)	102	1	20	4.88	4.89
Price of colony (Birr/colony)	126	42.00	1500.00	667.01	301.02

The traditional beehives were constructed using their indigenous knowledge by the owners themselves or purchased from the local market. As a result, the traditional beehives of the interviewed farmers varied in length and width, but all had cylindrical shape. The size of the beehive depended on strength of the colony, the availability of bee forages and number of colonies. According to the interviewed farmers and the district experts, the farmers used locally available materials to construct the traditional beehives. Materials like *Arundinaria alpine*, locally termed 'shenbeko', which is then cemented with mud and cow dung, finally covered with grass and straw

4.4.2. Frame beehive beekeeping

According to the survey result, 95.5% of the beekeeper owned frame beehives (Table10). The mean number of frame beehives owned/house hold is 6.39 with a maximum of 100 beehives /HH. The mean productivity from one frame beehive is 19.4 kg/beehive/harvesting ranging 3 kg to 60 kg/beehive/harvesting of 1 to 3 times per year.

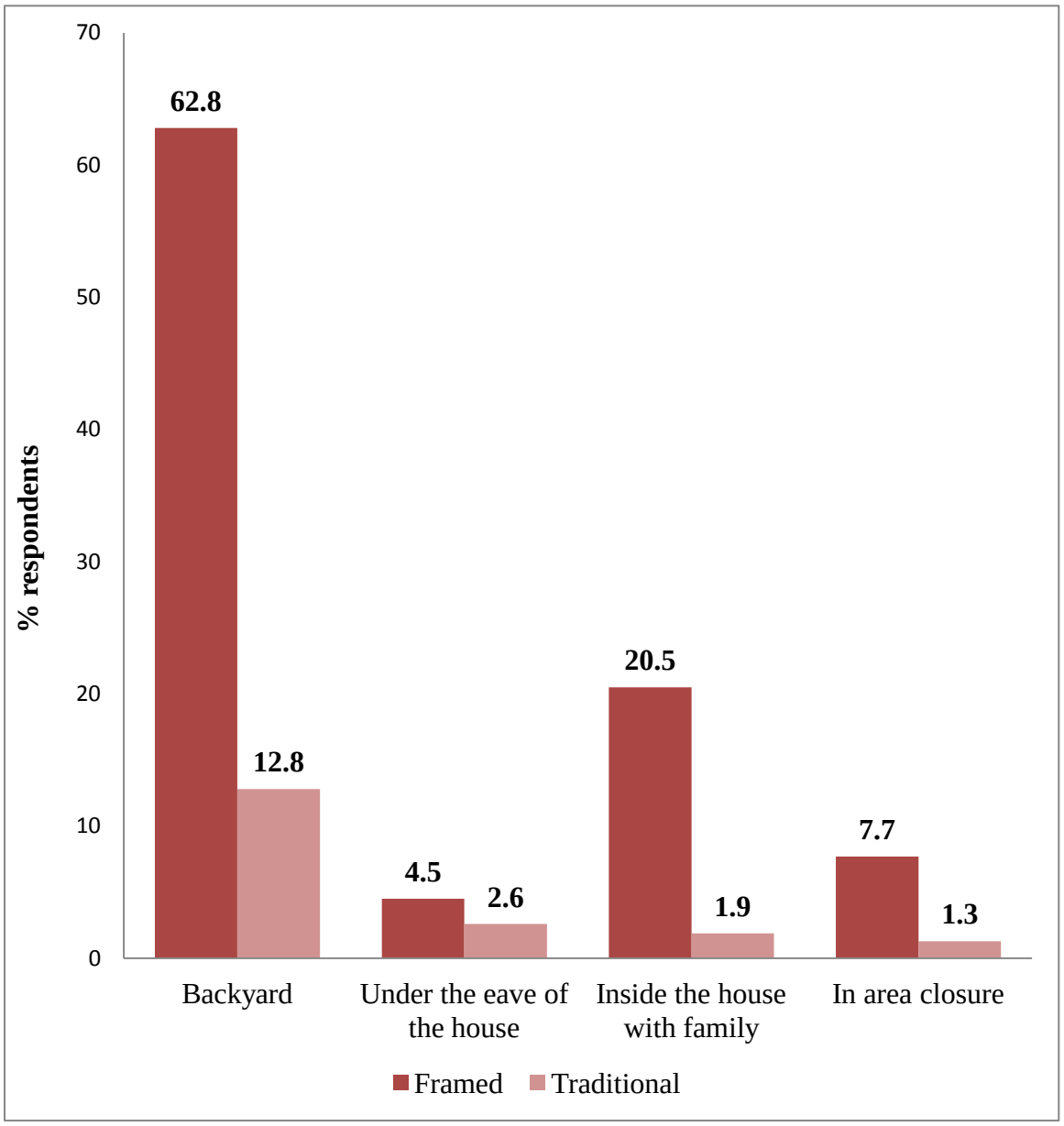

Figure 2. Traditional and frame beehive placement in Kilte-Awlaelo district

About 12.8% of the respondents kept the traditional beehive in the backyard followed by under the eaves of the house (2.6%), in the house with family (1.9%) and in area closure (1.3%) (Fig.2). Whereas, 62.8%,4.5%,20.5% and 7.7% of the beekeepers kept their framed beehive at backyard, under the eaves of the house, inside the house with family and in area closures, respectively. Contrast

From the sample respondents (9.6% and 75.5% with local and framed hive, respectively) declared that the trend in honey production is increasing from time to time. Among the sample respondents (2.6% and 1.3%) responded as the production of honey remain stable in local and modern beehive, respectively. Besides, 6.4% and 19.2% of the sample respondent pointed out that there is decreasing in honey production in traditional and frame beehive, respectively (Fig. 3).

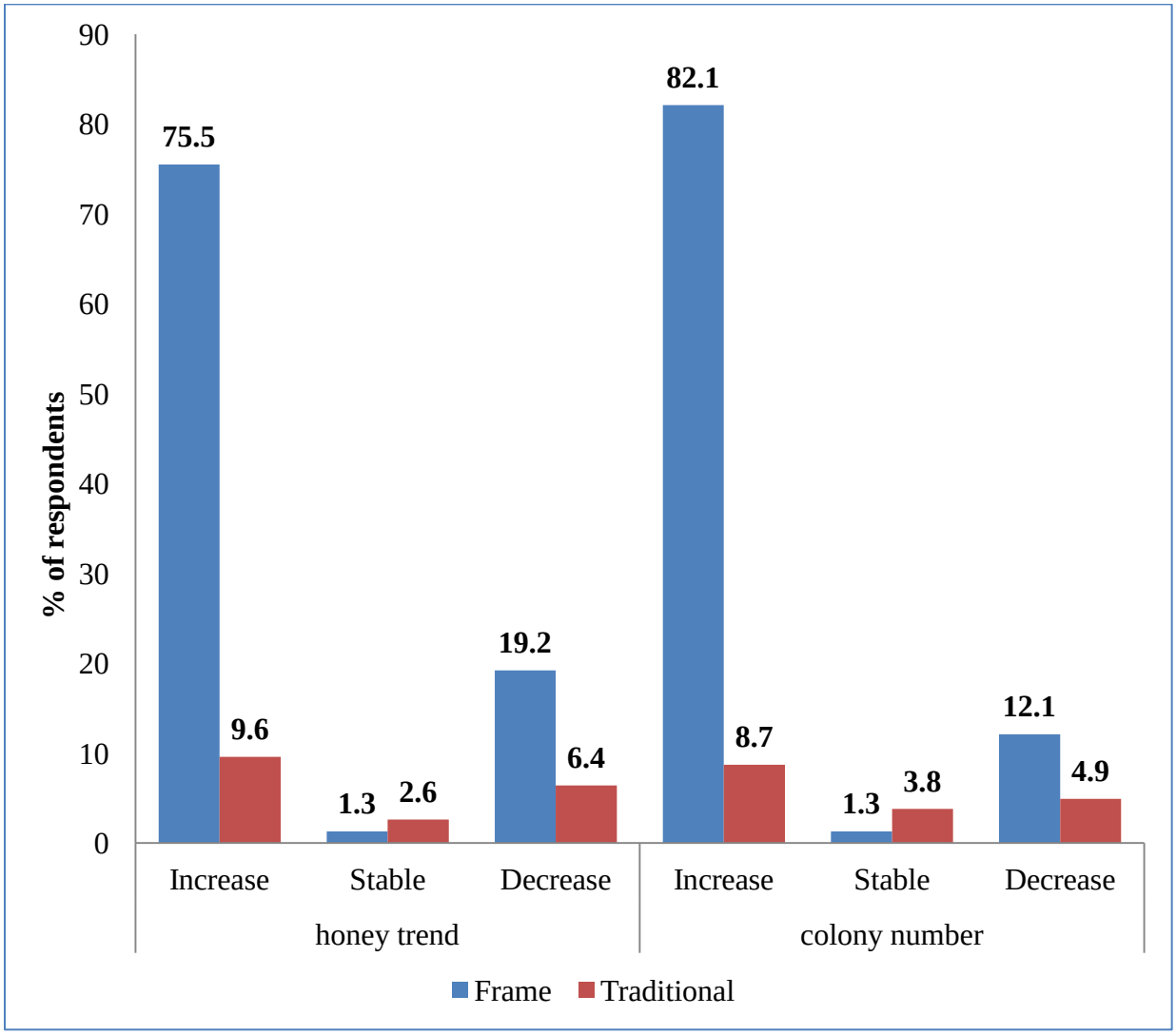

Figure 3. Honey production trend and colony number in Kilte-awlaelo district

Furthermore, majority of the respondents declared that number of colonies is increasing from time to time both in local and frame beehive production. About 7.7%, 3.8% and

4.5% of the respondent suggested that colony number for traditional beehive is increasing, stable and decreasing, respectively. About 82.1% 1.3% and 13.5% responded frame beehive is increasing, stable and decreasing, respectively (Fig.3). However, the secondary data from the study district BoARD indicated that in the past decades the production of honey and beehive productivity increased from time to time but there is inconsistency in the increments rate (Table 11).

Table 11. Trend in honey production and productivity from frame and traditional hives

Year	Framed hive		Traditional hive	
	Honey production(Qt.)	Productivity/year/hive	Honey production(Qt.)	Productivity/year/hive
1999	15.05	35	3.9	7.5
2000	76.2	36	2.4	6.0
2001	23.6	13	3.4	8.5
2002	83.3	41	6.9	9.0
2003	162	25	12.8	9.6
2004	201.7	13	16.4	7.2
2005	1551	33	261.52	7.9
2006	1997	27	370	6.9
2007	1952.28	24.75	460.34	7.9
2008	2993.55	35	483.28	9.1
2009	1917	25.35	268.14	8.3
2010	4625.62	46	274.33	10.8
2011	3956.25	40	260.25	8.3
2012	7189	41	182.36	7.2
2013	2966.25	36	211.66	7.4

Source: Kilte Awlaelo district bureau of agriculture and rural development

4.4.3. Hives source, beekeepers and bee preference to types of beehive

According to the survey result, 98.7% and 1.3% of the sample respondents replied that they constructed and purchased traditional beehive, respectively. Majority (83.3%) of the sampled respondents got frame beehive from government (Table 12). Also, NGO´s participated in the distribution of frame beehive in the district. Thus, 12.8% and 1.3% of the respondents have got their frame beehive from different NGOs on credit basis and free support, respectively and 2.6% of the sampled respondents purchased the framed beehive from the local market sold by other farmers.

Table 12. Distribution of respondents by source of hives (percent)

Beehive type	Sources of beehive						Cost/beehive (Birr)			
	Home made	Local market	GOV credit	NGO credit	NGO support	Total	Min.	Max.	mean	SD
Traditional	98.70	1.30	-	-	-	100	30	200	115.00	120.21
Framed	-	2.60	83.30	12.80	1.30	100	400	1000	653.78	121.73

GOV=governmental, NGO= nongovernmental

Although frame beehive require extensive establishment cost and training to perform different activities, 98.7% of the beekeepers responded that they preferred to have framed beehive to produce high quality and quantity of honey. Beekeepers were also asked to compare and contrast the types of beehives that the bees prefer or stay for long time in the beehive. According to the beekeepers, the preference of the bees for the different beehives depends on apiary management, the materials the beehives were made, and the environmental condition. However, 50% of the respondents declared that local beehive is preferred by the bees, whereas the remaining 50% responded that their bees prefer to stay longer in frame beehive (Fig. 4).

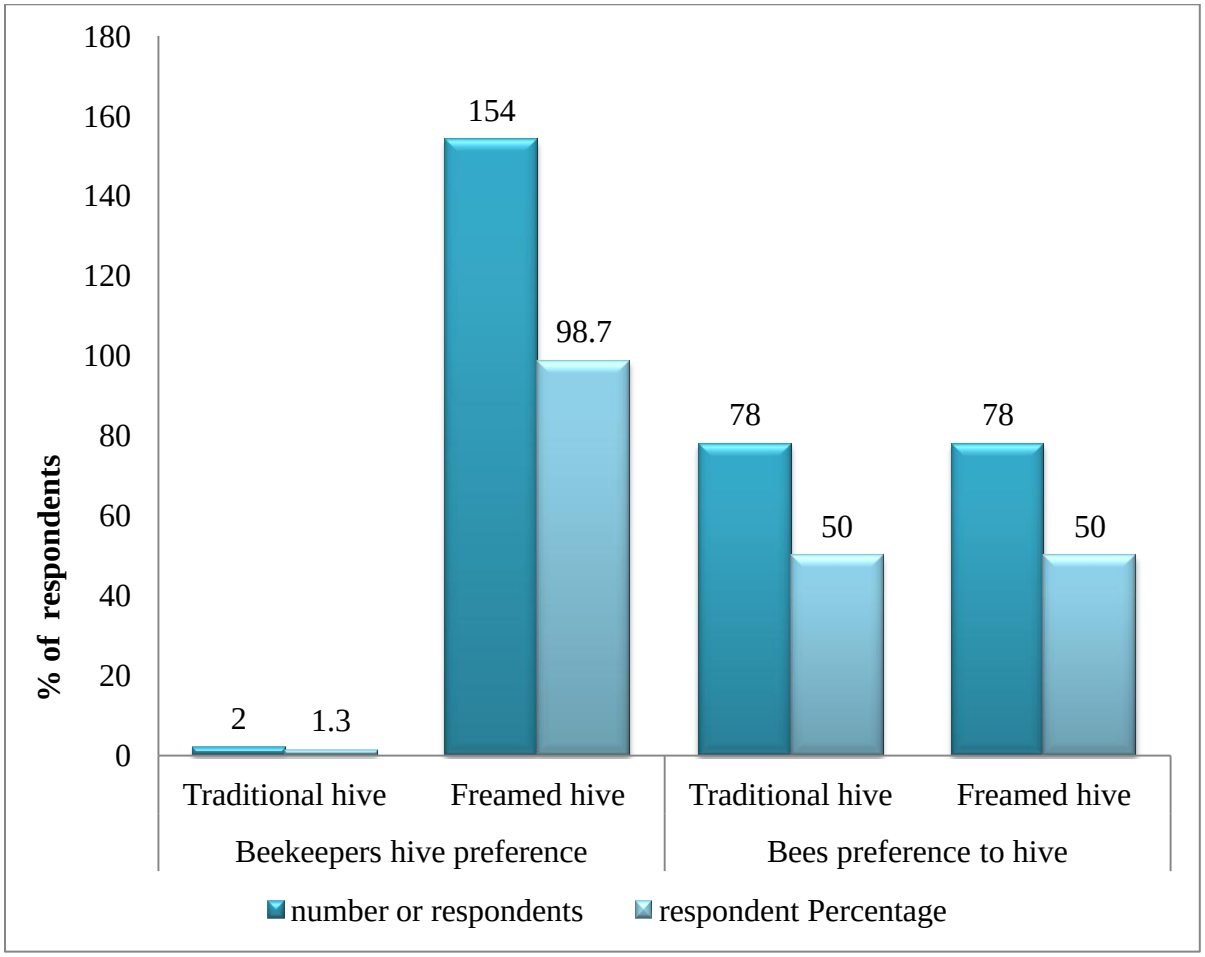

Figure 4. Beekeepers and honeybee preference to local and frame beehives

4.4.4. Apiary inspection and honey harvesting frequency

Sample respondents were interviewed to describe the frequency of inspection of their apiary and colonies and 53.2%, 9%, 30.1%, 2.6% and 3.2% inspected the apiary and colonies every day, in every two to three days, weekly, in every two weeks and monthly, respectively (Fig. 5). However, 1.9% inspected both the apiary and the colonies yearly only at the time of honey harvesting. Very few beekeepers (1.9%) harvested honey three times a year depending on the condition of the rainy season, whereas the majority, 61.5%, and 36.5 % harvested once, twice a year, respectively.

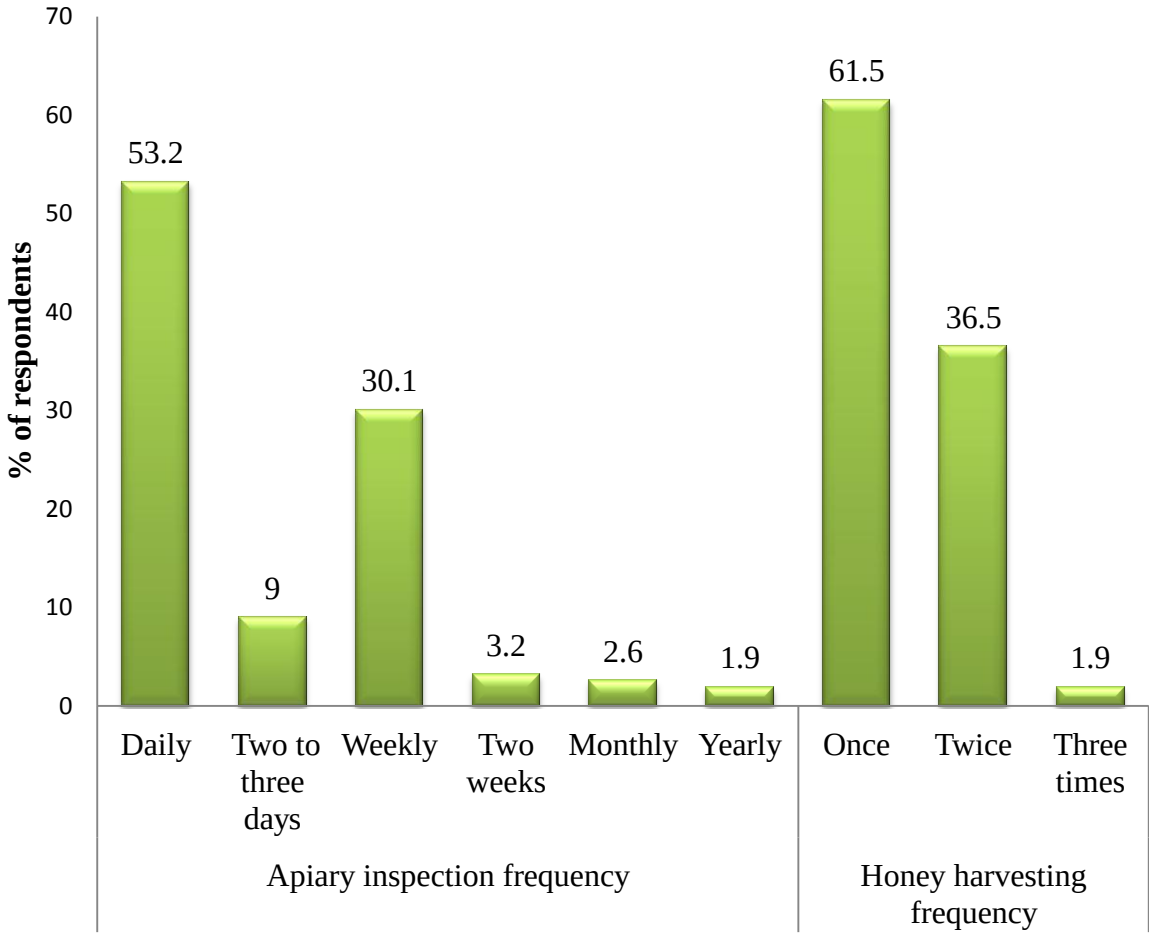

Figure 5. Apiary inspection and honey harvesting frequency in Kilte-awlaelo district

4.4.5. Honey marketing, storage containers and income from beekeeping

As honey is a good source of income, most of what farmers produce is brought to different market places. Regardless of which market, about 82.7% of the farmers sell all their produce. However, 16% used the honey for both home consumption and selling and 1.3% used for home consumption only (Table 13). The majority of the beekeepers (85.3%) sell their honey at nearby markets and 9%, 4.5%, 0.6% and 0.6% sell their honey in the main honey markets at home/farm gate, to beekeepers cooperative and in the capital city Mekelle, respectively (Fig. 6).

