Strategic Plan to Develop a Globally Competitive Honey Industry in Ethiopia

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By

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Chapter one. Introduction

Three of the pillar development agendas of the Ethiopian government have been poverty alleviation, diversifying the economic and export structure as well as creating a green economy. The development of the Ethiopian honey industry, therefore needs to be gauged from its potential contribution to these three pillar objectives.

Indeed, the unique feature of the honey industry is the fact that it simultaneously achieves equally to multiple objectives and reconciles conflict of interest between the present and future generations.

The potential benefits of transforming the honey industry broadly include both direct and indirect benefits. Honey bees as agents of pollination promote and enhance the productivity of the vegetation system, re-vegetation efforts and many cereal and cash crops, oil seeds crops, fruits, as well as vegetables. Indeed, in recognition of the importance of this contribution, pollination service is being promoted, developed and even subsidized in the developed countries.

The direct benefits include the income generated from the production of bee products, which include the conventional products of honey and beeswax and the high-value products including propolis, royal jelly, pollen, venom. Moreover, bee products are the basis for the development of different agro-industries like pharmaceuticals, beverage, cosmetics, sweet manufacturing industries. Through these direct benefits, the industry has immense potential for simultaneously achieving both poverty alleviation and export promotion development objectives. The success in poverty alleviation can have almost equivalent direct impact towards export promotion.

In addition to these features, bee keeping is essentially scale neutral and less resource-intensive compared to other industries. The honey industry is scale neutral accommodating household level production, small-, medium- and large-scale commercial production. This feature is one of the reasons which makes this industry quite instrumental to achieve simultaneously growth, redistribution and sustainability objectives.
It is not only less-resource intensive, but essentially the industry does not compete much with other industries. Rather the degree of its complementarity is higher than its competing for such resources as land and water.

The grand question that this study intends to address is, what does it take to realize these claimed potential advantages of the industry? Since, we are operating in a globalized world, an alternative statement of the question is what does it take to develop a globally competitive honey industry?

Since all bee products, except pollination services are all traded goods, aiming for developing a globally competitive industry, not only enables the development of a dynamic export sector, but it also is a dynamic and sustainable industry of transforming the lives of the beekeepers. This makes the industry a preferred poverty alleviation industry, without or at a minimal risk of vulnerability. Developing a globally competitive honey industry simultaneously benefits both the local consumer and producer as well as the global consumer and attain a sustainable means of poverty alleviation and diversifying and establishing a strong foundations for the export sector.

To this effect the strategic directions should be to boost productivity of the production of quality bee products aiming at exploiting the wider scope for product differentiation and upgrading into high value products and agro-industries, which complement to each other. Boosting the productivity of bee keeping and improving quality products at farm household level would not only boost total supply and achieve growth objective, but would play a critical role in alleviating poverty as sole source of income and/or as a supplement to other sources of income.

Thus it was very logical and realistic for the Ministry of Industry (MoI) of the Federal Democratic Republic of Ethiopia, to identify the honey industry as one development industry in transforming the lives of millions of Ethiopians and promote it as one industry for diversifying the Ethiopian export sector.

Thus the governing objective and direction is to develop a globally competitive honey industry. This presupposes the fact that the economic (market) setting is governed by the globally
competitive environment. Therefore, one of the prime tasks is to identify the major drivers of global competitiveness of the honey industry and then assess and evaluate the Ethiopian beekeeping industry from this framework of global competitiveness.

The value addition of the present study includes the fact that the intervention to develop the industry should be gauged from its potential to contribute to the grand development objectives of the country. Indeed, the projected planned interventions aim to alleviate the poverty of targeted household beekeepers from each woreda of the country, depending on the natural resource endowment and the level of commitment of different stakeholders including the government and development partners. Moreover, the growth potential can be achieved through integrating apiculture with modern large scale farms, coffee, fruits, vegetables, oilseeds and other farms. The present study strongly argues that through concerted effort to enhance productivity, beekeeping can become a dependable, sustainable and globally competitive sole source of income and prime occupation of millions.

Through concerted effort to enhance productivity of beekeeping, it is possible to alleviate the absolute poverty of 8000 from each woreda and nearly six million Ethiopians of the country. Moreover, it is possible to increase the level of export earnings from USD 210 million in 2016 to about USD 4.8 billion in 2025. More than 50% of the planned export earnings is generated from farmer/pastoralist/ beekeepers, which means through alleviating poverty, that match complementarity of objectives. It has to be recognized that these preliminary estimates of benefits are clear understatements of the potential benefits that can be generated from transforming the Ethiopian honey industry. Both estimates of poverty alleviation and export earnings do not include all direct and indirect benefits. Once an apiary site is developed, it is possible to integrate other agricultural activities with the beekeeping. With such massive transformation, specializations and division of labor will expand in the near future. The supply of standardized inputs will generate a lot of employment opportunities. There will emerge specialized business lines like queen rearing as a business line. The indirect benefits of pollination services is immense. For instance, the potential impact on productivity of coffee for instance is in the range of 19-47%. The potential, indeed achievable, for high value bee products and the emergence of honey and beeswax based agro-industries is immense.
The critical factors of success are productivity performance indicators which essentially depend upon apiary site development and colony management. If each beekeeper is committed to develop his/her apiary site, then the momentum is set. The dynamism and potential impact of the sector depends upon designing, developing and managing the apiary site. Then beekeeping can be a dependable, sustainable and preferred sole source of income for millions of poor rural and even urban households and/or can support millions of unemployed youth organized as associations and cooperatives.

Though the investment to develop and strengthen the knowledge generating and disseminating system and establishing the quality assurance system would be shouldered by the government, the contribution of the private sector will be large. There is high possibility for the private sector to join in the manufacturing and distribution of standardized inputs to the sector, subject to close supervision to monitor the supply of standardized inputs. Moreover, since the transformation of the Ethiopian apiculture is simultaneously a transformation of the natural and environmental resources, there is high potential for mobilizing the required resources from development partners, multilateral and bilateral development partners.

Understandably, the methodology of a study is governed by the objective(s) and problem(s) the study intends to achieve and address, as well as the availability of research resources to generate, access and analyze data relevant for the study purpose.

Essentially the study is an exploratory one, basically aiming at understanding and drawing policy and strategic issues of the industry. The time given to undertake the study was four months. The scope of the study should cover the country in order to have an understanding of the state of the Ethiopian beekeeping sector. As a strategic document and hence to develop a global insight, the study has to review international experience, which was complemented with a benchmarking visit to Germany.

The study involved nine professionals from different fields, three core researchers team and the other six associate researchers. The mix of these nine professionals include two socio-economists, one from biotechnology and botany, two from animal science, one from quality standard and laboratory management and three from Holeta Bee Research center.
The study has relied on both primary and secondary data, which involved both desk and field studies.

The secondary data sources, included both qualitative and quantitative data from diverse sources. These include different ministries, authorities and agencies, including the Ministries of Industry (MOI), Agriculture (MOA) and Finance and Economic Development (MoFED), Ethiopian Central Statistical Agency, Ethiopian Revenue and Customs Authority (ERCA), and Ministry of Water and Energy. Quantitative data include agricultural production, export data of honey and beeswax. The study has depended upon FAO database for global production and export and import data.

Given the time budget of four months and the coverage of the country, at least the four regions, it was not practical to conduct a survey of meaningful sample size. Basically, the study was an exploratory one, aiming at understanding the root and reported causes of the sector and developing an insight to develop a roadmap for the industry into the next ten years.

The qualitative data and its sources include number of reports, workshop documents, policy documents, experience and professional opinion of officials and experts from the entire structure from federal to woreda institutions, non-governmental institutions, industry associations. The research team has made a serious of intimate discussions and dialogues with federal, four regional (Oromia, Amhara, Tigray and SNNP), nine zonal officials and authorities. The zones include two each from Tigray, Amhara and Oromia and three from SNNP. From each zone, two woredas were visited and explored. From each woreda, apart from the officials and experts, the research team has conducted intimate discussions with a number of elders and farmers. The study has made intimate discussions with a number of federal, regional, zonal and woreda officials and experts from the four regions and nine zones, investors in the industry, farmer beekeepers and elders aiming at understanding the sector, its challenges and problems and develop an insight into the future.

The industry associations include the Ethiopian Apiary Board (EAB), Exporters Associations and the Beekeepers Association. The study benefited full support in terms of accessing to
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To the best knowledge of the core researchers of the study, there is no single best approach for undertaking such strategic studies. The study team has employed multiple analytical approaches including both quantitative and qualitative analytical approaches. Essentially, the situation analysis of both global and country wide has employed quantitative analysis that aims to show the structure and trend of the global and Ethiopian apiculture.

The essence of the strategic document which aims to draw the road map of the coming ten years or so will be dependent upon qualitative analysis using global competitiveness analytical approaches. The task at hand is to create a globally competitive Ethiopian apiculture. In such analytical approach, the pillar development objectives of the Ethiopian government, expertise opinions and professional imagination and foresight are used to define the strategic direction of the sector.

Having this background, the first chapter depicts the global competitiveness framework of developing a globally competitive industry, which blends the analytical framework, international data on production and exports as well as a brief outline of the benchmarking study in Germany. The third chapter assesses the Ethiopian honey industry, from the perspective of its global competitiveness across the entire domestic value chain. Since the central focus of this strategic document is on developing a productive sector, chapter 4 deals with the strategy for the development and management of floral resource of Ethiopia followed by chapter 5, which deals with the colony management and the Ethiopian knowledge generation and dissemination system of the country. Of course it is inconceivable to think of develop a honey industry without a
quality assurance system, which is treated in chapter 6. The last chapter by a way of synthesizing all the works, sets the strategic directions and projections into the future ten years.

Chapter Two. Drivers of Global Competitiveness of Bee Products

1. Analytical Framework for the Global Competitive Environment

The objective of this section is to provide a cursory review of the global competitive environment which would shed some light on how to develop a globally competitive Ethiopian apiculture.

Any strategic decision-making that aims to strengthen, create and build country-wide capacity needs to seriously understand the external environment, the global competitive environment that governs the playing field of the apiculture industry across the globe.


If indeed, globalization is an irreversible process then low income countries like Ethiopia need to recognize, understand and endeavor to maximize the possible gains from globalization and minimize or avoid the risk of marginalization from this dynamic global setting. This dynamic globalization process which involves an "accelerating pace of technological change and globalization of production, defines new opportunities and challenges" for low income countries like Ethiopia (Lall,1999, p.2). This global trade integration and decentralization of production systems is both an opportunity and a challenge for new entrants like Ethiopia.

Globalization has created relatively better opportunities for new entrants into the global market. It is an opportunity because there is better opportunity to export and join in the global supply network. If not for all goods and services, production of most consumer goods has been decentralized such that a number of countries and firms from different countries have been joining the global supply, as suppliers of finished commodities and parts and components of a
commodity. Globalization through the expansion of global value chains can reduce the costs of entry of new exporters and ease the entry barriers. Indeed, the share of developing countries in world trade has been improving since the 1990s. In fact, "South-South trade – that is, trade among emerging and other developing economies – has grown from 8 per cent of world trade in 1990 to around 25 per cent today, and is projected to reach 30 per cent by 2030" (WTO, 2014, p.43).

However, it is up to economic agents and decision makers to take advantage of the opportunities through tackling and dealing with the challenges. The challenges cannot be evaded or avoided. Success has never been automatic in the globally competitive market. Mere participation in the export market did not, and will not ensure success. Rather, the entry and survival of new entrants (countries, industries and firms) critically depends upon the intimate understanding of the nature and behavior of the global markets and accordingly design and develop policies, strategies and capabilities at country and firm levels along the value chain of a given commodity. One needs to create the capacity it takes to be globally competitive (OECD, 2005, p.16, WTO, 2014, p.79).

Basically, the challenge is the fact that the nature, intensity and challenges of competition is changed. The global competitive environment sets the parameters of global competition and defines the drivers of competition for each industry.

One of the outcomes of decentralized global supply which is coordinated and managed globally is the fact that supply of many consumer goods is exceeding the demand for the same. Due to different reasons supply of many commodities is exceeding demand in the biggest market areas, the USA, EU and Japan, which has been the destination of the lions' share of global exports (WTO, 2014). The immense change in production technology in many industries has been contributing to scale economies and exhibiting higher productivity contributing to excess supply of many consumer commodities in at least the markets of large economies which have been attracting exports across the globe (OECD, 2005, p.16). Even if there are shortages of supply globally, the persistently increasing trade deficit of low income countries is forcing them to sacrifice domestic consumption and resort to compulsory exports of commodities in short supply.

The global decentralization of production created a wide network of suppliers (exporters) from all corners of the world involving quite large number of countries and firms which have different
competitive and bargaining positions, usually having weaker position in front of the few but powerful global buyers of most consumer goods including food items like bee products. Thus, even if supply is not exceeding demand, the fact that the supply is decentralized and disintegrated across countries and firms has made suppliers relatively weaker in front of 'global buyers' who are operating in highly concentrated markets (Gereffi, 1999; Wood, 2001; Sturgeon, 2003, p. 5).

Thus the approach to enter and survive in the global market should be based not on gap analysis, but should be directed at creating the required capacities and capabilities to become globally competitive in the given commodities. Given this nature and intensity of the globally competitive market, one needs to establish the competitiveness capacities and capabilities along all economic agents and the different activities involved along the entire global value chain of a given product, honey or bee wax or all other bee products. In other words, the requirement is for creating and building competitive capacity at a system level, not at a single activity or single economic agent level.

Global value chains involve every activity and economic agent from the conception and production of a commodity or service up to the final consumption and disposal or recycling of the same commodity. Broadly global value chain analysis involves major functions of design, production, marketing, transportation, customs clearance, consumption and disposal after consumption or recycling (Gereffi, 1994, 1999a & b, Kaplinsky, & Morris, 2001, p. 4; Sturgeon J. Timothy, 2001). The unit of analysis is therefore the chain of activities and actors involved in the chain of activities and the relative contribution and power of each actor, be it the producer (firms, farms), marketer, transporter, logistic operator, customs clearance, financial companies, etc. which involve both private and public(state) organizations and activities. Thus, global competitiveness involves building the competitive capacity along the multi-activities and multi-economic-agents.

One of the formidable challenges for buyer-driven consumer commodity chains is the fact that global competitiveness depends not only upon performance of entire chain of activities and

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1 Buyer-driven commodity chains refer to those industries in which lead firms “happen to be large retailers, marketers, and branded manufacturers play the pivotal roles in setting up
economic agents, but the entire chain of activities and economic agents involved in the global value chains are governed and controlled by "lead firms" of the chain, which are "global buyers", who operate as retailers, marketers, supermarkets in the developed world, who have the power to coordinate, manage and control the entire global chain and set the competition parameters along the entire chain. The lead firms' power rests upon knowledge and information they have, design capacity, branding, proximity to customers and management capacity to coordinate and manage global supply network, which helps them to play the coordinating and mobilization role across the globally scattered production system along all directions of the globe (Gereffi, 1999, pp. 1-3; Gereffi, 2002, p. 5; WTO, 2014, p.100).

Since there is power asymmetry along the entire global value chain, major business decisions are directly or indirectly made by the lead firms of the global value chain of each commodity. These decision variables, which are the drivers of global competitiveness of a given commodity include price, quantity (volume) of supply, packaging requirements, quality, delivery time and meeting standards (labor, environmental, health and safety requirements). Thus, competitiveness is a multi dimensional competence(both capacities and capabilities), which cannot be reduced to the acquisition of a single competitive advantage at a given period. In other words, competitiveness is determined by a number of competitiveness variables, which may include price range, product range, quality range, delivery time, production capacity (critical mass to attract buyers), meeting decentralized production networks in variety of exporting countries, typically located in the third world. This pattern of trade-led industrialization has become common in labor-intensive, consumer goods industries such as garments, footwear, toys, house wares, consumer electronics, and a variety of handcrafts.” Along the value chain, there is power concentration in the hands of designing and marketing firms, who command the chain without having the production facilities. “Profits in buyer-driven chains are derived not form scale, volume, and technological advances as in producer-driven chains, but rather from unique combinations of high-value research, design, sales, marketing and financial services that allow the retailers, designers, and marketers to act as strategic brokers in linking overseas factories and traders with evolving product niches in their main consumer markets.” (Gereffi, 1999, pp. 1-2; Gereffi, 2002, p. 5; WTO, 2014, p.100).
the ‘clean product’ and health and safety standards, flexibility to cope up with market developments.

Two points worth-noting are the fact that there are multiple criteria (requirements) of competitiveness and the power of setting the criteria is not in the hands of the seller but the buyer, the global retailer who leads and controls the entire global value chain.

Cursory review of regulatory requirements of the developed countries, the EU show the fact that the standards of health and safety of food products in general and in particular importation of animals and animal products are stringent and involve multiple sets of criteria that involve competence along the entire system of the value-chain of production, marketing, transportation, storage, availability of competent regulatory system including effectively functioning competent laboratories, well equipped, furnished, staffed and well-managed. The growing global concern about consumer protection and safety issues have resulted in every increasing stringent multiple standards which include both mandatory technical standards and voluntary but equally enforceable private standards with strong institutional capacity meant to ensure safety and health from the apiary site to the consumer table (Will Margret and Guenther Doris; 2007(2nd edition), 2007, pp.2, 21)

It has to be noted the fact that there are different categories or levels of standard settings each involving a number of regulations and requirements including the following: (Will Margret and Guenther Doris; 2007(2nd edition), 2007, p.21)

a. Multilateral standard ruling (e.g. WTO) and multilateral standard setting organizations (e.g. Codex Alimentarius)

b. Supranational standard setting organizations (e.g. trading blocs such as the EU)

c. National standard setting organizations (e.g. EU Member States)

d. Private industry and trade (e.g. collective and corporate standards)

In general, these legislations "impose a series of health and supervisory requirements, designed to ensure that imported animals and products meet standards at least equivalent to those required for production in, and trade between Member States" (European
This means the quality of imports from third country like Ethiopia are expected to have a production, transportation, handling, packaging, storage, laboratory services etc. higher than or at least equivalent to quality assurance system in EU or its member countries. The standards are not confined to testing of certain products but require transformation of the entire system along the value chain, which involve making major decisions on strategic directions on production systems, technologies, institutional capacity to generate knowledge and their dissemination, prevention, controlling, reporting of diseases, veterinary services, hygiene conditions of production, handling, storage, dispatch, historical background of the country, timely performance of the country and economic agent (exporter, producing firm.), and the availability and competent management of diagnostic facilities (European Commission, 2007, pp.6-7).

The scope of the legislation include animal health situations, residues, contaminants and additives controls, microbiological control, food safety standards in processing establishments, and animal welfare provisions (European Commission, 2007, p.7)

The real strategic question for new entrants or for those at low capacity is how to become beneficiary from the global market opportunities and ensure sustainable success starting from marginal position, being a price-taker, a follower of all major decisions? Alternatively the question is to how to become productive to produce quality products and services as well as to upgrade the Ethiopian production and exports to higher levels, which fetch better prices and involves higher value-addition? This essentially involves transforming the entire value chain from the production up to the delivery to the importer, which revolve around generation and dissemination of knowledge, skill and awareness in order to enhance productivity of quality production systems and to upgrade to high-value activities and products along with a strong and effective law enforcement in the country.

It is prudent to note the fact that failure to give due attention to productivity, innovativeness and quality assurance system along the entire chain and hence develop dynamic globally competitiveness, may encounter two risks. The first risk is to remain with marginal participation in the global competitive markets, as it has been the experience so far with many less developed countries including the Ethiopian apiculture.
The other is the risk of immersization, which is the "race to the bottom", which means the country would not benefit commensurate to the extent of its export participation (WTO, 2014, p.108). There is a danger that countries, which actually manage to increase their export participation may not benefit from such apparent achievement merely if the costs of exporting are greater than the benefits generated from exports. The risk of 'racing to the bottom' happens if the export direction is not centered at productivity, innovativeness and product differentiation. If on the other hand the brunt of exports is shouldered by government support and incentives, which does not include adequate provision on productivity, quality, innovation and product differentiation, then that is the surest race to the bottom.

2. Global Production and Trade of Honey and Bee Wax

A. Global honey Production and Trade

Although almost all countries in the world produce honey, the production varies in quantity and quality dramatically. Based on the available data, for the last twenty years china has been the leading producer of honey with an average 279,000MTs honey per annum. The second producer is USA with an average annual production of 85,000MTs. The third largest producer is Argentina with an average annual production of 75,600MTs. The other top producers include Turkey, Mexico, Ukraine, India, Russia, Ethiopia, Iran and Brazil (see Fig1)

Figure 1: Global Average annual production of honey for the last twenty years
One can see from following figure that global honey production was relatively constant at the start and increased throughout the last decade since 1998-1999.

Figure 2: Global honey production trend for the last twenty years

Source: FAOStat
In general highest proportion of the production of honey is produced in transition and developing economies, while the developed countries are the largest consumers. The leading producer of honey, China, produced 436,000 tons in 2012. The second and third largest producers, Turkey and Argentina produced 88,000 and 75,500 tons, respectively. Other relatively large producers of honey in the developing world include India, Tanzania, Ethiopia, Mexico, Kenya and Angola. From developed countries USA, Canada, Germany and Spain were largest producers. Ukraine, Russia and Spain are other large producers of honey, producing 70,134 tons, 64,900 and 29,735 tons in 2012, respectively (ITCa, 2014).

China, the world’s largest producer of natural honey, produced 436,000 MTons (which constituted 34% of the total production in the year, 2012. The other natural honey producing Asian country is India. Average Honey production in India was about 53,400 tons a year for the last twenty years. The output of beekeeping In India has increased over the past decade and is expected to continue growing as only approximately 20-25% of the bee flora is being exploited at present.

The EU produced 165,762 MTs (13 %) of the total production produced by the major global honey producers in 2012. Similarly, Africa produced 97,405MTs (or 8%) of the total production produced by the major global honey producers in 2012. Within Africa, Ethiopia is the largest producer of honey.

Figure 3 : Top natural honey producing EU countries, -2012
The North American, as opposed to the EU, is one of the largest producer of honey in the world. Although starting in October 2006, large-scale unexplained losses of honey bees began occurring in the US and EU, USA still is the second largest producer of honey with average annual production of 85,000MTs. But due to this phenomenon, termed Colony Collapse Disorder (CCD) production of USA decreased by 33% from 2000-2012. An interesting fact associated with beekeeping in the US, which highlight the positive ecological effect of honeybees, is that US farmers (of various types of crops) actually rent beehives (at $150 per hive) from honey producers for honey bee's pollination services. These hives are used to assist in the agricultural production to fertilize flowers in order to increase the output of other agricultural commodities. The second top producer of honey in Northern America is Mexico with an annual average production of 56,855 tones. In 2012, Mexico produced 64,900 tons which is the sixth global largest producer. Also Canada is one of the top twenty honey producing country with an estimated production of 29,440 tons of natural honey in 2012.

South American especially Mercosur (Mercado Comom do Sul), which consists of Argentina, Brazil, Paraguay and Uruguay all (with the exception of Paraguay) important actors in the global honey sector. Argentina is the third largest producer of natural honey. In 2012 Argentina produced 75,500 tons of natural honey, a decrease from 2005 when 110,000 tons of natural honey was produced by Argentinean beekeepers (12). This is due to extreme climatic conditions such as drought and floods. However, only about 8% of the honey produced in Argentina is consumed domestically making Argentina the world’s largest exporter of natural honey.

In Africa, Ethiopia is the largest producer of honey. According to FAOSTAT 45,900 tons of honey was produced in Ethiopia in 2012. The other top producers in Africa are Tanzania and Angola. In 2012 these two countries were producing 28,500 and 23,000 tones of natural honey respectively (12).

Figure 4 : Global top natural honey producing countries of Africa
Figure 5: The global share of natural honey production for the global top producers in 2012

Source FAOStat
In terms of quantity exported, the major honey exporting regions in the world are South America, East Asia, the EU and North America Free trade Agreement (NAFTA) and these exports is destined for either EU or USA market. In terms of countries the largest exporters in the world are China, Argentina (exports equals 17% of world trade of honey) followed by Vietnam, Mexico, India, Germany, Belgium, Ukraine Hungary, and Spain in 2013 (see the following figure).

Figure 6: Global honey Export trade by country, 2009-2013
Productivity of Honey Production

From the following figure, we can see that world honey yield per beehive remained fairly constant throughout the years. The range of the variation of the global average was between the lowest of 38kg in 1992 and the highest was 47kg in 2006. The average productivity of the period 1990-2012 was only 44kg per year.

Table 1. World Natural Honey Average Productivity per Year, in kg, 1990-2012
As can be verified from the above table and the following figure, Chinese average productivity of honey productivity has shown a clear trend of growth from as low as 27kg in 1990 to 51kg in 2012.

Figure 7 : Global honey yield (in kgs/per bee hive) from 1990 to 2010

Source: FAOSTAT © FAO Statistics Division 2015 retrieved on 10 January 2015

China's average productivity of natural honey has surpassed the world average since 2008. In the year, 2012, while the world average productivity of honey was 45kg per year, China's average was 51kg.

Consumption and Imports of Honey
The EU is the world’s principal importer of natural honey. The average annual growth of imports to the EU region from 2005 to 2013 was 10%. The following figure shows the value of imports where the majority of the fluctuation is accounted for by the change in price of honey—a peak was reached in the price of honey in 2013. A substantial amount of the honey consumed in the EU is imported from other EU countries while NAFTA on the other hand is not such a large supplier of honey to the EU markets. The Leading EU suppliers of honey from the developing world includes Argentina, Mexico, Brazil and Chile – where Argentina is the overall largest supplier.

Figure 8: Global natural honey import trend by country from 1991 to 2011

![World top honey importer countries, 1991-2011](image)

Source FAOStat

China used to be a large exporter of honey to EU markets, but due to the ban of Chinese honey in 2002 China has lost most of its market share. Although this ban was lifted in 2005 the effect is still there in the form of a relatively high level of skepticism amongst European consumers towards Chinese honey (CBI Market Information Database).
The biggest consumer of natural honey in the world is NAFTA. The US is the largest importer of honey in NAFTA. The annual average growth of imports to the US from 2005 to 2013 was 16%. In 2013 the US imported honey to the value of US$ 497.9 m.

US is a lucrative market where it would be worth-while for Ethiopian beekeepers to attempt to increase their market share. Mercosur members have an advantage due to their proximity to the US market, however the US consumers have become more health aware and Ethiopian producers could, through focusing on supplying NAFTA with organic and/or fair-trade honey, manage to compete with these exporters as well as with Chinese honey which will be sold at a lower price than Ethiopian honey.

In Asia the largest importers of natural honey are Japan, Saudi Arabia and Hong Kong. Hong Kong’s honey imports have experienced an average annual growth rate of 22% from 2005 to 2012 – when it reached the value of US$ 26m. The Japanese market for honey is almost 10 times larger than the Hong Kong honey market. Although the Japanese market for honey imports has grown, this has happened at slower pace than the Hong Kong market with annual average growth of 9%. China is the
largest supplier of honey to Japan, the value of Chinese honey has increased by an annual average rate of 6% from 2005 to 2013.