Most of the beekeepers, 96.8%, had access to market price information from one or more than one sources. About 57.7%, 30.1%, 4.5% and 1.9% beekeepers get market price information from traders, other farmers, regional radio and from the surrounding beekeepers association, respectively. The price of honey is determined by the market driving forces, the demand and supply.

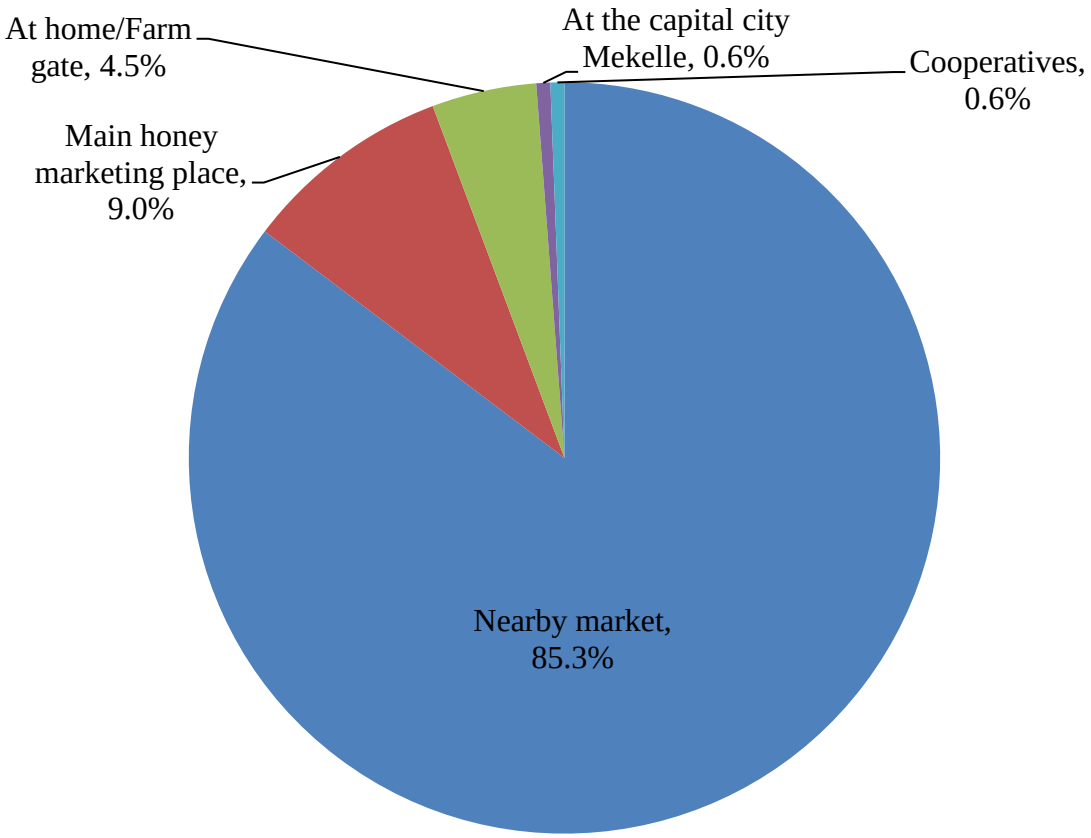

Figure 6. Honey marketing places in Kilte Awlaelo district

About 66.7% household decision was made by husband regarding marketing of honey followed by husband and wife (30.1%), only wife (1.9%) and only children (1.3%) (Table 13). Although, different family members participate in honey marketing, about 81.4% household honey income was controlled by both husband and wife. The remaining 17.9% and 0.6% household income from honey was control by husband and wife, respectively.

More than half of the beekeepers (51.3%) responded that they stored their honey, out of which14.7%, 15.4% and 21.2% were storing for 1-3, 4-6 and more than 6 months, respectively whereas, 48.7% of the beekeepers in the district did sale their honey immediately after harvesting (Table 13).

Table 13. Honey marketing and purpose of honey production **(N= 156)**

	Respondent	
Variables	**N**	**%**
Involvement in honey selling		
Husband	104	66.7
Wife	3	1.9
Children	2	1.3
Husband and wife	47	30
Money control from honey sale		
Husband	28	17.9
Wife	1	.6
Children	-	-
Husband and wife	127	81.4
Purpose of honey production		
Home consumption	2	1.3
For sale	129	82.7
Home consumption and sale	25	16.0
Honey sale time: Do you sale honey?		
Immediately after harvest	76	48.7
Not immediately after harvest	80	51.3
Honey storage duration		
For 1-3 moths	23	14.7
For 4-6 months	24	15.4
For more than 6 months	33	21.2

According to the survey result and personal observation, the majority of the beekeepers that had no critical financial problems kept their honey for extended period of time with the assumption of fetching higher honey price at off season (Table 13). Nearly 54.5% stored their honey in plastic containers with different sizes. The remaining 30.1%, 9.6% and 5.8% stored in tin- can, glass and clay pot, respectively (Fig. 7).

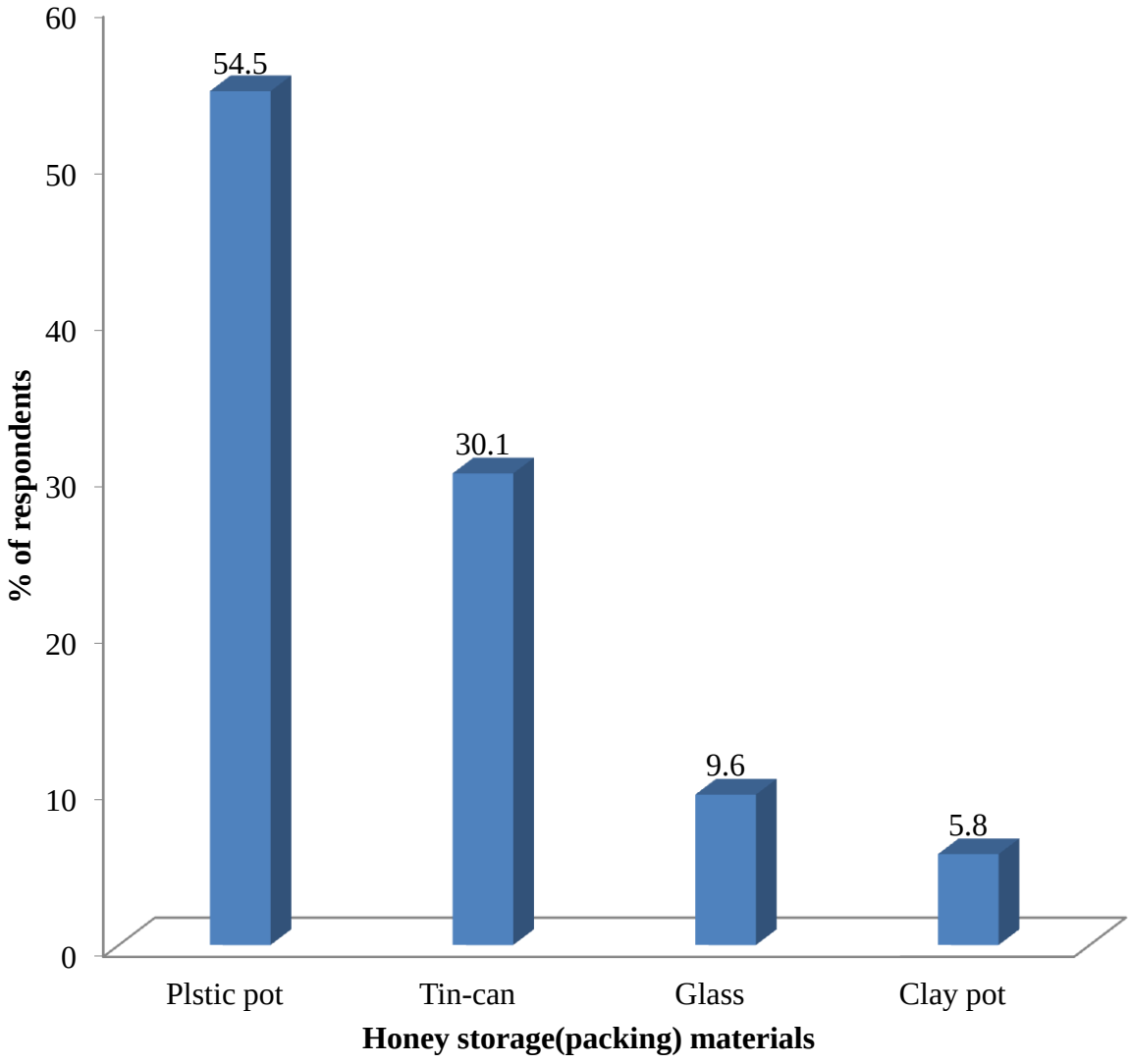

Figure 7. Honey storage (packing) materials in Kilte-Awlaelo district

According to the study result, the average income from honey and bee colony is 9180.48 and 6836.84 birr per year, respectively. About 98.7% of the sampled farmers responded

that because of the use of frame beehive, lack of wax processing skill and materials the production and income from wax is very minimal (Fig. 8).

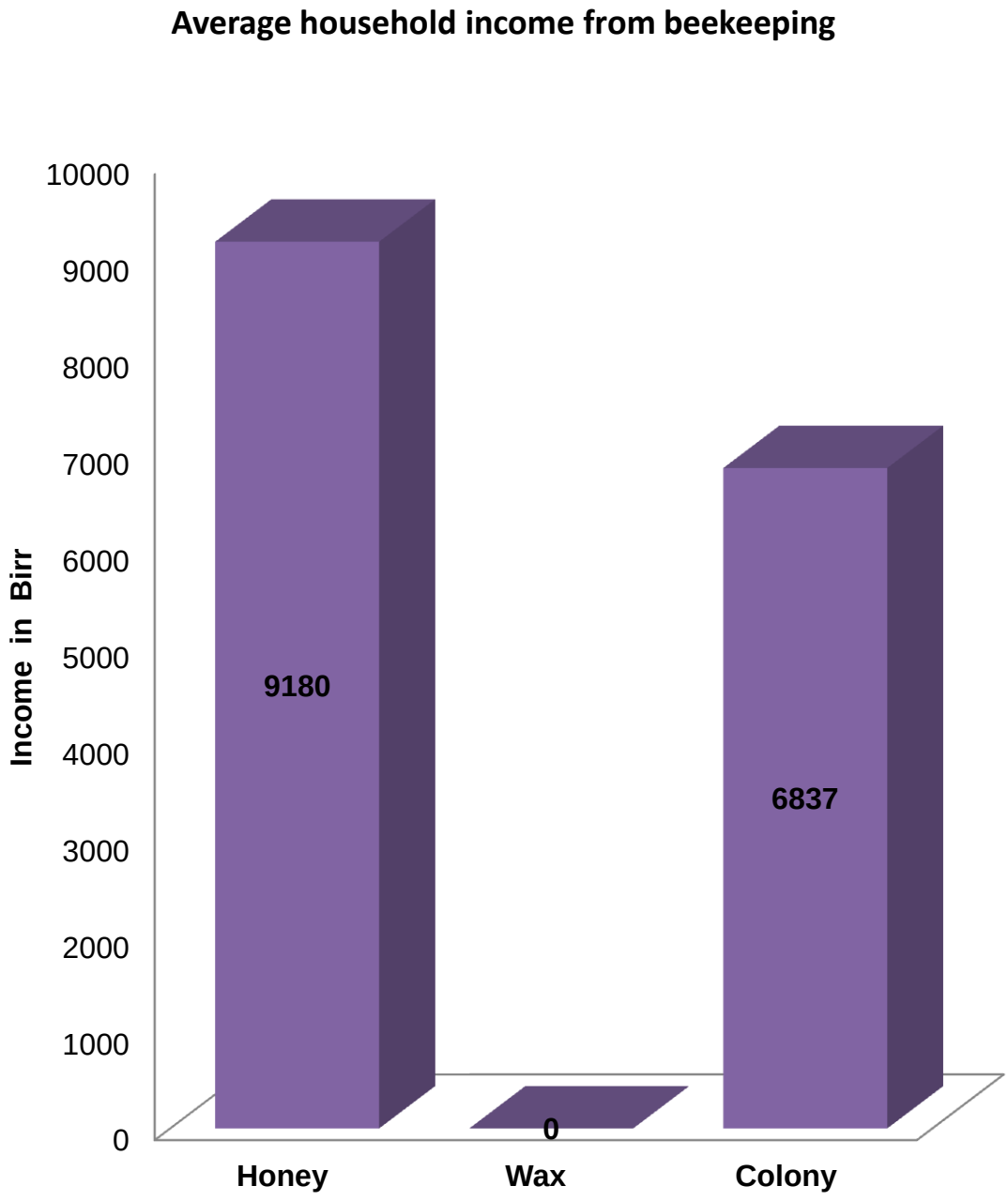

Figure 8. Average income from honey, wax and honeybee colony selling in Kilte-awlaelo district

4.4.6. Honeybee flora and dry season feeding

Honeybees collect nectar and pollen for their own consumption and store honey for the dearth period. Bee forage types affect the amount of honey yield obtained per colony. According to the beekeepers the existence of some special bee forages in the district results in the production of high quality and quantity honey. In the study area there has been an encouragement by governmental and nongovernmental organizations to plant and to cultivate different bee forages. Thus, the beekeepers grow indigenous bee forages around homesteads, in area closure and in and around their apiary sites.

According to this study, about 89.1% of beekeepers cultivated different local bee forages like Seseg (*Ocimum basilicum*), Hamliadri (*Brassica spp.*), suf (*Helianthus annus L.),* Keyh-Bahrzaf (*Euccalyptusc amaldulenisis*.), Gesho (*Rhamnus prinoides L.)*. A total of 37 commonly grown bee flora species are identified and are recorded with their local name (Table 14). The information obtained on common bee flora species from the respondents was triangulated the scientific names from reference book of Fichtl and Admassu (1994) and Alemtsehay (2011). Generally, the result showed that, the honeybee forages included cultivated crops, trees, shrubs and herbs.

Table 14. Common bee flora species in Kilte Awlaelo district according to social survey

Local name (Tigrigna)	Scientific name	Life form	Flowering time (month)												
			Source (P/N)	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Tebeb	*Becium grandiflorum*	S	P & N												
Girbiya	*Hypoestes forskaolii*	H	P & N												
Siwakerni	Leucas abyssinica	S	P & N												
Kileaw	Euclea schimperi	S	P & N												
Awhi	*Cordia africana*	T	P & N												
Kelamitos	*Eucalptus spp*	T	P & N												
Beles	*Opuntia ficus-indica*	T	P & N												
Hohot	*Rumex nervosus*	S	P												
Dander	*Carduus amaecephalus*	S	P & N												
Kolqwal	*Euphorbia candelabrum*	S/T	P & N												
Lucina	*Leucaena leucocephala*	S	P & N												
Sasbania	*Sesbania sesban*	S	P & N												
Gul′i	*Ricinus communis*	S/T	P & N												
Ire	*Aloe berhana*	H	P & N												
Awlea	*Olea Africana*	T	P & N												
Suf	*Helianthus annus*	C	P & N												
T´qur-berbere	*Schinus molle*	T	P & N												
Agam	*Carissa edulis*	S	P & N												
Seraw	*Acacia spp*	T	P & N												
Chea	Acacia pilispina	T	P &N												
Demihal	*Andropogon abyssinicus*	H	P												

Local name (Tigrigna)	Scientific name	Life form	Flowering time (month)												
			Source (P/N)	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Kebkeb	*Maytenus senegalensis*														
Seseg	*Ocimum basilicum*	S	N												
Thases	*Dodonaea angustifolia*	S	P & N												
Mango	*Mangifera indica L.*	T	P & N												
Dairo	*Ficus vasta*	T	N												
Geligel Meskel	*Bidens spp.*	H	P & N												
Ater	*Pisum sativum*	C	P & N												
Mishelabahir	*Zea Mays*	C	P												
Hamiliadri	*Brassica spp.*	H	P &N												
Hitsawts	*Calpurnia aurea*	S/T	P & N												
Avocado	*Persea americana*	T													
Papaya	*Carica papaya L.*	T	P & N												
Komidere	*Lycopersicon esculentum*	H	P & N												
Chindog	*Otostegia integrifolia*	S	P & N												
Gesho	*Rhamnus prinoides L.*	T	P & N												
Tefreria	*Sida schimperriana*	S	N												

NB: T = Tree, S = Shrub, H = Herb, C = Crop, P = Pollen, N = Nectar

Although honeybees store honey for their own consumption during the period of feed scarcity, there is exploitation of honey by beekeepers. However, at times of feed scarcity the bees face starvation. To overcome the feed shortage during the dry season, some farmers usually take different measures like supplementary feeding and migratory beekeeping practices to areas with source of water and good vegetation. In this study, it was found that 89.1% of the beekeepers provided supplementary feed for the dearth period. The supplementary feed included *besso*, *shiro*, sugar syrup and honey with water. This feeding practices did take mainly from February to May (87.2%), May to June (0.6%) and June to September (1.3%).

About 24.4% practiced migratory beekeeping to escape the dry season. However, the rest (85.6%) practiced migratory beekeeping to prevent the bees from agrochemicals, diseases, for surplus honey production, and crop pollination. The beekeepers could take bees on average about 2 km to 10 km minimum and maximum distance, from the original location, respectively.

Honeybees require large quantities of water in the beehive to dilute brood feed and to cool the beehive during high temperature (Fig. 9). The source of water in the area comprised rivers, ponds, wells and drinking water (taps water). The beekeepers provide water or other solution by putting grass, stone and maize cobs in the container to avoid the sinking or death of bees during drinking.

4.4.7. Poisons plants and honeybee poisoning

Nearly 43.6% of the beekeepers were victims of poisonous plants. The majority of the bee poisoning occur due to the use of agrochemicals mainly insecticides and herbicides. However, the beekeepers stated that currently at district level, the use of agrochemicals has been restricted only to time of application. So, there had been an improvement on the effect of chemicals on bee colonies from time to time.

About 43.6% of experienced beekeepers identified the major poisonous plants in their surroundings. Plants like acacha (*Acacia saligna*), qnchb *(Euphorbia tirucalli*); limo or false neem *(Melia azedarach), Neem* (*Azadirachta indica)* are identified as poisons plants. However, the applications of agrochemicals and identification of poisons plants need to be confirmed by further research.

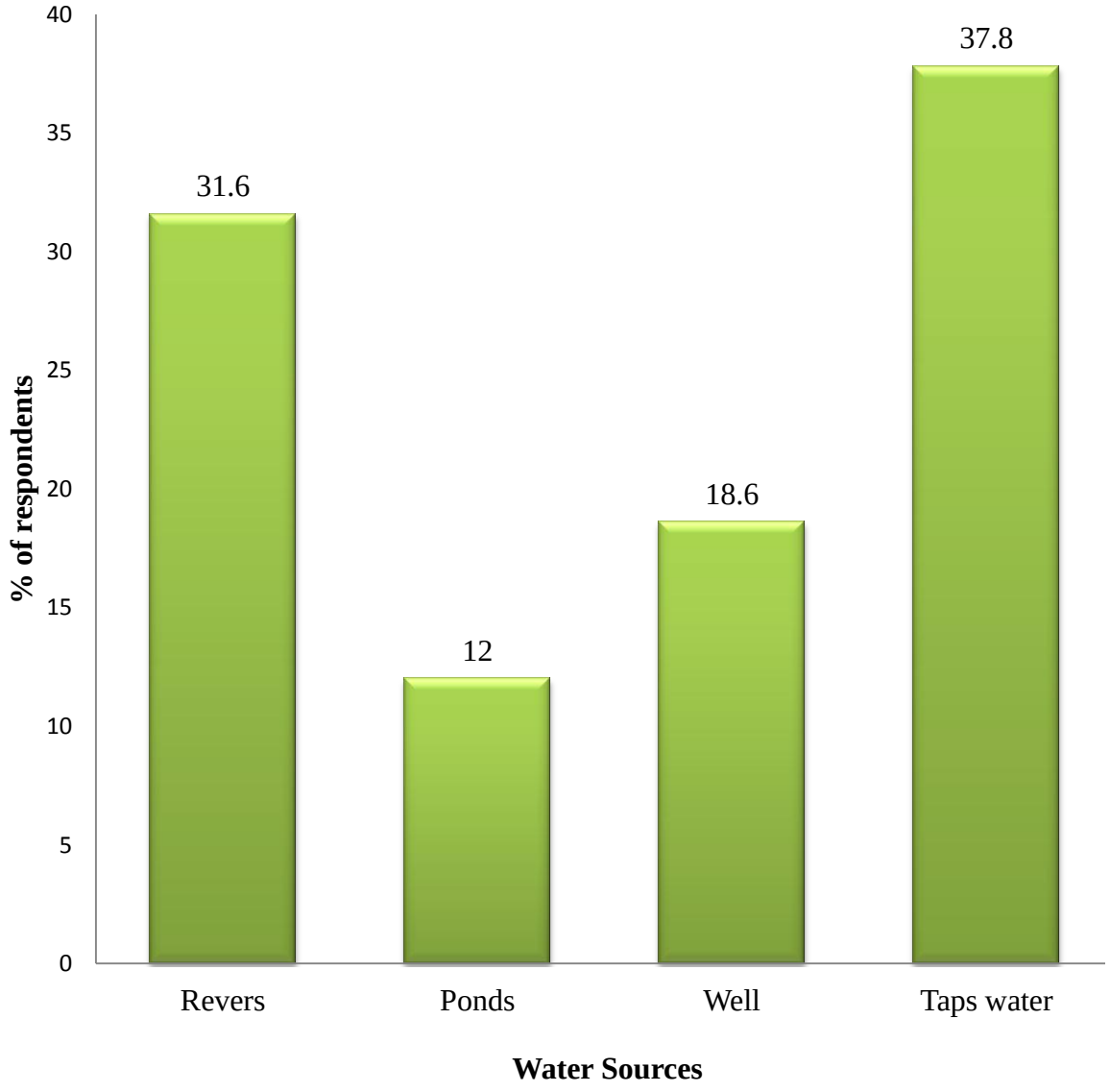

Figure 9. Water sources to bee colonies in Kilte Awlaelo district

4.4.8. Honeybee pests and predators

Based on the result of this study, in addition to the poisons plants and agro-chemicals the existence of pests and predators was the major challenge to the honeybees and beekeepers in the district. According to the identification of the beekeepers, the major honey bee disease and pests were honey badger, ants, wax moth, spider, lizard and birds. The honey badger was a serious problem in the area. Beekeepers have developed different experiences and practices in controlling some of the honeybee pests and predators (Table 15).

Table 15. Percent and rank of major pests and predators **(N = 156)**

Major pest and predator	Respondent %	Rank	Indigenous preventive measures
Ants	18	2	Clean apiary, Place fresh ash, plastering hives stands with mud or cement, put metals between the hive and hive stands and pour used engine oil around the hive stand
Wax moth	15.5	3	Clean apiary, remove old comb, and strengthen the colony, remove empty hives from the apiary
Spider	10.5	4	Clean apiary, frequent inspection, removal of spider´s web and killing
Honey badger	40	1	Killing, Fencing of the apiary, use dog to keep at the night
Lizard	4.5	6	Clean apiary, frequent inspect and kill
Snake	3.5	7	Clean apiary, Smoking with plant materials and horn and kill
Birds	8	5	Putting cloths, festal, killing using “wonchif” or watch guard
Total	100		

4.4.9. Beekeeping extension service

According to the information from the farmers and Kilte-Awlaelo district apiculture experts, extension service was main related to beekeeping activity in the district as well the region. The beekeepers also agreed that the sub sector is given more attention in the district along with area rehabilitation and integrated crop livestock program since the past ten years. Table 16 indicates the yearly distribution of beehives and number of farmers engaged in beekeeping sector.

Moreover, in addition to the farmers indigenous knowledge, the district agricultural bureau, NGOS and other governmental projects have distributed modern beehive and offer training to the beekeepers. According to the report from the district bureau of agriculture and rural development, the government and NGO distributed around 23106 frame beehives to 7423 beekeepers.

Based on the result of this study, 75% of the beekeepers received beekeeping extension service and out of which 45% have got training from the district DAS, Wukro ATVET College, Wukro St. Marry´s college, REST, World Vision Ethiopia and EOCDICAG (Ethiopian Orthodox Church Development and inter-church aid commission).The trained farmers have the opinion that the training obtained had an impact on increasing their understanding of beekeeping practices. The beekeepers explained that the training has helped them to maintain the quality of their honey and improve the management of the colonies. Besides, more farmers are encouraged to buy frame beehive after training because of the increased understanding about the importance of framed hive.

The main goal of any extension service has always remained the same, which is transferring of important skill, technology and technical information to the farmers. For this, extension agents are typically trained professional adult educators that often serve as a communicator, educator and translator; connecting rural communities to government, NGOs, credit mechanism and other related services that could benefit the farmers (Guy, 2010).

Table 16. Frame and Traditional hive distribution 1998 – 2013

	Frame hive distribution		**Traditional hive distribution**	
Year	Number of hive	Number of beekeepers	Number of hive	Number of beekeepers
1998	43	23	60	60
1999	140	92	35	35
2000	190	141	33	33
2001	213	169	-	-
2002	125	87	-	-
2003	5247	2672	1406	757
2004	3601	1801	1248	871
2005	163	88	265	133
2006	758	440	564	385
2007	434	250	764	411
2008	1894	864	1783	555
2009	2174	950	1891	1077
2010	2622	997	1238	739
2011	2800	791	0	0
2012	2212	896	0	0
2013	490	162	0	0
Total	**23106**	**7423**	**9287**	**5056**

Source: Kilte –Awlaelo district bureau of agriculture and rural development

4.4.10. Beekeeping opportunities and constraints

Kilte-Awlaelo district is one of the districts in eastern part of Tigray with rehabilitated and transformed to one of the potential areas for beekeeping in the region. According to the district apiculture expert and group discussion result the district is highly potential and have many opportunities to the beekeeping sector due to the following reasons;

- In the district there has been high soil and water conservation practice and efforts of area enclosure which is a source of different species of bee forages.

- Honey from this district is already known by its quality and attractive color, this is good opportunity to the district honey in national and international markets.
- The district has planned to distribute area enclosure to the landless youth for beekeeping practices.
- Since the district is near to the regional capital city, there is high market demand to honey.
- In the district, there is high involvement of NGOS and investors in beekeeping sector and other developmental activities.
- Availability of credit service by the government for beekeeping investment.

The beekeepers also explained that the profitability of the sector in the district is very good and encouraging to engage in this activity. About 98.1% of the beekeepers pointed out that beekeeping is profitable in the district due to availability of different bee forage species, honey produced is quality and had extremely white color, good governmental attention to training and input supply, good market price to honey and bee colonies.

All problems may not be equally important to the sector. The most important constraint that hampered the development of beekeeping sub-sector arises from bee colony management or environmental factors. According to the responses of the beekeepers and available information, the major challenges of the beekeepers were seasonality of bee forages (Table 17). The majority of respondents (24.4%) listed shortage of bee forage as a major constraint. Thus, the bees migrate to other areas where forage is available. Pests and predators of bees accounted 16.7% and 12.2 % of the constraint of beekeeping, respectively. In addition to this, 10.3%, 9%, 7.1%, 5.1%, 4.5%, and 4.5% 3.2%and 3.2% of the beekeepers were constrained by absconding, shortage of honeybee colony, application of pesticides and herbicides, death of colonies, water shortage, storage facilities, swarming and marketing problems, respectively.

Table 17. Beekeeping constraints in the study area

No.	Constraints	Frequency	Percentage	Rank
1	Bee forage shortage	38	24.4	1st
2	Pests and predators	26	16.7	2nd
3	Beekeeping equipments / materials	19	12.2	3rd
4	Absconding	16	10.3	4th
5	Honeybee colony	14	9.0	5th
6	Pesticides and herbicides application	11	7.1	6th
7	Death of colony	8	5.1	7th
8	water Shortage	7	4.5	8th
9	Storage facilities	7	4.5	9th
10	Swarming	5	3.2	10th
11	Marketing	5	3.2	11th

4.5. Honey Quality

The physico-chemical properties of honey play an important role in determining the honey quality and affect international honey marketing business. Thus, the present study dealt with the various physico-chemical properties of honey in relation to district storage containers and storage durations.

4.5.1. Moisture content

There was highly significant difference ($P<0.001$) among the three storage containers in the moisture content of honey collected from the study district (Table 18). The results indicated that honey stored in plastic containers had higher moisture content and followed by glass and tin-can. The results revealed that storage duration had an effect on the moisture content of honey, where the moisture content of the sampled honey increased with time and varied from 16.9% at the time of harvesting (fresh sample) to 17.5% after 6

months of storage. Moreover, there was significant ($p < 0.05$) effect of the interaction the storage container and storage time on the moisture content.

4.5.2. Ash content

The storage duration significantly ($P<0.001$) affected the mineral (ash) contents of honey, but the interaction between storage time and container type did not affect honey mineral content. The mineral (ash) content of the samples from the current study ranged between 0.06 – 0.29% with a mean value of 0.14%. The mineral content of honey samples in the present study lied within the accepted honey mineral contents of less than 0.6% (Table 18).

4.5.3 Acidity

Acidity of honey samples analyzed for this study were significantly different ($P<0.001$) for storage containers and duration of storage (Table 18). However, acidity was not affected ($P>0.05$) by the interaction between storage container and storage duration. The acidity of the honey in this study ranged from 15.08 – 20.1 meq acid/kg with a mean value of 17.57 meq acid/kg. The acidity value of the present honey sample lied within the accepted range of acidity value.

4.5.4. The pH

The pH of sampled honey as a factor of storage container and time and their interaction is presented in Table 18. The honey pH was highly significantly ($p<0.001$) affected by storage duration, although no statically difference could be detected between 3 and 6 months of storage. The honey pH was also significantly ($p<0.01$) affected by the type of storage container and the interaction between container and time was also significant ($p<0.05$). The honey pH ranged between 3.7 to 3.99 and an average of 3.86 which is in the international acceptable pH value of honey.

Table 18. Physico-chemical component of honey samples as affected by storage duration and storage container type

Factors	Physico-chemical component				
	Moisture, %	Ash, %	Acidity, meq/kg	pH	HMF, mg/kg
Container					
Glass	17.29[a]	0.12[a]	17.95[a]	3.86[a]	1.70[a]
Tin-can	17.02[b]	0.15[a]	17.25[b]	3.87[a]	1.94[a]
plastic	17.43[a]	0.14[a]	17.55[ab]	3.84[b]	1.49[a]
SEM	0.05	0.01	0.19	0.01	0.17
Significance	***	NS	***	**	NS
Overall mean	17.25	0.14	17.57	3.86	1.71
Time (months)					
0 (fresh)	16.9[c]	0.16[a]	15.1[b]	3.99[a]	0.00[c]
3	17.5[a]	0.09[b]	18.9[a]	3.78[b]	0.84[b]
6	17.3[b]	0.15[a]	18.7[a]	3.80[b]	4.29[a]
SEM	0.06	0.01	0.19	0.01	0.17
Significance	***	***	***	***	***
Overall mean	17.25	0.14	17.57	3.86	1.71
Container*time interaction	*	NS	NS	*	NS

a, b, c= Means within a column not bearing a common superscript differ significantly; LS= level of significant; ns= Not significant;* = P<0.05; **= P<0.01; ***= P<0.001; SEM= Standard error of means

4.5.5. Hydroxyl-methyl-furfural (HMF)

The honey HMF was not affected (P>0.5) by the interaction between storage container type and storage duration (Table 18). However, storage duration had highly significant (P<0.001) impact on honey HMF value. None detectable HMF was found in freshly

harvested honey, but the amount of HMF increased with increasing storage time. In this study the HMF value ranged between 0.00 and 5.4 mg kg^{-1} for the fresh and sixth months stored samples, respectively.

The honey quality results of the study area compare well with national and international standards for quality honey (Table 19)

Table 19. Study area honey quality result as compared to National and International Standards

Parameters	Standards			Study Area
	World	FAO/WHO	National/max.	Result (mean)
Moisture content, % by mass	18 – 23	21 – 23	21	17.25
Total ash, % by mass	0.25 – 1	0.6 – 1	0.60	0.14
Free acidity, milli equiv. acid/kg	5 – 54	40/kg	40	17.57
Hydrixymethylfurfural mg/kg	40 -80	80	40	1.71
pH	3.2 - 4.5	-	-	3.86

Source: Quality and Standards Authority of Ethiopia (2005)

4.5.6. Correlation between physico-chemical properties of honey

A correlation between different physico-chemical properties of honey in the study district is presented in Table 20. Storage duration was positively and significantly correlated with moisture ($P<0.05$), and ($P<0.01$) to acidity, pH and HMF. However, there was no correlation between ash and storage time. Moreover, moisture content was significantly and positively ($P<0.01$) correlated with acidity, however, moisture was significantly ($P<0.01$) and negatively correlated with ash and pH. Similarly, acidity was significantly

(P<0.01) and negatively correlated with ash and pH and it was positively correlated (P<0.01) with HMF content. Ash was positively (P<0.05) correlated with pH and no significant correlation between ash and HMF, and pH was highly significant and negative (P<0.01) correlation was observed with HMF.

Table 20. Correlation between different physico-chemical properties of honey

	Time	Moisture	Acidity	Ash	pH	HMF
Time	1					
Moisture	446*	1				
Acidity	.793**	.766**	1			
Ash	-.082ns	-.503**	-.504**	1		
pH	-.779**	-.834**	-.955**	.484*	1	
HMF	.914**	.166ns	.539**	.144ns	-.507**	1

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

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

4.6. Honey Value Chains Analysis

The results presented in the following sections are mainly obtained from qualitative data which were gathered through semi-structured questionnaire conducted with key informants at all levels of the value chain, focus group discussions and personal observations during the study periods.

4.6.1. Actors in honey value chain

The main actors were identified based on their main roles in the value chain. Thus, the following main actors were identified at different levels of the chain (Fig 10).

4.6.1.1. Input providers

Value chain function starts from different inputs used to produce honey and other beehive products. Thus, for sustainable beekeeping, establishing an effective input supply system based on market demand is important for the farmer to obtain quality input in the required amount at the right time. Inputs including beehives, colonies, training, credit services, bee forages and other improved beekeeping technologies were found to be very important. In the study area, the major actors that supported the farmers through supply of inputs included BoARD, REST, Dedebit Credit and Saving Institution (DCSI), World Vision, Ethiopian Orthodox Church Development and Inter-Church Aid Commission (EOCDICAG), IFAD, Save the Children, GIZ, Helivethas, Wukro St. Marry´s College, Wukro Agricultural Technical and Vocational Training College and the regional research system.

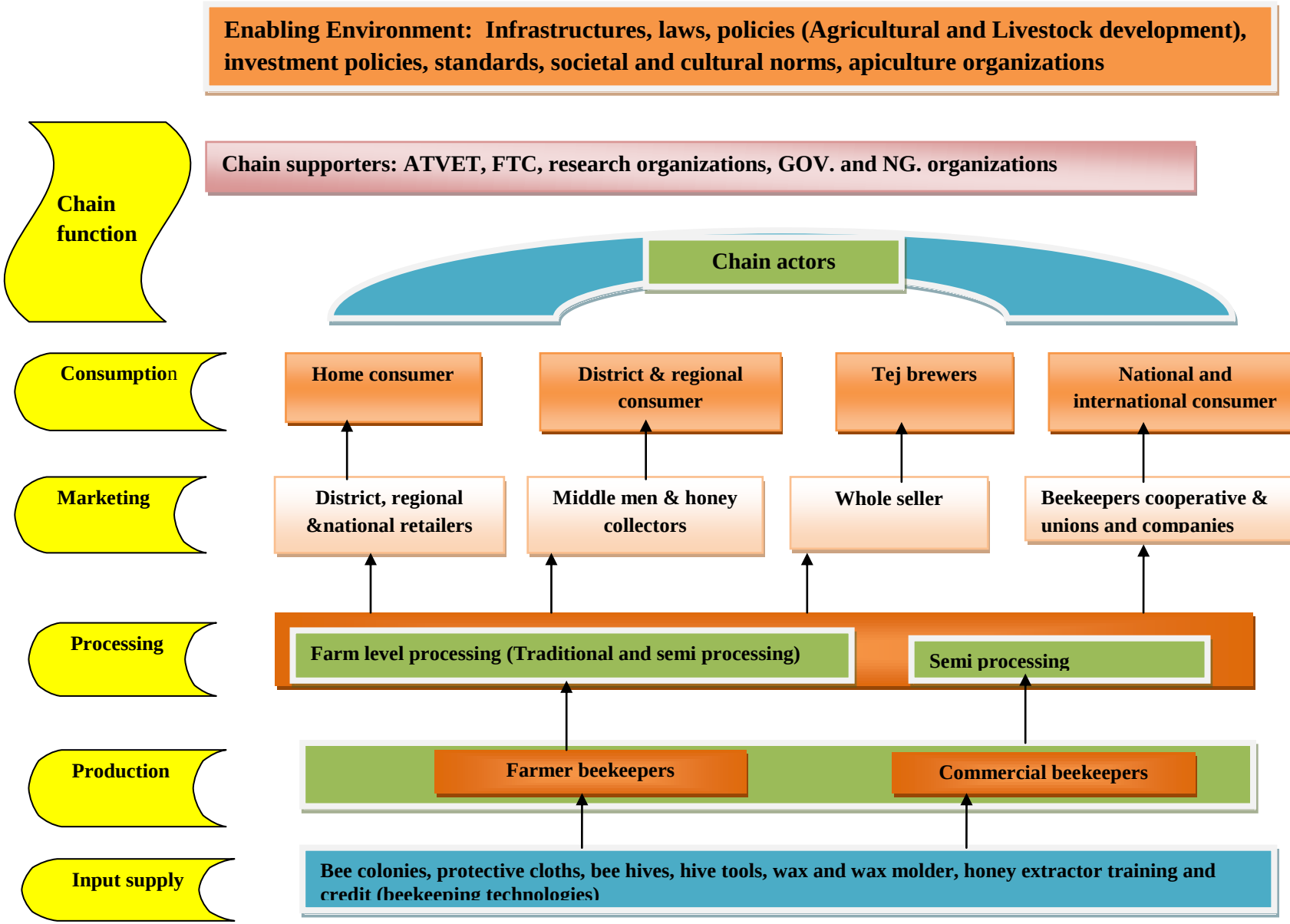

Figure 10. A schematic diagram describing honey value chain in Kilte Awlaelo district

I. Bee equipment and colony supply

Bee equipment and colonies are the most important input for beekeeping (Fig 10). Even though beekeeping has a long history in the area, the contribution of the sector is still low. To enhance honey productivity, adoption of modern beekeeping practice is very crucial. About 83.3% of frame beehives in the district were supplied by the BoARD and honey extractor (one per kebele) and wax molder (one per tabia) were also provided by the district BoARD. According to the district BoARD, the demand for frame beehive by beekeepers is increasing. Table 20 shows that the supply of modern beehive in the study area from 1998-2013. Non-governmental organizations like REST, World Vision, EOCDICAG and Wukiro St. Marry´s College supplied different bee equipment and colonies to the district farmers. Moreover, workshops owned by small and micro enterprise in the district involved in the production of beehives, honey extractors and bee smokers, who mainly supplied their products to BoARD and NGOs for distribution of the inputs to the farmers.