Saudi Arabia’s honey imports, which has experienced an average annual growth rate of 10%. In 2013, Germany and Pakistan are the major suppliers of honey to Saudi Arabia, USD 14.9m and US10m, respectively. Especially Germany has experienced annually average growth rates of 22% from 2005 to 2013. But the largest increase in supply, however, comes from India (although from a very low base) – an average annual growth rate of 24% from 2005 to 2013. Yemen was the second biggest supplier of natural honey but now it is the only large honey supplier to Saudi Arabia with a negative growth rate of 4%. Yemen exports destined for Saudi Arabia decreased from USD 7.5m in 2005 to US$ 5.5m in 2013.

Saudi Arabia, could potentially be very promising markets for Ethiopian beekeepers – where they could increase their market shares through supplying exotic honey from beehives which are placed in the vicinity of flora that is not commonly found in other regions of the world.

When looking at the worldwide honey consumption patterns, one can see that the three major consumers are the EU (20-25% of global consumption), China (approximately 15%) and the US (approximately 10%) (ITCa, 2014). In 2013, apparent honey import in the EU amounted to 273 thousand tons. The two major honey consumers in the world are the USA and Germany. USA accounts for approximately 26.6% of global consumption and the Germany 15.7% in 2013 (FAO, 2014).

Although the EU consumes approximately 20-25% of the world’s honey production, only 50% of this is produced in the EU. The majority of this honey is imported from the developing world especially from Argentina and Mexico. The total EU honey consumption in 2012 was 466,000 tons. The EU countries have increased the consumption of natural honey by 2.5% annually from 2009 to 2012. From 2009 to 2012 the average annual growth was 2.7% (EU ARD DG Report, 2012).
From the EU, Germany is the leading market for natural honey accounting for 24.9% of total EU consumption. The second largest market for natural honey, in Europe, is France; followed by Belgium and Spain. France consumes roughly 44,763 tons of honey in 2012, where only 16,000 tons are produced domestically, hence almost two thirds of the amount of natural honey that the French consume is imported. Between 2009 and 2012 the French honey consumption increased by 13.3%. It is apparent that although the EU is a large consumer of honey it is not a large global producer (FAO, 2014).

North America is not only one of the main producers of honey but also a large consumer. In terms of countries, the US, consumed 207,737 tons of natural honey in 2012, is the world’s second largest consumer (FAO, 2014).

According to the general EU trend of honey trade, 10% of the consumption is accounted for by industrial uses and 90% for household consumption. Some of industrial uses of honey include the production of cereals, nougats and cosmetics (EPOPA, 2006). The US is one of the world’s largest markets for industrial honey where industrial Honey accounts for approximately 45% of total domestic consumption. Primary users of industrial honey are bakeries, health food and cereal manufacturers. Other users, such as the food service industry account for another 10% of domestic consumption.

**B. Global Beeswax Production and Trade**

As a food additive, beeswax is known as glazing agent. It is also a release agent, stabilizer, texturizer for chewing gum base, carrier for food additives (including flavors and colors) and a clouding agent. The melting temperature of around 40°C makes waxes particularly interesting for the cosmetic industry as an emollifier, emulsifier and stiffening agent for oils and fats. Due to the high melting energy needed for fluidization, it adds to the properties of cosmetic products, making them more resistant to melting by sun heating (Bagdanov, 2009). Unlike honey, beeswax is not a food product and is simpler to deal with - it does not require careful packaging which simplifies storage and transport.
As can be seen from the following figure, global production of bee wax remained stable for the period 1991-2012, with low annual growth rate. Global production increased from the order of about 45,000 tons in 1991 to about 60,000 tons for the period 2008-2012.

![Figure 10: Global Total Production of Bees wax, 1991-2012](image)

**Source FAOStat**

India is the leading beeswax producing country for the last twenty years and produced an average 20,000MTs annually. Mexico is the second largest beeswax producing country globally producing 4,300MTs annually. Argentina and Turkey are third and fourth by producing 3,845MTs and 3,687MTs respectively. Other relatively large producers of beeswax in the developing world include Ethiopia, Tanzania, Kenya, Angola, Uganda and Central Republic of Africa. Ethiopia has remained the fifth largest producer and exporter for the last twenty years.

![Figure 11: Global share of top beeswax producing countries in 2012](image)
The majority of the production of beeswax takes plays in developing countries, while the developed countries are the largest consumers. From the developed countries, USA and Spain are among the largest producers.

Figure 12: Beeswax production in EU for the last twenty years by country
The North American is not a large producer of beeswax like EU but it is the largest consumer of beeswax. The largest producer of beeswax in North America is Mexico producing 1,990MTs in 2012 while second producer of beeswax in Northern America is USA with production of 1.600MTs. Like EU, North America is largest consumer of beeswax. In terms of countries, the US is the leading consumer of beeswax in the world by consuming 5,062MTs of beeswax in 2013 (14).

Source FAOStat and ITC

Figure 13: Beeswax production in the North America for the last twenty years by country

Source FAOStat
In Africa, Ethiopia is the largest producer of beeswax. According to FAOSTAT estimate, 5,000 MTs of beeswax were produced in Ethiopia in 2012. The other top producers in Africa are Kenya and Angola. In 2012 these two countries were producing 2,300 and 1,850 MTs of beeswax respectively. Other producers of beeswax in Africa include Tanzania and Central Republic of Africa. (see Fig 14)

Figure 14 : Beeswax production trend in Africa for the last twenty years by country

![Beeswax production trend in Africa by country](source)

The world export trade in beeswax is rather stable due to limited industrial demand for beeswax. In the global beeswax market, beeswax traded grew at an average annual rate of 10% since 2000 and reached the value of US$ 148 million in 2013 whereas the quantity grew by 6% and reached 24 thousand tons in 2013 but there is a decline in quantity from 33.7 thousand in 2012.
Figure 15: Global Beeswax export trend, 2000-2013

Source: UNComtrade

**Import of Bee Wax**

Global imports of bee wax show a steady trend over the period 2000-2013. Imports of bee wax grew from the order of about USD thirty million to more than USD 110 million worth of trade.

Figure 16: Global Beeswax import trend, 2000-2013

Source: UNComtrade
As can be seen from the following figure both import and export values of bee wax showed similar trend for the period 2000-2013. The fact that the value of exports is consistently exceeding imports may indicate the value of re-exports to a third party.

Figure 17 : Global Beeswax import-Export trend, 2000-2013

Source : UNComtrade

The EU imports around 6,000 tons of beeswax per annum, approximately 50 percent of this coming from developing countries. The main importing countries are Germany, France and the UK. These nations all have significant pharmaceutical and medical industries requiring beeswax. Tropical countries dominate world beeswax production and export, with developed countries needing to import beeswax(Bagdanov, 2009).
Figure 18: Global Beeswax import trend by country, 2000-2013

From the above graph it is apparent that eight out of fourteen countries are EU members. This indicates EU is the major importer of beeswax in the world. In terms of country, Germany is the second importer of beeswax in the world in 2013. The total EU beeswax import by 2013 almost reached the value of US$ 37.6m. This is after an annual average growth rate of 10% since 2000. The major consumer of EU beeswax import is Germany. In 2013 alone, Germany imported beeswax with value USD19.7m i.e. 52.4% of the total EU beeswax trade to the world. The other major importers in EU are France, Spain, Netherlands and UK. The major exporters of beeswax to EU market are China and Ethiopia having a market share of 76% and 4% respectively in 2013. Especially China market share is growing exponentially in the EU. While the other exporters are much below china in market value in EU with no trend.
According to the available data, apparent consumption of beeswax in the EU amounted to approximately 10 thousand tons in 2005. Actual consumption is estimated to be considerably higher. According to industry sources, consumption of beeswax is relatively stable. The product is used in various matured niche markets, such as cosmetics, pharmaceuticals, candles, food coatings and polishes.

The largest consumers of beeswax in the world is Europe. The EU accounts for approximately 50% of global beeswax import. The two major consumers of beeswax in the world are the USA and Germany. USA accounts for approximately 21.2% of global consumption and the Germany 18.8% in 2013 (FAO, 2014).

Although the EU imports approximately 50% of the world’s bee total import, less than 15% of world’s beeswax produced in the EU. The majority of this beeswax is imported from the developing world. Turkey the major producer of beeswax in EU produced 4,235MTs and the second largest producer of beeswax in EU, Spain, produced 1,545MTs in 2012. The other major producers of beeswax in EU are Greece and France.

The total EU beeswax consumption in 2012 was 15,088MTs. The EU countries have increased the consumption of natural beeswax by 7% from 2009 to 2012 while the average annual growth of consumption was 2.9%. When breaking down the EU stats of consumption; Germany is the leading market for beeswax accounting for 19.5% of total EU consumption between 2009 and 2013 the Germany beeswax consumption increased by 29.6%. The second largest market for natural beeswax, in Europe, is France; followed by Romania and Spain. France consumes roughly 3,016MTs of beeswax in 2012, where only 420 MTs were produced domestically; hence almost all the amount of natural bee’s wax that the French consume is imported. While Romania, Spain, United Kingdom, and Greece are other large consumers of beeswax in EU.

3. Lessons from German Apiculture

Germany is the largest market for honey in the European Union. The natural honey import market of Germany has grown at an average annual rate of 8% from 2005 to 2013. On the other hand, Germany is the largest European exporter of honey - exported US$ 124 m in 2013,
is more than 17% of EU’s total honey export, and 6% of the world total. From 2009 to 2013 the honey exportation from Germany grew at an average annual rate of 2.1%. The majority of German honey exports, 74.9%, were destined for the twenty eight European Union members in 2013.

So the experience of Germany as producer and exporter as well as importer and consumer of bee products is important.

In view of developing a globally competitive apiculture, reviewing the experience, requirements, and nature of the market of one of the potential export destination sheds a light of different perspectives, which could have strong policy implications.

**Organic bee products are no more niche markets:**

One of the major lessons is the fact that the market for organic products has become a mainstream market instead of niche market. Many factors have been contributing towards this development. Among others, the level of income of the society, the size of the market and the high market bargaining power of buyers, increasing health knowledge and awareness of the public etc have been contributing towards mainstreaming organic products.

Thus organic bee products are not window of opportunity that we should aim as niche market. Rather our policies, programs, plans and actual behavior should be organized, structured and governed by full and unreserved and unqualified appreciation of this fact.

**Highly differentiated market for bee products:**

The study team had a chance to visit some store houses in Stuttgart. A number of long shelves are dedicated for bee products in different packaging units, both bottled and plastic, all clean, well-labeled. Some of the products are labeled and branded by the producers while others are labeled and branded by the global retailing buying companies. The retailing global buyers,
purchase in bulk and then assort and pack them in their own labels, branding their company but ignoring the producers.

In addition to supermarkets and store outlets of global retailing companies, there are local specialty stores who specialize in bee products and inputs of the beekeeping industry.

The extent of product differentiation is quite high. There were more than a dozen of different table honey brands. There is high product differentiation in terms of brand names, color difference, a specialty (mono-flora) honey, multi-flora honey.

Another product differentiation was the high value bee products, propolis, royal jelly, pollen and venom, in dedicated shelves of the super markets, indicating the fact that they highly marketed, appearing over the shelves of a super market like table honey.

In addition, too many products of agro-industries based on bee products, pharmaceuticals, cosmetics, beverages, candy and sweet are shelf items of super markets, indicating to what extent the bee products are vertically integrated and to what extent the agro-industries are developed.

**Well established and strong regional research center**

Apiculture research centers are organized around the federal government of Germany and in accordance with agro-ecology of the country. The research center the study team managed to visit and talk to is affiliated with both a university and Ministry of Agriculture. It has dual accountability to both the university and the Ministry of Agriculture and it mobilizes resources from the two sources too. Dual accountability has its own merits and challenges. Yet, if the management philosophy and style is participatory, encouraging and letting people be innovative
and responsible, the advantages outweigh the challenges and difficulties. Indeed, the dean and management of the research center did not consider it as a problem, rather as a unique opportunity. One can note that such dual accountability is not conducive and compatible to highly bureaucratic and control-based management system, mostly practices in less developed countries and poorly managed organizations.

As university professors, the staff of the research center do provide courses on apiculture and train people for the sector. Definitely, the courses are not text-based but rather practical and upto the recent frontier research areas, issues and developments.

The fact that the research center is affiliated to a development ministry (specifically the Ministry of Agriculture), the research agendas are jointly set by the university and the developmental organization. That enabled the research to establish the right mix of basic and applied research in the area of apiculture.

The extension system which is organized regionally is closely related to the research center and to all and every beekeeper. According to the extension worker, he pays particular attention to those who are week in communication, who fail to appear in meetings, who do not respond to our interventions. Usually it is those beekeepers who need our support and attention. Thus the extension service is tuned to every beekeeper, oriented and directed at everyone, not group intervention. It is possible to organized group trainings. But every individual beekeeper has his/her own unique problem that needs to be addressed. The search team learned that the extension workers are responsible, owning their job, love and know what they are doing to provide individually tuned extension service, like the physician treats her/his patient.

The research center is not only vertically coordinated through its vertical accountability to its superior bodies, but horizontally coordinated through its close and intimate relationship with the 'Beekeepers Association' which is quite strong association that is making a real and substantial difference in the German apiculture and for that matter contributing to global apiculture.

The relationship of the research center is not confined to its intimacy with the beekeepers association. The Dean of the research center has established personal relationship with every
beekeeper in the region to the extent he has the telephone numbers and e-mails of all beekeepers, both hobby and commercial beekeepers.

This intimate relationship of the research center with honey bee operators keeps the research center and the researchers abreast with whatever developments of the sector be it bee health, colony productivity, bee forage, bee farming practice, etc.

It may be difficult to think of developing such personal relationship with the millions of households in each region in Ethiopia. But why not with the few possible investors the country may have in the near future? Why not research centers could not develop such intimacy with those who have outstanding performance and with those who are specially lagging behind?

The major lesson is the need for regional or agro-ecology based research centers, who are formally affiliated both to universities and colleges and Ministry of or Bureau of Agriculture, with strong data base, active mechanism of follow-up and monitoring system, active and strong relationship with every stakeholders, the extension system, honey bee association, directly with honey bee operators (both hobby and solo-business operators).

**Beekeepers Association**

It is a well-structured along the federal arrangement, strong outreach to everyone in the business. It is an association which gained the confidence of the industry and eventually earned its legitimacy.

It is professionally managed by personalities who globally known in the apiculture industry. As an association is structured and organized such that it is accessible to every beekeeper from every district and county.

It has established a strong relationship with the research center. The research center has observed shared laboratory and workshop, which is under the premises of the university but jointly used with the beekeepers association.
The association gained the confidence of its members through the services it provides. It disseminates knowledge using different mechanisms. It regularly and permanently organizes planned annual workshops twice every year, involving training by authorities in the area of apiculture, organizing educational retreat. It has intimate and personal relationship with every beekeeper. Moreover, it distributes bee forage seeds and seedlings to every beekeeper.

Moreover, the beekeepers association has established its own standards of beekeeping and extraction processing, which is superior than the national(country wide or EU) level standards. This has earned the association the recognition, which is serving as a brand name not only for the association but for all member beekeeper and for that matter the region and the country. The image has become like a quality certificate which is earning a premium quality price. Those who have attached the label of the association sell at higher prices in every super market. It has established a preference of the consumer. Consumers are more willing to pay more for such products which have the labels of the association.

**Quality Standards:**
Quality standards, health and safety standards, environmental standards and requirements are mainstreamed along the entire value chain of production, trade, marketing and consumption behavior of the society. Thus instead of considering these standards as trade barriers, it would be advisable to recognize this fact positively and rather develop our production, trade and marketing systems along with such quality requirements and standards, which is the basis of sustainable global competitiveness.

The strategic direction should rather aim at achieving simultaneously high quality, high product diversification and productivity and hence price competitiveness (which means lower prices). In fact, it appears that the German market for bee products is operating beyond and above the national standards. The industry standards of the German apiculture appears to be higher and superior than the country health and safety standards.

**Well-Established Market for Beekeeping Inputs:**
The market for beekeeping inputs, both the beekeeping inputs like hives, hive tools, beekeeping outfits, etc and honey and wax extraction equipment are well established and accessible to the beekeeper.

**Beekeeping as Hobby and Solo Business**

The German or particularly the Stuttgart apiculture is characterized by a large number of hobby beekeepers and few commercial operators.

The critical factor in commercial beekeeping is not the size (or number) of hives or colonies. What matters most is the management of apiary site and hives, which governs the productivity, quality and type of bee products. A business entity with 100 hives, in fact sometimes the actual size of operating colonies could reduce to 70 hives, was commercially feasible, which paid its bank debt and running as a sound business. The size of a given apiary site and the number of apiary sites a business person can should be governed by managerial capacity apart from the size, diversity and intensity of bee forage. There is no dearth feeding mechanism for poor management. In fact, as per one beekeeper, one should not enter into beekeeping for money but for the love of beekeeping in and for itself. If you do not love beekeeping, then you cannot manage it passionately and intimately, without which it is difficult to conceive of a productive apiculture that can serve as sole source of income.

One of the strategies they adopt to enhance productivity of their colonies and to produce specialty honey types is mobility of bee hives from place to place, taking care of health risks and with due tests and procedures of transporting bee colonies from one place to another. This is not, however, a substitute to apiary site management. There are good reasons for mobility in search for special forage type somewhere else to produce specialty mono-flora honey and enable multiple harvesting.

Moreover, business operators have dedicated packing, stores and even cars to transport both the bee hives and honey.
**Industry working culture**

The major lesson, we learned is the industrial working culture. Though the research team did not undertook formal research on the subject, what we observed and understood was the fact that every job, every responsibility, every occupation is not only a source of income(employment) but a source of satisfaction and meaning of life. Everyone we talked to was knowledgeable, passionate, responsible person, who loves what he/she does. Everyone in the honey production is indeed effective and dynamic.

There is strong symbiotic relationship between research, honey bee association, extension and honey-bee operators.

There is vertical coordination between universities, research centers, ministry of agriculture, honey bee associations, extension system, at higher level. But that is not the major lesson, we happen to appreciate. The major lesson is the horizontal coordination at all levels of everyone, irrespective of the vertical organizational structure. People are mainly responsible to their jobs not to the hierarchy of authorities. The formal hierarchical accountability is the minimum requirement that everyone may adhere to. In actual everyone operates and performs to his/her best level. To that end, there is strong, smooth and effective communication with everyone at every-time and condition with no hindrances of communications. Vertical structures are not excuses for creating organizational silos, rather they are agents of both vertical and horizontal communication and smooth and up-to-date flow of data and information throughout the system.
Chapter Three. Ethiopian Apiculture: A Growth Industry That can Achieve Multiple Objectives and Interest

Given the fact that the objective of the Ethiopian government is to promote 'inclusive growth' which has both growth objectives like increasing export earnings and a redistributive objective of alleviating and eventually eradicating absolute poverty, the strategic direction of the development of the Ethiopian apiculture should be tuned towards achieving these pillar government objectives.

Given the objective of the present assignment is to develop a globally competitive Ethiopian apiculture, this section aims to assess the competitiveness of the Ethiopian apiculture, bearing in mind the drivers of global competitiveness of bee products. Achieving global competitiveness having an inclusive growth strategy, could lead to a sustainable achievement of the redistributive development objectives of poverty alleviation. If indeed, Ethiopia manages to develop its apiculture through transforming the Ethiopian farmer beekeeper, which has remained essentially the sole producer and supplier to both domestic and export markets, absolute poverty will be eradicated in a very sustainable way. Given the structure of the Ethiopian apiculture and given the government commitment to alleviate poverty and create a global competitive apiculture, the objective of creating a globally competitive apiculture can achieve both the growth and redistributive objectives. Achieving global competitiveness through transforming the Ethiopian farmer/pastoralist/ beekeeper creates a very solid basis for both poverty alleviation and creating a dynamic export sector.

It is possible to create a globally competitive export sector through promoting commercial(private) beekeeping, whose impact on poverty alleviation may be indirect and less compared with transforming the farmer beekeeper. Indeed, it is true with many other industries that the impact on poverty reduction is small and/or indirect, mainly through employment creation. With apiculture, both strategies of promoting the farmer beekeeper and private commercial beekeeper are complementary and in fact reinforce each other in many ways. Both can re-enforce each other through creating a collective supply capacity to the export sector, through production and marketing networks. Even without such relationship, essentially there is no conflict of interest between promoting both farmer and private beekeeping. There is no competition for scarce resources like land, water and even financial resources as the resource
requirement of the sector is less compared with other policy intervention areas to alleviate poverty and other investment opportunities.

Thus, the global competitiveness of the Ethiopian apiculture is consistent and in fact a direct mechanism of creating a sustainable and surest way of poverty alleviation strategy and at the same time boosting the export sector.

1. **Ethiopian Export of Honey and Bee Wax**

Given the persistent and increasing trade deficit, one of the prime objectives of the Ethiopian government has been to transform the Ethiopian export sector through increasing the traditional exports and diversifying into new export commodities. Though marginal participation, exports of bee wax and honey has been one of the traditional export commodities. Thus the prime objectives of the present study is to assess the sector in terms of its potential to develop a globally competitive apiculture.


But is Ethiopian apiculture ready to take advantage of this opportunity? The answer does not seem on the affirmative.

The contribution of Ethiopian apiculture in terms of export earning has remained marginally low throughout the period, 1997-2013. It remained consistently less than 0.5% of the total export earning of the country.
Nevertheless, the significance of the Ethiopian apiculture should not be understood in terms of what has been experienced in the past. Rather, it has to be appreciated that much could have been achieved in terms of income generation and hence poverty alleviation in the country. It could have contributed much as a strategic input to enhance productivity of other agricultural commodities through providing pollination services. The Ethiopian apiculture could have generated much export earnings had there been concerted and coordinated efforts to enhance productivity of the existing bee products. Much income and export earnings could have been achieved had there been concerted and coordinated efforts of innovativeness and product differentiation to promote high-value bee products.

One reason for low export earning is low supply to export. The share of exports of honey and bee wax from the total production of these bee products has been low throughout 2005-2013. As can be noted from the following figure, the share of exports from total honey production was less than 1% in the period 2005-2009 and increased to more than 1% but not more than 2% for the recent years, 2010-2013.
With due appreciation of the recent trend of improvement, in export participation of exports of both honey and bee wax, the major question is, however, to raise the question of why low export participation? Before attempting to address this question, it would be more enlightening if we could see more the profile of the Ethiopian exports of honey and bee wax.
As can be seen from the figures above and below, the exports of both honey and bee wax have been generally low but picking up since 2005. Both volume and value wise, the exports of honey was substantially lower than that of exports of bee wax for the period 1997-2009 but that relationship has changed in the last four years, 2010-2013.

Figure 3. Ethiopian Value of Exports of Honey & Bee Wax (in 1000 USD, 1997-2013)

Figure 4. Ethiopian Volume of Exports of Honey & Bee Wax (in tons, 1997-2013)
**Exports by Destination**

Sudan and Norway, has been the two biggest importers of Ethiopian honey in terms of volume and monetary value. Exporting to the Sudan, a neighboring country promotes interregional trade, which is a good sign of the South-South trade with wide economic and potential political economy significance. However, the trend seems to dwindle for the recent years as the share of exports to Europe is picking up since 2012.

Figure 5.Ethiopian honey exports by top four export destinations

Source : ERCA

Even if the South-South trade has its own merits which needs to be promoted, the real test of global competitiveness is if the Ethiopian apiculture could establish itself in European markets, which is believed to be highly and more globally competitive. There is ample alternative source of bee products competing in European markets. There is strong institutional set up that monitor exports of quality bee products, which could be taken as a real test of the quality of bee products. Entrance and survival in European market has wider implications. First of all if one can meet European standards, it is possible to take that as a certificate of entrance to every other global market. Moreover, there is quite large European market for bee products.
The other bee product is bee wax for which it has been very difficult to obtain the production data for beeswax in Ethiopia because The livestock survey that CSA conducted each year do not gather data about beeswax production. So the only available data about beeswax is the import - export data obtained from ERCA. So based on the ERCA data, Ethiopia’s beeswax export market focuses on European, USA and Japan markets. Germany accounts 52% of the total export in quantity and 50% of the total earning obtained from beeswax i.e. Germany is Ethiopia’s number one customer of beeswax followed by Japan.

Figure 6. Volume of Beeswax Export Destination Countries from 2009 to 2013

![Beeswax export volume by destination countries](chart.png)

Source : ERCA

In general, the existing entrance to European markets should be taken as an opportunity that needs to be exploited.

Yet entrance to a well-established market like the European market is one thing, survival and branding is another thing. Much attention should be given to strengthen and increase the export participation in both honey and bee wax. Yet, surviving and establishing a branding position in European markets could be more challenging and with inbuilt risks of losing the opportunity due to failures in ensuring quality and meeting desired standards of safety and health. It is more challenging to reenter again in a market once the image is lost, especially when it involves an image loss in front of the direct consumer of consumer goods like honey.
Figure 7. Beeswax total FOB value by export destination countries from 2009 to 2013

![Bar chart showing Beeswax exported total FOB Value by destination countries from 2009 to 2013.](chart.jpg)

Source: ERCA

The strategic question, therefore, is as to why Ethiopian apiculture has been marginally contributing to export earnings of the country, despite the huge potential?

The other strategic question, is as to why the Ethiopian apiculture has been playing a supplementary role in reducing absolute poverty?

There are a number of explanations for the marginal export participation of the Ethiopian apiculture and marginal role in poverty reduction. One major reason is the pessimistic perspective (unfortunately commonly shared by many) of apiculture as a supplementary source of income. With this mind set, it is difficult to attract neither policy attention nor private investment.

The major underlying factors behind this pessimistic perspective of supplementary apiculture is the low productivity of the sector and the failure to come out of the box to see the possibility and scope of improvement in productivity. The other related underlying reason is the failure to see the scope of product differentiation towards high-value bee products. Apart from honey and bee wax, there has not been attempts with product differentiation towards high-value bee products.
addition, high domestic prices and hence lack of price competitiveness, poor quality assurance system of the country, law awareness of the importance of appropriate storage, packaging and transportation and a number of incidences of adulteration could be sighted as the major problems for low contribution of the Ethiopian apiculture.

These major challenges and problems are discussed in some detail in the following pages starting with the production system.

2. The Potential for Ethiopian Apiculture

The country has a high potential for beekeeping as the climate is favorable for growing different vegetation and crops, which are a good source of nectar and pollen for honeybees. It is endowed with botanically diversified honey forage plant species which supply ample food to the honeybees. Some 800 bee plants had been already identified across the country. According to reported estimates, Ethiopia, with over 10 million honeybee colonies, out of which about 5 to 7.5 million are estimated to be hived while the remaining exist in the wild has large production potential (MoARD, 2007).

Most studies and policy documents are based on these and similar but different estimates of the existing vegetation cover, the bee fodder species that exist and the size of the honey bee colonies. The present study does not aim to assess the reliability of the existing estimates. Yet, both estimates are static estimates based on what existed during the survey period. These estimates do not consider the dynamics of the forces that have direct impact on both the flora and fauna. The long standing persistent land degradation that have been going on for centuries which has been eroding the top soil and hence the vegetation cover of the country, which definitely have negative impact on the potential of apiculture of the country needs to be recognized, as a negative force that downgrades the potential of apiculture in Ethiopia. On the positive side, there have been aggressive soil and water conservation efforts that aim to reverse this trend, which enhance the potential for apiculture. There is policy level recognition both in the agricultural development and the green economy policy documents and dedicated government organization at ministry level, staffed and budgeted to reverse this persistent trend of land degradation, which should count positively in the understanding of the dynamics of the potential for apiculture in
Ethiopia. Indeed, there have been success stories in different parts of the country. Following the construction of major hydro-dams, the Ethiopian government has been mobilizing huge rural population for soil and water conservation aiming at improving the management of watersheds of these major rivers in order to avoid or minimize the danger of siltation of newly constructed big and expensive dams. The special quality of apiculture is the fact that apiculture is both a means and an end of the watershed management, enclosure, reforestation programs, and promotion of the protected areas. As an end, the apiculture industry is beneficiary of the recovery and rehabilitation of the vegetation system. As a means, honey bees should and could be taken as pollinators to enhance the success of the land and forest reclamation efforts. The productivity impact of pollination service of honey bees, which has never been recognized at policy level in Ethiopia, in crop production, fruits and vegetation and recovery of vegetation system is substantial, which could range between 10% and 50% for different types of crops, fruit trees and vegetation types, (discussed in detail in the body of the present work).

Moreover, such estimates do not explicitly consider the scope that the country could have achieved in production through improving productivity within the existing vegetation coverage and intensity and through improving the intensity and coverage of vegetation.

Thus, not only is the existing potential immense and significantly underutilized, but there is large potential to enlarge the potential for Ethiopian apiculture with wider scope to make substantial difference even in the near future (2-3 years). What it calls for attaining synergetic advantage is strengthening the coordination and promoting an integrated approach in the massive soil and water conservation efforts in the country being promoted by different ministers and organizations, including Ministries of Agriculture, Ministry of Water and Energy, Ministry of Environment and Forest and a number of non-governmental organizations. In view of this dynamic considerations, it is time to recognize the fact that the Ethiopian apiculture is seriously underutilized.

Although, the present study could not come up with documented evidence about the history of Ethiopian beekeeping, one can safely state the fact that beekeeping in Ethiopia is an ancient tradition which stretches back into the millennia of the country’s old history. Indeed, there is no segment of the Ethiopian population which does not share this historical technology.
Beekeeping is an important activity for many rural people and is also carried out in homesteads in all parts of the country. It is the most widely spread practice in the farming communities and is a traditionally important off-farming activity for an estimated 1.7 million rural households (MoARD, 2007). Honey and beeswax also play a big role in the cultural and religious life of the Ethiopian people. This historical and traditional knowledge can serve as a spring board to disseminate latest technologies as disseminating a familiar technology is more likely to be easier than disseminating an entirely new technology.

Owing to the level of development and/or level of chemical application in the economy, Ethiopian honey is organic, mainly because the honeybees produce honey from forest plants and honey plants growing in areas that are free from inorganic fertilizer and chemical application. This fact of organic honey production should be taken as one competitive advantage that policy makers and other decision makers should give due attention. Since the 1990s or so, organic products are transforming from niche markets into mainstream markets owing to different developments in the markets of developed economies (MacKinnon, 2013, p.5). High income levels and increasing health awareness and increasing concern and knowledge about the need to take care of 'mother nature' are factors that have been contributing to expansion of the demand for organic products in general and organic honey in particular. Not only is the demand for organic honey increasing, but appropriate institutions of standard and regulatory framework are established in all developed economies to enforce the importation and distribution of organic, quality and residue-free bee products. Thus, the future is for organic honey (MacKinnon, 2013, p.5).

Moreover there is large potential for product differentiation of different bee products that creates wider opportunity for the country and exporters to mobilize substantial foreign earning through exporting more of the same bee products and through exporting high value bee products.

Yet, with these potential, there are peculiar features of apiculture which makes it more attractive to less developed countries like Ethiopia.

First and foremost, apiculture is not only environmentally friendly economic activity, rather it is an agent of environmental rehabilitation through its pollination services. If not all, most other
development industries and projects are evaluated whether or not they have large or small impacts on the environment. On the contrary, honey bees as pollinators promote and enhance the productivity of reforestation process, contributing to the success of soil and water conservation, which means beekeeping can be promoted as a strategy to promote reforestation program.

On the other hand, apiculture reconciles the inherent conflict of interest between the present and future generations. One of the problems that enclosures, preserved areas like natural parks, preserved natural forest areas are facing is the encroachment of these preserved areas by surrounding communities. Grazing, collecting fuel woods, cultivating preserved areas do compete against the very reason why the preserved areas are established. Since there is good reason for preserving the protected areas, one has to ensure that they are not encroached. Essentially preserving the natural resources and forest areas is an interest of the future generation. On the other hand, surrounding communities have the right to live and lead a sound life by exploiting whatever resource can manage to exploit. The conflict is difficult to reconcile because the conflicting entities have the legitimacy to exist and to live. Apiculture can reconcile the interest of both the present and future generations.

The other quality of apiculture is its peculiar feature of simultaneous achievement of a number of objectives. It is a common knowledge and fundamental law of economics that there are many objectives to be met in the face of scarcity of resources. For instance, aiming for export earning usually requires introduction of capital intensive technologies which, however, may not be consistent with the objective of employment creation. Growth objectives may not necessarily be compatible with employment creation and alleviation of poverty. Indeed, the entire political economy issues of societies and economies dwell on this conflict of interest among different segments of societies. While this is a general rule and challenge of development process, apiculture can simultaneously achieve poverty alleviation, employment creation and export earning without an inherent conflict of interest among conflicting social objectives.

Development of the apiculture industry can create substantial employment and hence mitigate the ever growing rural youth unemployment. The space requirement for beekeeping is quite small compared with other industries, be it livestock or cereal production. Moreover, the nature of land, slope and depth of soil required for promoting beekeeping could be different and less
from that required for other agricultural practices. Honey bee's consumption of nectar and pollen does not exhaust rather complements and supplements the regeneration of the vegetation coverage through its pollination service. The honey bee does not graze the grass nor does it compete for cultivable land. Whatever agriculture is required the honey bees do not compete for soil or water or for grazing, rather apiculture can be promoted as an integrated business. This income gain and poverty reduction through such employment creation simultaneously contribute to export earnings.

Furthermore, apiculture compared with most other industries does not require more resources in terms of land, water and financial capital. It is a sector which is relatively easier to promote to alleviate poverty. Beekeeping can be promoted without much financial investment through an effective extension service. Moreover, even the knowledge requirement to promote beekeeping is small in view of the fact that there is long tradition of beekeeping. Building on what exists is easier than creating something from the scratch.

Thus, the potential of apiculture as an industry to mitigate poverty, to create employment, to increase and diversify export sector is substantially large. Ethiopia's potential for developing the apiculture industry is not only large but there is quite large opportunity to enlarge the potential itself. Moreover, development of the Ethiopian apiculture is consistent with and can and should have been a good catalyst to the prime objectives of the Ethiopian government of poverty alleviation, employment creation, diversification of export sector as well as with the green economy policy. Therefore, Ethiopian apiculture not only should it have been a priority industry so far, but no time should be wasted further to make it a priority sector of development in the country.

Indeed, the Ethiopian policy and the large outreach created to reach the farm household should be counted as institutional opportunity to develop the Ethiopian apiculture. Indeed, the development and transformation of the Ethiopian apiculture is consistent with the agricultural and rural transformation policy, export diversification desire and policy, the aggressive water and soil conservation works of the country and basin developments of the major Ethiopian rivers, development and management of the Ethiopian preserved areas and enclosures, poverty
reduction, employment creation strategies of the Ethiopian government. Moreover, the fact that there is very high outreach of the Ethiopian farm households, through woreda level constitutional decentralization, kebele and organization of the farm households in the group of 5 or so has created the higher degree of outreach, which could be effectively used to transform the Ethiopian apiculture and to ensure a system of traceability and accountability in the country, and control the opportunistic behavior of individuals to adulterate honey and bee wax.

If indeed, there is such potential, the real question is then why is that the sector did not get due attention that it deserves? Why has the Ethiopian apiculture failed to be a sole source of income for farmer beekeepers and why it failed to attract private investment?

3. Honey Production and Productivity in Ethiopia

One of the important questions to be addressed is, how much of each bee product can Ethiopia deliver to the global markets?

One of the drivers of global competitiveness is the capacity to deliver a volume of shipment which makes international procurement economical such that it attracts the business interest of global buyers, meeting quality requirement. Moreover, price competitiveness essentially determined by productivity of the production of bee products. Thus, this sub-section attempts to address the question of how much Ethiopian can participate in the export market through assessing the production and productivity of the Ethiopian apiculture from the point of their contribution towards global competitiveness.

There are two operators in the Ethiopian production system, the farmer/pastoralist/ beekeeper and the private investor. So far the sole producer of bee products in Ethiopian apiculture has been the Ethiopian farmer, and partly the pastoralist who does beekeeping as supplementary off-farm activity. Though the potential production from private investment is quite large, still the contribution of the private sector has been negligible at its best. Thus we discuss the production system considering these two operators.
Production of Honey and Bee Wax in Ethiopia

Ethiopia is a country with the highest honeybee population in Africa and a honey production estimated at 50,000 metric tons per annum, which constituted about 11% of the country’s production potential. It is the 4th largest producer of beeswax and the 10th largest honey producer in the world. Ethiopia produces around 23.6% and 2.1% of the total African and world’s honey, respectively (FAO; 2014).

According to CSA data, the total honey production in Ethiopia has been a small portion of the estimated potential, indicating the state of underutilization of the existing resources. As can be seen from the following figure, the best year of production were in 2006 and 2010 with 51,000 tons and 53,000 tons, respectively.

Figure 8. Ethiopian honey production, in tons, 2005 to 2013

![Ethiopian Honey Production, in tons, 2005-2013](image)

Source: CSA, different years

The average production for the period was 44.4 thousand tons of honey for the last ten years with average annual rate of increase in production of 2% since 2005.

As can be noted from the following table, the lion's share of honey and hence bee wax production has been from traditional hives. The share of frame bee hives which are believed to
be and expected to be more productive has been low, though improving over the recent years from less than 1% to about 5% in 2013.

Table 1. Share of Different Types of Beehives in percent for the period, 2005-2013

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional hives</td>
<td>98.63</td>
<td>98.60</td>
<td>97.70</td>
<td>97.37</td>
<td>96.71</td>
<td>96.38</td>
<td>95.57</td>
<td>95.96</td>
<td>94.37</td>
</tr>
<tr>
<td>Intermediate hives</td>
<td>0.47</td>
<td>0.51</td>
<td>0.63</td>
<td>0.67</td>
<td>0.72</td>
<td>0.81</td>
<td>1.63</td>
<td>1.06</td>
<td>0.95</td>
</tr>
<tr>
<td>Frame Beehives</td>
<td>0.90</td>
<td>0.89</td>
<td>1.68</td>
<td>1.96</td>
<td>2.57</td>
<td>2.81</td>
<td>2.80</td>
<td>2.98</td>
<td>4.68</td>
</tr>
</tbody>
</table>

Source: CSA, different years

Though the percentage share of frame hives remained low and less than 5% of total bee hives, the distribution of frame hives have been increasing at an increasing rate.

As can be seen from the figure below, the supply of frame hives have been increasing at an increasing rate in the period 2005-2013. Indeed, the number of frame hives distributed across the country has increased by more than six fold from the order of 36,200 in 2005 to more than 230,000 in 2013.

Figure 9. Distributed Number of Frame Hives in Ethiopia, 2005-2013

Source: CSA different documents for respective years
There are indications that the actual distributed number of frames are significantly higher than these CSA data. Indeed, the preliminary data the research team collected from the four regions, Oromia, SNNP, Amhara and Tigray show the fact that the distributed number is by far larger than those reported by CSA data.

Since the CSA data, which is suspected for understatement, clearly show the fact that the resource flow to the Ethiopian apiculture is indeed encouraging, if indeed these modern hives, which are expected to be more productive than the traditional and transitional hives, were effectively and efficiently managed, which is not the case as discussed in the next section of this document.

**Regional Distribution of honey production in Ethiopia**

All regions have the flora and fauna for beekeeping though with differences in potential owing to the differences in vegetation type and intensity. Even though honey is produced in almost all parts of Ethiopia, the most important honey and beeswax producing regions in Ethiopia are Oromia, SNNPR, Amhara, Tigray and Benishangul-Gumuz. These areas hold the majority of honey bee population in the country; with distinctive types of honey coming from different regions. Probably the most famous and characteristic in terms of color and taste comes from Tigray. The honey’s pure white color (due to bees foraging on Tebe plant [Basium clandiforbium]) and its low moisture content have garnered fame; some people even believe that this honey has medicine like proprieties. Similar in terms of color, white honey is produced in the Highlands of southwest and southeast Ethiopia, but it does not have the same prestige and renown as Tigray’s honey. Yellow honey, also referred to as multi-flora honey, is also commonly produced and available in almost all regions of Ethiopia. It is harvested in different parts of the country and gets its color from the various crops produced(Miklyaev, et al, 2013).

The third type of honey is referred to as Lalibela honey and is produced in central Ethiopia. Its main characteristics include light color and fine creaminess that come from bees foraging on acacia trees. This particular honey variety is well known and in high demand in the domestic market (Agonafir, 2005).
Somewhat less-appreciated varieties of Ethiopian honey are dark brown in color and bitter in taste, making them less popular for consumption. They are produced in areas with altitudes of 1,200 to 2,400 meters (m) above sea level (Miklyaev, et al, 2013).

The last type of honey widely produced and marketed is crude red honey. Its main usefulness and popularity among beekeepers comes from its low quality requirements, because tej houses buy it in crude, totally unprocessed form to produce an Ethiopian type of mead (Agonafir, 2005).

In terms of quantity, the honey belt zones of Western and Southern parts of Ethiopia produce the lion's share of bee keeping products. There are abundant apicultural resources, particularly in the South Western and South Eastern zones of the country including zones like Jima, Illubabor, Bale, West Wellega, Keffa, Benchi Maji, Sidama and Gedeo zones. There is ample moisture, with almost nine month rainfall. The top soil is not yet eroded. The remaining natural forest coverage of the country is largely located in these parts of the country. There is large concentration of plantation of cash crops like coffee which has very wide opportunity for an integrated agriculture, cash cropping and apiculture. Honey bees could have enhanced the productivity of such cash crops like coffee and it would have been possible to harvest specialty honey, coffee honey and others.

Although almost all regions produce honey and bee wax, there is significant variation in the volume of production. Based on the available data, for the last ten years Oromia regional state has been the leading producer of honey. As can be noted from the following figures, production and supply of honey by regions shows that Oromia accounts for over 51% of the bee colonies and 38% of the Honey production, followed by Amhara which accounts for about 21% of the colonies and 26% of the honey production.
Figure 10. Regional share of Beehives in 2013

The Southern Nations, Nationalities Peoples Regional State, on the other hand, accounts for about 18% of the bee colonies and 18% of the honey production. While Tigray and Benshangul accounts for 5% and 4% of the total bee colonies, and 8% and 7% of the total honey production, respectively.

Figure 11. Regional Share of Honey Production for 2013

Source: CSA
The majority of beehives are found in Oromia regional state followed by Amhara and South Nations and Nationalities People (SNNP). The three major honey producing regions in Ethiopia are Oromia, Amhara and SNNP. In each of these regions there are zones which are endowed with high potential for the production of bee products. From Oromia, Jimma zone accounts 20% of the total production followed by Illuababora (14%), Bale (10%), West Welega, West Showa, Guji are the major ones. From Amhara, North Gonder accounts 37% of honey production followed by South Gonder (12%), East Gojam (11%) and West Gojam (11%) . Also from SNNP, South Omo accounts 16% of the production followed by Bench Maji (13%), Gammo Gofa (12%), Kaffa (11%) and Hadiya (9%).

**Honey and Bee Wax Productivity in Ethiopia: Whether Beekeeping Can be a Sole Source of Income**

One of the strategic questions is whether or not beekeeping can be a sole source of income. So far, beekeeping has been a source of supplementary source of income, one type of off-farm activity in rural Ethiopia. If indeed, the sector has a supplementary role, it was natural for the policy makers to give it corresponding level of attention. But should the country move along with this mentality? Can't we transform the Ethiopian apiculture to play a pivotal role in poverty reduction and export earnings for the country?

One of the main reasons for low performance and low productivity of the Ethiopian apiculture is the low policy attention given to the sector. There have been different manifestations for this low attention given to apiculture. The fact that the production system is dominated entirely by farmer bee keepers, and low or absence of private investment in beekeeping, dependence on traditional hives, etc. are indeed outcomes of the low attention given to the Ethiopian beekeeping.

In general there has been low attention given to the Ethiopian livestock sector compared to the cereal and cash crop production. Recently, the attention given to the Ethiopian livestock is increasing and it is organized under a state minister under the Ministry of Agriculture (MOA). Yet, the attention given to apiculture compared to the other livestock sector has been low as can be seen from the allocation of extension time to the farmer.
The Ethiopian government has been implementing different packages in the livestock sector but the proportion of the package for honey bee development has been low and rather decreasing instead of increasing over time.

Figure 12. Number of farmers who Practiced Different Livestock Extension Packages by Type, 2005-2013

Source: CSA

The attention given to dairy, beef/meat/mutton/ and poultry developments has been consistently higher than the extension packages provided to promote apiculture.

From the explorative study of the present work, it was understood that there are no dedicated extension workers at Tabia level except in Tigray. The agricultural extension system is suffering from low motivation and high turnover and yet that level of attention and performance is missing for apiculture. Apparently, officials do recognize the importance of the apiculture, but the actual attention they give in terms of resource allocation has been low.

One reason for low attention is the view that beekeeping can only be a supplementary source of income, not a sole source of income. Owing to this perspective of supplementary off-farm activity, the potential of the Ethiopian apiculture in reducing and/or eradicating absolute poverty has been undermined.
Apiculture pays more if indeed it is promoted as one of integrated agriculture. In fact, this is a special merit of apiculture. Apiculture essentially does not compete for land or any other resource with any other industry. However, the fact that apiculture has high degree of complementarity with other agricultural industries, does not mean it should be treated as a supplementary source of income. Instead of this peculiar characteristics of high degree of complementarity making apiculture highly popular and emerging industry, it seems serving the sector otherwise. The underlying factor is the low productivity of the Ethiopian apiculture.

Indeed, productivity is one of the major and sustainable factor that determine the relative performance of different variables that drive global competitiveness. Price competitiveness, capacity to deliver the volume that can attract global buyers and build the image of a reliable supplier, are directly related to productivity. The capacity to satisfy domestic demand which currently competing against exports is determined by productivity of production of both honey and bee wax.

Table 2. Honey Productivity by type of hive, (kg/hive, 2005-2013)

<table>
<thead>
<tr>
<th>Type of hive/Year</th>
<th>Honey Productivity (kg/hive), 2005-2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Productivity for all</td>
<td>10</td>
</tr>
<tr>
<td>Traditional hive</td>
<td>10</td>
</tr>
<tr>
<td>Intermediate hive</td>
<td>13</td>
</tr>
<tr>
<td>Frame hive</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: computed from CSA dataset

Definitely the overall productivity of honey production which has been in the range of 8kg to 10kg per hive in the period 2005-2013, is extremely low compared with world average of 45kg. One of the reasons for such low productivity is the fact that Ethiopian apiculture is dominated by traditional beekeeping technology, which remained unproductive and without visible innovativeness for centuries.
Yet, though there is relative difference between the different types of bee hives, in general the productivity of frame hives has been low throughout the study period, 2005-2013. The highest recorded productivity is only 21kg per hive, which, however, is low even considering only one time harvest in a year, let alone considering the possibility of multiple harvesting. Compared against world average, of an average of 44kg and China's recent years average of above 50kg per year, the Ethiopian average productivity of frame hives of about 20kgs per year is quite low.

The rapidly increasing distribution of frame hives (an average increasing rate of 29% per year for the period, 2005-2013), did not bring about an improvement of productivity of honey in the same period.

This shows the fact that the sole reason of opting frame hives is not achieved in the given period. The problem is not, however, with the hardware of the technology. The frame hive have a well-established truck record across the world including the developed economies. The problem area for investigation should be in the transfer of soft knowledge along the distribution of the hardware, which is related to the capacity and performance of the agricultural extension system of the country.
The relative differences of productivity performance of the regions in the country convey the importance of institutional factors in explaining differences in productivity. The productivity of the naturally endowed regions is lower than those regions which are less endowed in terms of natural, moisture, soil, vegetation coverage.

The average productivity of the regions with the 'honey belt' zones has been lower than that of Tigray.

Table 3. Regional Distribution of Honey Productivity, (Yield (in kg) per Hive per year, 2005-2013)

<table>
<thead>
<tr>
<th></th>
<th>Productivity (yield, in kg) per Hive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>10.35</td>
</tr>
<tr>
<td>Amhara</td>
<td>8.10</td>
</tr>
<tr>
<td>Oromia</td>
<td>10.93</td>
</tr>
<tr>
<td>Benshangul-Gumuz</td>
<td>3.80</td>
</tr>
<tr>
<td>SNNP</td>
<td>12.78</td>
</tr>
<tr>
<td>Harari</td>
<td>7.20</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>3.28</td>
</tr>
</tbody>
</table>

Source: CSA, different years

The moisture stressed region with large land degradation, with very little coverage of natural forest, with relatively shorter and unreliable rainfall supply has exhibited relatively higher yield per hive per year, higher than all regions and the country average except instances of two years, when the average productivity of SNNP was higher than that of Tigray.
The other regions, mainly Oromia, SNNP and Amhara were expected to be more productive than that of Tigray, because of their large endowment of forage resources and size of honey bee colonies. The main reason for such difference in productivity lies in the commitment and institutional arrangement of the agricultural extension system. The Tigray's regional state has committed a bee keeping extension worker in every Kebele, which is not the case in the other regions up to this year. If indeed, these regions consider to seriously improve their respective apiculture, then they can bring about substantial improvement in yield per hive per year through learning from the experiences from Tigray and elsewhere.

The fact that the average productivity of Tigray regional state has been higher than that of the other regions, does not and should not be taken for best performance. There is quite wide room for improving the productivity of the apiculture industry in Tigray through enhancing apiary site development and hive(colony) management.

Indeed, if something is not done to transform the productivity of the Ethiopian apiculture, the sector will remain playing a supplementary role. The scope for improving productivity per harvest per hive is indeed large, that deserves the attention of all stakeholders of the apiculture industry. Instead of evaluating the income generating potential of apiculture through
transforming the existing low productivity of the sector, the sector has been evaluated taking productivity as if it is an exogenously given variable, implicit assumption, of course. The scope for making dramatic improvement of productivity is wide and attainable.

With this level of productivity, the scope for expanding for exports of even the traditional bee products is limited. Moreover, with such productivity the capacity to deliver large volume of honey and bee wax at predictable and consistent time table is difficult, which is one of the drivers of competitiveness.

Broadly, there are two areas where substantial improvement in productivity can be achieved. One is hive selection and colony management. The other is developing and managing the apiary site to ensure sufficient supply of bee forage along the beekeeping or flower calendar of a given apiary site. Within each category and along the entire production process, productivity is affected by a number of factors. It is sensitive to bee species selection, forage supply and management, type and quality of bee-hive, bee hive management for any problem including bee diseases, cleanness of hive site, degree of smoking during inspection and harvesting, timing of harvesting(ripeness), cleanness of the harvesting process, transportation of honey combs from harvesting site to extraction site, management of the extraction process, the quality of the extraction technology, storage, packing and transportation(Gallmann and Thomas,2012, p 15).

All factors that affect the quality of honey can be taken as productivity variables. Low quality or quality deterioration increases waste and reduces market value and leads to a loss of market image.

**Hive Technology Selection and Colony Management**

Regarding selection of hives, instead of comparing the development of the apiculture as one policy instrument of poverty alleviation, the relative prices of hives were considered as a criteria for selection of bee hives. Recognizing the existence of only three types of hives, traditional, transitional and frame hives, the frame hives were rated to be more productive but expensive than the other two. Indeed, the cost of the traditional and transitional hives is almost zero except the labor of the beekeeper in collecting and constructing these locally made hives. As may be recalled discussions above on productivity differences of these hives, indeed, frame hives are superior in terms of productivity.
It is to be noted that there is a fourth type of hive, which is more likely to be more productive than the vertically structured frame hives, which is innovated by an Ethiopian farmer from Becho woreda of Illu Abo Bora zone, Oromia, which is in the process of being patented. Irrespective of the patent right, this type of hive has clear advantage over the vertically structured hive. It is more conducive for inspection and harvesting, which is one factor that determines productivity. It involves less smoking, which is one quality parameter of honey.

If the decision variables are productivity and financial costs, what weight should be given to productivity and financial costs in the selection of bee hives? Without addressing this question explicitly, much weight has been given to financial costs instead of productivity. In view of the potential of apiculture in alleviating poverty and its contribution to export earning, the major criterion should be productivity not financial cost.

Even if we give weight to financial costs, should the comparison be between the relative cost of hives or the comparison between the relative benefits and costs of beekeeping compared with other interventions, application of chemical fertilizers to produce cereal crops or buying other livestock or any other policy intervention to alleviate poverty? The correct approach should be to compare the relative benefits and costs of different policy interventions to alleviate absolute poverty in rural Ethiopia.

Poverty alleviation is a declared government policy and one of the MDGs, which is embraced by the Ethiopian government. One of the strategies pursued to alleviate poverty in rural Ethiopia is to ensure asset ownership of poor households, including livestock ownership, like oxen and cows. The other is through distributing chemical fertilizers in order to enhance land productivity of the Ethiopian farmer. The cost of the choice of bee hive should then be compared with that of the costs and risks of other livestock assets and that of other agricultural inputs. In fact, oxen is complementary asset to cultivation of cereals. So the cost of developing the apiculture sector should be compared against the costs of intervention areas in cereal production and other livestock development.

The cost of one frame hive is in the order of Birr 2000, with two supers, it may increase to Birr 5000. The cost of a colony differs from like zero in the South West and about Birr 3000 to Birr 5000 in Tigray. Accessory inputs may cost another Birr 2000, which could be used for running
and managing a number of hives. The total cost of single frame hive could add up to about Birr 10,000, which definitely is less than the price of an ox. Given well managed, it is possible to recover the cost in one year or at most two years of harvest. Moreover, the cost of having productive bee hives should be compared against the productivity gain and its financial implications, which is discussed further in the following sections.

Having this in mind and considering the productivity gains, discussed hereafter, we urge the government and other stakeholders that the prime strategy should be to enhance productivity. Hence the governing technology selection should be productivity not financial costs. Given this, we urge the government to speed up the process of patenting the claimed innovation by Ato Mohamed Fiseha and promote this type of hive instead of the others. Irrespective of the patent status, we urge the government to go for promoting this new hive, which has a virtue of combining the merits of both the vertically supered hive and the transitional hive.

Yet the source of the productivity gain is not the hardware as such. The focus so far has been wrongly on the physical distribution of the frame hives not on creating the required human capital that could make the best use of the frame hives. The hardware technology was meant to enhance the productivity of the human factor. Hence the focal point should have been the human factor not the distribution of the wooden hive box. Since the major agent of the distribution of these hives have been the government and the fact that the present study is primarily meant to serve the government, it would be wise if the government could examine the effectiveness of the extension system, which is responsible for the effective dissemination of the required knowledge about beekeeping. Basically, the reason for the establishment of the existing long and extended agricultural extension system is to create the human capital not to distribute goods, including bee hives. The distributed inputs like bee hives, fertilizers, improved inputs and others by themselves do not secure productive use of the same inputs. Thus, the focus should be on the institutional arrangement which was meant to transmit and disseminate the required knowledge, skill and awareness of effective use of the selected hives.