Table 21. Frame beehive distribution in Kilte-Awlaelo district from 1998 – 2013

Year	Number of hive	Number of beekeepers
1998	43	23
1999	140	92
2000	190	141
2001	213	169
2002	125	87
2003	5247	2672
2004	3601	1801
2005	163	88
2006	758	440
2007	434	250
2008	1894	864
2009	2174	950
2010	2622	997
2011	2800	791
2012	2212	896
2013	490	162
Total	**23106**	**7423**

Source: Kilte –Awlaelo district bureau of agriculture and rural development

II. Bee forage

Area rehabilitation efforts have played a role in recovering the areas like mountains and hill sides to previous natural condition; and helped to increase agricultural productivity. In addition to the BoARD, different nongovernmental organizations in the study area (REST, World Vision, EOCDICAG and Wukiro St. Marry´s College) are taking part in different interventions to overcome deforestation and reduction in vegetation cover. These organizations together with BoARD have area conservation and rehabilitation programs by mobilizing the community. The main objective of the program is rehabilitation of degraded lands for the production of livestock fodder, bee forage, firewood and other related benefits for the community or environment. Most of the enclosed areas have become potential sources of white honey source bee forages like girbiya (*Hypoestes forskaolii*), kileaw (*Euclea schimperi*), Seraw (*Acacia etbica*.), Siwakerni (*Leucas abyssinica*), Tebeb (*Becium grandiflorum*), Awhi (*Cordia africana*), Kelamitos (*Eucalptus globules*).

III. Credit service

Dedebit Credit and Saving Institution is one of the micro-finance institutions operating in Tigray. This institution supports the beekeepers with credit to set-up or further develops their beekeeping activities. The organization supports the engagement of people to different activities and provides loan for purchase of dairy cows, bee colony, fertilizers, improved seed and animals for fatting. This institution is the major credit provider with interest rate of 18% and the maximum loan in the rural area is 5000 Birr. However, according to the response of the beekeepers, the loan from this institution is not sufficient for their activity; the interest rate is high and has trouble in using group as collateral. Nongovernmental organizations like Wukiro St. Marry´s College provide credit in-kind to farmers in the form of frame beehive, bee equipment and colonies. Beehive and colonies are provided to selected farmers and women headed rural families with in-kind return of credit without interest payment. According to the owner of frame beehives beekeepers, about 83.3% and 12.8% are sourced from the government and NGOS on credit bases, respectively. The NGOs provide about 1.3% credit free support, whereas 2.6% of the beekeepers purchase from other farmers (Fig.11).

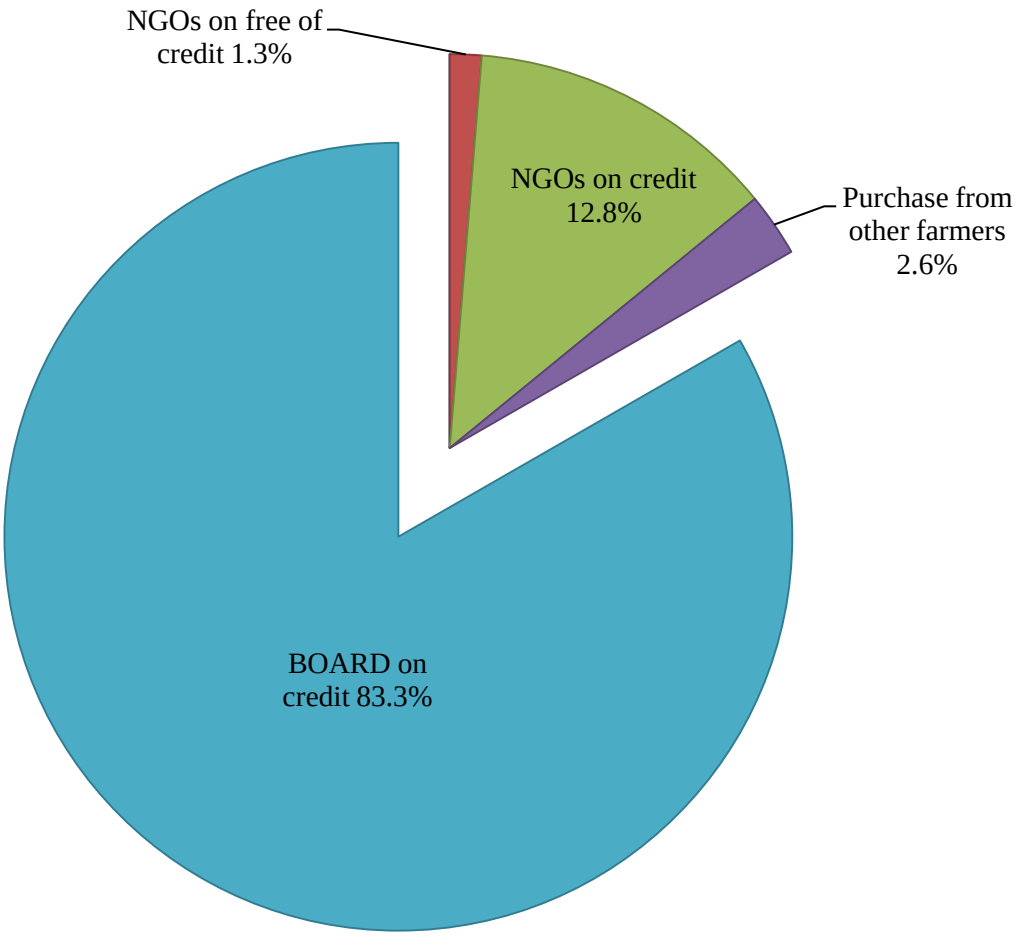

Figure 11. Source of frame beehive and credit in the study area

IV. Extension service

About 75% of the farmers were involved in various agricultural extension services and packages while the rest did not participate in any service. According to the apiculture expert of the district, extension services provision is based on the needs of the farmers and the scheme is implemented in collaboration with governmental and nongovernmental organizations. From the agricultural extension beneficiaries only 45.5% of the beekeepers received formal and informal training on general aspects of beekeeping, queen rearing and colony splitting, honey harvesting and processing organized by BoARD, REST, World Vision, Wukiro ATVET College and Wukiro St. Marry´s College.

V. Market information

In honey value chain, market information for the product is very important. About 3.2% of the beekeepers had no market information and sale their products without any market information by negotiation. About 4.5%, 2.6%, 30.1%, 57.7% and 1.9% of the beekeepers get market information from regional mass media, extension agents of their surroundings, other farmers, traders and association, respectively. Although, 69.2% of the sample beekeepers had access to mass Media, the market information is very limited. The Tigray Agricultural Marketing Promotion Agency (TAMPA) broadcasts weekly average prices of agricultural commodities in the region. However, the beekeepers suggested to include the honey market information in the weekly program of the district air time broadcasted from the region.

4.6.1.2. Honey producers/beekeepers

In Kilte-Awlaelo district, honey is mainly produced by individual farmers, associations and investors. About 95.5% and 4.4% of the beekeepers owned only frame and traditional beehives, respectively. About 82.7% of the beekeepers produced honey for sale or for commercial purpose and 1.3% and 16% of the beekeeper used honey for home consumption and for both consumption and sale, respectively. The average honey yield of traditional and frame beehive was indicated to be 7.66 kg/beehive and 19.4kg/beehive, respectively. The district BoARD report showed that, 12,479 households were involved in beekeeping activities in 2013 with 2966.25 and 211.66 quintals of honey produced from frame and traditional beehive, respectively. Honey is harvested mainly in the months of September to November (Table 22), because during this time honey is considered to have good quality and lower price (170-230 Birr/kg). On the other hand, the honey which is harvested in other months is considered to be of low quality and sold with relatively low price. The seasonality of honey production in the district clearly showed that the availability of fresh quality honey follows the following pattern of major flora.

Table 22. Response of beekeepers to season vs. honeybee activities

Activities	Seasons of occurrence (% of respondent)			
	Sept. to Nov.	Dec. to Feb.	Mar. to May	June to August
Colony Swarming	87.8	-	-	12.2
Honey flow season	92.9	6.4	.6	-
Colony migration	-	1.3	93.6	5.1
Brood rearing period	44.2	1.3	1.9	52.6
Dearth period	.6	.6	96.8	1.9
Colony Absconding	1.3	.6	94.9	3.2

4.6.1.3. Honey collectors and traders

Honey produced in the study district is sold to different consumers in the local markets and to honey collectors or traders. However, 96.8% the beekeeper sell to individual consumers, whole seller (89.7%) and retailers (66.7%) at the district market (Table 23). The collectors in turn resell to other retailers or in their own honey shop. In the study district and at the regional city Mekelle, there are legal traders and collectors who trade honey as their main business activity. However, majority of the traders were facing competition with unlicensed traders.

Table 23. Multiple responses of beekeepers to the different honey marketing route

Honey marketing route	Beekeepers	
	frequency	% of respondents
Tej brewers	45	28.8
Middle men	90	57.7
retailer	104	66.7
wholesaler	140	89.7
Individual consumer	151	96.8
Co-operatives	21	13.5
Processing companies	30	19.2

4.6.1.4. Honey processing/Processor

According to the district BoARD, honey processing association in the study district is at its younger stage (Selam Beekeepers Association, Awlaelo honey processing and production union and Eastern Tigray honey processing and marketing center) and these different associations now starting the collection of honey from the district beekeepers and cooperatives and have started processing and packing of honey to national and international markets. In addition, Dimma honey production and processing in Adigrat and Comel honey production and processing Pvt Ltd. Co in Mekelle purchased honey from different areas of the region including the study district, directly from farmers or from rural collectors and retails in different parts of the region and processed. However, still the supply from these processing companies did not satisfy the demand of supermarkets in Mekelle, forcing many supermarkets bring additional honey from Addis Ababa and other parts of the country.

4.6.1.5. Consumer

Consumption of honey started at farm and farmers consumed limited quantity of honey in different forms. This showed that in addition to creating access to food through increased cash income, honey directly contributed to the food security at the household level. In the study area, honey from the beekeepers reached the final consumers passing through different channels (Fig. 9). According to the survey results, two types of honey consumers were identified: national and international consumers. The national consumers include individual rural and urban consumers in the district, consumers in other district of the region and in the country, tej brewers, hotels and restaurants. According to the response of the honey shop owners in the study area and in Mekelle, there are buyers who send honey abroad to their families and relatives, mainly to United Arab Emirates, Sudan, Djibouti, USA and Europe. Since the study district is the nearest to Mekelle, many regional and national meetings are taking place. Thus, this is a good opportunity for the beekeepers and honey traders to sale their honey at reasonable price.

4.6.1.6. Value chain enabling environment

The enabling environment comprised infrastructures, laws, policies (agricultural and livestock development), investment policies, standards, societal and cultural norms, apiculture organizations.

The key infrastructures that had substantial role in facilitating honey value chain development in the study district were roads, ICT, and different mass media. These all are important to the value chain for timely information dissemination about the honey production, consumption, marketing and application of different technologies and practices.

The existence of conducive policy frame work in the development of agricultural sector in general and the beekeeping sector in particular have significant roles to play in enabling the performance of a commodity value chain. Specific policy modifications such as privatization, commercialization of agricultural products, cooperative promotion, youth and gender policies, natural resources management, rehabilitation of degraded areas and livestock management and poverty reduction strategies and other policies and strategies are believed to create an enabling environment that would enhance efficiency of commodity value chains. To this end, the government has been encouraging the strengthening of the extension system through policies and strategies aimed at the restructuring the system. For instance, the establishment of agricultural technical vocational training centers for building the capacity of the extension staff is worth mentioning. Following this, restructuring of extension services in such a way that each village is supported by three development agents was detrimental. Moreover, the existence of development projects by different NGOs in the study district was a good opportunity for the development of the beekeeping sub sector.

In the 2006 to 2010 five years plan for accelerated and sustained development to end poverty (PASDEP) carried forward important strategic direction pursued under the sustainable development and poverty reduction program (SDPRP) and some bold new directions. In this strategy, Agricultural Development Led Industrialization (ADLI) was a central pillar of economic policy. In the five years strategic plan, beekeeping (honey) production has been given

significant attention and it is anticipated to increase the production of honey from 38000 tons to 98,600 tons with the expansion of irrigated areas integrated with fruits production and agro-forestry development. In addition to this, the strategy stated the adoption of queen rearing technologies and introduction of migratory beekeeping to produce honey on continuous basis in potential areas of the country. Moreover, smallholder farmers played a leading role in the marketing of agricultural products. The government facilitated appropriate conditions through providing access to necessary infrastructure, land and new technologies to enable small farmers obtain relevant market information and fairly compete with well to do farmers, cooperatives and modern private sector at large.

Next to the five years PASDEP strategy plan, the government launched Five Year Growth and Transformation Plan (FYGTP). During this 2011- 2015 GTP period, a key strategic direction was to ensure smallholder agriculture become the main source of agricultural growth through scaling up of interventions. By doing so, improved honey production technologies would be introduced to the potential areas. Generally, honey and beeswax production, processing and exporting activities were the top priorities that fell into agricultural and industrial strategies of the nation. Hence, the government took different institutions and development activities and regulations that have direct or indirect influence to the honey production and marketing. Among which:

- Declaration of Proclamation 660/2009 Proclamation to support the Apiculture Resources Development and give Protection to the sub sector.
- Establishment of National Conformity Assessment Organization (which constitutes the Testing Laboratory to ensure production of quality products including honey
- Establishment of a new Apiculture Research Division at National and Regional Agriculture Research,
- Continuous training on routine extraction and pesticide residue tests for agro-products by the laboratory under the MoARD since 2009,
- Establishment of the Ethiopian Honey Board (EAB, established in February 2009) in Tigray, Oromia, Amhara and Southern Nations and Nationalities and Peoples (SNNP),

- The attention given by the MoARD to increase honey production in 5 years (2010-2015) of the Five Year-Growth and Transformation Plan (FYGTP, 2011-2015) and to improve the quality of animal products and to increase export of honey by volume and value,
- Presence of a well-equipped laboratory with planned activities for accreditation, quality assurance and document preparation projects that includes drugs and pesticide residue analyses and publications of Ethiopian standards for honey, beeswax and beehives

Generally, the government set different developmental policies and strategies for the enhancement of apiculture sectors in the country both in small and commercial scales. However, this would be successful if it would be supported through strategies and program at regional, district and sub sector levels.

5. DISCUSSION

Beekeeping sector is one of the few sub sectors that had the most inclusive ability to achieve transformation and growth across all categories of rural household (Paulos, 2011). Because of adequate water resources and various honeybee floras, Ethiopia creates a fertile ground for the development of beekeeping. Ethiopia is among the leading honey producer in Africa and one of the ten largest honey-producing countries in the world and it is also one of the four largest bees-wax producing countries in the world (Ayalew, 1990). Thus, increasing productivity of honey and other beehive products will contribute to household food and income security. Honey can be marketed in several forms in local and foreign markets and the price and demand of honey depends on the quality of that honey.

Thus, in this section, results from the different activities are discussed in the order presented in the results section.

5.1. Household Socio-Economic Characteristics

The participation of women in beekeeping in this study was better than the findings by different authors in different areas of the country (Tessega, 2009, Tesfaw, 2012). The results of this study contradicted earlier study results (Hartmann, 2004; Solomon, 2009; Mengistu, 2010). This might be due to the increased intervention of the federal and regional governments and different NGOs in the region to economically empower female headed farmers through different agricultural activities. However, their participation was still limited, mainly because of the nature of the job, which requires closely working with the bees for honey harvesting, transferring of colonies and beehive inspection, although beekeeping has strong potential for poverty reduction (income and employment generation for smallholders, including women, landless youth and elderly) (Gizachew, 2011). The same author also pointed out that among the agricultural activities, beekeeping is suitable and compatible with living conditions of women in Ethiopia, and therefore has potential to promote women's economic leadership. Especially in Kilte Awlaelo district women were actively involved in the soil and water conservation work in different watersheds

and considerable benefits have accrued to them, including involving in honey production (Nick and Tassew, 2012).

The household size of a family may imply the level of dependency in the household or the labor force in the household. This labor force has involved in different beekeeping activities like beehive and apiary inspection, honey harvesting and colony management. Workneh *et al*. (2011) stated that beekeepers with large family size have interest and potential for promotion of improved technologies to improve productivity and incomes. Adopting improved box beehives demands additional labor and therefore, households with larger family size are more able to meet these demands. The present study showed that the large proportion of beekeepers were with the mean age of 47.62 years and ranging from 20 to 80 years. The mean age of the beekeepers in the study area was comparable with that of Tessega (2009) findings. This study showed that people at younger and older age were actively engaged in beekeeping activities. Among the beekeepers 82.7% were well educated and this had positive contribution to the success of beekeeping activities in the study area. Formal education is important to farmers to adopt modern inputs and technologies in beekeeping sector. Thus, farmers (beekeepers) need to get basic education for the reasons of adopting new technologies. Education is an important factor which if lacking can negatively impact on future improved beekeeping and livestock production.

According to the beekeepers, the main purpose of keeping different livestock species was for draught power, fuel, manure, cash income, household food consumption. Tessega (2009) reported the same livestock functions in Burie district of Amehara region. Keeping of different livestock species by farmers and/or beekeepers is used for the diversification of farmers′ incomes. Regarding the livestock management system, majority (78.8%) of the livestock owners used controlled grazing (cut and carry system) to feed their animals, which positively contributed to the improvement of soil and water conservation in the district. Due to this livestock management practice, different bee flora has grown in the rangelands and enclosed areas and honey productivity of the district increased from time to time. According to a report by Gebremedhin *et al*. (2012), cut and carry system of animal feeding practice is an important venture to introduce different bee forages in the steep and bottom lands.

5.2. Honey Production System

5.2.1. Traditional beekeeping

The results of the survey of this study indicated that there were no farmers, whose livelihoods depended only on traditional beehive beekeeping system. The traditional beehive beekeeping system had been practiced a long time ago as a sideline activity mainly to crop production. Beekeepers owning traditional and both traditional and frame beehive were 4.5% and 14.1%, respectively. The mean honey production from traditional hive was 7.66 kg/hive, which was comparable with the results of Tessega (2009). However, the average honey yield of the district was more than the national average honey yield reported by GDS (2009). Because of the demand for quality honey and good price of honey from movable frame beehive; farmers have recently shifted to frame beehives.