**Multiple Harvesting through Developing and Managing Bee Forage Resources**

There is quite large potential for multiple harvesting in the country, which did not get due attention at all levels of the Ethiopian apiculture. There is quite large potential and wider
opportunity for promoting multiple harvesting in almost all parts of the country, though there will be differences in potential and the level of effort required to attain so. Honey bees depend upon diverse vegetation for their forage. The honey bee forage include a mix of grasses, shrubs and trees, which have different life cycles, requiring different moisture level, and different depth of the top soil. Thus, this gives a wider policy and decision space to promote bee fodder in each geographical apiary site. The fact that there are more than 800 endogenous plant species in the country that have been growing and can easily be nurtured in the different agro-ecological zones of the country, also gives another decision space as to which species to cultivate and nature in each site.

As can be observed from the following figure, indeed there has been multiple harvesting in the country. For all types of bee hives, the frequency of harvesting has been between one and two.

Figure 15. Trend of average frequency of harvest of honey per year

![Trend of average frequency of harvest of honey per year](image)

Source: CSA

In all the years of the study period, 2009-2013, on average the harvesting period between once and twice. The average tendency falling between single and double harvesting show the fact that there are sufficient number of single and double harvesting to push the average to fall in between
and cases of triple and quadruple harvesting in some cases. If indeed, there is such tradition, the direction should be to supplement and support this traditional experience with knowledge and resources to increase the frequency of harvesting to four or more times a year and to ensure each harvesting period is equally productive. The opportunities for multiple harvesting could differ from region to region, from agro-ecology to an agro-ecology and for that matter from an apiary site to another site. It also may differ among beekeeper's knowledge, commitment and level of effort. Recognizing such differences, the direction should be to boost multiple harvesting as much as possible and creating the space for the operators to play in accordance to their will and capacity.

So far there has not been aggressive intervention to promote multiple harvesting through designing, developing and implementing a flowering calendar and hence a calendar for multiple harvesting not only for each region and agro-economy but for each site of the country. With well designed and concerted and coordinated effort it is possible to develop equally productive multiple harvesting of honey and bee wax as well other high-value bee products.

Definitely, the potential for multiple and equally productive harvesting is quite large in the South West and South East of the country, which are defined as the honey belt of the country.

There are perspectives (even shared by expertise in the apiculture industry) that argue that the ever greenness of the 'honey belt' zones of the country does not guarantee ever flowering season. Indeed, for apiculture, what is required is ever-flowering not ever-green vegetation cover. Yet, what is missing is the possibility of the fact that with small effort it would have been possible to ensure ever-flowering throughout the year. There are sufficient number of endogenous species, with different flowering calendar which, are growing in almost all parts of the country. There is ample supply of moisture, rainfall, and virgin land that could have been utilized for continual multiple harvesting of bee products, 4 to 6 times a year in the honey zones of the country, preserved areas and enclosures areas in particular.

There is ample experience with multiple harvesting even in the moisture stressed regions. Though the main harvesting seasons for Tigray and Lalibela honeys are October through
December there have been ample experiences of an additional harvest period for white honey in June and July.

Along with soil and water conservation efforts, it is possible to invest, develop and manage forage sites even in the moisture stressed areas, which is one of the principal factors that determine productivity of bee products. There have been massive soil and water conservation works in the country for some time. Ministry of Agriculture and respective Bureaus of Agriculture have been undertaking soil and water conservation works in many parts of the country for some time, for more than a decade in some regions. Moreover, following the construction of large hydro dams, there has been massive mobilization of the rural population for soil and water conservation as well as re-forestation works in the watersheds of the major rivers, like Abay, Tekeze and others. With the massive soil and water conservation works much could have been achieved if such efforts were integrated with apiculture, which could have made the communities who are undertaking these works beneficiary from these watershed management efforts, which in turn could have contribute to the success of such efforts. If indeed, there were concerted, coordinated and integrated soil and water conservation and plantation, it would have been possible to cultivate and grow bee forages, which could have served a win-win situation for the development of the apiculture sector and the rehabilitation and re-forestation of the water basins of the major rivers. Such apiary site development across the basins of the major rivers of the country could have increased productivity of each harvest and enabled multiple harvesting which could have justified for apiculture as sole source of income and feasible commercial venture.

In fact it is possible that apiculture could be a more preferred agricultural occupation in marginalized land for crop production. Cultivating crops in marginalized lands contributes to further soil erosion and land degradation, ever decreasing trend of crop productivity. On the other hand cultivating bee forages not only serves as an alternative sole source of income, it contributes to fast rehabilitation of land, recovery of endogenous vegetation cover, which would not only increase the productivity of beekeeping but also creates the condition for promoting integrated agriculture, like growing livestock feed, planting cash plant crops, fruit trees, etc. The critical factor for Ethiopian apiculture, therefore, is its productivity. If commensurate effort to enhance productivity is not exerted, then the country will not benefit from this massive resource.
If apiary sites are developed, through water and soil, conservation, development and management, then substantial improvements in productivity could be achieved.

If indeed, the policy focus is to promote productivity of the Ethiopian apiculture, the industry can contribute substantially in reducing and eventually eradicating absolute poverty, and boosting export earnings.

As a direction, the logic and its possibility is open to many places in the country. It is even possible in the moisture stressed, but at higher level of effort, in planting forage types that blossom during different seasons. This is more challenging than done, but doable. There is no detailed research based knowledge about the productivity of each forage species in producing the required nectar and pollen. So the estimation of the carrying capacity will remain trial and error up until the government develops the research capacity in this respect.

**Scope for Improvement in Productivity**

Given adequate capacity and capabilities are created to develop and manage apiary sites, it is possible to make significant changes in productivity through equally productive multiple harvesting from two to six times a year, depending upon the agro ecology of the country and the level of exerted effort.

The global average yield per hive per year was in the range of 40kg to 45 kg for the period 1993-2010 and the lowest record was 37.5kg per year per hive in 1992 (FAO and WTO data set). Moreover, the average of the largest producer and exporter of honey (China) has reached 51kg for the year 2012. The Ethiopian average productivity has been lower than the lowest average recorded in the period 1992-2010. If indeed, Ethiopia is to compete with countries like China, then it has to aim to achieve the average productivity they have achieved. To achieve the average attained by others, definitely, Ethiopia must aim at higher performance. Normally averages include both lower and higher performance. If one aims at the average, then it is more like to end at lower performance.
Experts and relevant literature state the fact that there are ten frames in each of the frame box and each frame can produce 3 to 4 kgs of honey. Yet, all ten of the frames may not be filled in with honey. Some of the spaces are occupied by brood and pollen. Hence it is assumed that 50% of the frames would be occupied with brood and pollen. In a resource full apiary site it is possible to harvest to the tune of 40kg per super per harvest. If we can take the lowest, then it is possible to harvest 15kgs per harvest per hive per super.

In a well developed and managed apiary site with adequate forage, it is possible to add up to 3 supers, each producing about 15kgs. Indeed there are such hives with three supers in few sites of the honey belt zones, example in Jimma zone, suburb of the city. If we settle for 2 supers instead of 3 supers, the productivity per hive per harvest would give 30 kgs per hive per harvest.

If one can think of multiple harvesting of equal productivity (which presuppose well managed apiary site), then productivity can be doubled, tripled and even quadrupled.

Even Ethiopia has a tradition of low productivity for long period of time, there are success stories that the country should emulate and disseminate their knowledge and experiences of those success stories.

There are a number of beekeepers who are exceptionally productive to the extent of harvesting 80kgs per harvest through harvesting twice in a single harvest season in Addis Ababa. There are farmer beekeepers who managed double harvesting in a single harvest season both in Tigray and Oromia. A farmer beekeeper in Hagere-selam, Tigray, who cultivated bee forage and manage it in his homestead, has managed to harvest twice per a given harvest season, earning about 40-50kg per harvest per hive. Of course, these beekeepers are not and cannot represent the productivity performance of the country. On the other hand, a strategic development endeavor is all about changing the average performance. So the exceptional success stories shed more insight than the average figures of the country or for that matter other countries.

The real question is what does it take to manage an apiary site that enables multiple harvesting, three to four times per year?
Generally from the different success case stories, beekeepers have different competencies. Some of them focus on the hive management. Others are quite exemplary in developing and managing their homestead apiary site, which enabled them doubled harvesting in a single harvesting season. If indeed, there is sufficient forage resource in a given apiary site, it means one can harvest twice or it could mean that it is possible to increase the supers to three.

The other interesting case was through managing their apiary site or taking advantage of the natural endowments, bee keepers were increasing their productivity through multiple harvesting.

**Potentials and Opportunities for private Investment in Beekeeping**

It seems that one of the manifestation of the low attention given to apiculture is the fact that there have not been a visible private (Commercial) investment in beekeeping. Formally, there are few registered investors in beekeeping. The study team had a chance to visit some of the apiary sites of the few registered and who has taken land for apiary site. Yet none of them have invested much in to develop their apiary sites. The apiary sites of farmer beekeepers, who did not register as investors and hence did not get the privilege of getting dedicated apiary site is by well developed and managed than that of the apiary sites of the investors.

So one of the problems of the Ethiopian apiculture has been the fact that the private sector is not yet up to apiary.

One area where the private investment could be promoted is to integrate apiculture with large commercial farms, like coffee plantations, sesame farms, other oil seed farms, large scale fruit and vegetable farms. The advantages clearly are two.

First and foremost honey bees as pollinators enhance the productivity of their farms. In fact commercial farms of most of the major cash crops and fruits can benefit tremendously from an increment of productivity of their production. For instance, productivity of coffee, the major export crop can increase by the range of 17-39% due to honey bee pollination. Indeed, the financial gain of such increase in productivity should be attractive to coffee growers, if such awareness is created.

Moreover, it is possible to produce coffee specialty honey, which attracts premium price in the export market. The productivity of bee products of coffee apiary site is likely to be high owing
to the diversity of vegetation of coffee plants. It is most likely the minimum harvesting time is two, during the main season where most plant species blossom and hence produce poly-floral honey and during the time coffee blossoms, when it is possible to produce coffee specialty honey. We said the minimum harvesting time is two, because with little effort to cultivate supplementary bee forage, in fact even managing with the coffee shed trees alone it is possible to harvest three to five times per year, which fetches quite large money to the investor. Imagine, 200,000 hectares of commercial coffee plantation areas and assume a conservative 10 colonies per hectare, which would mean two million colonies in the entire large commercial plantations. Assuming 15 kgs per super per harvest and assuming two supers per hive, it is possible to produce 60,000 tons of honey in a single harvest and double of it in double harvesting. This definitely doubles the existing production capacity of the country, which would mean Ethiopia could increase export volume by that amount, placing Ethiopia to be one of the fee major players in the export market.

The possibility for integrated agriculture and promotion of the pollination service is wide. Yet, there will be different potentials for integrated agriculture. The potential for integrating apiculture with coffee plantation is great. The density and diversity of vegetation is relatively higher than for instance in sesame farms. The density and diversity of sesame production is small in sesame production, because sesame production requires clearing the cultivable area. Thus the scope for multiple harvesting of honey and bee wax is limited, unless the investor deliberately invests on developing an apiary site from whatever land he/she has.

The scope for commercial or organized large apiary site is quite possible and recommended in the vicinity of protected areas, national parks, natural forests and enclosures, which makes the surrounding communities beneficiaries from the protected and preserved areas and reconcile the outstanding conflicts that exists in all or most of all the preserved areas.

Of course, doubling or tripling of production of bee products is not simple and straight forward. It requires knowledge, skill, and awareness of the investors. Moreover, it requires adequate supply of managers and professional beekeepers that can be employed by the private sector. The most challenging part will be to develop management of different apiary sites. It requires access roads to different sites of coffee plantations and other unforeseen problems and challenges. But
that is way development is. That is the way business is done. It involves ups and downs, failures and successes, learning from once mistakes and move ahead.

The same logic and possibility applies to other crops too. For instance, Sesame production and export is largest oil seed export of the country, involving large commercial farms in different parts of the country. It is said Sesame production could increase by 20% through honey bee pollination. The productivity gains from bee pollination of cotton, citrus and papaya, to mention few, are 10%, 7-23%, 10%, respectively.

Since the investment cost of beekeeping and extraction plants is relatively less expensive, the critical factor is not financial capital but knowledge capital and its management. The government may then take the initiative to create awareness and produce the necessary human capital in apiculture.

The other direction is to promote commercial beekeeping in different parts of the country. Potential investors and those in the area of apiculture, complain about the investment promotion instruments. Indeed, there is a dilemma as to how to differentiate commercial beekeeping from those who are not. The apparent criteria is on the number of hives or colonies. The critical factor in apiculture is not actually the number of bee hives nor the number of colonies. It is difficult to take the number of colonies because the number of colonies is a flow, a dynamic one rather than consider them as fixed assets. Moreover, what matters most is not the number of bee hives but their management that governs the worth of the investment. On the other hand, land grabbing and abuse of land has been one of the medium of corruption in the country, as repeatedly declared by the government. There is in built dilemma in the facilitation of investment and administration of land allocation for investment. On the one hand, there is every interest, policy and institutional system, meant to facilitate investment, which presuppose prompt service at all levels of the investment chain. On the other hand, there are procedures and systems of accountability meant to mitigate corrupted practices in land allocation. This dilemma would be more felt in the investment in apiculture, because of the fact that that the investment on fixed assets (mainly bee hives, extraction equipment) is large, compared with other investment areas.
Probably, post licensing monitoring of investment and holding investors for the investment facilities and incentives they enjoyed could reduce the incidences of corrupted practices in investment. That way, it would be possible to encourage a transparent and genuine investment and prompt service delivery in the investment process.

**Low or No Upgrading Strategies Towards Higher Value Bee Products**

Understandably one of the manifestations and outcomes of low attention given to the Ethiopian apiculture is the absence of upgrading and product differentiation efforts, despite the high potential for enhancing domestic income and foreign exchange earnings.

So far there has not been visible attempt to differentiate bee products in the country. Thus one of the limitation of the Ethiopian production system is the absence of attempts to differentiate bee products despite the existence of wide scope for it. Apart from enhancing a culture of management and leadership of productivity, the other critical factor that defines the dynamic competitive capacity of the Ethiopian apiculture would be the upgrading strategy or the road map towards production and exports of high value-addition. Indeed, there is very wide scope for upgrading into high values through different product differentiation strategies.

First and foremost there is wider scope to increase income (both off-farm income and business income) and export earnings through increasing the productivity of the production of the existing bee-products, honey and bee wax. There is wider room of exporting more through increasing productivity of honey and bee wax from the existing technologies and production sites. There is more room to earn more through playing with reliable supply at different seasons of the year, trying to take advantage of the winter season of the Northern hemisphere and taking advantage of niche markets playing with color, taste, odor of honey products.

There is wider room for product differentiation through branding of quality organic honey and bee wax, in the near future, playing with different colors, odor, and other attributes of the different types of honey produced in the country.

One area of diversifying the sector and hence expand employment creation opportunities is to diversify and increase specialization of the Ethiopian beekeeping. It is possible to think of queen
rearing as an independent business and area of specialization which may include or be based on selection of the bee species to each agro-ecology of the country and on the basis of the available types of endogenous species. Availability of a market for bee queen not only diversifies the employment opportunity, but it can contribute to improvement of productivity per hive per harvest and per colony per year.

One of the factors that enhances productivity is the availability of standardized beekeeping inputs and honey extraction equipments at competitive price. Less standardized inputs, including sub standard inputs can and do affect productivity and may expose the beekeeper to extra costs of alignment and loss of productivity.

In addition to multi-flora honey products, there is quite large potential for producing and exporting of more than ten specialty honey or mono-flora honey from endogenous plant species. Given, economic operators intervene at growing and nurturing different fodder species, it is possible to increase the types of specialty honeys and their productivity. There is large potential for multiple harvesting of specialty honey owing to the fact that the life cycle and growing season of many bee forages is different. Such specialty honey types fetch higher prices and have different niche markets, which could be additional dimension to competitiveness and gain market power.

Moreover, it is possible to start with the production of high-value bee products like propolis, royal jelly, bee venom, pollen and related others, which are high-value compared to table honey and bee wax. These high-value products essentially sensitive to scale economies. The higher the scale of beekeeping the larger the advantage. Thus, commercialization and increasing the size of the scale of beekeeping given the carrying capacity of a given apiary site becomes important. Though it is possible to promote these products even at farm beekeeping level, the prime target should be private/commercial/ investment in beekeeping. There is scale economies advantage in such high-value products. Relative to the conventional bee products of honey and bee wax, it is more knowledge and management intensive, which can easily be achieved by the private sector compared to the farmer/pastoralist/ beekeeper.
Over the medium to long-term period the Ethiopian government can and should consider to promote bee-products based pharmaceuticals, cosmetics, beverage, sweets and candy agro-industries.

4. Weak Quality Assurance System

In the area of food industry, quality expressed in terms of food and health safety standards is a governing variable that determine global competitiveness.

Quality of honey and bee wax are affected by a number of factors along the entire value chain, starting from bee-hiving, packing, storing, and transportation, which are closely related to knowledge and awareness of the operators. This calls for positive intervention in terms of creating human capital through knowledge generation and dissemination by establishing a strong and effective dedicated apiculture extension service across the country.

One factor that affects quality of honey and bee wax is application of pesticides and herbicides management, which involves a dilemma of promoting bee products on the one hand and enhancing productivity of cereals and cash crops.

The other factor is ensuring a system of quality control through ensuring reliable, timely and efficient and competitive testing services which requires quality laboratory services.

Of course there is no substitute for strong regulatory system to ensure the prevalence of rules of law in the supply and marketing of bee products in the country. Every operator in the value chain should be subjected to ex ante and ex post accountability to whatever quality deficiency which have health implications. This is important capacity to ensure safe and healthy supply of at least food products to domestic consumers, which further creates the institutional and cultural framework for exporting honey and bee wax which meet country and regional standards. (Hilmi et al, 2012, p.15)

Ethiopia is already listed as the third country exporter to EU. Indeed, the requirements for Ethiopia to meet and fulfill in order to enjoy the market opportunity of being listed to export to the European Commission include multiple criteria, categorized as primary and secondary requirements. (Gallmann & Thomas,2012, pp.3-4)
The primary requirements include viable offer to the market, listed in the EU inventory of Third Countries eligible to export honey to the EU, clean honey (i.e. filtered, with no chemical residues). The secondary requirements include business relation with a buyer, a traceability system for quality control and a hazard analysis and critical control points plan.

A viable offer to the EU market, means an offer which is acceptable by the buyer, including competitive price, acceptable quality, a reliable exporter who can supply at least some accepted minimum export quantity, at a predetermined delivery time, acceptable packaging. These are the minimum entrance requirements to get a business relation with the buyer, who is a big, in fact, a global retailing company, that outsource its supply from different sources, local and global suppliers. The requirement for establishing a business relationship with a global buyer is essentially to become globally competitive who can meet the multiplicity of requirements of being globally competitive. These conditions are sufficiently stringent to mean everything.

Yet, the conditions explicitly include requirements of being clean, traceable with clear and explicit plan and execution of hazard analysis and critical control points.

Quality of honey is quite sensitive to different variables across the entire value chain. It starts with the bee forage supply and management, type and quality of bee-hive, colony management for any problem including bee diseases, cleanliness of hive site, degree of smoking during inspection and harvesting, timing of harvesting(ripeness), cleanliness of the harvesting process, transportation of honey combs from harvesting site to extraction site, management of the extraction process, the quality of the extraction technology, storage, packing and transportation(Gallmann and Thomas, 2012, p 15).

Indeed, the EU requirements are all about creating a quality assurance system which includes all positive interventions to enhance knowledge, skill and awareness of the beekeepers and all actors in the industry to enhance quality of bee products. Moreover, productivity enhancement measures are complementary to quality assurance system. High productivity would increase the production capacity of each beekeeper which makes it possible to trace the beekeeper and for that matter the bee hive for undertaking positive interventions and for ensuring and implementing accountability measures. The positive side of the quality assurance system essentially depends upon the knowledge and skill generating and dissemination system in the
country. If there is strong extension system, then it is possible to develop the necessary capacities and capabilities to ensure quality bee products, which are clean and traceable.

Yet apart from the positive intervention areas of creating the necessary human capital to ensure quality honey production, storage, packaging and transporting up to the delivery to the consumer, there is a necessity to establish a strong regulatory system throughout the entire value chain including the existence and effective management of laboratory systems in the country.

This is so because there are always opportunistic behaviors of certain number of individuals who have the tendency and disposition to take advantage of weaknesses of the regulatory system. Indeed, there have been a number of incidences of adulteration of honey and bee wax in the country. There were cases of police force raiding of such centers of adulteration in the capital city even in the year 2014. Moreover, an exported lot was found to be adulterated after it was delivered to European customer in 2014, which however, was traced to one of the largest and organized exporters. The entire shipment was transported back to Ethiopia, which was at the expense of the exporter. Apart from the financial loss of such incidence, it is a serious blow to the image of the country and the Ethiopian apiculture.

One of the means of ensuring the prevalence of law and establishing accountability to any risk of adulteration is to establish traceability in the production and distribution of honey and bee wax. So far there has not been any mechanism of traceability in the country.

One of the major challenges in establishing traceability mechanism is the fact that about 90% of production of honey and bee wax is produced by small farm households, producing only few kilos of honey and bee wax. Definitely, it would be quite expensive to establish a mechanism of traceability to every small holder of the country which counts nearly 2 million farm households.

One resultant problem of the small scale production is the fact that honey and bee wax collectors, which remain the marketing outlets for large number of the small producers, are large number of small local traders. So it remains formidable challenge to establish a mechanism of traceability covering all of the millions of small beekeepers and large number of small collectors in every kebele and woreda.
Moreover, there has not been well organized, adequately equipped and staffed and managed laboratory center in Ethiopia to do required tests of quality, adulteration, residue analysis. As a result, the country has been doing the required laboratory tests abroad.

Though much remains to be done to establish internationally certified laboratory centers, there are laboratory centers that could be considered as candidate for capacity developing for establishing internationally certified laboratory centers.

Thus, developing the quality assurance system of the country presupposes aggressive measures of improvement of productivity and quality consciousness along the entire value chain. If Ethiopia fails to develop such quality assurance system then it is possible to lose the opportunity of being listed as an exporter to EU, which is a big global market to loose.

5. Price Competitiveness of Ethiopian Bee Products: Honey and Bee Wax

Price competitiveness, the capacity to sell and delivery at lower cost possible is the traditional mechanism of competitiveness. Firms and countries do compete to supply quality products at the lowest possible prices in the buyer's markets of the global markets. Thus, there is horizontal competition among alternative suppliers from the same industry, apiculture. Along with such horizontal competition, the profit margin of the buyer depends upon the power edge (governance of the entire value chain) the buyer has over the seller. The lower the price the seller gets, the higher the profitability of the buyer. So there is such strong pressure to sell at lower prices.

Indeed a number of factors determine price competitiveness. For instance the volume that each exporter can supply has got an impact in setting prices. If a firm or a country can deliver demanded quantity at the agreed delivery time, then this defines a bargaining power of the seller. Any deficiency of quality apart from the risk of being driven out from a given market, affects the bargaining power of the seller (exporter).

Though there may be a number of factors that contribute towards cost build up of a given commodity or service, the lasting factor that determines the cost and price competitiveness of a given exportable commodity is the efficiency and productivity of the production and delivery of the product along the entire chain. The history and track record of the supplier (seller), also matter in setting the competitiveness of prices.
In particular, cost and price competitiveness of honey and bee wax is governed by cost build up which is in turn determined by the investment costs and running costs of beekeeping provided a given level of productivity.

However, one of the features which makes apiculture attractive is the fact that the resource requirement in general and required financial capital in particular of the apiculture sector is low, which should have made it attractive not only to governments, non-governmental organizations but also to small farm households. The financial requirements in terms of investment and running costs of beekeeping, and for that matter of honey extraction is less expensive (taking the financial requirements in absolute value and comparing it with the potential multiple gains of beekeeping) and affordable to many governments and economic agents (Hilmi et al, 2012, p.6).

Rather the major factor which determines price competitiveness and attractiveness of the apiculture sector is the productivity per harvest and per colony per year, which critically and mainly depend upon two issues. First and foremost it depends upon the availability of adequate and reliable supply of nectar and pollen throughout the year. The availability of reliable supply of nectar and pollen which critically depends upon the vegetation intensity and type determines productivity of a given harvest and the possibility of multiple harvesting of all bee products.

The problem in countries even with diverse agro-ecological zones is the failure to recognize the fact that flowering calendar of given apiary site can be developed and managed, which not only enhances productivity of beekeeping but enables integrated agriculture and ensures sustainable environmental resources of a given site and country.

The other factor that governs productivity of beekeeping is failure to give due attention to the fact that the bee colony is a biological creature which is sensitive to any number of factors. Bee hive management which may include hygiene, bee health, feed, bee-hive inside management, protection from predators and insects, managing swarming, the age of the queen, managing the weather of the hives, managing the harvesting, etc have significant impact not only on the productivity of every bee colony but the risk and frequency of absconding.

These productivity enhancing mechanisms should be backed by strong knowledge generation and dissemination system in order to ensure sustainable and dynamic improvement of productivity over time.
So one of the principal strategies to ensure price competitiveness is to encourage and promote productivity and innovativeness, which is a necessary condition for productivity and product differentiation strategies. Thus, the low productivity of honey production in Ethiopia is a serious snag against price competitiveness. If indeed, the country manages to increase exports without bringing meaningful improvement, that can only happen through excessive government support and incentive instruments. This is not only unsustainable, but there is high risk of 'racing to the bottom' instead of racing up.

One of the strategies to ensure price competitiveness is product differentiation or upgrading strategies. Suffice is to state the fact that there has not been any introduction of new bee products in the country other than the traditional bee products, honey and bee wax. Thus, one of the strategic directions for the country should be to encourage product differentiation and upgrading strategies to start high-value bee products.

Having this background notes, let's consider the prices that the Ethiopian apiculture is experiencing. One price indicator is the unit Fob value of both honey and bee wax and the other is honey selling domestic prices in different parts of the country.

As can be seen from the following figure the FoB unit value for honey has been in the range of USD 2-4.00 per kg. Since 2009 the unit value has been in the range of USD 3-4 per kg exhibiting small variation.
Since 2004, the unit fob value of bee wax has been exceeding that of unit value of honey and showing an increasing trend from the order USD 3.18 in 2004 to USD 7.43 per kg in 2013.

Table 4. Exports Unit Values of Honey & Bee Wax, (FoB, USD/kg, 1997-2013)

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</thead>
<tbody>
<tr>
<td>Honey Export Unit Value (FoB USD/Kg)</td>
<td>5.68</td>
<td>3.92</td>
<td>3.97</td>
<td>2.29</td>
<td>2.06</td>
<td>1.78</td>
<td>3.43</td>
<td>2.85</td>
<td>2.80</td>
<td>2.31</td>
<td>3.18</td>
<td>4.26</td>
<td>4.51</td>
<td>4.41</td>
<td>4.57</td>
<td>4.61</td>
<td>5.70</td>
</tr>
<tr>
<td>Bee Wax Export Unit Value (FoB, USD per KG)</td>
<td>4.44</td>
<td>3.99</td>
<td>4.23</td>
<td>5.03</td>
<td>3.50</td>
<td>3.36</td>
<td>2.31</td>
<td>1.88</td>
<td>2.26</td>
<td>5.18</td>
<td>4.41</td>
<td>4.37</td>
<td>5.61</td>
<td>5.81</td>
<td>5.71</td>
<td>6.21</td>
<td>5.43</td>
</tr>
</tbody>
</table>

Source: computed from ERCA data set

Exporters complain that the export fob price is lower than the domestic prices, which is indeed a constraint that discourages exports.

There is wide variation of domestic prices. In the South West zones the prices at district level markets during the survey period, August 2014 was in the range of 60-65 for the 'best quality' honey, clean which at least in the domestic market, can be considered as table honey. This price...
increases to Birr 70 during the off-harvest season. Those who manage to store and wait can benefit from such price advantages. On the other hand the price at district level in Tigray, Hagere-Selam area was in the range of Birr 250 to 275 per kg.

Farmers and district (woreda) officials and experts in the Bureau of Agriculture complain that the domestic prices in their woredas and zone are low, which discourage production. Indeed, higher domestic prices are preferred from the point of mitigating absolute poverty. This, however, is not a sustainable strategy. In the long run, it is difficult to sustain supply shortfall.

On the other hand, exporters complain that one of the challenges of the export of honey and bee wax is the excessively high domestic prices. Indeed, a district level domestic price higher than USD 2.00 per kg can be considered as high against the fob unit value about USD3.00 per kg.

Currently, both the sellers and the buyers(mainly exporting companies) are not happy with the existing domestic prices. Considering the global market as the competitive market price, strategically the domestic price should adjust downward if indeed there will be sustainable supply to the export market. Indeed, one of the reasons for low share of exports of total domestic production is the fact that the domestic market has been paying more than the export market. Despite this fact, honey extraction companies and exporters are not observed starting beekeeping. So far there has not been commercial beekeeping in the country. Had there been commercial beekeeping, supply of both honey and bee wax would have increased and domestic prices would have declined to a globally competitive level.

The lasting solution is promote productivity and let the beekeeper benefit from high productivity, high volume of sales instead of selling small quantity at higher prices. Had it not been for supply shortfall, domestic prices would have adjusted downwards to international prices. The strategic direction should, therefore, be to encourage productivity and increase both domestic income and export earnings at the same time.

6. Traditional Packaging, Storage and Transportation
Quality of honey is quite sensitive not only to the harvesting and its extraction but to its storage, packaging and transportation. Honey is quite sensitive to temperature and light, as a result it can absorb moisture and odors from the air, from the packing tools, storage environment and its
handling during extraction, extraction, storing and transportation (Gallmann and Thomas, 2012, p 14).

One of the problems of the Ethiopian honey production and marketing is the traditional packing, storing and transportation. It seems that many of small farm households are not aware of the high risk of quality deterioration due to inappropriate packaging, storage and transportation.

One of the tasks of the Ethiopian extension system, should therefore be to create the awareness of the degree of risk in storing, packing and transportation of especially honey.

7. Low level of development of the knowledge generation system of the Ethiopian apiculture

Sustainable productivity and product differentiation calls for concerted R&D and innovativeness at all levels. In view of the fact that the Ethiopian apiculture has been dominated by traditional technology, there is a need for strong, concerted, well-managed R&D to generate adequate and timely knowledge to enhance the productivity and sustainability of beekeeping in the country.

The Ethiopia's R&D system for apiculture has remained weak and less effective. Not only the investment in R&D centers has been weak, but there has been high turnover of research personnel, low motivation, low facilitation and under budgeting of the existing few R&D centers.

Moreover, the relationship between the research centers and the extension system has remained very weak.

8. Weak Institutional Coordination

One of the problems of the promotion of the Ethiopian apiculture has been the fact that a number of government institutions are involved. At ministerial level, Ministry of Agriculture (MoA) is responsible and authorized ministry with an organizational structure up to kebele level (Lowest grass root organization in the country) and Farmers Training Centers (FTC) at kebele level. It has organized an extended agricultural extension system including a number of agricultural vocational training centers in the country meant to transform the lives of the Ethiopian rural population. Moreover, MoA through its extensive structure up to kebele level is responsible for mobilizing the rural population for soil and water conservation in order to halt or reduce the long-time land degradation process and promote soil and land fertility and rehabilitate the
vegetation system. Indeed, a number of enclosure areas are established in different parts of the country.

The ministry of energy and water development is undertaking massive soil and water conservation works with the aim of managing the watersheds of the major rivers of the country following the construction of major hydro-dams in the country.

Moreover, the newly established Ministry of Environment and Forest Development is closely related with the land rehabilitation of downgraded parts of the country and promoting, managing and preserving the existing forest coverage of the country.

The ministry of industry (MoI) is responsible for promoting private investment, encourage export through the promotion of agro-industries, one of which is the bee-products based agro-industries starting from honey extraction, up to bee products-based manufacturing process including cosmetics, pharmaceuticals, beverage, sweets and candies.

Moreover, the Ministry of trade, agency of cooperatives and for that matter Ministry of culture and tourism are related directly with the promotion of apiculture.

There are different scattered and unorganized efforts which however have direct impact on the development of the Ethiopian apiculture. For instance, the Ministry of Energy and Water who is in charge of developing and managing the basins of major rivers of the country is promoting soil and water conservation works. Indeed, the basin development plans and studies do recognize the promotion and development of bee keeping as one strategic instruments. Yet, such efforts are not coordinated with the efforts of other ministries. Nor are they managed by professionals who are familiar with apiculture. Clearly, there has not been conscious decision to include bee forages in the menu for seedlings and plantations to rehabilitate the watersheds of the major rivers. Essentially, this does not claim much additional resources. With the existing resource allocation to promote watershed management along the major river basins much could have been achieved if indeed, there were coordinated and concerted effort to cultivate bee forages.

After all honey bees are and should have been taken as agents of promoting the success of the water and soil conservation efforts through pollinating the existing vegetation cover and enhance the productivity of the reforestation works and enclosure works of the country.
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1. Overview

Ethiopia is home to some of the most diverse flora and fauna in Africa due to its myriads of edaphic, climatic and ecological factors as well as huge water resources. Its forests and woodlands contain diverse plant species, estimated at 7000, most of which are honey bee flora that provide surplus nectar and pollen to foraging bees. More than 800 honeybee plant species were collected and identified by the Holeta Bee Research Center as forage plants out of which 500 were described in detail and published in a book entitled “Honeybee Flora of Ethiopia” (Fichtl and Admasu, 1994). This diverse and unique flowering plants that are growing in different agro-ecological zones make the country highly suitable for sustaining a large number of bee colonies as result of which it has become a leading producer of honey and beeswax in Africa.

However, this potential of the country is not fully exploited and it has not yet developed globally competitive honey industry. To realize a vibrant honey industry, it is mandatory to characterize and document the apicultural resources of the country and study the constraints of the sector for proper intervention and utilization of these potential resources. Having detail knowledge on the available resources and identifying the challenges are very essential in the formulation of appropriate and sustainable development strategy for the sector.

It is possible to bring phenomenal change in production and productivities and hence maximize the advantage from the apiculture sub-sector through an integrated approach of fully exploiting and improving the locally adapted honey bee races, the available diverse floral resources, and
traditional knowledge of beekeeping and introducing frontier production technologies that could be adopted from elsewhere and/or developed within the country.

This chapter will therefore map the honeybee flora of the country by agro-ecology and farming practices, outline a roadmap as to how to develop and manage appropriate bee (vegetation) taking agro-ecology, farming practice and water resources in to consideration, identify and recommend suitable/productive bee forage and their carrying capacity and develop a strategy on how to integrate this development of apiculture to the integrated watershed management endeavors being massively implemented by different governmental institutions, non-governmental organizations (NGOs) and the public at large. Emphasis will also be given to the pollination services of honeybee in the promotion of commercial agriculture focusing on cash crops like oil seeds, pulses, cereals and vegetables and fruits. Lastly, both current agricultural practices of the country, i.e., the use of agrochemicals and organic farming and related policies will be examined to make policy recommendation on how to harmonize them on a case-by-case basis (for example based on agro-ecology and farming practices of each watershed regime).

2. Vegetation of Ethiopia in relation to Apicultural importance

2.1 Vegetation type and distribution

The vegetation resources of Ethiopia, including forests, woodlands and bush lands have been studied by several scholars and classified into twelve major vegetation types (Fig. 1). These include: i) Desert Vegetation, ii) Semi-Desert Scrub, iii) *Acacia-Commiphora* Bushland and Thicket, iv) *Acacia-Commiphora* Narrow-leaved Deciduous Woodland and Forest, v) Dry Evergreen Montane Forest, vi) Afroalpine and Sub-Afroalpine Vegetation, vii) Moist Evergreen Montane Forest, viii) *Combretum-Terminalia* Broad-leaved Deciduous Woodland, ix) Riverine Vegetation, and x) Fresh Water Lake Vegetation. Each vegetation types comprises different types of plant species of apicultural importance, however, all vegetation types are not equally important for honey production due to suitability of climate and other environmental factors. Some of the vegetation types relevant to apiculture will be briefly described below.
**Desert and Semi-desert vegetation**, found in Dalol depression extending along the Eritrean border, is characterized by highly drought tolerant species but it has limited contribution for beekeeping production due to erratic rainfall and extreme drought causing bee forage scarcity. Relatively, *Acacia-Commiphora* Bushland and Thickets are better than Desert and Semi-desert vegetation for beekeeping production which are predominately found in escarpments of Afar, Oromia, Amhara, Southern Nations, Nationalities and Peoples (SNNP), and Somalia regional states at altitudinal range of 400-1800m. This vegetation is also found along the Awash and Wabe shebele River basins and remains green throughout the year creating suitable condition for apiculture development. Some of the major bee forage species in this vegetation type are *Hypoestes forskaolii*, *Aloe* spp., *Acacia tortilis*, *Acacia senegal*, *Acacia brevispica* and *Terminalia brownie* which are adapted to the area. In this vegetation, honeybees (*Apis mellifera jementica*) adapted to these arid and semi-arid areas are found and have fast population build up as well as fast honey storing tendency which is an adaptive mechanism to cope up with arid to warm lowland where raining period and flowering duration are short and dry period is extensive (Chandler, 1976). The above facts clearly show that the promotion of beekeeping development is needed in these areas as crop cultivation is vulnerable to moisture deficit and recurrent drought. For this, assessment of beekeeping potential is a prerequisite to promote beekeeping development so as to support the overall socio-economic development of these communities.

**Dry Evergreen Montane vegetation**: The central and mountainous chains and some parts of eastern and northern Ethiopia which constitutes Oromia Region (Shewa, Arsi, Sidamo, Bale and Harerige floristic regions), Amhara Region (Gonder, Wello, Gojam and Shewa floristic regions), Tigray Region and SNNP Region (Sidamo and Gamo Gofa floristic regions) are covered by Dry Evergreen Montane vegetation. This vegetation type has canopies usually dominated by *Juniperus procera* and *Podocarpus falcatus* as dominant species, followed by *Olea europaea* subsp. *cuspidata* and *Hagenia abyssinica*. Other characteristics species include *Buddleja polystachya*, *Erica arborea*, *Hagenia abyssinica*, *Hypericum revolutum*, *Galiniera saxifraga*, *Nuxia congesta*, *Pittosporum viridiflorum* and *Prunus africana*. This vegetation type represents a complex system of successions involving extensive grasslands rich in legumes. Ethiopian agriculture has been well developed and practiced in these areas for thousands of years. Due to intensive utilization of this areas for agriculture forest loss has occurred and it has largely been replaced by bush lands.
This vegetation type which occurs in areas between 1800 and 3000 m. above sea level has significant contribution for apiculture due to availability of both wild plant species and cultivated crops such as oil crops, cereals, pulses and horticultural crops. The major bee forages include, *Olea europea* subsp. *cupsidata*, *Eucalyptus globulus*, *Acacia abyssinica*, *Cordia africana*, *Trifolium* species, *Becium grandiflorum*, *Hypoestes forskalii*, *Leucas Abyssinica*, *Hypericum revolutum* and *Guizotia scabra*. However there is high population pressure leading to deforestation and massive soil erosion resulting in scarcity of bee forage although this trend is currently reversing due to the massive water and soil conservation efforts in the country. Thus planting of additional bee forages and feeding of honeybee colonies during dry period will improve honey production of the area.

**Afro-alpine:** This vegetation type, particularly the Ericaceous belt, is potential for beekeeping and occurs mainly between 3000 and the 3200 m asl in most of the higher mountains in Ethiopia. The belt is most notable above the Harenna forest in the Bale Mountains. The Ericaceous belt is phsyiognomically characterized by the dominance of shrubs and shrubby trees such as *Erica arborea*, *Hypericum revolutum*, *Myrsine melanophloeos* and perennial herbs, *Alchemilla haumannii*, *Geranium arabicum*, *Anthemis tigreensis*. The *Erica arborea* vegetation could be exploited for its popular Erica mono-floral honey but the area is highly affected by overgrazing and massive soil erosion.

**The moist evergreen Afromontane forest:** According to Friis (1992) this vegetation type occurs mainly in the south-western part of the Ethiopian Highlands between (1500-1800) and (2600-3000m), with an annual rainfall between 700 and 2000 mm. This agro-ecological zone is one of high potential areas for beekeeping due to a great density of vegetation cover and high honeybee population. Bee keeping activity is major source of income for the community and contributing up to 95% of a household’s annual cash income (SNV, 2011). On average, households in South west Ethiopia own 20-30 beehives and can produce about 10-15 kg of honey per hive. The major honey producing plant species include *Scheffelera abyssinica*, *Croton macrostachyus*, *Polycias fulva*, *Coffea arabica*, *Vernonia amygdalina* and *Justicia schimperiana*. In this vegetation type, plants flower throughout the year since it receives rain for nine months. In this vegetation, during the last decades several factors, such as investment for coffee and tea plantation development and fast population growth have resulted in increasing...
pressures on the forests affecting livelihood opportunities of local communities which warrants conservation attention.

**Combretum-Terminalia Broad-leaved Deciduous Woodland and Semi-evergreen Lowland Forest:** This vegetation type which is found in Gambella and Bensagule Gumizi Regions, Tekeze River basin in Tigray and Amhara regional states along the Sudan border is also potential area for honey production. In this area farmers and pastoralists are producing honey traditionally for household consumption and income generation. The commonly known bee forage plant species in this vegetation include *Ozoroa insignis, Terminalia brownii, Combretum molle, Grewia bicolor, Anogeissus leiocarpa, Piliostigma thonningii, Acacia tortillis, Acacia sieberiana, Hypoestes forskaholii* and *Ziziphus spp.* In this vegetation types there is huge potential for production of *Ziziphus* mono-floral honey but most of the beekeeping practice is very traditional.
Fig. 1. Vegetation Map of Ethiopia (Source: Sebsebe D. & Nordal, I. (2010). Aloes and lilies of Ethiopia and Eritrea)
2.2 Honeybee flora potential by regions

The potential of land for beekeeping depends on the nature of the vegetation it supports. Based on floral richness and diversity the honey production potential of Ethiopia differs from region to region. Thus, vegetation characteristics of a region are considered to be an important indicator of its potential for beekeeping. In general, the potential areas for honey and beeswax production in the country include South-western, Western and North-western parts of the country (ARSD, 2000 and Gezahegn, 2001). These areas are grouped into high, medium and low potential areas depending on volume of honey production and vegetation cover of the area. According to this categorization of the area for honey production, many of the districts in Tigray, Wollo and eastern Oromia which are covered with marginal forests and bush lands do have relatively low potential in honey production as compared to parts of the country mentioned above (Beyene and David, 2007).

Identification of the honeybee plants and assessing their abundance, their value to bees, time of blooming and flowering period have a paramount importance for practical beekeeping as well as for planning appropriate seasonal management. Depending on type of vegetation and weather condition the floral calendar of an area however usually varies from year to year (Nuru et al., 2001; Gichora, 2003). Based on variation of vegetation types and the calendar of the flowers different regions in the country have different honey source plants with different brands of honey.

Major honey bee floras in Amhara Region

Beekeeping is a very long-standing practice in the farming communities of Amhara region and it plays a significant role as source of additional cash incomes and nutrition for many subsistence farmers (Nuru, 2002). It is an integral part of the smallholder farming system. Some recent studies indicated that the region has immense beekeeping resources attributed to existing bee floras including various cultivated oil crops, pulse and field flowers. Based on the survey result, in Western Amhara more than 249 honey bee floras including trees, shrubs, bushes, crops, spices, flowering weeds, and grasses were identified. Similar work was done on floral phenology and pollen potential of honey bee plants in North-East dry land areas of Eastern Amhara (Abebe,
2005). The lists of bee forages contributing for honey production in Amarha region (see Table 1).

Table 1. List of major honey bee flora in Amhara Region (compiled from different sources, e.g. Fitchel and Admasu, 1994).

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
<th>Flowering period</th>
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<tbody>
<tr>
<td><em>Eucalyptus spp</em></td>
<td>baharizaf</td>
<td>March-May</td>
</tr>
<tr>
<td><em>Croton macrostachy</em></td>
<td>Besana</td>
<td>May-June</td>
</tr>
<tr>
<td><em>Acacia spp</em></td>
<td>Girar</td>
<td>April-June</td>
</tr>
<tr>
<td><em>Rosa abissinica</em></td>
<td>Kega</td>
<td>October-May</td>
</tr>
<tr>
<td><em>Cordial africana</em></td>
<td>Wanza</td>
<td>July-November</td>
</tr>
<tr>
<td><em>Vernonia spp</em></td>
<td>Gerawa</td>
<td>Sep-May</td>
</tr>
<tr>
<td><em>Carissa edulis</em></td>
<td>Agam</td>
<td>February-May</td>
</tr>
<tr>
<td><em>Euphorbia spp</em></td>
<td>Kulkual</td>
<td>May</td>
</tr>
<tr>
<td><em>Brassica spp</em></td>
<td>Gomenzer</td>
<td>September/October</td>
</tr>
<tr>
<td><em>Guizotia scabra</em></td>
<td>Meche</td>
<td>September/October</td>
</tr>
<tr>
<td><em>Trifolium acaule</em></td>
<td>Maget</td>
<td>September/October</td>
</tr>
<tr>
<td><em>Mangifera indica</em></td>
<td>Mango</td>
<td>March</td>
</tr>
<tr>
<td><em>Citrus sinensis</em></td>
<td>Birtukan</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Carica papaya</em></td>
<td>papyia</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Acacia brevispica</em></td>
<td>-</td>
<td>May</td>
</tr>
<tr>
<td><em>Acacia tortolis</em></td>
<td>Abiqa</td>
<td>May</td>
</tr>
<tr>
<td><em>Balanite aegyptica</em></td>
<td>Bwdbo</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Becium grandiflorum</em></td>
<td>Mentese</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Boschia angustifolia</em></td>
<td>Shisha</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Ziziphus spinachristi</em></td>
<td>Giba</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Eucalyptus camaldensis</em></td>
<td>Key bahirzaf</td>
<td>May</td>
</tr>
<tr>
<td><em>Euclaea shimperi</em></td>
<td>Dedeho</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Grewia bicolor</em></td>
<td>Saha</td>
<td>September - October</td>
</tr>
<tr>
<td><em>Mangifera indica</em></td>
<td>Mango</td>
<td>September - October</td>
</tr>
</tbody>
</table>
**Honeybee flora in Tigray**

In Tigray land degradation and removal of vegetation cover was very high. Thus the major bee flora for beekeeping has become seriously degraded in the course of time. Despite such big challenges, there are a wide variety of plants which are used as honeybee flora. In some areas there is active planting of nectar yielding plants. In some places the beekeepers themselves have endeavored to restore the situation by planting good honey plants near their beehive colonies. Regardless of the beekeeping potential of Tigray region little is done to identify the existing honeybee plants. Alemtsehay (2011) and Twolde (2004) through their respective studies have identified different bee floras and recommended major bee forage for the region (see Table 2).

Table 2. The list of major bee forages identified and recommended for honey production in Tigray.

<table>
<thead>
<tr>
<th>Scientific name of the plant</th>
<th>Vernacular name</th>
<th>Flowering period</th>
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</thead>
<tbody>
<tr>
<td><strong>Cordia africana</strong></td>
<td>Awhi</td>
<td>October-November</td>
</tr>
<tr>
<td><strong>Beciumgrandiflorum</strong></td>
<td>Tebeb</td>
<td>August-September</td>
</tr>
<tr>
<td><strong>Hypoetses forskalii</strong></td>
<td>Girbia</td>
<td>September-October</td>
</tr>
<tr>
<td><strong>Euphorbium candelabrum</strong></td>
<td>Kolkal</td>
<td>October-November</td>
</tr>
<tr>
<td><strong>Opuntiaficus-indica</strong></td>
<td>Beles</td>
<td>February-May</td>
</tr>
<tr>
<td><strong>Andropogonabyssinicus</strong></td>
<td>Demhala</td>
<td>September-October</td>
</tr>
<tr>
<td><strong>Bidenspachyloma</strong></td>
<td>Adeyabeba,</td>
<td>September-October</td>
</tr>
<tr>
<td><strong>Bidensmacroptera</strong></td>
<td>Gelgelemeskel</td>
<td>September-October</td>
</tr>
<tr>
<td><strong>Eucalpytus globules</strong></td>
<td>TsaedaBahrzaf</td>
<td>All year round</td>
</tr>
<tr>
<td><strong>Carthamustinetorius</strong></td>
<td>SufBahri</td>
<td>September-October</td>
</tr>
<tr>
<td><strong>Carduuscamaecephalus</strong></td>
<td>Dander</td>
<td>October-November</td>
</tr>
<tr>
<td><strong>Guizotiaabyssinica</strong></td>
<td>Nihug</td>
<td>September-October</td>
</tr>
</tbody>
</table>
Honeybee flora in South Nations, Nationalities and Peoples Region (SNNP)

Apiculture in southwestern South nations and Nationalities of Ethiopia provides an opportunity for impoverished or low-income people to supplement their earnings by the sale of harvested bee products such as honey and beeswax at a suitable market. Despite severe deforestation throughout many regions of Ethiopia, the region still contains many nectar and pollen producing plants. The Survey of major bee flora of south west Ethiopia was investigated by Awraris Getachew et al 2012 in three zones (Kefa, Sheka and Bench Majii). According to this survey the honey plants like *Schefflera abyssinica* and *Vernonia amygdalina* are important for production of Mono-floral honey and the rest are contributing for production of multi-floral honeys (see Table 3).

Table 3. Major honey bee floras in south west Ethiopia

<table>
<thead>
<tr>
<th>Common name</th>
<th>Common name</th>
<th>Flowering period</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Schefflera abyssinica</em></td>
<td>Geteme</td>
<td>February – April</td>
</tr>
<tr>
<td><em>Vernonia amygdalina</em></td>
<td>Girawa</td>
<td>January – February</td>
</tr>
<tr>
<td><em>Dombeya torrida</em></td>
<td>Wolkeffa</td>
<td>November - December</td>
</tr>
</tbody>
</table>
### Honeybee flora in Oromia region

The Oromia region comprises forest land, woodland/savanna vegetation dominated by *Acacia*. Cultivated crops including horticulture, field crops and spices. This vegetation resources and favorable climatic condition favors for the presence of fauna and other biological resources including honeybees. Beekeeping in Oromia provides subsistence employment and investment opportunities for a number of people and serves as a source of additional income, food and pollination services. The lowland of Oromia is frequently affected by the recurrent droughts that significantly influence the livelihood of the community. In this regard, beekeeping is one of the income sources in the area as it is less affected by drought as compared to other agricultural sectors. Furthermore, currently beekeeping is also given high attention by the regional government of Oromia to the diversification of income sources of farmers in drought prone areas and highly degraded areas particularly in watershed management program. The honeybee flora of Oromia comprises variety of floral resources including forest trees, bushes, and cultivated crops including horticulture, oil crops and cereals. The honeybee forages of Oromia were studied by Admassu, (2004), Debissa (2007) and Amssalu (2006) and the major bee flora for honey production are as indicated in Table 4.

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Common Name</th>
<th>Flowering Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Syzygium guineense</em></td>
<td>Dokimma</td>
<td>December – April</td>
</tr>
<tr>
<td><em>Apodytes dimidiata</em></td>
<td>Cheleleka( oro)</td>
<td>January – April</td>
</tr>
<tr>
<td><em>Ilex mitis</em></td>
<td>-</td>
<td>October - November</td>
</tr>
<tr>
<td><em>Allophius abyssinica</em></td>
<td>Embuis</td>
<td>July</td>
</tr>
<tr>
<td><em>Ekebergia capensis</em></td>
<td>Sombo (oro)</td>
<td>January</td>
</tr>
<tr>
<td><em>Prunus africanus</em></td>
<td>Tikur inchet</td>
<td>November</td>
</tr>
<tr>
<td><em>Croton macrostachyus</em></td>
<td>Bisana</td>
<td>May</td>
</tr>
<tr>
<td><em>Jasminum species</em></td>
<td>Tenbelele</td>
<td>November</td>
</tr>
<tr>
<td><em>Ephorbia species</em></td>
<td>Kulkal</td>
<td>January - May</td>
</tr>
<tr>
<td><em>Aningeria adolfi-friederici</em></td>
<td>Kerero</td>
<td>July</td>
</tr>
<tr>
<td><em>Maesa lanceolata</em></td>
<td>Kelewa</td>
<td>September</td>
</tr>
<tr>
<td><em>Cordia africana</em></td>
<td>Wanza</td>
<td>July</td>
</tr>
<tr>
<td><em>Manigifera indica</em></td>
<td>Mango</td>
<td>September</td>
</tr>
<tr>
<td><em>Coffea arabica</em></td>
<td>Buna</td>
<td>February</td>
</tr>
</tbody>
</table>
Table 4. Main honey be flora found in Oromia Region as compiled from different sources.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Common name</th>
<th>Flowering period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trifoilum spp</td>
<td>Siidessa</td>
<td>September - October</td>
</tr>
<tr>
<td>Vernonia amygdalina</td>
<td>Ebicha</td>
<td>December</td>
</tr>
<tr>
<td>Echionpoes spp</td>
<td>Koshoshilla</td>
<td>October - December</td>
</tr>
<tr>
<td>Guizotia scabra</td>
<td>Tuffo</td>
<td>October - December</td>
</tr>
<tr>
<td>Datura arborea</td>
<td></td>
<td>Throughout year</td>
</tr>
<tr>
<td>Eucalyptus camaldunsis</td>
<td></td>
<td>March - May</td>
</tr>
<tr>
<td>Syzygium guineese</td>
<td>Badessa</td>
<td>January - May</td>
</tr>
<tr>
<td>Croton macrostachys</td>
<td>Bakkanissa</td>
<td>May</td>
</tr>
<tr>
<td>Rossa abyssinica</td>
<td>Gora</td>
<td>Sept - Nov</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>mango</td>
<td>Sept</td>
</tr>
<tr>
<td>Cordia africana</td>
<td>Wedessa</td>
<td>July - Sept</td>
</tr>
<tr>
<td>Gravelia robusta</td>
<td>Graviella</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Eucalypus globulus</td>
<td>Bargammo adi</td>
<td>March - May</td>
</tr>
<tr>
<td>Rhus vulgaris</td>
<td>Xaxessa</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Guizotia abyssinca</td>
<td>Nugi</td>
<td>October</td>
</tr>
<tr>
<td>Plantago lanceolatum</td>
<td>qortebi</td>
<td>through year</td>
</tr>
<tr>
<td>Acacia tortolis</td>
<td>Dodotii</td>
<td>April - May</td>
</tr>
<tr>
<td>Balanite aegyptica</td>
<td>Bedeno</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Ziziphus spina-christi</td>
<td>Qurqura</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Olea capensis</td>
<td>Ejerssa</td>
<td>April - May</td>
</tr>
<tr>
<td>Acacia senegal</td>
<td>Saphassa</td>
<td>April - May</td>
</tr>
<tr>
<td>Acacia sieberiana</td>
<td>Burquqee</td>
<td>April - May</td>
</tr>
<tr>
<td>Capparis tomentosa</td>
<td>Gora</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Pterolobium stellatum</td>
<td>Harrangama</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Agava sisalana</td>
<td>Algae</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Acacia etbaica</td>
<td>Dodotii</td>
<td>April - May</td>
</tr>
<tr>
<td>Boswellia papyrfera</td>
<td>qararri</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Citrus sinensis</td>
<td>Orange</td>
<td>Sept - Oct</td>
</tr>
<tr>
<td>Piliostigma thonningii</td>
<td>Liloo</td>
<td>Sept - Oct</td>
</tr>
</tbody>
</table>
The honey bee flora of the Gambela, Benesangul Gumze, Somalia and escarpments of Oromia, Amhara and Tigray are not well studied due to limited accessibility. However, it is well known that beekeeping is practiced in this area and contributing for food security and additional financial income. Therefore strong attention is needed to study species composition and apicultural production system in this area.