5.2.2. Frame beehive beekeeping

In the study district, the major portion of honey produced was using movable frame beehives. The highest percent of frame beehive in the study district indicated that the potential of the area for beekeeping and the attention of the regional government and different NGOs in the district to support the beekeepers in different aspects including training, credit and transfer of different modern beekeeping technologies. About 81.4% of the beekeepers owned only movable frame beehive and 14.1% owned both traditional and frame beehive. Because of the high honey price in the district and potential of the area, the use of frame beehive increased from time to time regardless of the high cost and its associated requirement for skilled man power. According to the report of the district BoARD in 2013, about 23106 frame beehives were owned by 7423 farmers in the district. Moreover, the average honey production from frame beehive improved to 19.4 kg/beehive with a minimum and maximum range of 3 to 60 kg/beehive which is lower than the average and maximum production of 28.7 kg/beehive and 110kg/ beehive in Atsbi Woberta district (Assefa, 2009), which was better than the study result of Tessega (2009). However, the large difference between the minimum and maximum honey production per beehive might be due to differences in management practices and availability of year round bee forages.

5.2.3. Hive placement, trend in honey production and colony numbers

Most of the beekeepers in the study area kept both traditional and frame beehives at their backyard. This could be for ease of follow up and inspection, and guarding. However, there are individual beekeepers, associations that place their frame beehive colonies in the rehabilitated area closures. According to the beekeepers, the main reasons for beehive placement or apiary selection were close supervision, availability of bee flora, availability of water and honey bee pests and predator condition. Similar observations were reported by different researchers in different areas of the country (Kerealem, 2005; Tessega, 2009; Nebiyu and Messele, 2013). Regarding to the beehive placement Deborah and Devid (2008) 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. It is also important to place beehives in sunlight preferably with the front of the beehive receiving morning sun to promote early foraging.

The production of honey and bee colonies was increasing from time to time in the study area, due to the use of improved beehive, availability of bee forages, high practices of community based soil and water conservation and attractive price for honey and bee colony. According to this study, the average honey and colony price in the study area was 131 Birr per kg and 667.01 Birr per colony, respectively. Other reason for increasing honey productivity and colony number could be the introduction of different new apicultural technologies like queen rearing, use of frame beehive and other bee equipment which is aggressively introduced to the farmers and the high adoption rate of technologies. The better integration of beekeeping with other agricultural development programs in the district could also be the reason for the increasing production of honey and number of colonies.

5.2.4. Hives source and honeybee preference to traditional and frame hives

Most beekeepers (98.7%) of the study area could construct traditional hives due to mainly the availability of local materials and ease of construction. Similarly, Mehari (2007) in Atsbi district of Tigray region, Nebiyu and Messele (2013) in Gamo Gofa zone of Southern Ethiopia, Tessega (2009) in Amhara region reported that majority of the beekeepers constructed the traditional hive by themselves with locally available materials. Although beekeepers preferred moveable frame

beehive for its improved quality and quantity of honey, ease of harvesting and processing of the honey, it yields very low wax and requires expensive accessories and skill. Additional advantage of the frame beehive over the traditional is its ease of inspection. According to the survey result, majority of the respondents (83.3%) owned frame beehive from the district BoARD with collaboration with NGOs in the district and the rest 12.8% and 1.3% of the beekeepers owned the frame beehive directly from NGOs on credit and credit free, respectively. About 2.6% of the respondents purchased the frame beehive from other neighboring farmers.

Regarding the preference of the bee colonies to the type of beehive, 50% beekeeper replied that bee colonies preferred frame beehive and the rest 50% beekeeper replied that bee colonies preferred the traditional hive. However, some experienced beekeepers pointed that the preference of the bees to hive depends on the apiary management, the material in which the beehive was made and environmental conditions. Although frame beehives require high establishment cost and training; 98.7% of the farmers preferred frame beehives over traditional one. The results were in agreement with the study by Workneh and Ranjitha (2011).

5.2.5. Apiary inspection and honey harvesting frequency

Colonies or apiary inspection was necessary to make sure that the honeybee colonies are safe from pests, diseases and predators. According to the respondents in the study area, the beekeepers believed that frequent opening of the beehive causes the colonies to disturb and it might be the reason for absconding. Yet, majority of the beekeepers (53.2%) in the study district visited their apiary and colonies every day and the farmers of this area are aware; especially of the internal beehive inspection time and season. The results were similar with what was reported by Tessega (2009) in Amhara region. Based on the season of the year, they harvest honey once (61.5%), twice (36.5%) and three times (1.9%) a year. However, harvesting frequency in the study area varies from place to place which is directly related to the availability of pollen and nectar source plants and different management practices of the beekeepers. Those farmers found near irrigation areas or those that use seasonal migratory beekeeping harvest more. Similarly, Yirgalem *et al*. (2012) in the study around Asgede Tsimbla district, Tigray reported that honey

was harvested once or twice a year, which in most cases depended on the availability of bee forages.

5.2.6. Honey marketing, storage containers and income from beekeeping

According to the survey results, majority of the beekeepers in KAD reported that the purpose of keeping honeybees was for income generation (82.7%), which is mainly sold at the nearby markets and to beekeepers associations. Similarly, Tessega (2009); Nebiyu and Messele (2013) reported similar advantage of keeping honeybees in different areas of the country. Beekeepers with no critical financial problems, stored their honey for extended period of time to get better honey price at honey off seasons. Thus, for storage of honey to different storage durations, beekeepers in the study district used plastic pots, tin-can, glass and clay pots. The storage containers used in KAD were different from plastic sack, earthen pot and animal skin reported by Tessega (2009) in Amhara region. For beekeepers in Bench-Maji Zone, the primary storage and transporting materials for honey was earthen pot (Awraris *et al*., 2012).

Honey production was an important source of household income in the study area and according to the results of this survey, the main reason for involvement of the farmers in beekeeping was income generation. Thus, beekeeper earned on average gross income of 9180.48 and 6836.84 Birr per year from the sale of honey and colonies, respectively. The average gross income of the beekeepers from honey in KAD is better than similar study made by Assefa (2009) in Atsbi Wemberta district. However, the use of other beehive product like bee wax was very minimal and only 1.3% of the beekeepers collect crude wax. The use of frame beehive, lack of knowledge and materials were the reasons for the low wax harvest. Beyene and David (2007) reported that beekeepers with transitional and frame beehives purchased beeswax to use as a starting input for honey production. Moreover, Nebiyu and Messele (2013) reported in their study at Gamo and Gofa district that beekeepers don′t collect crude beeswax. In another study by Nicola (2009) indicated that beekeeping generates attractive income to the beekeepers and the country. However, factors such as skill and beekeeping experience, market, climate and botanical resources can affect the level of outcome.

5.2.7. Honeybee flora and dry season feeding

According to the results of this study, beekeepers identified different species of bee forages which comprised trees, shrubs, herbs, cultivated crops and fruits. Beekeepers identified Tebeb, Girbiya, Siwakerni, Kileaw, Awhi and Kelamitos as the major bee forages which are believed to be responsible for the production of quality white honey. The result indicated that these different bee forage species give flower at different seasons and serve as a source of pollen and nectar and feeding bees complementally throughout the year. The result of this study coincided with the result which was reported by Haftom *et al.* (2013) in the same zone. Moreover, similar species of the identified bee forages in the study area have similar flowering season with the study result by Haftom *et al.* (2013). This might be the reason for the seasonal honey production in the region. However, some of the similar bee forages in the current study have different flowering season with the result reported by Tessega (2009) in Amhara region. This could be due to the variation in climate, soil and topography. The report by Bista and Shivakoti (2001) noted that the flowering time of bee forages may differ from one place to another due to variation in climate, topography and other farming practices. Above all, the beekeepers in the study area stated that the availability of different species of bee forage has increased from time to time as a result of the community based afforestation and integrated area rehabilitation programs of the district. The results contradicted with the study by Tesfaye and Tesfaye (2007) in another part of Ethiopia, who reported that the availability of bee forages decreased from time to time.

During the dearth period and heavy rainy season, 89.1% of the beekeepers provided supplementary feeds. This supplementary feeding practices was undertaken mainly from February to May (87.2%), May to June (0.6%) and June to September (1.3%). Almost all the beekeepers practice this dry season supplementary feeding outside the beehive using open locally available materials. However, this open air feeding may expose the bees to fight each other and attacked by other predators and insects. Similarly, in Amhara region, the same practice of supplementing of bees during dry season is reported by (Tessega, 2009), and in highlands of southeast Ethiopia (Solomon, 2009). Among the sampled beekeepers about 24.4% took their colonies to other better plantation area to escape the feed shortage period. Moreover, Gebregziabher *et al*. (2014) noted one of the management considerations in beekeeping is seasonal management requirements.

In order to meet the water needs of honeybees (honeybees need water for different purposes, like to dilute brood feed and to cool the beehive during hot/dry seasons), the GOV, NGOs and the local communities in the study area have constructed ponds and hand dug wells. This has created a good opportunity for beekeeping practices in KAD. The source of water for honeybees includes rivers (31.4%), ponds (11.5%), well (18.6%) and supplemental drinking water (37.8%) and other available sources in the surrounding. The beekeepers supplement water or other solution by putting grass, stone and maize cope in the solution container in order to avoid the damage of bees during drinking. Similar sources of water for honeybee were reported in the study by Tessega (2009) in Amhara region.

5.2.8. Poisonous plants and honeybee poisoning

According to the beekeepers, bees poisoning occurred due to different plant species and rarely by agrochemicals mainly herbicides and insecticides. About 43.6% of the beekeepers responded that plants like akacha (*Acacia saligna*), qnchb (*Euphorbia tirucalli*); limo or false neem *(Melia azedarach)* and Neem (*Azadirachta indica)* were identified as poisonous plant. According to the respondents in the study area, agro-chemicals become the major causes of bee poisoning if the chemicals are applied in bloom stage. According to the respondents, the community has formed local institutions to develop a mechanism to resolve the effects of agrochemicals. Accordingly, the community has agreed to minimize the use of agrochemical through determination of appropriate time of application and avoid application on crop fields closer to the apiary sites. The community has also agreed to apply the herbicides in the evening when the bee are assumed to be back to beehives and the crop farms should be relatively far from the apiary sites. Moreover, strong awareness has been created by the development agents to convince the farmers to practice environmentally friendly methods of weed and pest control. According to Kerealem (2005) and Chala *et al*. (2012), nectar or pollen of poisonous plants is toxic to bees, and the honey produced from such nectar is toxic to humans. The beekeepers also suggested that when government and nongovernmental organizations are introducing different plant species to the study area they should consider the potential and relevance of the plants as bee forage.

5.2.9. Honeybee pests and predators

Honeybee pests and predators are the major constraints for the beekeeping activities in the study area. About 40% of the beekeepers are currently constrained by honey badger. Sequentially insects and pests were ranked for the damage to the sector. Thus, honey badger (40%), ants (18%), wax moth (15.5%), spider (10.5%), birds (8%), lizard (4.5%) and snake (3.5%) were ranked, one to seven in their order of importance and beekeeper were losing significant amount of honey and bee colonies. However, majority (88.7%) of the beekeepers reported that they practice different indigenous mechanisms to minimize the effect of pests and predator. Moreover, frequent visiting and cleaning of apiary is considered as part and parcel and relevance of the solution to minimize the effect of the pests and predators. Previous research works in the study area and elsewhere in the country was indicated the significance of pests and predators to the sector. A report by (Tessega, 2009) in Amhara region, (Adeday *et al.*, 2012), (Chala *et al*., 2012) in Gomma district of Jimma zone, South-west Ethiopia and (Tesfaw, 2012) in Ada'a district of East Shoa Oromia region, (Tolera and Dejene, 2014) in Jimma Zone, Ethiopia investigate similar results with this study.

5.2.10. Beekeeping potentials and constraints

The major opportunities for beekeeping in KAD included high soil and water management practice, a high demand for honey and bee colonies, availability of potential flowering plants, availability of different water sources, high intervention by the government and different NGOs to the beekeeping sector and the long-standing tradition of beekeeping in the district. Thus, the beekeepers were well experienced in the sector and 98.1% of the beekeepers believed that the area is a potential for beekeeping and beekeeping as a profitable business in the district.

Major constraints to the development apiculture in the study district were pests and predators, bee forage, beekeeping equipment, absconding, honeybee colony, pesticides and herbicides, death of colony, water shortage, honey storage materials, swarming and marketing in their order of importance. Different researchers identified similar constraints in beekeeping sector in different parts of Ethiopia (Workneh, 2007; Tessega, 2009; Tesfaw, 2012; Nebiyu and Messele, 2013; Tariku and Mechthild, 2013). According to ADBG (2011), infrastructure, inadequate

access to credit and lack of extension services were identified as key constraints to agricultural productivity. Moreover, Mengistu (2010) identified lack of skilled human powers (apicultural extension staffs), absence of national training center and lack of standard training materials, high cost of beekeeping materials, absence of medium and long term credit institutions in rural areas and technological problems as a major constraints.

5.3. Honey Quality

The moisture values of this study are within the international allowed limit of 23% moisture content permitted by (Codex Alimentarius, 2001). The moisture content of the studied honey samples ranged from 16.9% to 18.1%. Thus, according to Ethiopian standard, to the moisture content of honey is categorized as grade "A" (QSAE, 2005). The moisture level of the analyzed fractions was lower than the previous reported values by (Tessega, 2009) in Amhara region and chemical composition of honey studied in different districts of Tigray the corresponding values ranged from 18.6% to 18.8 % (Kebede *et al*., 2012). In Codex Alimentarius and EU council directives the maximum moisture content value of pure floral honey is given as 23% for healthier honeys and not more than 20% in general (Codex Alimentarius,2001, EU,2001). The water content of honey depends on various factors, for example: the harvesting season, the degree of maturity reached in the beehive, and environmental factors (Acquarone *et al*., 2007). Furthermore, according to these authors, the water content value is also of great importance because it is considered to be a useful parameter for describing moistness and viscosity of honey. In general high amount of water causes the honey to ferment, to spoil and to lose flavor, with resulting honey quality loss (Ouchemoukh *et al*., 2007; Saxena *et al.*, 2010). According to these authors, this honey fermentation activity during storage is caused by the action of osmotolerant yeasts resulting in the formation of ethyl alcohol and carbon dioxide. The alcohol can be further oxidized to acetic acid and water resulting in a sour taste

The average ash content (0.13%) in the present study is lower than similar studies by Chala *et al*., 2012) in South West Ethiopia (0.23%) and Tessega (2009) in Amhara region (0.27%). This study result is in line with Kebede *et al.* (2012) (0.12%) in Tigray region. The similarity with Kebede *et al.* might be due to similarity in botanical origin. Honey normally has low mineral (ash) content and it depends on the material collected by the bees during foraging on the flora

(Ameera *et al*., 2014). The wide variability of honey composition is reflected also in the ash content; this parameter is used for the determination of the botanical origin of honey.

The average acid content of the current study (17.57 meq acid/kg) was lower than other results by (Tessega, 2009) in Amhara region (28.83 meq/kg) and (Chala *et al*., 2012) (28.2 meq/kg) in southwestern Ethiopia. The results were within the international and national recommended rages for honey free acidity value. According to Moussa *et al*. (2012), high free acidity values may indicate the fermentation of honey sugar by yeasts. It is well known that during fermentation, glucose and fructose are converted into carbon dioxide and alcohol. Alcohol is further hydrolysed in the presence of oxygen and converted to acetic acid, which contributes to the level of free acidity in honey.

The overall pH value of the present study falls within the range of 3.70 to 3.99 (Table 18) with average value of 3.86. These values were within the acceptable pH range of 3.2–4.5 (Codex Alimentarius, 2001). In general Kilte Awlaelo district honey showed relatively acidic behavior which was similar to other honeys in the world. The study results were closer to those values reported by different researchers in the country (Tessega, 2009 [3.53], Chala *et al*., 2012 [3.81] and Kebede *et al*., 2012 [4.03]). Moreover, among the honey quality criteria, pH value of honey is of great importance due to the fact that during extraction and storage, acidity can influence the texture, stability, and shelf life of honey. Thus, the low pH of honey inhibits the presence and growth of micro-organisms and makes honey compatible with many food products in terms of pH and acidity (Karla *et al*., 2014).

The HMF values in the current study were found to be between 0.00 to 5.4 mg kg-, which is similar for all the fresh and stored, respectively. The HMF range of this study was lower than the international and national limits set by (Codex Alimentarius, 2001). In Ethiopia, the acceptable HMF level is below 40 mg/kg honey and the HMF value of this study was below 40 mg/kg. Ethiopian honey mean HMF test result is 32.4 mg/kg (Nuru, 1999), 38.55 mg/kg (Tessega, 2009), 6.32 mg/kg (Chala *et al*., 2012). According to Kubis and Ingr (1998), the use of metallic container as storage is one factor for the formation of HMF. The same was observed in this study, relatively higher HMF value was recorded in honey stored in tin-can than glass and plastic

containers. Generally, HMF content is widely recognized as a parameter of honey samples freshness, because it is absent in fresh honeys and tends to increase during processing and/or aging of the product. According to different researchers, several factors can influence the levels of HMF, such as temperature and time of heating, storage conditions, pH and floral source, thus it provides an indication of overheating and storage in poor conditions (Fallico *et al*., 2004).

5.4. Honey Value Chain Analysis

5.4.1. Input providers

Input supply for beekeeping in the study district includes: bee production equipment and colony, bee forage, credit service, training and market information. Sources of these inputs are mainly the farmer themselves, BoARD, REST, DCSI, World Vision, EOCDICAG, IFAD, Save the Children, GIZ, Helivethas, Wukro St.Marry´s college, Wukro Agricultural Technical and Vocational Training College and the regional research Institution. Even though, many organizations are participating in the beekeeping input supply the integration among them is very loss which most of the time criticized by responsible bodies. However, for efficient and systematic way of developing the sector in the district their coordination in all aspect of activity is mandatory.

Because of the intervention by the government and other nongovernmental organizations in the study district many mountainous and hill side areas were rehabilitated and covered by different indigenous and exotic plant species. Plants like Tebeb (*Becium grandiflorum*), girbiya (*Hypoestes forskaolii*), kileaw (*Euclea schimperi*), Seraw (*Acacia etbica*.), Siwakerni (*Leucas abyssinica*), Awhi (*Cordia africana*), Kelamitos (*Eucalptus globules*) were used as a source of bee forage for the production of good quality white honey. The results were coinciding with the observation noted from related works in the study district (USAID, 2008).

The beekeepers obtained financial support primarily from micro credit institution (DCSI). The financial source on credit bases to the beekeepers owned frame beehive is 83.3% and 12.8% from the government and NGOS, respectively. About 1.3% of the finance is provided in a form of support from NGOs, whereas 2.6% of the beekeepers purchase in puts from own source. The

beekeepers stated that still they look for governmental and NGOS which provide beekeeping inputs with credit facilities. The credit service for beekeepers in the study district is better than other studies in similar sector (Abiyu, 2011**).** The problem, however, was that the credit system was not sufficient and the credit and support from the NGOS do not include all the beekeepers in the district. Thus, the beekeepers were demanding appropriate credit system from DCIS with the timeliness, group collateral, and high interest rate (18%) and insufficiency of the amount of credit provided. Most of the beekeepers lacked awareness about the credit they take from BoARD and the NGOS and they face difficulty to repay and thereby access to additional credit.

Apiculture extension service was provided by different organizations in the study district. The main actor is the oARD of the district. The office has structured itself to assign one livestock (Apiculture expert) in each PA. It is revealed that 75% of the beekeepers had access to extension services pertained to beekeeping activities. However, among these beekeepers only 45% received training on bee management, queen rearing, colony splitting, honey harvesting and processing by BoARD, REST, World Vision, Wukro ATVET College and Wukro St. Marry´s College. However, since extension services are required for increasing honey production and scaling up of different beekeeping technologies, all organization in the study district directly or indirectly are targeting towards this end. Focus group participants during the study discussed that there had been slight improvements in the extension service in the past five years. The study by Abiyu (2011) in other part of Ethiopia reported that lack or limited extension service is not only affecting honey production but also has its own contribution traditional beekeepers to remain in traditional beekeeping method.