3. Integration of beekeeping to watershed management

3.1 Watershed Management in Ethiopia

Sustainable development and food security in developing countries that are dependent on agriculture require availability of sufficient water and fertile land. However, the size of fertile land available for agriculture is decreasing due to land degradation which is caused by deforestation and inappropriate use and management of natural resources such as soil and water. This leads to both non-sustainable agricultural production and increased risks of catastrophic flooding, sedimentation, and landslides. Ethiopia is believed to be one of the countries in Sub-Saharan African that is most seriously affected by land degradation. It has been reported that land degradation in Ethiopia accounts for 8% of the global total (Habtamu, 2011 and references therein).

Cognizant of the above, natural resource conservation and sustainable utilization is among the top priority development agendas of the Government of Ethiopia. Accordingly, over the last two decades or more, the Government of Ethiopia and donors have committed significant sums on micro- and macro-watershed rehabilitation and development programs that have contributed significantly to rural development and poverty alleviation. Several NGOs and bilateral
organizations adopted watershed development in their respective intervention areas in collaboration with government partners.

The watershed management was placed firmly at the center of rural development in pursuit of the Millennium Development Goals (MDGs) with important interventions for the period 2005-2015 focusing on: watershed based natural resource management for sustainable development, and mitigation of resource degradation (proper land use, soil conservation, water/forest resource management, irrigation, and biodiversity conservation). This has been realized through various actions that have been undertaken through different initiatives such as Managing Environmental Resources to Enable Transition to more sustainable livelihoods (MERET), Productive Safety Net Programs (PSNP) and the national Sustainable Land Management Project (SLMP). The first phase of the SLMP was launched in 2008 and it has successfully introduced land management practices and rehabilitated thousands of hectares of degraded lands using physical and biological measures in 45 selected Woredas and watersheds. Reports indicate that the first phase of the SLMP was finalized in September, 2013 according to the plan (FDRE, 2013).

The second phase (SLMP II) prepared for the period 2013-2019. It will build on the results of the SLMP I and introduces measures to address climate change/variability related risks and to maximize Green House Gas (GHG) emission reductions so as to meet the Growth and Transformation Plan (GTP) and the Climate Resilient Green Economy (CRGE) goals while reducing land degradation and improving land productivity of small holder farmers. The SLMP II will be implemented in 90 new and 45 existing Woredas and watersheds through the existing government structures and community institutions in six regions namely Oromia, Amhara, Tigray, Southern Nations and Nationalities Peoples, Gambela and Benishangul Gumz (FDRE, 2013).

Watershed management implies the wise use of natural resources like land, water and biomass in a watershed to obtain optimum production with minimum disturbance to the environment. In the past, the concept of watershed management focused mainly on the management of these
resources in medium or large river valleys, designed to slow down rapid runoff and excessive soil erosion, and to slow the rate of siltation of reservoirs and limit the occurrence of potentially damaging flash flooding in river courses (Paul, 1997). At present, however, watershed development and management programs take watershed as the hydrological unit, and aims to increase the productivity of agricultural and other natural resources through a combination of re-vegetation and soil and water conservation (Turton, 2000). Watersheds, especially in the developing world, are increasingly being managed for poverty alleviation as well as environmental conservation objectives (FAO, 2006).

Management of these watersheds can be realized by using a variety of technologies such as vegetation conservation like grass contours, alternative tillage techniques and physical structures like terraces, stone bunds, gabion box etc. All of these will ultimately help to achieve sustainable development that can be replicated by the inhabitant of the watershed after the termination of short-term projects that are involved in such technology transfer activities.

3.2 Institutions/organizations involved in watershed management in Ethiopia

The organizations/ministries that currently exist at the federal level and are directly involved in the development and management of land and water resources include: Ministry of Water, Irrigation and Energy (MoWIE); Ministry of Agriculture (MoA); Ministry of Environment and Forestry (MoEF), and other affiliated authorities and agencies. A brief description of their roles and responsibilities is given below.

The Ministry of Water, Irrigation and Energy, the then Ministry of Water Resources (MoWR) has the powers and duties to make inventory of the country’s surface water and groundwater resources; basin level water management and benefit sharing; develop water infrastructure; issue permits and regulate the construction and operation of water works; and administer dams and hydraulic structures.
The Ministry of Agriculture (MoA), the then Ministry of Agriculture and Rural Development (MoARD), is responsible for initiating agricultural and rural development policies; food security strategies and extension programs, and ensuring conducive environment for development, supporting regions in expanding agricultural and rural development as well as monitoring the food security program. According to proclamation No.471/2005, the MoARD’s powers and duties include: to develop and implement a strategy for food security, rural development, and natural resources protection; support development of local (through expansion of cooperatives and the provision of credit facilities) and export markets; development of rural infrastructure and promotion of improved rural technologies and disaster prevention and agricultural research.

The Environmental Protection Authority (EPA), now upgraded to Ministry of Environment and Forestry (MoEF) through Proclamation no. 803/2013, is the government regulatory authority responsible for environmental protection. It aims to formulate policies, strategies, laws and standards, which foster social and economic development in a manner that enhance the welfare of humans and the safety of the environment, and to spearhead in ensuring the effectiveness of the process of their implementation. This is envisaged to be achieved through: development of enabling policy and regulatory frameworks; preparation and implementation of proactive environmental management systems; enforcement and compliance mechanisms and community empowerment; improving education and awareness and availing information and fostering participation in decision taking; and identification and availing of environmentally sound technologies and best practices and resource mobilization and channeling. The government has further defined the institutional frameworks, responsibilities and mandates for the implementation of the environmental policy (FDRE, 2002).

In addition to the above Federal ministries, Regional bureaus, have been established in the country with similar designations and responsibilities as the federal ministries described above. The most relevant state level bureaus in relation to land and water management include bureaus of water resources Development, Agriculture and Rural development (BoARD), and Environmental Protection and Land Administration and Land Use Authority (EPLAUA). There
are also many Non-governmental Organizations (NGOs) and bilateral and multilateral programs operating in all regions that are involved in sustainable land management endeavors.

By the coordinated activities of the above organizations, watershed management schemes have been embarked all over the country streamlined with integrated development master plan for the different river basins where apiculture is a major component due to the emphasis given by the government to date. There are eleven river basins in Ethiopia including, Abay (Blue Nile), Tekeze, Baro Akobo, Omo Gibe, Genale-Dawa, Wabi shebele, and the Rift Valley Lakes Basin (RVLB) and between 80-90% of the country’s surface water resources are found within these river basins (MoWR, 2008).

As mentioned in the above sections, Ethiopia has a wealth of experience in Soil and water conservation and watershed management. This wealth of experience has been condensed into a model for potential watershed management projects and published by MoARD as a Guideline to Community Based Participatory Watershed Development. A guideline was put in place with the intension of promoting and expanding participatory community watershed development in Ethiopia. This is an attempt to streamline the experiences of various actors (GOs and NGOs) in participatory watershed development, combined with the need to have a common and standardized, more effective approach to the country as a whole (Lakew et al. 2005a, b). The guideline aims to build upon exiting community-based participatory watershed efforts to harmonize and consolidate planning procedures at the grass-roots level. The objective is to provide development agents and communities with a workable and adaptable planning tool. Another objective of the guideline is to provide practical guidance on the correct selection of technologies under different conditions and their correct implementation (Lakew et al. 2005a, b).

Although Ethiopia has made significant achievements in watershed management activities and is hailed by development partners, the contribution to the economy of smallholder farmers has been low as it was not commensurate to the efforts put due to lack of effective community participation, limited sense of responsibility over assets created; inefficient implementation of
technologies, inadequate polices, lack of integration among stakeholders, unmanageable planning units and evaluation techniques for their feedback. If we take agriculture water management for example, the responsibility moves between sectors and scales. As a result the institutional arrangements have both gaps and overlaps (i.e., institutional fragmentation and redundancies). To improve agricultural water management, coordination mechanisms should be strengthened (e.g., through multi-stakeholder platforms), and the roles and responsibilities of the different actors should be clarified (Stein et al. 2014).

Watershed management can be augmented with market oriented commodity developments along the watershed resources gradient: upstream, valley bottoms and downstream in order to increase benefits to farmers through participatory, demand driven, and skill and knowledge approach. This opportunity can be exploited to create commercially viable and competitive honey industry in Ethiopia in a very short time possible.

Below are some examples of watershed management activities performed in Tigray and Amhara Regions over the last few years with high relevance to the apiculture sector.

Tigray watershed management activities

Land degradation, which includes degradation of vegetation cover, soil degradation and nutrient depletion, has been and still is a major ecological problem in Tigray, Northern Ethiopia. As a response of the ever expanding land degradation, rehabilitation of degraded lands through closed areas has been promoted by region mainly since 1991 (Wolde, 2005). For its implementation, Tigray region has developed a guideline for the utilization and development of closure areas and potential forests and hillsides. Tigray has made an exemplary achievement in the rehabilitation of degraded lands through community based soil and water conservation and reforestation activities in the last two decades. Through these concerted efforts vast degraded areas have been rehabilitated and are now covered with vegetation. This is more evident in Eastern, Central, South-eastern and part of North-western zones of the Region. In the years 2012, 2013 and 2014 alone, 275,239 ha, 250,144 ha and 267,913 ha of area closures, respectively, were delineated in
Tigray, according to data obtained from Bureau of Agriculture and Rural Development (BoARD). The trees grown in community forests and area closures have helped to significantly overcome the acute shortage of wood for fuel and construction.

Although the above is achieved, the region recognizes that more could have been done if the efforts were integrated with clear plans, sufficient funds, expertise, sense of ownership and benefit sharing of the people. Currently, an integrated watershed management is being implemented by the Regional Government through governmental and other funds obtained through bilateral and multilateral agreements. In this, apiculture development is integrated and is one of the major activities that generates additional income to thousands of households.

**Amhara Region watershed management activities**

According to Bureau of Agriculture (BoA), Critical and Micro-watershed activities are being carried out in the Amhara Region. The zones are divided in to two groups based on the source of the funds to support these activities. East Gojam, Awi, North Shewa, West Gojam, North Gonder, and South Gonder zones are funded by KfW Group- a German Government owned Development Bank. East Gojam, North Shewa, North Gondar, Oromia and South Wollo zones are funded by Canadian International Development Agency (CIDA).

The integrated watershed activities have an area coverage of 64,977 ha and have benefited so far about 35,708 households. A report on the performance of Natural Resource Development and Conservation activities in Amhara Region indicates the following:

1. Integrated watershed management
   - Out of the total 23,966 watershed areas designated in the Region, watersheds where soil and water conservation activities was carried out 2003-2006 E.C. are 17,513 (73%),
     i. 4,997 watersheds (29%) are fully conserved,
     ii. 5,148 watersheds, partially conserved and
     iii. 6,488 (37%) where there are various problems to implement the conservation efforts.
2. In 2,688 watersheds where water and soil conservation has been held, first round physical work is completed through coordinated work of 112,408 groups with a total of 4,891,401 people.

3. Conservation of degraded area (gullies): Out of the total 182,080 ha of land identified as degraded, conservation activities including building of physical structures and planting of multi-purpose trees has been carried out on a land of 62,182 ha (34%).

4. Tree planting on rehabilitated areas is done in 769 watersheds that have started reforestation activities with the participation of 45,010 households. It is estimated that an income of Birr 10,371,086.00 has been generated from sales of forest products (mainly for firewood and construction).

5. Horticulture development in rehabilitated areas- 694 watershed areas are engaged involving 24,119 households. Birr 14,646,711 income generated from sales of mango, orange, avocado, apple, etc.

6. 59,681 water ponds were prepared between 2003 and 2006 E.C. out these, 44,451 (74.5%) are being used for irrigation.

7. To promote forest and agro-forestry activities several nurseries were established that are owned by the regional government, private companies, cooperatives and others organizations and the nurseries are producing millions of economically important tree due to increasing demand for seedlings. 356 million seedlings of mainly Grevillia, Cordia, Acacia spp. and Moringa were produced in 2006 E.C.

8. 2,312 springs that were not present in the area came in to being after the above integrated watershed activities. These were supplemented through the construction of 390,836 hand pump water wells.

The above integrated watershed management work has created a window of opportunity for promoting beekeeping activities on rehabilitated areas. Currently, 816 watershed areas are engaged in beekeeping activities with an input of 10,835 improved/modern, 13,699 transitional and 15,936 traditional hives (total of 40,470). The total number of households engaged in beekeeping is estimated at 34,768.

### 3.3 Beekeeping and Watershed Management

Soil and water conservation as well as reforestation and area closures of watersheds have resulted in improved water retention capacity and recovery of perennial bee forage plants in cultivated lands, upstream hilly sides in areas where it is being implemented including Tigray and Amhara Regions. These activities have also revitalized surface and groundwater in the downstream of the watersheds in different parts of the country (Gebremedhin, et al., 2012).
The viability of productive conservation depends, however, on efforts to manage economic and ecological factors so as to ensure that the relationship between communities and environment are sustained. Beekeeping is linking conservation and local livelihoods based on the principle that watershed pay for itself by generating sustainable economic benefits for local communities (Kumsa and Gorfu, 2014). Beekeeping is important as a strong incentive and the cheapest eco-friendly approach to promote conservation of natural ecosystems as an adjunct to conventional subsistence agriculture in the face of growing human population and demand for land (Munthali and Mughogho, 1992, Tolera, 2014). It has a potential to increase resilience of the farming communities as a means of livelihood diversification. Beekeeping has also potentially low investment costs and promising high returns in the immediate and longer term. Thus promoting beekeeping leads towards sustainable livelihood options, household food security and improved incomes. Farmers can easily adopt beekeeping as an additional activity which will diversify their sources of income – and encourages land users to manage forest and woodlands better, therefore has win-win benefits (FAO, 2014). The generation of better benefits from the integrated watersheds interventions triggers the community to re-invest and protect the watersheds sustainably. Thus, knowledge and skill based market oriented commodity development unlocks the use of conserved watershed resources gradient effectively and efficiently (Gebremedhin, et al., 2012).

Beekeepers in watershed areas in various parts of the country have developed the practice of planting and maintaining trees, shrubs and herbs in coordinating honey production with erosion control, growing forage, fruit, vegetables and animal husbandry. This includes growing major bee forage trees, shrubs and herbs near homesteads, gully sides, river banks, hillsides and farm boundaries to increase honey production. However, such activities require continuous efforts to create awareness on how to maintain the existing bee flora and multiplication of selected plant species for its sustainability. Some plant species that are recommended as multipurpose by Holeta Bee Research Center for different watersheds include: *Acacia abyssinica*, *A. saligana*, *A. decurrens*, *Eucalyptus camaldulensis*, *E. gilbulus*, *Hagenia abyssinica*, *Cordia africana* and *Croton macrostachys*, *Chameacytisus palmensis* and *Sesbania sesban*. These species are flowering plants and could greatly contribute to sustainable beekeeping development and watershed conservation (Fichtl and Admasu, 1994).
A study conducted in eastern zone of Tigray by Emiru et al., (2006) shows that, species richness and ground cover in the area closure is much higher than in the open area, this shows the positive impact of area enclosure in the species biodiversity. In some places of Ethiopia, where the areas are well rehabilitated and increased moisture in the improved forage sites, the duration of bloom period of bee forage plants stayed longer than the none intervention sites (Berhanu et al., 2010). According to Jacobs et al. (2006), during watershed/degraded area rehabilitation through area enclosure and/or reclamation we have to consider and give special attention for the bee flora species and other multipurpose plant species. Moreover beekeeping should be incorporated into overall land management strategies and farming systems, so as to ensure abundant nectar and pollen for a good and successful apiculture development.

One aspect that should be looked at the in the farming system is to look at the effect of cattle grazing on bee forage. In Ethiopia and in other parts of the world, natural open landscapes are exploited for both livestock pasture and honeybee forage. Especially, where these natural open areas are limited due to overpopulation and land degradation, livestock grazing and natural honeybee forage spots could overlap. These becomes pronounced in the main honey flow seasons when high quality honey bee flora are available.

There are different views on whether such overlaps brings critical conflict between cattle raising and beekeeping. Some claim that intensive cattle grazing reduces the honey production potential in intensively grazed areas since the cattle removes most of the flowers, sometimes, before full bloom, and negatively influencing forage quality and honey production in the grazed area. Others believe that grazing may have positive effects on honeybee forage through increasing flower abundance in the area by suppressing grasses (Noy-Meir et al., 2006 as quoted in Kaminer et al., 2010). However, a study by Kaminer, et al. (2010) in Israel showed that intensive grazing during the flowering season in spring did not seem to suppress the full bloom potential or restrain flower production within the local flora and hence, the availability of nectar and pollen for honeybees was not likely to be reduced, as pollen and nectar in flowers are not utilized by any other livestock. It seems that some level of grazing is necessary to support natural honeybee forage by preserving a mixed structure of shrubs and open herbaceous patches. In some
ecologies bees are also attracted by flowers of perennial woods and shrubs than herbaceous plants and this reduces competition with the cattle.

Therefore, identifying the grazing regimes that can maintain or even enhance the abundance of important plant species for honeybee forage is crucial for sustaining apiculture in these areas. Where grazing is likely to reduce important bee forage that are sensitive to grazing, it should be restrained from such areas. Enhancing enclosures with selected multipurpose tree that could provide fodder for both cattle and honey bee is also a good strategy where overgrazing is supposed to have negative impact on bee flora.

There are success stories in Tigray and Amahara Regions showing that integrating beekeeping to watershed management are paying off by improving the life of thousands of farmers by generating income from honey and other bee products.

In order to increase benefits to farmers, participatory, demand driven, skill and knowledge based market oriented commodity development has been introduced, tested and promoted in Atsbi-Womberta district, northern Ethiopia, since 2005/06. It has been found that integrating natural resource conservation with market oriented commodity development provided real incentive for farmers to follow sustainable farming practices. This income difference was also observed in seasons with extreme rainfall variability when the traditional crops failed to produce grain and declined livestock productivity in the nonintervention sites (Gebremedhin, et al., 2012).

In a similar study by Alemtsehay (2011), in Gergera watershed of Atsbi Wonberta woreda, Tigray, the presence and diversified bee flora plants, especially in closed forest area, was very high as a result of watershed rehabilitation significantly benefiting beekeepers. However, these bee floras were only available during August to October due to short duration of the rain. During the dry season there was low cover of bee flora from late December to mid-March. This will certainly result in failure of honey production throughout the year as well as affect colony
strength. Therefore to solve this problem beekeeping based agro-forestry practices on cultivated
rain fed land, and selection of plant species that can resist drought and bear (set) flower for a
long period of time should be introduced in all land use types.

According to another study conducted in Burie District of Amhara Region by Tessega (2009),
bee keepers try to overcome the problem of reduction of honey bee plants, by growing different
local bee forage plants near by the apiary in degraded water shed sites. Some of the multipurpose
trees that were recommended the reclamation of the area included Acacia seyal, Cordia africana,
Croton macrostachys, Olea europeana. Thus beekeeping should be incorporate into overall land
management strategies or watershed management and farming systems, so as to ensure abundant
nectar and pollen for a successful apiculture development in the country. In addition to planting
of agro forestry trees, considering planting of herbaceous legumes such as Vicia sativa and
Desmodium spp which can be used as animal forage and improving soil fertility is important.

Based on data obtained from the Ministry of Water, Irrigation and Energy, a brief performance
of Tekeze-Tsirare Integrated Watershed Management and Development project is briefly
summarized below to illustrate the relevance of watershed management activities to the
apiculture sub-sector.

This project is run in 15 Woredas surrounding Tekeze Dam and that are found in both Amhara
and Tigray Administrative Regions. To protect the dam from siltation, water and soil
conservation and reforestation works were carried out during 2013-2014 budget years. This area
has been highly affected by land degradation but due to the intensive conservation work done
during this time, the area is rehabilitated and is opening job opportunity for the inhabitants.
Apiculture is part of the integrated watershed and development work and forage plants are also
included to support people who are engaged in beekeeping activities in the area.

The following are some of the activities that were accomplished so far:
• 2355 ha of land has been covered with 10,468,128 seedlings that were produced in 51 nurseries established in these woredas.
• In 2013, about 7,580,644 seedlings have established and some of these are good honeybee forage plants locally known as Goza, Akma, Tselwa, Kurkura, Giba and Girar.
• An area closure of 35,032 ha is also demarcated to create conducive environment for beekeeping activities.
• Water structures are built to store enough water to maintain moist conditions for the growth of bee forage. The farmers are now earning additional income for their families from the sale of honey and bees wax.
• As most farmers carryout traditional beekeeping, the project and other NGOs operating in the area are offering training to selected beekeepers on how to make transitional hives from bamboo which is abundant in the area.
• During this period beekeeping job opportunity has been created for 331 farmers (215 men and 116 women).
• Training will intensively be given to farmers and improved/modern hives with accessories and necessary inputs will be distributed in 2015 budget year for additional 150 farmers (105 men and 45 women).

In Conclusion, beekeeping is an environmentally sound, technically suitable and economically feasible income generating activity for poverty alleviation and food security. It could diversify the watershed community economic base, and therefore, encourage to be allied with the current efforts in disseminating conservation-based development. Selecting and planting of flowering shrubs, herbs and trees that are found to be prolific producers of nectar/pollen should be enhanced around homesteads, gully sides, river banks, hillsides and farm boundaries which is important to the benefit of productive beekeeping (Fig. 2) While selecting multipurpose trees for watershed, one of the factors to consider should be nectar/pollen production.

Therefore, governmental and non-governmental development agencies should provide support for the promotion of the current efforts of watershed conservation by integrating it with improved beekeeping for surplus honey production as income generation and to eventually build household assets. Active research should be initiated to provide continuous information on bee-plant interactions supplemented by seasonal colony management practices for surplus honey production as incentive to watershed conservation. This will be useful given the opportunity and potentials for increased export of honey from Ethiopia. The government at all levels should provide technical services to align improved beekeeping to watershed conservation so that honey production is increased and sustained (Kumsa and Gorfu, 2014).
3.4. Floral calendar and honey flow season

The presence of honey plants that provide pollen and nectar is very important for survival, colony strength, production and productivity of the honeybee colony. To set up a favorable landscape for honeybees, therefore, it is essential to understand the relationship between this insect and the pollen/nectar providing flora in their environment. This is because the potential of land for beekeeping depends on the nature of the vegetation it supports. Thus, vegetation characteristics of a region are considered to be an important indicator of its potential for beekeeping. As honey bees do not visit all plants for their nutrition, identification of the honey bee plants and assessing their abundance, their value to bees, time of blooming and flowering period have a paramount importance for practical beekeeping and in assessing the potential of an area for beekeeping (Nuru et al., 2001; Amssalu, 2004) as well as in planning appropriate seasonal management and effectively uses of the resources. The floral calendar of an area however usually varies from year to year since flowering depends on the weather conditions (Nuru et al., 2001; Decourtye et al., 2011, Hagler et al., 2011).

Floral calendar for beekeeping is a time-table that indicates to the beekeeper; the approximate date and duration of the blossoming (flowering) periods of the important honey and pollen plants.

Fig. 2. Apiaries in closure areas and rehabilitated hillsides in Tigray

a) Dega Tembien  

b) Abrha-Atsbeha
(Fig. 3). It also includes various information of the apiary such as decision of different beekeeping managerial activities (Amssalu B., 2004; Admasu et al., 2004).

The distribution and type of honeybee plants as well as their flowering duration vary from one place to another due to variation in topography, climate and farming practices. Hence, every region in Ethiopia has its own honey flow and dearth periods of short or long duration. Beekeepers must have a working knowledge of flowering periods of both major and minor nectar and pollen producing plants in the vicinity of their apiaries for successful honey production and to enable them determine when to carry out various management practices with their colonies. Generally flowering calendars can make easier to plan various beekeeping management operations such as the placing of hives in particular sites and deciding the best time for honey harvest and/or colony swarming.

The major flowering period of honey plants in Ethiopia is from September to November and April to May, after the two known rainy seasons. Following the main rainy season (June to August), the highlands of Ethiopia including central and northern Ethiopia are colored with golden-yellow flowers of *Bidens* species, indigenous oil crops and red violent flower of *Triflouim* spp. Consequently, the major honey flow period is expected from end of October to early December for central and northern parts of Ethiopia. On the other hand in south west and south eastern parts of the country, the major honey flow period occurs during May-June.

Assembling a floral calendar for a specific area is simple but time consuming. It requires complete observation of the seasonal changes in the vegetation patterns and or agro-ecosystem of the area, the foraging behavior of the bees, and the manner in which the honeybee colonies interact with their floral environment (Husien, 1992). The accuracy of a floral calendar and hence its practical value depend solely on the careful recording of the beginning and end of the flowering season of the plants and how they affect the bees. The preparation of an accurate, detailed calendar therefore often acquires several years of repeated recording refinement of the information obtained (Tewolde, 2006 and references therein).
Perhaps due to the above, extensive and detailed studies have not been carried out on the type of plants, their flowering calendar as well as potential for beekeeping in Ethiopia. However, there are some recent studies in different regions in the country which could be used as indicative of the major honeybee flora and their flowering calendar. These include: Kaffa, Sheka and Bench-Maji zones of Southern Ethiopia (Awraris et al., 2014), Sekota area of Amhara region (Tewodros et al., 2013), Western Amhara (Tesfa et al., 2013), Debekidan and Begasheka Watersheds of Tigray (Haftom et al., 2013), Atakilty Kebele, Tigray, (Tewolde, 2006), and Gergera Watershed Atsbi Wenberta, Tigray (Alemtsehay, 2011). Representative floral calendar for some of the areas listed above are shown in Table 5, 6 and 7 and Fig. 3 below.

Fig. 3. Floral calendar of some plants which serve as honey bee forage in different seasons.
Table 5. Dominant honeybee floras, their ranks according to importance and their flowering time in Kaffa, Sheka and Benchi Maji zones.

<table>
<thead>
<tr>
<th>No.</th>
<th>Major honey bee floras</th>
<th>Kaffa +/- Rank</th>
<th>Sheka +/- Rank</th>
<th>Bench-Maji +/- Rank</th>
<th>Flowering period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Schepflera Abyssinica</em></td>
<td>+ 1</td>
<td>+ 1</td>
<td></td>
<td>February-April</td>
</tr>
<tr>
<td>2</td>
<td><em>Vernonia Amygdalina</em></td>
<td>+ 2</td>
<td>+ 3</td>
<td>+ 2</td>
<td>January-February</td>
</tr>
<tr>
<td>3</td>
<td><em>Dombeya torrida</em></td>
<td>+</td>
<td>+ 2</td>
<td></td>
<td>November-December</td>
</tr>
<tr>
<td>4</td>
<td><em>Syzygium guineense</em></td>
<td>+ 5</td>
<td>+ 4</td>
<td></td>
<td>December-April</td>
</tr>
<tr>
<td>5</td>
<td><em>Apodytes dimidiate</em></td>
<td>+ 6</td>
<td>+ 5</td>
<td></td>
<td>January-April</td>
</tr>
<tr>
<td>6</td>
<td><em>Ilex mits</em></td>
<td>+ 7</td>
<td>+ 6</td>
<td></td>
<td>October-November</td>
</tr>
<tr>
<td>7</td>
<td><em>Allophyllus Abyssinica</em></td>
<td>+ 3</td>
<td>+ 7</td>
<td></td>
<td>July</td>
</tr>
<tr>
<td>8</td>
<td><em>Ekebergia capensis</em></td>
<td>+ 4</td>
<td>+ 8</td>
<td></td>
<td>January</td>
</tr>
<tr>
<td>9</td>
<td><em>Prunus africanus</em></td>
<td>+ 9</td>
<td></td>
<td></td>
<td>November</td>
</tr>
<tr>
<td>10</td>
<td><em>Croton Macroystachyus</em></td>
<td>+ 11</td>
<td>+ 10</td>
<td>+</td>
<td>May</td>
</tr>
<tr>
<td>11</td>
<td><em>Jasminum sp.</em></td>
<td>+ 11</td>
<td></td>
<td></td>
<td>November</td>
</tr>
<tr>
<td>12</td>
<td><em>Euphorbia sp.</em></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><em>Aningeria adolfi-friedrici</em></td>
<td>+ 12</td>
<td>+ 1</td>
<td></td>
<td>January-May</td>
</tr>
<tr>
<td>14</td>
<td><em>Maesa lanceolata</em></td>
<td>+ 10</td>
<td></td>
<td></td>
<td>July</td>
</tr>
<tr>
<td>15</td>
<td><em>Cordia Africana</em></td>
<td>+ 3</td>
<td></td>
<td></td>
<td>September</td>
</tr>
<tr>
<td>16</td>
<td><em>Mangifera indica</em></td>
<td>+ 9</td>
<td></td>
<td>+</td>
<td>Throughout the year</td>
</tr>
</tbody>
</table>

Source: Awraris et al. (2014)
Table 6. Major honeybee plants, floral types and flowering calendar in Sekota District, Amhara Region.

<table>
<thead>
<tr>
<th>Local Name (Agewugna)</th>
<th>Scientific Name</th>
<th>Plant Type</th>
<th>Flowering calendar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentesie</td>
<td>Becium grandiflorum</td>
<td>Shrub</td>
<td>15 August- 20 September</td>
</tr>
<tr>
<td>Dedho</td>
<td>Ecullea shimperi</td>
<td>Shrub</td>
<td>All year round</td>
</tr>
<tr>
<td>Kushashle</td>
<td>Echinops spp.</td>
<td>Crop</td>
<td>September-October</td>
</tr>
<tr>
<td>Mashila</td>
<td>Sorghum bicolor</td>
<td>Herb</td>
<td>January-February</td>
</tr>
<tr>
<td>Abika</td>
<td>Acacia tortilis</td>
<td>Tree</td>
<td>March-June</td>
</tr>
<tr>
<td>Keyi Grar</td>
<td>Acacia seyal</td>
<td>Tree</td>
<td>March-June</td>
</tr>
<tr>
<td>Tsalwa</td>
<td>Acacia asak</td>
<td>Tree</td>
<td>All year round</td>
</tr>
<tr>
<td>Ekima</td>
<td>Terminalia glaucescens</td>
<td>Tree</td>
<td>All year round</td>
</tr>
<tr>
<td>Qundoberberie</td>
<td>Schinus molle</td>
<td>Tree</td>
<td>All year round</td>
</tr>
<tr>
<td>Teji matebia</td>
<td>Hypoestes trifolia</td>
<td>Herb</td>
<td>September</td>
</tr>
<tr>
<td>Aba tsemare</td>
<td>Ocimum bacilicum</td>
<td>Herb</td>
<td>15 August- 20 September</td>
</tr>
<tr>
<td>Sibkana</td>
<td>Albizia amara</td>
<td>Tree</td>
<td>May-August</td>
</tr>
<tr>
<td>Kenteftafa</td>
<td>Pterolobium stellatum</td>
<td>Shrub</td>
<td>March</td>
</tr>
<tr>
<td>Wanza</td>
<td>Cordia Africana</td>
<td>Tree</td>
<td>October-December</td>
</tr>
<tr>
<td>Eret</td>
<td>Aloe spp.</td>
<td>Shrub</td>
<td>September-October</td>
</tr>
<tr>
<td>Agam</td>
<td>Carissa edulis</td>
<td>Shrub</td>
<td>October-December</td>
</tr>
<tr>
<td>Yeferenji suf</td>
<td>Helianthus annuus</td>
<td>Crop</td>
<td>September-October</td>
</tr>
<tr>
<td>Adey ababa</td>
<td>Bidens Spp.</td>
<td>Herb</td>
<td>15 August- 20 September</td>
</tr>
<tr>
<td>Beles</td>
<td>Opuntia spp.</td>
<td>Shrub</td>
<td>April-June</td>
</tr>
<tr>
<td>Bahirzaf</td>
<td>Eucalyptus camldensis</td>
<td>Tree</td>
<td>May</td>
</tr>
<tr>
<td>Giba</td>
<td>Ziziyphus spin-christi</td>
<td>Tree</td>
<td>September-February</td>
</tr>
<tr>
<td>Kalkalda</td>
<td>Euphorbia spp.</td>
<td>Shrub</td>
<td>All year round</td>
</tr>
<tr>
<td>Goza (bedana)</td>
<td>Balanites aegyptica</td>
<td>Tree</td>
<td>January-February</td>
</tr>
<tr>
<td>Noug</td>
<td>Guizotia abyssinica</td>
<td>Crop</td>
<td>September</td>
</tr>
<tr>
<td>Bakela</td>
<td>Vicia faba</td>
<td>Crop</td>
<td>15 August- 20 September</td>
</tr>
<tr>
<td>Dikuan tilla</td>
<td>Verbena officinalis</td>
<td>Herb</td>
<td>July 15-December</td>
</tr>
<tr>
<td>Bisana</td>
<td>Croton macrostachyus</td>
<td>Tree</td>
<td>January-February</td>
</tr>
<tr>
<td>Vernacular name (Local name)</td>
<td>Scientific name of the plant</td>
<td>Plant type</td>
<td>Rank</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------</td>
<td>------</td>
</tr>
<tr>
<td>Awhi</td>
<td><em>Cordia Africana</em></td>
<td>Tree</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tebeb</td>
<td><em>Beciumgrandiflorum</em></td>
<td>Shrub</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Girbia</td>
<td><em>Hyposusariculatal</em></td>
<td>Herb</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kolkal</td>
<td><em>Euphorbium candelabrum</em></td>
<td>Tree</td>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Beles</td>
<td><em>Opuntia ficus-indica</em></td>
<td>Shrub</td>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Demhala</td>
<td><em>Andropogonabyssinicus</em></td>
<td>Grass</td>
<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adeyabeba, Tnigti</td>
<td><em>Bidenspachyloma</em></td>
<td>Herb</td>
<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gelgelemeskel</td>
<td><em>Bidensmacroptera</em></td>
<td>Herb</td>
<td>8&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>TsaedaBahrzaf</td>
<td><em>Eccalyptus globules</em></td>
<td>Tree</td>
<td>9&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hamliadri</td>
<td><em>Cassia arereh</em></td>
<td>Herb</td>
<td>10&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>SufBahri</td>
<td><em>Carthamustinitorius</em></td>
<td>Crop</td>
<td>11&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dander</td>
<td><em>Carduus scamcecephalus</em></td>
<td>Shrub</td>
<td>12&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Nihug</td>
<td><em>Guizotiaabyssinica</em></td>
<td>Crop</td>
<td>13&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sesegwukaria</td>
<td><em>Saturejapunctata</em></td>
<td>Herb</td>
<td>14&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tambuh/k</td>
<td><em>Croton macrostachys</em></td>
<td>Tree</td>
<td>15&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Awlie</td>
<td><em>Olea Africana</em></td>
<td>Tree</td>
<td>16&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Source: Tewodros et al. (2013)
The above section has tried to show the list of main honey bee flora in different areas of the country and their blossoming period (the floral calendar). This illustrates that with proper identification, selection, and multiplication of the plants that are appropriate for each agro-ecology, we can have flowering plants almost throughout the year and thereby enabling producers enjoy multiple harvest of honey. In moisture stressed areas, flowering plants can be made available during the dry season through appropriate water harvesting schemes. Seeds of herbaceous plants that could have otherwise failed to germinate due to absence of adequate moisture can germinate and serve as bee forage during this time there by extending the floral calendar. Deliberate sawing of seeds that are identified as good honey bee forage can also be used as strategy to enhance this endeavor.

### 3.5 The potential for production of Mono-floral honey in Ethiopia

As mentioned in the last section, knowledge of floral calendar of honeybee forages found in forests, area closures and rehabilitated hillsides in different parts of the country is important. This helps to identify areas with potential for the production of mono-floral honey. Mono-floral honey is obtained due to the presence and abundance of certain floral species at some specific periods of the year. Mono-floral honey is a type of honey which is valued because it has a distinctive flavor or other attributes due to its being predominantly from the nectar of one plant species.

In most parts of Ethiopian, beekeepers harvest honey once or twice a year depending on whether the area receives rain once or twice a year and depending on the flowering season of the honeybee flora. As such, the bulk of honey produced is poly-floral honey (honey sourced from different types of nectars). However, an understanding and proper designing of the floral calendar of an area could help to establish mono-floral honey production with the possibility of harvesting 3-4 times a year. This maximizes the amount of honey produced and increases the benefit from the honey value chain.

<table>
<thead>
<tr>
<th></th>
<th>Plant Name</th>
<th>Type</th>
<th>Date 1</th>
<th>Date 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chea</td>
<td><em>Acacia Seyal</em></td>
<td>Tree</td>
<td>17&lt;sup&gt;th&lt;/sup&gt; September</td>
<td>November</td>
</tr>
<tr>
<td>Momona</td>
<td><em>Acacia albida</em></td>
<td>Tree</td>
<td>18&lt;sup&gt;th&lt;/sup&gt; October</td>
<td>November</td>
</tr>
<tr>
<td>Ekatalian</td>
<td><em>Agave sisalana</em></td>
<td>Tree</td>
<td>19&lt;sup&gt;th&lt;/sup&gt; October</td>
<td>September</td>
</tr>
</tbody>
</table>
The current situation of world honey market indicates that there is an increasing trend of consumers preferences towards honey types based on geographical origin or specified floral origins (mono-floral or poly-floral honeys). Such honey types often lead to a premium price due to their organoleptic or pharmacoactive properties. In addition, the increased importance of quality, integrity, sanitation and nutritional value of honeys also contribute to a rising demand for organic honey (Gemechis Legesse 2004, EU, 2014). Consumers are willing to pay for specialty honey but for producers there is a need to meet strict production requirements to achieve either an organic or Fair-trade certification to demonstrate the added value of the honey to the consumer. Therefore production of mono-floral honey based agro-ecologies and characterizing them according to botanical origin is very important for maximizing the profits of beekeepers.

According to a report from the European Commission (EU, 2013), the price received by beekeepers for their honey is affected by two main drivers: the type and quality of honey (including the differences between table and industrial honey, and mono-floral and poly-floral honey) and the market structure (sales done directly to the consumer vs. sales to packers and distributors). In general, table honey reaches higher prices than industrial honey, and mono-floral and honeydew honeys fetch higher prices than poly-floral honeys. It was generally agreed, as a matter of fact, that mono-floral honeys reach higher prices in the market than multi-flower honeys.

In Germany, it is estimated that 1/3 of German honeys are sold as mono-floral honey. The average consumer price for honey being around €8/kg, that of honeys from specific botanical origins, such as heather honey, reaches up to €16/kg (EU, 2013, Benchmarking experience). In Hungary, acacia honey –the most typical mono-floral honey in the country- has consumer prices in the range of €7-7.5/kg while multi-flower honeys have consumer prices of around €4.5/kg. Other examples of top quality well-known honey types are Lavender from France, Heather from Germany, Chestnut from Italy, and wild-oregano, wild-levanter, and salvia from aromatic plants of Greek.

Ethiopia has also great potential for the production of mono-floral honey and can obtain premium prices by competitively penetrating into global market in general and the European market in particular. Industry sources estimate the size of the market for mono-floral honeys at
10-15% of the total market, or 8-12 thousand tons (Personal communication). Thus, identification of mono-floral honey is necessary for our country to benefit from this market. Although much has not been done to study mono-floral honey resources in Ethiopia, Gemechis Legesse (2004) and Belay (2014, unpublished data), have tried to carry out physico-chemical analysis to identify sources of mono-floral honey. Based on this studies, Ethiopia can possibly produce mono-floral honey from different potential areas (Table 8). The most important mono-floral honeys that can possibly be produced from Ethiopia are: *Schefflera abyssinica, Croton macrostachys, Vernonia amygdalina, Syzygium guineense, Eucalyptus globulous, Becium grandiflorum, Hypoestes foraskli, Acacia Senegal, Ziziphus spina-christi, Erica arboria, Acacia tortilis and Leucas Abissinica*. 

It can be safely construed that Ethiopia can produce many more mono-floral honeys than the above because of its floral diversity and variations in agro-ecologies. This is because the quality of mono-floral honeys vary according to location and seasonal variations. However, intensive research is required to better characterize specific properties and better manage the production of specific honeys. Findings from such research activities can help beekeepers to formulate precise product descriptions for communication and promotion of the honeys towards the consumers. Establishing well equipped physico-chemical analysis laboratories to establish botanical and geographical origin of the honey is a move in the right direction to gain substantially form the export of branded mono-floral honey.

Some mono-floral honey produced from different vegetation types in Ethiopia and their quality parameters are shown in Table 8.
Table 8. Location of and type of plants with potential for mono-floral honey production (some of them are still under investigation).

<table>
<thead>
<tr>
<th>Region/zone of sample collection</th>
<th>Woreda/place (Label)</th>
<th>Type of mono-floral honey (treatment)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oromia, Guji</td>
<td>Uraga</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td>SNNP, Sheka</td>
<td>Masha</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>Andracha</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td>SNNP, Bonga</td>
<td>Guata</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>Chena</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td>Oromia, Guji</td>
<td>Uraga</td>
<td>Scheffleria Abyssinica</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>Ana Sora</td>
<td>Syzygium guineense</td>
<td>Identified</td>
</tr>
<tr>
<td>AA, Yeka</td>
<td>AA 1</td>
<td>Eucalyptus globulous</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>AA 2</td>
<td>Eucalyptus globulous</td>
<td>Identified</td>
</tr>
<tr>
<td>Oromia, Illubabor</td>
<td>Becho</td>
<td>Croton macrostachys</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>Yayo</td>
<td>Croton macrostachys</td>
<td>Identified</td>
</tr>
<tr>
<td>Oromia, Bale</td>
<td>Mena</td>
<td>Croton macrostachys</td>
<td>Identified</td>
</tr>
<tr>
<td></td>
<td>Angetu</td>
<td>Croton macrostachys</td>
<td>Identified</td>
</tr>
<tr>
<td>Tigray &amp; Amhara</td>
<td>Wukro</td>
<td>Becium grandiflorum</td>
<td>To be identified</td>
</tr>
<tr>
<td></td>
<td>Maychew</td>
<td>Becium grandiflorum</td>
<td>To be identified</td>
</tr>
<tr>
<td></td>
<td>Lalibela</td>
<td>Becium grandiflorum</td>
<td>To be identified</td>
</tr>
<tr>
<td>Tigray</td>
<td>Maychew 1</td>
<td>Leucas abyssinica</td>
<td>To be identified</td>
</tr>
<tr>
<td></td>
<td>Maychew 2</td>
<td>Leucas abyssinica</td>
<td>To be identified</td>
</tr>
<tr>
<td>Tigray</td>
<td>Wukro 1</td>
<td>Hypoestes forskaolii</td>
<td>To be identified</td>
</tr>
<tr>
<td></td>
<td>Wukro 2</td>
<td>Hypoestes forskaolii</td>
<td>To be identified</td>
</tr>
<tr>
<td>Amhara</td>
<td>Zikuala 1</td>
<td>Acacia senegal</td>
<td>To be identified</td>
</tr>
<tr>
<td></td>
<td>Zikuala 2</td>
<td>Acacia senegal</td>
<td>To be identified</td>
</tr>
<tr>
<td>Tigray</td>
<td>Tekeze</td>
<td>Zizyphus spp.</td>
<td>To be identified</td>
</tr>
<tr>
<td>Amhara</td>
<td>Debark</td>
<td>Erica arboria</td>
<td>To be identified</td>
</tr>
<tr>
<td>Oromia</td>
<td>Wonchi</td>
<td>Erica arboria</td>
<td>To be identified</td>
</tr>
<tr>
<td>Amhara</td>
<td>Andassa</td>
<td>Syzygium guineense</td>
<td>To be identified</td>
</tr>
<tr>
<td>Oromia</td>
<td>Ziway</td>
<td>Acacia tortilis</td>
<td>To be identified</td>
</tr>
<tr>
<td>Oromia</td>
<td>Wellega</td>
<td>Vernonlia amygdalina</td>
<td>To be identified</td>
</tr>
<tr>
<td>Oromia</td>
<td>Becho</td>
<td>Vernonlia amygdalina</td>
<td>To be identified</td>
</tr>
</tbody>
</table>
Table 9. Types of mono-floral produced from different agro-ecologies in Ethiopia and their physico-chemical characteristics as compared to world standards.

<table>
<thead>
<tr>
<th>Botanical source</th>
<th>Percent age of pollen</th>
<th>Moisture content</th>
<th>HM F</th>
<th>Mineral content</th>
<th>Acidity</th>
<th>Area of production</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Guizotia spp</em></td>
<td>62.3</td>
<td>19.06</td>
<td>4.5</td>
<td>0.16</td>
<td>26.93</td>
<td>Central and northern highlands</td>
</tr>
<tr>
<td><em>Eucalyptus globulus</em></td>
<td>56.3</td>
<td>19.0</td>
<td>18.5</td>
<td>0.2</td>
<td>21.72</td>
<td>Central highlands</td>
</tr>
<tr>
<td><em>Schefflera abyssinica</em></td>
<td>100</td>
<td>19.6</td>
<td>14.9 4</td>
<td>0.13</td>
<td>22.24</td>
<td>Moist humid forest</td>
</tr>
<tr>
<td><em>Acacia spp</em></td>
<td>86.4</td>
<td>18.4</td>
<td>14.2 6</td>
<td>0.22</td>
<td>22.72</td>
<td>Rift valley system</td>
</tr>
<tr>
<td><em>Vernonia spp</em></td>
<td>83</td>
<td>18.64</td>
<td>24.3 4</td>
<td>0.15</td>
<td>29.9</td>
<td>Moist humid forest</td>
</tr>
<tr>
<td><em>Crotom Macrostchys</em></td>
<td>93</td>
<td>23</td>
<td>10.2 5</td>
<td>0.04</td>
<td>13.69</td>
<td>Moist humid forest</td>
</tr>
<tr>
<td><em>Syzygium guinnesse</em></td>
<td>80.7</td>
<td>21.3</td>
<td>37.7</td>
<td>0.18</td>
<td>39.24</td>
<td>Moist humid forest</td>
</tr>
<tr>
<td><em>Erica arborea</em></td>
<td>100</td>
<td>18.7</td>
<td>Nd</td>
<td>0.3</td>
<td>25.9</td>
<td>Afro alpine</td>
</tr>
<tr>
<td><em>Becium grandiflorum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopian standards</td>
<td>17.5</td>
<td>&lt;40</td>
<td>&lt;0.6</td>
<td>&lt;40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>World standards</td>
<td></td>
<td>&lt;80</td>
<td>0.25-1.0</td>
<td>&lt;50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gemechis Legesse, 2004

3.6 Honeybee flora and carrying capacity

In most cases, success in beekeeping depends on the availability of sufficient bee forage in terms of both quality and quantity of nectar and pollen grains. Hence, beekeeping is more dependent on the existing natural resource conditions of an area than any other livestock activities. In areas, where beekeeping is not suitable, other improved management skills and advanced technologies alone cannot make beekeeping successful. For this reason, availability of adequate bee forage is considered to be one of the most important elements in the beekeeping industry (Al-Ghamdi, 2014).

Although the honey industry sub-sector is growing significantly, overcoming the seasonal shortage of bee forage could be one of the critical challenges among others to its development. When food resources of an area designated for beekeeping vary in quantity and quality over a temporal and spatial scale, the nutritional carrying capacity for honeybees varies a lot as well. The challenge will be even more pronounced in moisture stressed and highly degraded areas. In this case, the foraging ecology of honeybees has to be considered within temporal and spatial
scales. Foraging is the act of honeybees fetching food, nectar and pollen from flowers scattered around their beehive in order to feed the colony.

Determination of the carrying capacity of apiary sites requires the careful measuring of the nectar secretion of selected forage species recorded as trees/shrubs/herbs with massive flowers during flowering season. Optimum honey yield of such apiary in turn will be estimated as the amount of honey yield to be harvested based on nectar secretion potential of that selected bee forage species. Estimating honey yield based on nectar secretion is a challenging task (Al-Ghamdi et al., 2014). Part of the challenge is, apart from genetic factors, nectar production (volume and concentration) depends on the developmental stage of the plant, as well as the time of day and the age and position of the flower on the plant. Even more, it depends largely on environmental factors such as soil type and moisture level, cultivation practices, and weather conditions such as wind, temperature, relative humidity (Decourtye, et al., 2011).

Literature is scanty related to carrying capacity of apiaries and there is none in Ethiopia as far as we know. However, some studies are emerging such as one by Al-Ghamdi et al., (2014) on a new approach for determination of an optimum honeybee colonies carrying capacity based on productivity and nectar secretion potential of bee forages species. The study was initiated because it was revealed that the average annual yield of honey per colony declined to 3.7 kg/ traditional hive and 6.6 kg/ Langstroth hive in 2012 (Nuru, et al., in press), which is a great challenge for beekeeping industry in Saudi Arabia. This decline in honey yield per colony was attributed to many factors, the most important of which are scarcity of bee forage and overstocking honeybee colonies above the carrying capacity of available forage area (Al-Ghamdi, 2005).

The findings of the above study are summarized below in order to draw a lesson from it for properly managing apiaries that are currently mushrooming in forests, area closures, rehabilitated hillsides and even backyards of individual beekeepers in the country.

This study was carried out to determine an optimum honeybee colonies carrying capacity of selected valleys dominated with Ziziphus spina-christi and Acacia tortilis in Al-Baha region, Kingdom of Saudi Arabia. It was conducted based on the assessment of number of colonies kept, their productivities and the existing productive bee forage resources (nectar secretion potentials) in the target valleys and with its economic implication. The optimum carrying capacity was
defined as how many honeybee colonies on a given number of flowering plants per given area can be kept or placed without negatively affecting honey production potential of individual colonies. In the existing beekeeping practice, the average number of managed honeybee colonies introduced per square kilometer were 530 and 317 during the flowering periods of \textit{Z. spina-christi} and \textit{A. tortilis}, respectively.

This study revealed that the number of honeybee colonies introduced in relation to the existing bee forage potential was extremely overcrowding which is beyond the carrying capacity of bee forage resources in selected valleys and it has been observed to affect the productivities and subsequent profitability of beekeeping. The study infers that, by keeping the optimum honeybee colonies (88 in traditional hives/km2 or 54 in Langstroth hives/km2 in \textit{Ziziphus} field and 72 in traditional hives/km2 or 44 in Langstroth hives/km2 in \textit{A. tortilis} field) profitability of beekeeping can be boosted up to 113.91\% and 247.57\% during \textit{Z. spina-christi} and \textit{A. tortilis}, flowering seasons respectively (Table 10).

This study is particularly relevant and worth repeating in Ethiopia because both plants grow in the \textit{Combretum-Terminalia} Broad-leaved Deciduous Woodland and Semi-evergreen Lowland Ecosystem of Ethiopia and are registered as important bee forage plants. Particularly, these plants grow in Tekeze River basin of both Tigray and Amhara Regions, in the Rift Valley and other lowland areas of the country from 0-1900 m above sea level. So, \textit{Ziziphus spina-christi} and \textit{A. tortilis} can be promoted to harvest mono-floral honey in areas where they grow predominantly. If the above carrying capacity can be established for Saudi Arabia, a desert, it can be much higher in Ethiopia due to higher moisture which increases the productivity of the plants.

From the above study, illustrates that determining the carrying capacity of an area used for beekeeping is crucial to decide the number of colonies to be placed in the apiary site. Studies reported that honeybees are threatened by overpopulation which is caused by limited resources that can support certain number of honeybee colonies only (Esteves et al., 2010). This could be due to the fact that, as the number of colonies increases the amount of nectar source consumed by large number of colonies for survival is high. Furthermore, strength of colony could be negatively affected by overcrowdings due to high floral resource competition during flowering season of the plant species in the area (Esteves et al., 2010).
Determining optimum distance between apiaries could also help minimize floral resource competition. Hagler et al. (2011) reported that honey bees can forage up to 6 km from their apiaries. However, on average honeybees tend to visit within 800 m from their apiary if attractive floral resources are available, and honey yield per hive almost can be doubled within 1 km from the forest compared to hives placed about 3 km from the forest. Therefore, productivity of colonies can be improved by maintaining the optimum honeybee colony size that match with the carrying capacity of specific apiary sites and determining optimum distance between apiaries.

In many parts of Ethiopia bees and beekeepers suffer from seasonal drought, which causes a shortage of bee forage especially during the dry season. Moreover the shrinkage of natural habitat of plants also cause severe food shortage to honey bees leading to colony absconding. These conditions force many beekeepers to move their colonies from one area to another in search of better nectar and/or pollen sources and to avoid severe weather condition. In this regard, there are no directives to guide or determine the number of colonies to be placed per unit area, nor has it set out the minimum distances between two adjacent apiaries to minimize competition caused by the overlapping of foraging ranges and subsequent declines of productivity of colonies. This information is helpful to guide small or large scale investors to place appropriate colonies size in relation to population density, nectar and pollen potential of honey plants. Therefore determination of carrying capacity or stocking rate of the given area is important to increase productivity and profitability of beekeeping.