About 3.2% of the beekeepers had no market information and sell their products simply by negotiation. For most of the beekeeper (57.7%) the main sources of market information are traders and the beekeepers noted that lack of market information directly affect farmers from obtaining a better price for their honey and other products. So, all organizations have responsibility to increase awareness about the current price of honey using different information roots in the district. Similar to this limited market information was reported for the study district and Tigray region (Haile, 2012; Gidey and Mekonen, 2010).

5.4.2. Producers/beekeepers

In the study area, honey was mainly produced by small individual farmers. Majority (95.5%) of the beekeepers engaged in frame beehive honey production and only 4.5% of the beekeepers owned traditional beehive. The main purpose of keeping honeybees were for sale (82.7%) and 1.3% and 16% of the beekeeper used honey for home consumption and for both consumption and sale, respectively. Similar beekeeping purpose was investigated by different researchers in other parts of Ethiopia (Assefa, 2009; Nebiyu and Messele, 2013). According to the district of BoARD, the demand of the producers for modern beekeeping technology is increased from time to time and great efforts has been made by government to introduce package of technologies and NGOS to adopt movable frame beehive technology to the district to increase quantity and quality of honey. Variation in the bee management system, availability of bee forage and other factors resulted in the difference in honey production and productivity of the district. On average beekeepers harvest 7.66 kg and16 kg per beehive per year and 19.4 kg per beehive/harvest and 35 kg per beehive per year for the traditional and frame beehive, respectively. This result is lower than the study report by (Tolera and Dejene, 2014) in Jimma Zone, Ethiopia which was 9.5 kg and 23 kg per harvest for traditional and modern beehive, respectively.

5.4.3. Marketing, processing and consumption

Honey marketing in the study district was characterized by direct to individual consumers (96.8%), whole seller (89.7%), retailers (66.7%); and to middle men or brokers (57.7%). However, the role of processing companies and cooperatives was very minimal 19.2% and 13.5% of the beekeepers sell their honey to the processing companies and co-operatives, respectively. The study by USAID (2008) in the same district indicated that most of the beekeepers sell their honey directly to individual consumers of the surrounding areas. Moreover, the whole sellers in the district collect the honey from the beekeepers and resell or redistribute to other consumers, retailers in the region and to the capital Addis Ababa. The different traders in the study district stated that there are provisions of low quality honey, which might arise from harvesting, storage and adulteration, presence of unlicensed traders, and shortage of finance and unfair tax payments. Similar honey marketing problems had been reported in the same region (Assefa, 2009; Gidey and Mekonen, 2010).

In Tigray there are two registered large private honey processing companies namely Dimma beekeeping and honey processing company and Wellela Mear (Comel PLC.). Accordingly, the two companies have the capacity to process more than 500 kg honey per day. However, the supply from the beekeepers is still very small and the problem of postharvest handling of the honey, the quality of the honey remains poor, resulting in the rejection of the honey for further processing and value addition.

In the study district there are beekeeper associations, cooperatives and unions organizing farmers for improved production and better marketing. One of the associations is Selam Beekeepers Association which is supported by Slow Food International Organization. This association collects about 10,000 kg honey per year from the members and other beekeepers and sell the semi processed honey to different market roots (national and export). The other one is Awlaelo Honey Production Union and Eastern Tigray honey marketing and processing center which are established and already started processing, packing and selling to different market routes.

Consumption of honey starts at farm. Farmers consume limited quantity of honey in different forms and this shows that in addition to creating access to food through increased cash income, honey directly contributes to the food security at the household level and has great social and cultural values. Consumers and honey traders stated that they faced quality problems, where adulteration of honey with sugar and banana is common problem. Similarly, Assefa (2009) reported similar problems in the same region.

6. CONCLUSIONS AND RECOMMENDATIONS

This section concludes the piece of research work based on the findings obtained from the study. Finally, appropriate and possible recommendations are forwarded.

6.1. Conclusions

Beekeeping is practiced as an integral part of other agricultural activities mainly livestock and crop production with commercial type of production system. The majority (95.5%) of the beekeepers own frame beehives. This makes the district a center of excellence or a model district for modern bee keeping. The honey produced from the frame hive by far higher (19.4 kg/beehive/harvesting) than the transitional and traditional beehives. The honey collected from the frame beehive is also easy to refine which enables to give quality final product.

It is also concluded that there is an increasing trend of honey production and colony number both from the local and frame beehive. This is definitely the result of the ongoing effort of natural resource conservation which contribute for increasing availability of potential bee forages and the market demand for both honey and bee colony. There is attractive market price for honey and bee colony.

There has been an encouragement by governmental and nongovernmental organizations to plant and to cultivate different bee forages. Thus, the beekeepers grow indigenous bee forages around homesteads, in area closure and in and around their apiary sites. The existence of some special bee forage in the study district results in the production of high quality and quantity honey. A total of 37 commonly grown bee flora species were identified by the beekeepers. Among which Tebeb *(Becium grandiflorum),* Girbiya *(Hypoestes forskaolii),* siwakerni (*Leucas abyssinica*), kileaw (*Euclea schimperi*), Awhi (*Cordia Africana*), kelamitos (*Eucalptus spp.) and* beles *(Opuntia ficus-indica)* are the major bee forages.

During the dry season supplementation with besso (roasted barley flour), shiro (roasted spiced pulses flour), sugar syrup and honey solution is a common practice. There is also practice of

migration to escape effects of dry season and of agro-chemicals. These practices are contributing to the sustainable honey production in the study district.

The beekeepers loss significant amount of honey and honeybee colonies due to shortage of bee forage, pests and predators, bee equipment, absconding, honeybee colony, application of agro-chemicals, death of colony, shortage of water, lack of honey storage containers, swarming and market information as important beekeeping constraints. Plants like akacha (*Acacia saligna*), qnchb (*Euphorbia species*); limo or false neem (*Melia azedarach)* and neem (*Azadirachta indica)* are identified as the most important poisonous plants.

More than half of the district beekeepers store their honey more than six months using plastic pots, tin-can, glass pots and clay pots of different sizes. This is to get better honey price at off season.

Beekeepers store their honey in different sizes and type of materials available in the area with the most common being plastic pot (54.5%), followed by tin-can (30.1%), glass (9.6%) and clay pot (5.8%) from one to more than 6 months. Although, all the honey samples were found to be in good and acceptable quality range of national and international standards, storage of honey in all the materials up to a period of six months was marked to be safe for human consumption both for export as well as local consumption.

Input supply, production, processing, marketing and consumption is the honey value chain. The value chain is not lengthy and farmers are getting their fair gain as one of the most important actor. The different services are still insufficient and inefficient. Similarly, different governmental development policies are playing their roles in creating enabling environment.

6.2. Recommendations

Possible recommendations that could be given on the basis of the study so that can be considered in the future intervention strategies which are amid at the promotion of honey production and marketing of the study area are listed as follows:

- Since most of the beekeepers in the district used frame beehive, the district can be considered as a model for modern beekeeping technology for the country.
- The current effort of natural resource rehabilitation should strongly consider the plantation of indigenous potential bee forages such as tebeb , girbia and siwakerni based on the appropriate propagation technique
- Regular and up to date market information should be channeled to the beekeepers using both mass media and mobile messaging
- Strengthening of existing beekeepers associations and establishment of new once which can play significant role for production need immediate attention
- The extension system should actively aware the beekeepers towards honey handling, storage and food safety to compete with international market
- The opportunity of wax, propolis, pollen and other products production from the bee sector should improve and awareness creation on the use, processing system and market value of these products needs attention.
- The use of agro chemicals related with crop production and existence of poisonous plants is critically important. However, the significance of the problems and problem solving research is critical to further confirm the antagonistic nature of the plants and devise complementary production system of both the bee keeping and irrigated crops. Moreover, for agro chemical poisoning there should be informal local beekeepers plan and apply during the evening, when bees are not actively foraging.

7. REFERENCES

Abiyu Z. (2011). An Assessment of factors that affect Development of Beekeeping in rural areas: the case of Hurumu district, Ilubabor Zone, Oromia Regional state, Ethiopia. Thesis submitted to the school of graduate studies of Addis Ababa University, Ethiopia

Acquarone C, Buera P, Elizalde B. (2007). Pattern of pH and electrical conductivity upon honey dilution as a complementary tool for discriminating geographical origin of honeys. *Food Chemistry* **101**: 695-703.

Adeday G., Shiferaw M. and Abebe F. (2012). Prevalence of Bee Lice *Braula coeca* (Diptera: Braulidae) and Other Perceived Constraints to Honey Bee Production in Wukro Woreda, Tigray Region, Ethiopia. *Global Veterinaria,* **8** (6): 631-635, 2012 ISSN 1992-6197 © IDOSI Publications, 2012

ADBG (African Development Bank Group) (2011). Federal Democratic Republic of Ethiopia Country Strategy Paper 2011-2015, Addis Ababa, Ethiopia.

Adimasu A., Gizaw E., Amsalu B., and Debisa L. (2004). Effect of honeybee pollination on seed *Allium cepa*. Holeta Bee Research Center, Holeta

Adjare S.O. (1990). Beekeeping in Africa. Food and Agriculture Organization of the United Nations (FAO) Agricultural Service Bulletin 68/6. FAO, Rome, Italy.

Ameera H.H., Saadiyah A.D., Fadhil .M A. (2014). Physiochemical Properties for Some Kinds Honey in Iraqi Markets. Online *International Interdisciplinary Research Journal*, {Bi-Monthly}, ISSN2249-9598, Volume-**IV**, Issue-V, Sept-Oct 2014

Amssalu B., Nuru A., Radloff S.E. and Hepburn H.R. (2001). Multivariate Morphometric Analysis of Ethiopian Honeybees. Proc. 37th Int. Apic. Congr., 28 Oct – 1 Nov 2001, Durban, South Africa.

Amssalu B. (2002). Multivariate morphometric analysis and behaviour of Honeybees (Apis mellifera L.) in the Southern Regions of Ethiopia. Ph.D dissertation. Rhodes University, Department of Zoology and Entomology, South Africa. 332p.

Amssalu B. (2004). Multivariate morphometric analysis and behaviour of Honeybees (Apis mellifera L.) in the Ethiopia Regions. Apidologie Volume **35**, Number 1, INRA, EDP Sciences, DIB, GIB 2004.

Arsham H. (2005). Questionnaire design and survey sampling. 9th edition,

http://home.ubalt.edu/ntsbarsh/stat-data/surveys.htm (Retrieved September, 2011).

Assefa A. (2009). Market chain analysis of honey production: in Atsbi Wemberta district, eastern zone of Tigray national Regional state. A Thesis Submitted to College of Agriculture Department of Agricultural Economics, School of Graduate Studies Haramaya University.

Awraris G., Yemisrach G., Dejen A., Nuru A., Gebeyehu G. and Workneh A. (2012). Honey production systems (*Apis mellifera* L.) in Kaffa, Sheka and Bench-Maji zones of Ethiopia. *Journal of Agricultural Extension and Rural Development* Vol. **4**(19). Available online at http:// academicjournals.org/JAERD

Ayalew K. (1990). The Honeybee (Apis mellifera) of Ethiopia: A Morphometric Study. M.Sc. Thesis, Agricultural University of Norway, Norway.

Ayalew K. and Gezahegn T. (1991). Suitability Classification in Agricultural Development, Ministry of Agriculture, Addis Ababa, Ethiopia.

Ayalew K. (2001). Promotion of beekeeping in rural sector of Ethiopia: Proceedings of the third National Annual Conference of Ethiopian Beekeepers Association (EBA), September 3-4, 2001, Addis Ababa, Ethiopia, pp.52-58.

Ayalew K. (2008). Establishment of apiculture data base in Ethiopia. SNV honey and beeswax value chain of BOAM programme. June 2008, Addis Ababa, Ethiopia

Bammann H. (2007). Participatory Value Chain Analysis for Improved Farmer Incomes, Employment Opportunities and Food Security, Pacific Economic Bulletin Vol. **22** Number 3 October, Accessed at: http://peb.anu.edu.au/pdf/PEB22-3-bammann.pdf.

Berhanu G., Pender J. and Girmay T. (2002). Collective action for grazing land management in mixed crop–livestock systems in the highlands of northern Ethiopia. Socio-economic and Policy Research Working Paper 42. ILRI (International Livestock Research Institute), Nairobi, Kenya. 2p.

Beyene T. and David P. (2007). Ensuring small scale producers in Ethiopia to achieve sustainable and fair access to honey markets. Paper prepared for international development enterprises (IDE) and Ethiopian society for appropriate technology (ESAT), Addis Ababa, Ethiopia.

Bista S. and Shivakoti P. G. (2001). Honeybee flora at Kabre Dolakha District, Nepal. *Journal of Napal Agric. Res.* (**4 & 5**): 16-25.

BoANR (Bureau of Agriculture and Natural Resources) (2004). Water Harvesting Progress Report; Annual report: BoANR, Mekelle, Tigray.

BoARD (Bureau of Agriculture and Rural Development) (2010). Annual report of Tigray region, Mekelle Ethiopia.

Bogdanov S., Martin P., Lüllmann C. (1999). Honey quality and international regulatory standards: review by the International Honey Commission, Bee World 80, 61–69.

Bogdanov S. (2002). Harmonized Methods of the International Honey Commission. Swiss Bee Research Centre FAM, Liebefeld, CH-3003 Bern, Switzerland.

Bogdanov S, Jurendic T, Sieber R (2008): Honey for nutrition and health: a review. *Am J Coll Nutr,* **27**:677–689.

Chala K., Taye T., Kebede D. and Tadele T. (2012). Opportunities and challenges of honey production in Gomma district of Jimma zone, South-west Ethiopia. *Journal of Agricultural Extension and Rural Development* Vol. **4**(4), pp. 85-91, 5 March, 2012. Available online http://academicjournals.org/JAERD Codex Alimentarius Commission (2001). Revised Codex Standard for Honey.

Codex Standard 12-1981, Rev. (1987), Rev.2 (2001). Joint FAO/WHO Food Standards Programme. 24th Session, FAO Headquarters, Rome, Italy. http://www.fao.org/docrep/w0076e/w0076e30.htm.

Crane E. (1980). A book of honey. International Bee Research Association, Oxford University Press, Great Britain.

Crane, E. (1990). Bees and Beekeeping: Science, Practice and World Resources. Comstock Publishing Associates (Cornell University Press), Ithaca, New York.

CSA (2002). Ethiopia Statistical Abstract 2002. Central Statistics Authority. Addis Ababa, Ethiopia.

CSA (2009). Ethiopia, Statistical Abstract 2002. Central Statistics Authority. Addis Ababa, Ethiopia.

CSA (2011). Key Findings of the 2008/2009-2010/11 agricultural sample surveys for all sectors and seasons country summery. Central Statistics Authority. Addis Ababa, Ethiopia.

CSA (2012). Agricultural sample survey 2011/2012 on livestock and livestock characteristics. Central Statistics Authority. Addis Ababa, Ethiopia.

Deborah A. D. and David R. T.(2008). The role of honeybees in apple pollination. North Carolina State University. Beekeeping Note 3.03

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

Edessa N. (2002). Survey on honey production system in West Shoa Zone. Holeta Bee Research Center (HBRC), Ethiopia.

EHBPEA (Ethiopian Honey and Beeswax Producers and Exporters Association). (2010). The third residue Monitoring plan for honey from Ethiopia. Addis Ababa, Ethiopia.

EMA (Ethiopian Mapping Authority) (1988). National Atlas of Ethiopia. Addis Ababa.

EU Council Directive 2001/110/CE relating to honey (2001). Official Journal of the European Communities **10**: 47-52.

FAO (1990). Beekeeping in Africa, Rome, Italy.

FAO (2009). Bees and their role in forest livelihoods. A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Rome, Italy.

FDRE (Federal Democratic Republic of Ethiopia). (2008). Population Census Commission 2008. Summary and statistical report of the 2007 population and housing census: Population size by age and sex. FDRE, Addis Ababa, Ethiopia.

Fichtl, R. and Admasu A. (1994). Honeybee Flora of Ethiopia. Margraf Verlag, Weikersheim, Germany.

GDS (Global Development Solutions) (2009). Global Development Solutions paper. pp 19-29.

Gebreagziabher A., Mohammed T., S.K. Gangwar ,Girmay G., Girmay T. (2014). Performance of *apis mellifera* spp. on honey and beeswax production in different type of beehives in enda mekoni woreda, Tigray region, Ethiopia. *G.J.B.B., VOL*.**3** (3) 2014: 324-329.

Gebremedhin W., Berhanu G., Dirk H.,Azage T., Kahsay B. and Dawit W. (2012). Market-oriented beekeeping development to improve smallholder income: Results of development experiences in Atsbi-Womberta district, northern Ethiopia. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project-International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Gezahegne T. (2001). Beekeeping (In Amaharic), Mega Printer Enterprise, Addis Ababa, Ethiopia.

Gichora. M. (2003). Towards Realization of kenya's Full Beekeeping potential: A Case Study of Baringo district. Ecology and Development series No.6, 2003. Cuvillier Verlag Gottingen, Gottingen, Germany. 157p.

Gidey Y. and Kibrom F. (2010). Beekeeping for Rural Development: Its Potentiality and Constraints in Eastern Tigray, Northern Ethiopia. *Agricultural Journal* Volume: **5** Issue: 3 Pp 201-204.

Gidey Y. and Mekonen T. (2010). Participatory Technology and Constraints Assessment to Improve the Livelihood of Beekeepers in Tigray Region, northern Ethiopia. *Momona Ethiopia journal of Science*, Vol.**2** No.1.

Girma D. (1998). Non-Wood Forest Production in Ethiopia. Addis Ababa,Ethiopia http://www.fao.org/DOCREP/003/X6690E/X6690E00.htm.

Gizachew S. (2011).Women Economic Leadership through Honey Value chain Development in Ethiopia. Paper presented on Workshop on Gender & Market Oriented Agriculture 1st February 2011, Addis Ababa, Ethiopia

Guy I. (2010).Human Capital VS. Social Capital-Influences on Egg productivity in Southern Ethiopia. University of San Francisco. San Francisco, CA 94117

Haftom G., Tesfay Z., Murutse G and Estifanos A. (2013). Seasonal honeybee forage availability, swarming, absconding and honey harvesting in Debrekidan and Begasheka Watersheds of Tigray, Northern Ethiopia. *Livestock Research for Rural Development. Volume **25**, Article #61*. Retrieved March 8, 2005, from http://www.lrrd.org/lrrd25/4/haft25061.htm

Haile T. (2012). Can Provision of Household Agricultural Extension Packages Reduce Rural Food Insecurity and Poverty in Tigray? Relief Society of Tigray, Research and Policy Unit. DCG Report No.70.

Hailu, A., Yohannes, G., Abera, G & Ann Waters-Bayer. (2007). Participatory research that builds on local innovation in beekeeping to escape poverty, Rural Development News 1/2007.

Hartmann I. (2004). "No Tree, No Bee – No Honey, No Money": The Management of Resources and Marginalization in Beekeeping Societies of South West Ethiopia. Paper submitted to the Conference: Bridging Scales and Epistemologies, Alexandria, March 17 – 20, 2004.

HBRC (Holeta Bee Research Center) (1997). Beekeeping Training Manual (unpublished), HBRC, Holeta, Ethiopia.

HBRC (Holeta Bee Research Center) (2004). Beekeeping training manual. Holeta, Ethiopia.

Issa S. (2010). How to Conduct a Food Commodity Value Chain Analysis? Technical guidance sheet (TGS).World food program, September 2010.

Iuliana M., Lavinia B., Alvija S. (2007). Researches about the quality honey dependent on same factors and processing method. THE ANNALS OF ''VALAHIA'' UNIVERSITY OF TÂRGOVIŞTE. Fascicle VIII.

Jacobs F., Simoens C., Graaf D. and Deckers J. (2006). Scope for non-wood forest products income generation from rehabilitation areas: focus on beekeeping. *Journal of the Dry lands* **1(2)**: 171-185.

Jonathan W. (1994). The role of HMF and diastase assays in honey Quality evaluation. *Bee World* **75**(3): 104-117.

Jun N. (2009). Development of Beekeeping in Developing Countries and Practical Procedures – Case Study in Africa – JAICAF (Japan Association for International Collaboration of Agriculture and Forestry). P1.

Kaplinsky R. and Morris M. (2001). A Handbook of Value Chain analysis. Working paper prepared for the IDRC, Institute for Development Studies, Brighton,UK.

Karla R. A. Adriane A. M. and Celso J.e M. (2014). Analysis of moisture content, acidity and contamination by yeast and molds in *Apis mellifera* L. honey from central Brazil. *Braz J. Microbiol.* 2013; **44**(3): 679–683.

Kato M. and Kawakita A. (2004). Plant-pollinator interactions in New Caledonia influenced by introduced honeybees. *American J. of Botany*. **91**: 1814-1827.

Kebede N. P.A. Subramanian and Gebrekidan M. (2012). Physicochemical analysis of Tigray honey: an attempt to determine major quality markers of honey. Bull. Chem. Soc. Ethiop. 2012, **26**(1), 127-133. ISSN 1011-3924

Keralem E. (2005). Honey bee production system, opportunities and challenges in *Enebse Sar Midir Woreda* (*Amhara* Region) and *Amaro* Special *Wereda* (Southern Nations, Nationalities and peoples Region), Ethiopia. M.Sc. thesis presented to Alemaya University 133p.

Kubis I. and Ingr I. (1998). Effects inducing changes in hydroxymethylfurfural content in honey. *Czech Journal of Animal Science, **42**, 379–383*.

Marina D. M. Messele A. L. Nikolaus K. Stefan F. (2011). The honeybees of Ethiopia represent a new subspecies of Apis mellifera—Apis mellifera simensis n. ssp. INRA, DIB-AGIB and Springer Science+Business Media B.V., 2011, DOI: 10.1007/s13592-011-0007-y

Meaza G. (2010). Socio-economic analysis of market oriented beekeeping in Atsbi Wemberta District of Eastern Zone, Tigray Region. MSc. Thesis. Mekelle University Department of Management College of Business and Economics, Ethiopia.

Mehari G. (2007). Impact of Beekeeping on Household Income and Food Security: The Case of Atsbi Wemberta and Kilte Awlailo Woredas of Eastern Tigray, Ethiopia M.Sc. Thesis, Mekelle University.

Mengistu A. (2010). Improving market access and income of small-scale beekeepers through value chain analysis: a case study from Gera District in South West of Ethiopia. Msc thesis presented at Copenhagen University, Faculty of Life Sciences.

MoARD (Ministry of Agriculture and Rural Development). (2006). Annual Reports Series 2005, 2006. MoARD, Addis Ababa, Ethiopia.

MoARD (Ministry of Agriculture and Rural Development). (2008). Government of Ethiopia, December 2008.

MoARD (Ministry of Agriculture and Rural Development). (2010). The third residue monitoring plan for honey from Ethiopia. Produced by members of the Ethiopian Honey and Beeswax Producers and Exporters Association (EHBPEA). Addis Ababa Ethiopia

Moguel O.C., Echazarreta G. and Rosalva M. E. (2005). Physicochemical quality of honey from honeybees *Apis mellifera* produced in the State of Yucatan during stages of the production process and blossoms. Téc Pecu Méx 2005; **43**(3):323-334. Available at: http://www.tecnicapecuaria.org.mx/trabajos/200510 202266.pdf.

Momose K., Yumoto T., Nagamitsu T., Kato M., Nagamasu H., Sakai S., Harrison R., Itioka T., Hamid A. and Inoue T. (1998). Pollination biology in a lowland dipterocarp forest in Sarawak, Malaysia. I. Characteristics of the plant-pollinator community in a lowland dipterocarp forest. *American Journal of Botany* **85**: 1477- 1501.

Moussa A., Noureddine D., Saad A., Abdelmelek M. (2012) Anti-*Aspergillus niger* of eucalyptus honey influenced by thermal treatment. 1: 175. Doi: 10.4172/ scientificreports.175.

Nebiyu Y. and Messele T. (2013). Honeybee production in the three Agro-ecological districts of Gamo Gofa zone of southern Ethiopia with emphasis on constraints and opportunities. Agriculture and biology journal of North America ISSN Print: 2151-7517, ISSN Online: 2151-7525, doi:10.5251/abjna.2013.4.5.560.567.

Nick C. and Tassew W. (2012). "Managing watersheds for resilient livelihoods in Ethiopia", in OECD,Development Co-operation Report 2012: Lessons in Linking Sustainability and Development, OECD Publishing. http://dx.doi.org/10.1787/dcr-2012-15-en.

Nicola B. (2002). Taking the sting out of beekeeping. Arid Lands Information Network-East Africa (CD-Rom). Nairobi, Kenya.

Nicola B. (2004). Beekeeping and Sustinable Livelihoods, Food and Agriculture Organization of the United Nations, Rome.

Nicola B. (2009). Bees and their role in forest livelihoods. A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Food and agriculture organization of the united nations, Rome.

Nombré I, Schweitzer P, Sawadogo M, Boussim JI, Millogo R. J (2010). Impacts of storage conditions on physicochemical characteristics of honey samples from Burkina Faso. *Afr. J. Food Sci*. 4(7), pp. 458 - 463, July 2010. Available online http://www.academicjournals.org/ajfs.

Nuru A. (1999). Quality state and grading of Ethiopian honey. Proceedings of the first National Conference of Ethiopian Beekeepers Association (EBA), June 7-8, 1999, Addis Ababa, Ethiopia pp. 74-82.

Nuru A. (2002). Geographical races of the Honeybees (Apis mellifera L.) of the Northern Regions of Ethiopia. PhD dissertation. Rhodes University, South Africa.

Nuru A. (2007). Atlas of pollen grains of major honeybee flora of Ethiopia. Holetta bee research center. Holetta, Ethiopia.

Ouchemoukh S., Louaileche H. and Schweitzer P. (2007). *Food Chem.* 1**8**, 52.

Patricia L. C., Rosie S. and Lai T.(2010). The Value-adding Potential of Prebiotic Components of Australian Honey. Rural Industries Research and Development Corporation. *Publication No. 09/179*

Paulos D. (2011). Ethiopian Honey: Accessing International Markets with Inclusive Business and Sector Development. Post Implementation Review Report, November 2011.

QSAE (Quality and Standards Authority of Ethiopia) (2005). Ethiopian Standard Honey – Specification. ES 1202:2005. Addis Ababa, Ethiopia.

Radloff S.E., Hepburn H.R. (1997). Biogeographical correlates of population variance in the honeybees (Apis mellifera L.) of Africa. Apidologie **28**, 243–258.

Rainer K. (1996). Value-Added Products from Beekeeping (Fao Agricultural Services Bulletin). Food & Agriculture Organization of the UN (FA. ISBN 92-5-103819-8).

Rich K. M., Ross R. B., Baker A. D., Negassa A. (2011). Quantifying value chain analysis in the context of livestock systems in developing countries. *Food Policy* **36**. 214-22.

Ruttner F. (1975). African races of honeybees. Pp325-344. Proceedings of XXVth International Beekeeping Congress, Grenoble, France.

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

SAS (Statistical Analysis System). (2002). SAS Institute Inc., Version 9.00, Cary, NC, USA.

Saxena S., Gautam S. and Sharma A. (2010). *Food Chem.* 2010, **118**, 391.

Segeren P. (1995). Beekeeping in the Tropics, 5thed. Agrodok-series No 32, CTA/AGROMISA,Wageningen, The Netherlands.

Smith F.G. (1961). Races of honeybees in East Africa. *Bee World* **42**: 255-260.

Sreejith A., Worku J. N., Mir H. K., Waliu G. (2011). Research report On Exploring the Potential of Non-timber Forest Products: The Case of Ethiopian Honey Export to Denmark. Submitted to the University Of Copenhagen Online at http://mpra.ub.uni-muenchen.de/35483/

SNV/Ethiopia (2005). Strategic intervention plan on honey & beeswax value-chains, snv support to business organizations and their access to markets (boam), p: 5.

SNV (2009). Integrated Value Chain Analyses for Honey and Beeswax Production in Ethiopia and Prospects for Exports. The Netherlands Development Organization (SNV). Global Development Solutions, LLC.

Solomon B. (2009). Indigenous knowledge and its relevance for sustainable beekeeping development: a case study in the Highlands of Southeast Ethiopia. *Livestock Research for Rural Development. Vol. **21**, Article #184.* http://www.lrrd.org/lrrd21/11/boga21184.htm

Svensson B. (1991). Bees and trees. Swedish university of agricultural sciences. International rural Development Center, Uppsala, Sweden.

Taddele A. and Nejdan Y. (2008). Field research report on Beekeeping and Honey Production in the Tigray Region, Ethiopia. African Services Committee Ethiopia

Tariku O. and Mechthild R. (2013). Circumstances, Constraints and Prospects of Honey-Bee (Apis mellifera) Conservation: The Case of Dale District, Sidama zone,Southern Ethiopia. Available: http://www.tropentag.de/2013/abstracts/links/Jawo_aSyvYLYm.pdf

Tchoumboue J., Awah – Ndukum J., Fonteh F.A., Dongock N.D., Pinta J. & Mvondo Z.A. (2007). Physico – chemical and microbiological characteristics of honey from the Sudano – Guinean Zone of West Cameroon, *African Journal of Biotechnology*, **6**(7): 908 – 913.

Tesfa A. (2012). Beekeeping systems, opportunities and challenges in honey production and marketing in Ada'a district of Oromia region, Ethiopia. A Thesis Submitted to the Department of Animal production studies to Addis Ababa University College of Veterinary Medicine and Agriculture, Ethiopia.

Tesfaye K. and Tesfaye L. (2007). Study of honey production systems in Adami Tulu Jido Kombolcha district in mid rift valley of Ethiopia. *Livestock Research for Rural Development*. Vol. **19**, Article # 11. From http://www.lrrd.org/lrrd19/11/kebe19162.htm.

Tessega B. (2009). Honeybee Production and Marketing Systems, Constraints and opportunities in Burie District of Amhara Region, Ethiopia. A Thesis Submitted to the Department of Animal Science and Technology, School of Graduate Studies Bahir dar University.

Thomas D., Pal, N. and Subba R.K. (2002). Bee management and productivity of Indian honeybees. Apiacta 3.

Tony R. (2010). Trip Report and Recommendations Regreening Tigray. World Vision Australia, 15 - 22 July 2010.

Tolera K. and Dejene T. (2014). Assessment of the effect of seasonal honeybee management on honey production of Ethiopian honeybee (*Apis mellifera*) in modern beekeeping in Jimma Zone. Research Journal of *Agriculture and Environmental Management*. Vol. **3**(5), pp. 246-254, May, 2014.

USAID/Ethiopia (2008). Sector assessment and identification, Kilte Awlaelo incorporating sector assessment/ identification into a graduation pilot for safety net beneficiaries in Kilte Awlaelo, pp: 9-14.

Workneh A. (2007). Determinants of adoption of improved box hive in Atsbi Wemberta District of Eastern Zone, Tigray Region. M.Sc. Thesis, Haramaya University, Ethiopia.

Workneh A.**,** Ranjan S. K. and Ranjitha P. (2011). Determinants of Box Hive Promotion and Financial Benefits in Selected District Of Ethiopia. International Journal of *Agricultural Science, Research and Technology.*

8. APPENDIX

Appendix 8. 1. Traditional hive placement

Appendix 8.2. Frame hive Placement

Appendix 8. 3. Some of the come honeybee forages in the study area

Appendix 8.4. Honey packing materials and marketing in the study area

Appendix 8. 5. Some of the poisons plants as mentioned by the beekeepers.

Appendix 8.6 Relationship of water content of honey to refractive index

Refractive index(20 $^{0}_{C}$)	Moisture content(Percent)	Refractive index(20$^{o}_{c}$	Moisture content (Percent)	Refractive index(20 $^{0}_{C}$)	Moisture content (Percent)
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		

Source: Quality and Standard Authority of Ethiopia
Temperatures above20 o C: add 0.00023 per o C.
Temperatures below 20 o C: subtract 0.00023 per o C.

Appendix 8.7 Honey grading according to Ethiopian condition

S.No	Characteristics	Requirements
1	Moisture content % by mass max	21
2	Apparent reducing sugar (as invert sugar), % by mass min.	65
3	Apparent sucrose content % by mass, max.	5
4	Water insoluble content % by mass max.	0.1
5	Mineral content (ash), % by mass max	0.6
6	Acidity mill equivalents acid per kg	40
7	Diastase activity, 1% starch solution hydrolyzed by the enzyme in 1 gram of honey in hour at 40^{o}c, min.	3
8	Hydroxymethyl furfural content mg/kg	40

Source: Quality and Standard Authority of Ethiopia

Appendix 8.8 Laboratorial procedure of honey quality analysis

Moisture Content

The moisture content of honey was determined using the refractive index of the honey by reference to a standard table (Appendix 8.7). Digital refractometers that can be thermo stated at 20^{o}_{C} regularly calibrated with distilled water were used. For this purpose, cleaned and dried prism of the refractometer was used. The surface of the prism was covered with homogenized honey samples. The refractive index after 2 minutes was read and the corresponding moisture content was read from the table. Water content of samples was measured twice and the average value was recorded. Finally the prism was cleaned after use. The table is derived from a formula developed by Wedmore, (1955) from the data of Chataway, (1932) as cited by Bogdanov, 2002.

$$W = \frac{1.73190 - \log (R.I - 1)}{0.002243}$$

Where
W is the water content in g per 100 g honey and R.I. is the refractive index

Mineral (ash) content

Ash content was determined after the sample was burnt in an electric muffle furnace. First the ash dish was cleaned and heated in the electrical furnace at ashing temperature, subsequently cooled in a desiccator to room temperature and weighed to 0.001g (M_2). Then, 5 gram of honey sample was weighed to the nearest 0. 001g (M_0) and put in the prepared ash dish and 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 $^0{}_C$ by using electrical device. Hot plate was used to burn the sample before inserting into the furnace. After the preliminary ashing with hot plate, the dish was placed in the preheated muffle furnace at $600^0{}_C$) and heated for 1 hour. The ash dish was cooled in the desiccator and weighted. The ashing procedure was continued until constant weight is reached (M_1). Percent ash in g/100g honey is calculated using the following formula:

Calculation and expression of result

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

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

pH and Free acidity

Ten gram of the honey samples were dissolved in 75 ml 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). For precision the reading to the nearest 0.2ml 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 decimals.

$$\text{Acidity} = \frac{VxNx1000}{X_1} 10V$$

Where,N= Normality of NaOH= 0.10125704N NaOH

V = the volume of 0.1N NaOH in 10 g honey, X= mass of the sample taken

Hydroxymethylfurfural (HMF)

The determination of the hydroxymethylfurfural (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 wave length, the difference between the absorbance of a clear aqueous honey solution and the same solution after addition of bisulphite was determined. The HMF content is calculated after subtraction of the background absorbance at 336 nm. Spectrophotometer operating in a wave length range from 284 and 336 nm was 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 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 NaHS03 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% $NaHS0_3$ 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 sodiumbisulphite solution in order to obtain a sample absorbance low enough for accuracy. When dilution is necessary,

The dilution, $D = \frac{\text{final volume of sample solution}}{10}$

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

Appendix 8.9. ANOVA Table for honey quality (Moisture, pH, Ash, Acidity and HMF)

The SAS System

The GLM Procedure

Dependent Variable: mois

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	3.12740741	0.39092593	14.07	<.0001
Error	18	0.50000000	0.02777778		
Corrected Total	26	3.62740741			

R-Square	Coeff Var	Root MSE	mois Mean
0.862161	0.966287	0.166667	17.24815

Source	DF	Type I SS	Mean Square	F Value	Pr > F
tme	2	1.90518519	0.95259259	34.29	<.0001
con	2	0.78296296	0.39148148	14.09	0.0002
tme*con	4	0.43925926	0.10981481	3.95	0.0179

Dependent Variable: acid

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	89.42742963	11.17842870	33.55	<.0001
Error	18	5.99773333	0.33320741		
Corrected Total	26	95.42516296			

R-Square	Coeff Var	Root MSE	acid Mean
0.937147	3.282958	0.577241	17.58296

Source	DF	Type I SS	Mean Square	F Value	Pr > F
tme	2	84.76320741	42.38160370	127.19	<.0001
con	2	2.18098519	1.09049259	3.27	0.0613
tme*con	4	2.48323704	0.62080926	1.86	0.1608

Dependent Variable: Ash

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.03240000	0.00405000	3.67	0.0105
Error	18	0.01986667	0.00110370		
Corrected Total	26	0.05226667			

R-Square	Coeff Var	Root MSE	Ash Mean
0.619898	24.50806	0.033222	0.135556

Source	DF	Type I SS	Mean Square	F Value	Pr > F
tme	2	0.02195556	0.01097778	9.95	0.0012
con	2	0.00428889	0.00214444	1.94	0.1722
tme*con	4	0.00615556	0.00153889	1.39	0.2757

Dependent Variable: pH

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.24853333	0.03106667	56.30	<.0001
Error	18	0.00993333	0.00055185		
Corrected Total	26	0.25846667			

R-Square	Coeff Var	Root MSE	pH Mean
0.961568	0.608764	0.023492	3.858889

Source	DF	Type I SS	Mean Square	F Value	Pr > F
tme	2	0.23386667	0.11693333	211.89	<.0001
con	2	0.00695556	0.00347778	6.30	0.0084
tme*con	4	0.00771111	0.00192778	3.49	0.0280

Dependent Variable: HMF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	94.43333333	11.80416667	45.66	<.0001
Error	18	4.65333333	0.25851852		
Corrected Total	26	99.08666667			

R-Square	Coeff Var	Root MSE	HMF Mean
0.953038	29.71444	0.508447	1.711111

Source	DF	Type I SS	Mean Square	F Value	Pr > F
tme	2	92.91555556	46.45777778	179.71	<.0001
con	2	0.93555556	0.46777778	1.81	0.1923
tme*con	4	0.58222222	0.14555556	0.56	0.6925

Appendix 8:10. Questionnaire used in the study

Addis Ababa University, College of Veterinary Medicine and Agriculture

Department of Animal Production Studies

PhD Program in Animal Production

Characterization of beekeeping systems and honey value chain questionnaire

General information

1.1 Zone_____1.2 Wereda_____ 1.3 Tabia_____

I. House hold characteristics

1. Name of house hold head----------2.Sex------3.Number of years in beekeeping practice-

4. Age of the household head---

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

6. Family size--------

7. Education level of household head:

(1) Illiterate (**2**) Can read and write (**3**) Primary education (1-4) (**4**) Junior (5-8) (**5**) Secondary education (9-10) (6) religious school (7) university

II. Crop Production

1. Landholding (ha)

1.1 Total land holding _____1.2 Farmland ___1.3 Forest land____1.4 Grazing land_____ 1.5 Others _____

2**. Major crops grown**

No.	Crop type	Area(ha)	Yield(qt)	Purpose*
1	**Annual**			
1.1				
1.2				
2	**Perennial/tree/fruits**			
2.1				
2.2				

*1. Household consumption 2. Seed 3. Sale 4. Others (specify)_____

3. What are the major crop production problems you encountered?

No	Production problems	Rank
1	Shortage of seed	
2	Shortage of fertilizer	
3	Shortage of farmland	
4	Shortage of oxen	
5	Drought	
6	Soil fertility	
7	Weeds	
8	Disease	
9	Insects	
10	Rodents	
11	Others(specify)	

III. Livestock Production

1. **Which livestock species do you have? How many? and what is the purpose of keeping?**

	Cattle					Small ruminants		Equines			Chicken	Honey bee colony
	Ox	Cow	Bull	Heifer	Calves	sheep	Goat	Donkey	Mull	Horse		
No.												
Purpose*												

*cattle: 1. Draught____2. Milk____3. Beef____4. Breeding_____5. Sale 6. Others___

* Goats: 1. Meat _____2. Milk____3.Breeding_____4. Sale 5. Others_____

*Sheep: 1. Mutton ____2. Milk____3. Breeding____ 4. Sale 5. Others_____

*Equines: 1. Transportation____2. Draught_____3. Sale 4. Others_____

*Chickens: 1.Meat_____2. Eggs____3. Sale 4. Others_____

* bee colony:1. honey production 2. to sale colony 3. pollination 4. others_____

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

No	Production Constraints	yes	No	Season
1	Shortage of feed			
2	Shortage of grazing land			
3	Shortage of drinking water			
4	Shelter and housing			
5	Disease			
6	Low productivity			
7	Insects /Parasites			
8	Market unavailability/price			
9	Others(specify)			

3. Which feeding technique you use for the livestock?

No	Livestock species	Feeding technique	yes	No
1	Cattle	Tethering		
		Free grazing		
2	Small ruminant	Tethering		
		Free grazing and browsing		
3	Equine	Tethering		
		Free grazing		
4	Chickens	Free-range		
		Semi intensive		
		Intensive		

IV. Beekeeping/honey production/ Activities and Potentials

Beekeeping

1. Do you own honey bee colonies? (1) Yes (2) No If yes,

2. How many honeybee colonies you owned? Traditional------, Movable frame hive ---------

3. When did you start beekeeping?_____year (s).

4. How did you start beekeeping? (1) by training (2) learning from family (3) other specify

5. What is the source of bee colonies when you start?

1. By catching the swarm 2. By purchasing the honeybee colony 3. Gift from parents 4. other

6. If the answer for question 5 is purchased, where is the market?

(1) In our locality (2) Woreda market (3) at the neighbor woreda (4) other specify

7. If yes, what is the price of one colony? _____ ETB

8. How many times in a year do you harvest? 1. Once 2. Twice 3. Three times

9. How much honey do you harvest from a single hives per harvest?

No	Types of hive	unit	Maximum/hive	Minimum /hive	Average	Total/year
1	Traditional	Kg				
3	Modern	Kg				

9. Where did you keep your bee colonies?

No	Site or placement of hive	Traditional	Movable-frame
1	Backyard		
2	Under the eaves of the house		
3	Inside the house/with the family		
4	Hanging on trees near homestead		
5	In area enclosure		
6	Others (specify)		

10. In which types of hive your colony remains or stays for a long time? (1)Traditional (2) frame/modern

11. Do you have empty beehives? (1) Yes (2) No

12. If yes, list the number of empty hives you have.

No	Types of beehives	Numbers	Suggested reason
1	Traditional		
2	Movable-frame		

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

No.	Bee hives type	Where did you get your hive? 1. Constructed by me self 2. Bought from local market 3. Bought from other farmer 4. Supplied by the gov. on credit basis 5.Supplied by NGOs on credit basis 6.Supplied by NGOs free of cost 7. Supplied by NGOs on in-kind return	If you bought/got the hives on credit basis what is the price of one hive
1	Traditional		
2	Movable-frame/modern		

13. What is the trend of your colony number?

Traditional (1) Increasing (2) Stable (3) Decreasing

Movable-frame (1) Increasing (3) Stable (4) Decreasing

14. Did your honey production increase or decrease every year?

Traditional (1) Increasing (2) Stable (3) Decreasing

Movable-frame (1) Increasing (3) Stable (4) Decreasing

15. If there is an increase in trend in number of bee colonies over the years, what is the cause?

(1) Availability of bee forage (3) Improved hive

(2) Management (4) Others (specify) _____

16. If there is an increase in trend in honey yield over the years, what is the cause?

(1) Good market price
(2) Use new technologies
(3) added more bee colonies
(4) Others (specify

17. If there is a decrease in trend in the number of bee colonies and honey yields over the year, what is the cause in order of importance?

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

V. Vegetation, honey plants and water availability

1. What are the major honeybee floras in your area? List in terms of priority?

No	Local/Common name of the plant	Type (Tree, shrub, herb, cultivated crop)	Flowering time (months)	Source (nectar, pollen, propolis)
1				
2				
3				
4				
5				

2. Are there any poisonous plants to bees in your area? (1) Yes (2) No

3. If yes, mentioned these poisonous plants and their flowering time.

No	Local/Common name of the plant	Type (Tree, shrub, herb, cultivated crop)	Flowering time (months)	What is the effect on bees
1				(1) kill
2				(2) paralyze
3				(3) other
4				
5				

4. Did you plant bee forage species purposely for your bees? (1) Yes (2) No

If yes list them (1)_____(2) _____(3) _____

5. Does water available for your honeybees at all the time? (1) Yes (2) No

6. If yes, what is the source?

(1) Rivers (2) Lakes (3) Ponds (4) Water harvesting structure (5) Others: specify_____

7. If your response is no, how do you provide water to your bee colonies? _____

8. Did you feed your honeybee colonies? (1) Yes (2) No

9. If yes, when do you feed your honeybees? (Months): _____

10. What kind of feed you offer to your honeybees?

- Besso_____ kg/colony/season

-Shiro_____ kg/colony/season

- Sugar syrup_____kg/colony/season

- Honey + Water_____ kg/colony/season

- Others (specify)_____ kg/colony/season

11. Do you practice migratory beekeeping? (1) Yes (2) No, If yes, how far do you take them

12. If yes, what are your reasons for bee colony migration?

- Crop pollination 1. Yes 2. No
- Honey production 1. Yes 2. No
- Fetch of forage and water 1. Yes 2. No
- Disease control 1. Yes 2. No
- Agrochemicals prevention 1. Yes 2. No

VI. Beekeeping equipments

1. Which of the following beekeeping equipments you own?

No	Materials	Home made	Locally made and purchased	Provide on credit (purchased)	Donated by GO or NGO's	Price (ETB)		Service period (years)
						Rent	purchase	
1	Smoker							
2	Veil							
3	Gloves							
4	Overall							
5	Boots							
6	Water sparwer							
7	Bee brush							
8	Queen catcher							
9	Queen excluder							
10	Chisel							
11	Knife							
12	Embeder							
13	Frame wire							
14	Honey presser							
15	Beeswax pure)							
16	Casting mold							
17	Uncapping fork							
18	Honey extractor							
19	Honey container							

2. What are the smoking materials you are using? (Rank) (1) Dry grass (2) straw (3) cow dung

VII. Honey harvesting, Colony Management and characteristics

1. What are the characteristic features of your honeybees?

1. Behaviour: (1) Docile (2) Aggressive (3) Very aggressive
2. Colour: (1) Black (2) Red (3) Grey (4) Mixture
3. Size: (1) Big (2) Medium (3) Small

2. Which one is productive? Behaviour: ____, Colour:____, Size:___

3. Do you visit and inspect your beehives and colonies? (1) Yes (2) No

4. How frequently do you inspect your hive? (1) Every day (2) Every two to three days (3) Every week. (4) Other (specify)_____

5. If no inspection, what is the reason? _____

6. Do you clean your apiary? (1) Yes (2) No, If no why? _____

7. If yes, what material do you use for cleaning? _____

8. When the following activities occur in your area?

No.	activities	Season(s) of occurrence			
		Sept. to Nov.	Dece. to Feb.	March to May	June to August
1	Colony Swarming				
2	Honey flow season				
3	Colony Migration				
4	Brood rearing period				
5	Dearth period				
6	Colony Absconding				

9. Is there colony absconding following the main honey fallow season and through the dry season? (1) Yes (2) No

10. If your answer is yes, what do you think is the reason? 1. Shortage of feed

2. Shortage of water (3) Pests and predators (4) Poor bee management (5) Other

11. During harvesting do you remove all honeycombs? (1) Yes (2) No

12. During harvesting do your bee colony leave? (1) Yes (2) No

Swarming

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

2. If your response is yes, what is the frequency?

(1) Every season (2) Every year (3) Once in two years (4) Others, specify: _____

3. When does swarming occur more frequently? (Months) From_____ to _____

4. Is swarming advantageous to you? (1) Yes (2) No

5. If yes, describe the reason(s)

To increase my number of colony To replace non-productive bee colonies

To sale and get income Others specify:_____

6. Do you control / prevent/ swarming? (1) Yes (2) No

7. If yes, what methods do you use to control / prevent/ swarming?

Removal of queen cells (1)Yes (2) No - Using large volume hive (1) Yes (2) No

Harvest or cut honey combs (1)Yes (2) No -Others, specify:_____

Supering (1)Yes (2) No

8. Do you have swarms catching experience? (1) Yes (2) No

9. If yes, do you use swarm attractant materials? (1) Yes (2) No

10. If your response in question 9 is yes, describe what types of attractants and methods of application you use (rank them)._____

11. How many swarms do you catch in this production year? 2004_____

12. List the home use of honey. _____, _____,_____

VIII. Honey Marketing

1. For what purpose do you use your honey? 1. Consumption 2. Selling 3. Both

2. What is the annual income from sale of hive product and bee colonies?

No	Type of product	Quantity	Unit price	Total
1	Honey			
2	Beeswax			
3	Bee colonies			

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

1. Seasons of the year 1. Yes 2. No

2. Colours and taste of the honey 1. Yes 2. No

3. Distance from market 1. Yes 2. No

4. Traditional ceremonies 1. Yes 2. No

5. Others (specify): _____

4. How do you set the price? (1) the buyer (2) myself (3) negotiation

5. During the different harvesting season what is the price of 1 kg of honey?

No	Colour of honey	Price of honey (Birr/kg)					
		Traditional hive			Movable-frame hive/modern		
		1st harvest	2nd harvest		1st harvest	2nd harvest	
1	White						
2	Yellow						
3	Red						
4	Brown						
5	Mixed						

6. Who are your customers?

(1) 'Tej' houses 1. Yes 2. No

(2) Middlemen 1. Yes 2. No

(3) Retailers 1. Yes 2. No

(4) Wholesalers 1. Yes 2. No

(5) Individual consumers 1. Yes 2. No

(6) Beekeepers co-operative 1. Yes 2. No

(7)Others/specify/_____

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

8. How is the price trend of honey in your locality? 1. Increasing 2. Stable 3. Decreasing reason for your answer _____

9 . How did you fix the price of honey?

1. Consideration labour and other cost incurred
2. Market force (supply and demand)
3. Colour of honey
4. Table honey and crude honey
5. Customs and Traditional ceremonies
6. Others (specify_____

10. Where do you sell your honey? (More than one answer)

1. In your home
2. Near by market place
3. Major honey market place
4. Beekeepers cooperatives
5. Other (specify)_____

11. Who sell the honey?(1) me (2) wife (3) children

12. Who is controlling the many? Why?

13. Do you have any contract agreement with the buyers/processors? 1. Yes 2. No

14. If your answer is yes, please indicate the kind of agreement? _____

15. Do you keep the contract agreement? 1. Yes 2. No

16. In your answer is no, why?_____ _____ _____

17. If your answer to Q 15 is no, are you willing to enter in to contact agreement with the processors/exporters in the future? 1. Yes 2. No

18. If yes, do you have skills to produce quality product that is required by exporters? 1. Yes 2. No

19. Do you sale your honey after harvest? (1) Yes (2) No

20. If no, for how long you store it?

1. One to three months 3. Four to six months 4. More than six months

21. For what reason do you store honey? _____

22. What container do you use for storage?

1. Tin can 2. Clay pots 3. Plastics 4. Kill 5. Animal skin and hide 6. Glass 7. Other, Specify-

23. Do you also process and sell beeswax? 1. Yes 2. No

24. If your answer is no, what is the reason? 1. Lack of awareness about its importance 2. Lack of processing skill 3. Lack of processing material 4. Lack of beeswax market in the area 5. Other (please specify)____

25. List problems you encounter to take your product to market.

(1) _____(2)_____(3)_____

VIIII. Constraints of beekeeping

1. What are the major constraints of beekeeping in the area? (Rank them and give the possible measure)

No.	Constraints	Rank	What measures will be taken?
1	Bee hives		
2	Beekeeping equipments / materials		
3	Honeybee colony		
4	Storage facilities		
5	Drought (lack of rainfall)		
6	Shortage of water		
7	Shortage of bee forage		
8	Swarming		
9	Absconding		
10	Death of colony		
11	Pesticides and herbicides application		
12	Marketing		
13	Pests and predators		
14	Diseases		
15	High temperature		
16	High wind		
17	High rainfall		
	Others (specify		

2. Does beekeeping profitable to the area? (1) Yes (2) No, reason_____

X. Beekeeping extension linkage

1. Do you participating in beekeeping extension packages? 1. Yes 2. No

2**.** Did you receive training/ advice of improved beekeeping management practice from DAs? 1. Yes 2. No

3. If yes where you obtained?

1. Development agent 2.community leader 3. Market participant farmer

4. Neighbors 5. Relatives and friends 6. Radio, television, news letter 7. Others------

4. If yes in what aspects? 1. General inspection of hive 2. Queen and brood management 3. Dry season management 4. About abscond and swarming 5. Honey harvesting and processing

6. Bee health and management 7. Other, specify_____

5. Did you apply the training/advices received to your bee colony? 1. Yes 2. No

6. If you applying the training/advices, did you achieve any improvements in your colony

1. Yes 2. No

7. If not, why?

(1) not affordable (2) not simple to apply/not understood (3) Not accessible

(4) Socially and culturally not acceptable in the area

(5) Not relevant to my colonys´ problem (6) labour shortage (7) others, specify_____

8. Is there a beekeeping association in your area? 1. Yes 2. No

9. If your answer to the above question is yes, are you a member? 1. Yes 2. No, if, yes since when?

10. If your answer to question 9 is yes, what kind of benefits are you getting from the association?(1)---------- (2)---------- (3) ----------

(4) ----------(5) ----------

11. Do you get market information of honey? 1. Yes 2. No

12. What is the source of information? (1) radio (2) extension (3) farmers (4) trader (5) association

13. Do you know about community FM radio transmitted from Mekelle? 1. Yes 2. No

* According to your opinion what kinds of interventions are required to improve the productivity of beekeeping in your area? _____ _____ _____ _____ _____

* If you have any comments or suggestion?_____ _____ _____

Thank you for your cooperation! Compiler: Name_____ Signature ___Date____

Interview guideline for Kilte-Awlaelo w43oreda Office of Agricultural

1. Number of PAS in the woreda----------

2. Total number of house hold in the Woreda: Male------- Female----------.

3. What is the total number of beekeeper in the Woreda? Male ---------- Female ----------

4. What is the main source of income of the rural people in the Woreda?

5. How is the contribution of beekeeping to income generation for households?

6. What is the general perspective of the beekeeping activities in the Woreda?

7. How is the potential of the area for beekeeping?

8. What is the total number of bee hives in the Woreda in 2012, Traditional hives--- Modern hives—

9. What is the average productivity of the different hives in the Wereda?

Modern hive_____(kg/ harvest), Traditional hive _____(kg/harvest)

10. What are the major materials used for hive construction in the study area (tree bark, clay, mud, etc)

11. What are the major advantages of the different beehives in the area?

12. What are the advantages and disadvantages of using the different types of materials?

13. How is the trend in the number of honey bee colonies in the Wereda (increasing Or decreasing)? Explain the reason for both trends?

14. What are the main problems in honey production and marketing in the District (market price, traditional production system, inaccessibility of the area due to poor road infrastructure, etc)?

15. What can be done to increase the efficiency of honey production in your area? Who should do it?

16. What opportunities do exist in your area to improving the beekeeping activities?

Interview guideline for beekeepers associations

1. When was the association established? _____

2. What was the objective to establish the association?

3. What are the criteria for membership?

4. How many members does the association have at the moment?

5. What kinds of services (provision of inputs, training, assistance in product marketing, etc) does the association provide to its members? To the community around?

6. Does the association have honey collection centre in the major honey producing areas?

7. If the association is also involved in honey and beeswax marketing, is there any kind of contract agreements with the honey producers? How is the price set?

8. How is the benefits redistributed to the members of the association?

9. How do you evaluate the quality of the honey supplied by the producers? If the quality is low what do you think is the reason?

10. If the quality of honey is low do you accept or reject?

11. What type of problem does face from the supply side? From the customer side?

12. How many kilogram of honey does the association collect per year from its member? Who are the main customers of the association?

13. What are the main problems faced by the regional association in performing its task?

14. Is your association a member of Ethiopian Honey and Beeswax Producers and Exporters Association? If yes, what kind of services /benefits you get from being a member of the association?

14. How is the support of the governmental organizations for the association?

15. How is the support of the non-governmental organizations for the association?

16. Can you mention the major constraints in the honey and beeswax value chain? (Production, processing, marketing, coordination, etc)?

17. What do you suggest to improve the situation?

18. What opportunities do exist in the beekeeping sector?

Interview guideline for Organization who participate in beekeeping sector in the region and in the study destrict

1. What are the main development objectives of the organization in Tigray?
2. How does the organization assist honey and beeswax value chain development?
3. Who are the main target groups get assistance in the value chain?
4. How does the organization assist small-scale beekeepers to improve their living standards?
5. What kinds of value chain (s) have you identified so far (local and regional, export led, niche market –organic/fair trade value chain etc)?
6. How does organization see the current honey and beeswax value chain coordination (legislative system in setting the standards, communicating the standards, authority to set standards, etc)
7. How is the success of the organization in achieving its objective so far?
8. What kind of problems does the organization faced in achieving its objectives?
9. What measures were taken to solve these problems?
10. Are there any innovations in bee farming? What are these? (list)
11. How do you evaluate the current performance of the honey and beeswax value chain (effectiveness, efficiency, information flow, relationship between different actors in the chain, chain coordination, etc)?

12. According to your opinion what are the main drivers of changes in honey value chain? How is upgrading of the chain is occurring?

Interview guide line for Honey and Beeswax Processors and Exporters

1. When was your company established? Since_____

2. Where do you get your honey?

3. How is the supply (quantity and continuity of the supply)?

4. Do you have any kind of contract agreements with the honey producers? If yes please specify

5. How do you evaluate the quality of the honey supplied? If the quality is low what do you think is the reason?

6. If there is a problem from the supply side (quantity, quality, on time delivery, etc), what do you think is the solution to improve these problems?

7. What service and help you provide to the producers?

8. In addition to honey what kinds of inputs do you use? Where do you get them?

9. What kinds of product your company produce in addition to honey?

10. What are the steps involved in honey and beeswax processing?

11. Where do you sale your products (local and or international market)? If you are exporting your product, please mention the type of product and the countries to which you are exporting your product and export volume?

12. How many kg of honey do you process per day? How much percent of your product is exported?

13. How is the price trend?

Interview guideline for Tigray Agricultural Research Institute

1. What kinds of research have been done on bee and bee products so far?
2. What areas of research need much focus and Why?
3. How is the productivity of honey bees in Tigray?
4. What are the improved technologies generated by research?
5. How is the dissemination and adoption rate of the improved technologies developed by the centre?
6. If the dissemination rate is low, what are the reasons and what could be done to improve the conditions?
7. What are the main constraints to strengthen bee research and what could be done to improve the situation?
8. What are the opportunities to improve the productivity of apicultural sector?

Question for the regional agricultural office

1. How many registered honey and bee wax processors and Exporter Company are available in the region? mention them
2. Is there registered traders and honey collectors involved in honey collection and marketing?
3. Is there any private business or association involved in modern beekeeping in the region
4. Is there association/union which supply beekeeping equipments for the farmer?
5. Is there any plan to integrate forest conservation and area rehabilitation with beekeeping development?
6. In your opinion what is the major problems and constraints in the beekeeping development and marketing in the region?
7. What can be done to increase the efficiency of honey production in the region? Who should do it?
8. What opportunities do exist in the region for beekeeping activity?