To achieve the above objective, research has to be carried out by agricultural research centers and universities to estimate the nectar and pollen production of the potential honey bee flora that are found in different parts of the country. This will help to select the best forage plants for bee keeping and promote their propagation and dissimilation to the agro-ecology they are best adapted to. This will also help to determine the carrying capacity of the these plants during their pick flowering season so that beekeepers decide the number of hives that can placed per given area (e.g. km²) for optimum honey production.
Table 10. Density of colonies, optimum and current honey yield (kg) of *Ziziphus spina-christi* in different valleys.

<table>
<thead>
<tr>
<th>Name of Valley</th>
<th>Productive trees (A)</th>
<th>Number of apiaries</th>
<th>Number of colonies (B)</th>
<th>Traditional hives (C)</th>
<th>Langstroth hives (D)</th>
<th>Ratio of trees to colonies</th>
<th>Optimum honey yield expected (5.21kg *A)/2</th>
<th>Current honey yield (1.25<em>C+ 2.26</em>D)</th>
<th>Distance between apiaries (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkhaita</td>
<td>1695</td>
<td>21</td>
<td>3587</td>
<td>3563</td>
<td>24</td>
<td>0.47</td>
<td>4415</td>
<td>4508</td>
<td>495</td>
</tr>
<tr>
<td>Baraha-Magamaa</td>
<td>1007</td>
<td>36</td>
<td>1778</td>
<td>799</td>
<td>979</td>
<td>0.57</td>
<td>2623</td>
<td>3211</td>
<td>250</td>
</tr>
<tr>
<td>Waable</td>
<td>695</td>
<td>29</td>
<td>1262</td>
<td>585</td>
<td>677</td>
<td>0.55</td>
<td>1810</td>
<td>2261</td>
<td>350</td>
</tr>
<tr>
<td>Kahla</td>
<td>571</td>
<td>10</td>
<td>1004</td>
<td>750</td>
<td>254</td>
<td>0.57</td>
<td>1487</td>
<td>1512</td>
<td>295</td>
</tr>
<tr>
<td>Neera</td>
<td>725</td>
<td>20</td>
<td>847</td>
<td>118</td>
<td>729</td>
<td>0.86</td>
<td>1889</td>
<td>1795</td>
<td>510</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4693</strong></td>
<td><strong>116</strong></td>
<td><strong>8478</strong></td>
<td><strong>5815</strong></td>
<td><strong>2663</strong></td>
<td><strong>0.55</strong></td>
<td><strong>12225</strong></td>
<td><strong>13287</strong></td>
<td><strong>380</strong></td>
</tr>
</tbody>
</table>

Note: Average productivity data for traditional (1.25 kg) and Langstroth hives (2.26 kg) per harvest were adopted from honey production study (unpublished). The value 5.21 kg represents honey production potential of productive *Ziziphus spina-christi* tree per flowering season. (Source: Al-Ghamdi, et al. (2014), unpublished, accessed from the Internet).

3.7. Pollination services of honeybee

Pollination is an essential ecosystem service that enables plant reproduction. This important step depends, to a large extent, on the symbiotic relationship between the plant species to be pollinated and the pollinator. The reduction or loss of either will affect the survival of both. Pollinators contribute to the maintenance of biodiversity and ensure survival of plant species including plants that provide food security to innumerable rural households. It is reported that more than half of the world's diet of fats and oils comes from oilseeds: coconuts, cotton, oil palm, olives, peanuts, rape, soybeans and sunflower that are dependent upon or benefited by insect pollinators. The most important pollinating insects include insects such as bumblebees, solitary bees, stingless bees but honeybees play the most important role.

The total economic value of insect pollination worldwide is estimated to be more than $200 billion and accounts for around 10 percent of agricultural production. To the European agriculture alone, it is estimated that pollinators contribute at least 22 billion EUR each year. They ensure pollination for over 80% of crops and wild plants in Europe thereby fostering the sustainable development of rural areas and maintaining biodiversity (EU, 2013). This benefits of honeybee also hold true for the rest of the world.
Beekeepers in industrialized countries usually charge for pollination services, because they bring the farmer a significant increase in production and bring more work for the beekeeper. The beekeepers do not usually produce a honey crop while supplying the service. Commercially managed bees are available for pollination services and are used in large commercial fields, small gardens, or enclosures such as greenhouses and screen houses.

It is not however apparent to many particularly to the farming community and to policy makers in our country that the economic value of bee pollination is several times more than the value of the worldwide production of honey. They appear not only to be extremely important for traditionally grown and known crops, but also essential for economically promising tropical and less common crops such as *Guizotia abyssinica* (Noug) which is widely grown in Ethiopia. It is important to know the relationship between the pollinator and bee flora to obtain more knowledge about the specific pollinator essential to improve the production of traditional crops (Amsalu, *et al*., 2003).

In addition to the direct economic importance for agricultural pollination, bees play an essential role as the major pollinator of natural eco-systems. Again the honeybees and in certain areas other species of social bees, do take care of large proportion of the pollination in natural ecosystems. Honeybees are very efficient general pollinators of the natural flora through their numbers and special behavioral features such as highly developed communication and recruitment behavior and their ability to store large amounts of food in the nest, which makes them more effective than other insect pollinators (Admasu and Nuru, 1999).

Honey bees are also believed to play a significant role in the economy of the country through pollination services as well. In Ethiopia, an experiment was conducted to evaluate the effect of honeybee pollination on Niger seed (*Guizotia abyssinica*, locally known as Noug) as the crop is self-sterile and requires bees for cross-pollination. The results revealed that honeybees increased the seed yield of Niger seed by about 43 percent and it also increased the oil content of the seed (Admassu and Nuru 2000, Ejigu et al., 2009). In the country, hundreds of thousands of hectares of land is annually covered with this crop and in fact it is currently becoming one of the major sources of foreign currency. The direct monetary value that can be obtained from niger seed pollination service could be huge if properly utilized in the future. Admassu Addi *et al* (2009) carried out similar studies on Onion (*Allium cepa*), which is an important condiment and
vegetable in Ethiopia cultivated for local as well as export market. The intensity of cross-pollination in this crop varies between 30 to 94% depending on availability of pollinators. Results have shown that honeybee pollination increases the seed yield by 84%. Such kinds of studies should expand to other crops as well so that farmers are convinced on the benefits of pollination services.

The above results illustrate the fact that commercial farms could benefit a lot if they could integrate keeping with their crop, fruit and vegetable production systems reaping dual benefit, i.e., increased quality and quantity of production from the pollination service and production of honey for local as well as export market. The coffee production system could be one that could benefit from such endeavor. It is known that there are different Coffee production systems in Ethiopia, namely, forest coffee, semi-forest coffee, garden coffee and coffee plantations. These are mainly produced in the Southern, South Western and Eastern parts of the country. Forests in Southwestern of Ethiopia, West Wellega, Illubabor, and Sheka-Kefa, Bench-Maji zones, are the primary center of origin and center of genetic diversity of Coffee (Coffea Arabica). There are also large plantations (state and private coffee farms) covering large areas such as those in Limu, Tepi and Bebeka. So, if these coffee plantations are integrated with beekeeping they can bring substantial economic benefits both from the pollination service of the bees and production of honey for local and global market. In fact, these areas could bring special mono-floral coffee honey to the global market in the same manner as we are benefiting from our specialty coffee by getting premium price.

To attain the above benefits, pollinators should be protected and sustained. “Pollination is not just a free service but one that requires investment and stewardship to protect and sustain it,” noted the United Nations Environment Program in its 2010 report on pollinators. While very stringent regulatory safeguards are in place to ensure that crop protection products do not pose unacceptable risks to wildlife, good stewardship practices by the crop protection industry, farmers and beekeepers are necessary to help protect the health of pollinators. The crop protection industry should be committed to educating farmers on best practices to minimize any risks to these beneficial insects. Farmers can improve and protect pollinator habitats in a variety of ways. And beekeepers should regularly monitor colonies for mites and diseases.
In conclusion, honeybees have a vital role in increasing food production and overall agricultural productivity. Therefore, more studies should be carried out to demonstrate to farmers how pollination by honeybees can boost productivity of their crops. The agricultural extension package should also take this into consideration so that awareness is created among all stakeholders about the huge economic and ecological benefits of pollination services.

3.8. Current farming practices and their impact on apiculture
To prevent crop loss, plant pests and diseases need to be controlled to maintain the quality and abundance of food, feed, and fiber produced by growers around the world. Subsistence farmers in Ethiopia, and elsewhere in Africa, traditionally use a combination of several pest management practices (such as cultural control, habitat manipulation, mechanical and physical control). However, such practices are not enough to fully control pest and the use of synthetic chemical products are often the first choice in their control regardless that they raise environmental concerns such as toxicity to humans and biodiversity. Although regular chemical pesticide use by small holder farmers in Ethiopia has historically been low, recent developments to increase and diversify food production as well as the rapid expansion of the floriculture industry has resulted in an increased use of chemical pesticides. The effect of these agricultural chemicals on honeybees has been regularly reported by beekeepers.

The use of chemicals and pesticides for crop pests, weeds, Tsetse fly, mosquitoes and household pests control brings with it the possibility of damaging the delicate equilibrium in the colony, as well as the contamination of hive products. Chemical threats may come in multiple forms. For example, in addition to insecticides that may have lethal or sub-lethal effects on honey bees, herbicide drift from adjacent fields may reduce floral density and diversity.

The inadvertent application of chemicals may, for example, create a shortage of bee forages by eradicating some of the important bee forage weeds. Weeds like Guizotia scabra and Bidens species are among the most important honeybee forages and are sources of honey in the country and there are reports that the population density of these plants is decreasing in the hillsides of highlands where they were growing abundantly.
Insecticides have a much more dramatic effect on population of bees, thus, the important contribution made by bees to the production of food and human nourishment is being jeopardized. Moreover, chemicals may contaminate the bee products and can affect the health of consumers and export market of bee products. The types of chemicals used in Ethiopia include Malathion, Sevin, DDT, 2-4 D and Acetone. From the beekeepers’ point of view interviewed during the field work, poisoning of honeybees by agrochemical has increased from time to time. Some beekeepers said that they have lost totally their colonies due to agrochemical. In Hagereselam, Tigray, we met a farmer at the Office of Agriculture and Rural Development who came with mixture of dead/weak bees to appeal to the authorities that this happened because of spray of chemicals by a neighbor (Fig. 4).

![Fig. 4. Dead or weakened bees as a result of spray of herbicides in the vicinity of an apiary.](image)

Today, there are strict regulations on chemical pesticide use, and there is political pressure to remove the most hazardous chemicals from the market. Consequently, some pest management researchers have focused their efforts on developing alternative inputs to synthetic chemicals for controlling pests including bio-control agents and bio-pesticides. Bio-pesticides in general are considered advantageous over conventional chemical pesticides because they affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals. Bio-pesticides often are
effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.

The adoption of bio-pesticides is low in Ethiopia perhaps due to low level of awareness of their positive impacts on agricultural production and lack of appropriate policies and regulatory frameworks to support such endeavor. Recently however, large number of growers in Ethiopia acknowledge the need for adoption of Integrated Pest Management (IPM) partly because of market requirements and due to pressure from environmentalists. The strict regulation by European market to monitor chemical residues in honey will eventually warrant the adoption of bio-pesticides and organic herbicides. Until such time comes, the use of agrochemicals should be restricted to high crop production areas so that organic honey production from the other parts of the country is not affected by their use. In developing countries like Ethiopia no one can avoid totally the application of agro-chemicals since crop production is necessary to feed ever growing population and honeybees must also be kept as they are important for the pollination of the crops. In this regard there must be win-win solution to both crop growers and beekeepers by designing appropriate management plan which is safe to the honeybees and the environment. The most widely recommended practice to reduce pesticide hazards are integrated pest-management practices, use of less toxic chemicals, adjusting of timing of the sprays, early warning practices and creation of awareness, etc. Other practices promoted by the crop protection industry, government agencies, universities and beekeeper organizations among farmers to protect bees include following instructions on crop protection product labels, only using genuine products, avoiding use of certain products during the activity of pollinators in the crop or under windy conditions, and planting flowers at field borders. Farmers can also minimize the distribution of dust from treated seeds by carefully pouring seed out of bags, using properly calibrated and specialized seeding machinery, avoiding seed spillage, properly disposing of unused seed and bags, and regularly cleaning seed equipment. These and other practices can minimize or eliminate any risks to pollinators posed by crop protection products.

Another important way to protect pollinators is for farmers and beekeepers to communicate. Farmers can inform beekeepers when they are going to apply crop protection products to their fields so hives can be moved. Similarly, communication among all parties involved in protecting pollinators is critical. In addition to this promoting organic agriculture and demarcating organic
honey production sites is very important. For instance the forest areas in Ethiopia can be used for organic honey production. On top of this it is very important to have rules and regulations and policies that enforce the importation of less hazardous agro-chemicals that effectively control the target pests and is less toxic to honeybees.

4. Strategies to enhance apicultural production

4.1 Honeybee flora development through area enclosure

As discussed earlier, success in beekeeping depends on the availability of sufficient bee forage in terms of both quality and quantity of nectar and pollen grains. In areas, where beekeeping is not suitable, other improved management skills and advanced technologies alone cannot make beekeeping successful. For this reason, availability of adequate bee forage is considered to be one of the most important elements in the beekeeping industry. However the shrinkage of natural plant habitat due to deforestation is one of the bottlenecks in the country particularly in degraded mountain in central and northern parts of the country. Thus a number of interventions have been made in country to restore degraded areas to protect from massive soil erosion and loss of biodiversity to increase the productivity of ecosystem including apicultural production. For instance bee forage developments and rehabilitation in degraded areas through reclamation and enclosure approach in northern Ethiopia can be mentioned as best practice for conservation of natural resource which improves appropriate condition for apiculture. Area enclosure activity in Tigray and Amhara regions is well developed and as the result the most degraded mountain and valleys have recovered with diversity of plant species creating suitable condition for apiculture development.

The closed areas, which are a type of land management implemented on degraded, generally open access land, are a mechanism for environmental rehabilitation with a clear biophysical impact on large parts of the formerly degraded commons. In closed areas, it is generally believed that the land resources such as soil, wild flora and fauna, or water will be protected from degradation.

Reduced erosion is expected to occur in well-developed closed areas because the canopy formed by the mature shrubs and under-story vegetation shields the soil from the erosive energy of the raindrops thereby protecting it from being eroded. Water infiltration in the soil is enhanced by both preferential flow along trees roots and accumulation of absorbent humus on the soil surface.
which reduces leaching of surface runoff (Jiang et al., 1996 as quoted in Wolde and Veldkamp, 2005).

When an area closure is enhanced through tree planting and continued investment in soil and water conservation structures (particularly given relatively low opportunity costs of labour and the greater benefits of such technologies in drier areas) it may have significant potential to improve land productivity. Biological nitrogen fixation by leguminous plants, uptake by trees of nutrients that are unavailable to crops, and transfer of biomass from outside the farm do increase the stock of nutrients available to the farming system, and can be very important components of a low external input strategy.

In moisture-stressed areas with otherwise suitable soil conditions (particularly areas close to roads and markets), high priority should be given to irrigation investments where irrigation potential exists. Where such potential does not exist because of topography and other ecological reason, simple and affordable water harvesting schemes should be taken in to consideration (Fig. 5)
In addition, adaptive and participatory research is needed to develop more targeted recommendations for integrated nutrient management practices. Recommendations need to take into account available sources of organic matter, local sources of soil nutrients and potential for leguminous crops or trees. Development of high-value perennial crops for the sustainability of land use should also be considered. The priority for such research in the near term should be high-potential areas where this strategy is most feasible. For the longer term, continued basic research is needed to develop varieties that are suitable for use under lower potential conditions, such as in moisture-stressed and drought-prone environments.

In area closures maintained and managed in the aforementioned manner, beekeeping is as an attractive means for improving rural livelihood and even open investment opportunities for who want to engage in the apiculture sub-sector. There are clear evidences in several parts of the country including Amhara and Tigray that farmers can harvest great benefits from area enclosures. This is because of benefits of the area enclosures in increased biodiversity, less soil erosion, more continuous water discharge from the land and increased honey production due to more flowers. Area enclosures also improve the possibility for beekeeping since the vegetation cover will return.

Therefore, transforming enclosure or watershed areas in to apiary is just one example of a possible “win win situation” for poverty alleviation and gain in economic development.

4.2 Planting of bee forages

Land clearance for various purposes led to increased forest product scarcity that in turn resulted in increased demands and further forest destruction. As a result, the closed natural forest, which in the 1930’s covered more than 35% of the country, has now been reduced to less than 3% (FAO, 2001, 2003) resulting in bee forage scarcity. Thus to address this, in different parts of the country including moist and moisture stressed areas, planting of bee forage is to be anticipated.
for sustainable honey production. These problems call for urgent actions for planting and conserving indigenous trees for honey production based on agro-ecologies. In this regard planting of multipurpose trees such as fruit trees (mango, avocado and apple) and Agro forestry trees (Acacia spp, Cordia africana, Shinus molle and Vernonia spp) and others around the apiary site, waste land and home garden may increase honey production and improves the environment. In addition to the selection of appropriate and productive honeybee flora fast methods of propagation should be introduced to facilitate their establishment.

In Tigray (e.g. Atswbi Wonberta) and Amhara (e.g. in the Highlands of Sekota Area), there is a plant known as Becium glandiflorum (Mentesie, Amh. and Tebeb, Tig.) which grows in highly degraded areas. Extra white honey is produced from this plant and farmers are getting between 150-250 Birr/kg depending on the season and the market place. There are other plants (Lecuas abyssinica & Hypoestes foreskoalii) that are found in similar agro-ecology and liked by beekeepers for the production of white honey (Fig. 6). Honey harvested from this plants is even getting international recognition and are being sold in Europe and Middle East countries. These plants are easily propagated either through seed or by vegetative growth by splitting. We have come to learn that farmers in Tigray propagate this plants in their homesteads and their apiaries by bringing them on donkey back from areas where they dominantly grow. Others collect seeds to grow them on their own mini-nursery for transplanting on hillsides in their locality. If such activities are supported by research and best propagation method is developed for these and other plants of apicultural importance, it can be disseminated to similar agro-ecologies elsewhere.
Fig. 6. Plant species known as a source of Extra white honey (a) is a demonstration site for farmers at Hagereselam where the seeds of the plant were brought from elsewhere and grown there).

a) *Becium grandiflorum*

b) *Leucas Abyssinica*

c) *Hypoestes forskaolii*
Some of list of recommended potential multipurpose bee flora are indicated in the table below.

Table 11. List of some recommended honeybee flora to be conserved and planted in and around the apiary in different agro-ecologies.

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common name</th>
<th>Flowering time</th>
<th>Agro-ecologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cordia africana</em></td>
<td>Wanza</td>
<td>July – sept</td>
<td>Mid highland</td>
</tr>
<tr>
<td><em>Grevillea robusta</em></td>
<td>Gravillea</td>
<td>Sept- Oct</td>
<td>Highland &amp; mid highland</td>
</tr>
<tr>
<td><em>Eucalyptus spp</em></td>
<td>Beharzaf</td>
<td>April –May</td>
<td>highland</td>
</tr>
<tr>
<td><em>Manigifera indica</em></td>
<td>Mango</td>
<td>Sept-oct</td>
<td>Mid highland &amp; Lowland</td>
</tr>
<tr>
<td><em>Persea americana</em></td>
<td>Avocado</td>
<td>Sept-oct</td>
<td>Mid highland &amp; Lowland</td>
</tr>
<tr>
<td><em>Psyidium gauvae</em></td>
<td>Zeytun</td>
<td>Sept-oct</td>
<td>Mid highland &amp; Lowland</td>
</tr>
<tr>
<td><em>Carica papaya</em></td>
<td>Papaya</td>
<td>Throughout year</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Acacia spp</em></td>
<td>Grar</td>
<td>April –May</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Schinus molle</em></td>
<td><em>Kundo berbere</em></td>
<td>Sept-Oct</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Caesalpina decapetala</em></td>
<td>Kontir</td>
<td>Sept-Oct</td>
<td>Mid highland &amp; Lowland</td>
</tr>
<tr>
<td><em>Vernonia amygdalina</em></td>
<td>Grawa</td>
<td>December-January</td>
<td>Highland &amp; Mid highland</td>
</tr>
<tr>
<td><em>Agava sisalina</em></td>
<td>Chiret</td>
<td>Sept-Oct</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Ziziphus spinacristi</em></td>
<td>Kurkura</td>
<td>Sept-Oct</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Beccium grandiflorum</em></td>
<td>Mentesie</td>
<td>Sept-Oct</td>
<td>Degraded highlands</td>
</tr>
<tr>
<td><em>Hypoestes Foreskoali</em></td>
<td>Gerbia (Tig.)</td>
<td>Sept-Oct</td>
<td>Degraded highlands</td>
</tr>
<tr>
<td><em>Luecas Abyssinica</em></td>
<td>Swakerni (Tig.)</td>
<td>Sept-Oct</td>
<td>Degraded highlands</td>
</tr>
<tr>
<td><em>Buddleja polystachya</em></td>
<td>Anfar</td>
<td>Sept-Oct</td>
<td>highland</td>
</tr>
<tr>
<td><em>Pterolobium stellatum</em></td>
<td>Kontir</td>
<td>Sept-Oct</td>
<td>Lowland</td>
</tr>
<tr>
<td><em>Opentia ficus indica</em></td>
<td>Beless(Tig.)</td>
<td>Sept-Oct</td>
<td>Mid and lowlands</td>
</tr>
</tbody>
</table>

4.4 Conservation of forest with community participation

Realizing the value of beekeeping for forest conservation and poverty alleviation, integration of beekeeping with participatory forest management (PFM) is best practice for sustainable honey production and for climate change mitigation. Thus the strong link between forests and traditional beekeeping creates opportunities for promoting beekeeping as an incentive for sustainable forest management. Based on this approach of forest management, few attempts has been made by Farm Africa to implement beekeeping technologies around Chilimo and Bonga state forests as incentive for conservation of existing natural forest by providing beekeeping
accessories and training to farmers living in or close to the forests (Regassa Ensermu et al., 1998.). As the result the project linked honey producer groups with buyers, with a recorded achievement of an annual export of 250 tons of honey from the project area (Abebe 2013). This PFM activities should spread to other forest areas to maximize organic as well as mono-floral honey which fetches premium price in the global market.

In addition to PFM approach, traditional beekeepers plant and conserve forest for beekeeping than other ordinary farmers. For instance the traditional beekeepers in south west Ethiopia have long established cultural forest management practices for traditional beekeeping which are locally called “Kobo”. *Kobo* is a block of forest land bounded and demarcated by big trees and or physical features like river and small streams exclusively used for the purpose of traditional beekeeping and hunting (Dereje Tadesse & Tadesse Woldemariam 2005). In “Kobo” system nobody is allowed to cut a single stick or hang hives in the forest which does not belongs to him. Through this traditional system of forest conservation, the forest is conserved for more than 100 years as their own property for honey and beeswax production. Therefore integration of beekeeping with forest conservation programs will maintain a forested landscape to support improved livelihoods forest-dependent communities and ensure the delivery of environmental services in a wider context.

**4.5 Integration of beekeeping with watershed management**

Restoration of the watershed to the previous natural condition aims to increase the productivity of agricultural land and other natural resources through a combination of re-vegetation and soil and water conservation. Watersheds, especially in the developing world, are increasingly being managed for poverty alleviation as well as environmental conservation objectives (FAO, 2006). Bedru et al. (2006), revealed that a large amount of natural resources in Ethiopia are degraded and or deteriorating due to over utilization and inefficient use of natural resources, specially the forest resource. This deforestation as well as reduction in vegetation cover has negatively affected the biodiversity of honeybees and honey bee flora. According to the study conducted in Burie District of Amhara Region by Tessega (2009), bee keepers try to overcome the problem of
reduction of honey bee plants, by growing different local bee forage plants near by the apiary in degraded water shed sites. Furthermore planting of improved bee forage makes a significant contribution to slow down runoff, increased water infiltration to the ground and helped to stabilize gullies. Some of the multipurpose trees that are recommended for planting in reclamation of the area, such as: *Acacia seyal*, *cordia africana*, *Croton macrostachys*, *Olea europaeenia*. Thus beekeeping should be incorporated into overall land management strategies or watershed management and farming systems, so as to ensure abundant nectar and pollen and successful apiculture development in the country. In addition to planting of agro forestry trees, but also considering planting of herbaceous legumes such as *Vicia sativa* and *Desmodium* spp which can be used as animal forage and improving soil fertility.

### 4.6 Integrating Beekeeping with Ethiopian Protected Area Systems

Sovereign nations declare National Parks to preserve their Natural Heritage, to conserve representative portions of ecosystems or critical populations of endangered species and to protect ecosystems that provide vital environmental services to their nation and the globe at large. Owing to its immense ecosystem diversity and natural resources, Ethiopia has also established protected areas in the form of national parks, wildlife sanctuaries and wildlife reserves to protect its biodiversity. To fulfill its commitments of the protection of these Natural Heritage and Biodiversity, Ethiopia is signatory to a number of international conventions such as the Conservation of Biodiversity (CBD), the Ramsar Declaration and the Convention on International Trade of Endangered Species.

Some of these protected areas are administered by the Federal Government through Ethiopian Wildlife Conservation Authority (EWCA) based on the powers entrusted to it according to Regulation No. 163/2008, Council of Ministers Regulations to Provide for Wildlife Development, Conservation and Utilization. These consist of Simien Mountains National Park, Bale Mountains National Park, Nechsar National Park, Omo National Park, Abijata Shala Lakes National Park, Awash National Park, Senkele Swayne’s Hartebeest Sanctuary, Babille Elephant Sanctuary, Gambella National Park, Alatis National Park, Kafita Shiraro National Park and
Geralle National Park. The same regulation provides for the administration of wildlife conservation areas by the regional governments and local communities. Both EWCA and regional states conserve the wealth of nature for present and future generations of Ethiopians, so they can always enjoy their nation's natural heritage and benefit from the economic opportunities that well-protected national parks bring to both the federal economy as a whole and to each Regional State.

There are activities that are prohibited by law in these National Parks, Wildlife Sanctuaries and Wildlife Reserves: undertaking agricultural activities or preparing land for cultivation; Planting, cutting, chopping, removing, taking, damaging or transferring any plant species; Setting or attempting to set fire; and Beekeeping or honey harvesting, removing or attempting to remove wildlife products, to mention but a few.

The role of the state in protected area management is in conflict with community rights in its attempt to enforce the above and these conflict has led to rapid and continued degradation of resources. Rural people encroach to the protected areas because wild plant resources from the forest for example, provide rural people with a wide range of basic needs: building materials, wood fuel, household utensils, medicines, food supplements and a source of income from the sale of honey and other resources. Unsustainable development outside the Parks forces people, especially during times of environmental stress, to resort to Park resources for food, subsistence products and even to generate cash income.

If we take Awash National Park, the first protected area to be gazetted in Ethiopia, for instance, wildlife have declined drastically, resulting in species extinction, and the habitat is heavily degraded. At present, more than two thirds of the Park is either permanently or temporarily used for non-conservation related activities ranging from permanent settlement to extensive grazing. The park’s resources are severely threatened due to poor relations between park management and the neighboring communities and to the latter having minimal understanding about the economic values of the wildlife resource. The competition between livestock and Awash NP’s grazers and
browsers has led to range and food loss. In similar manner, human settlement and cultivation inside Bale Mountains National Park has been increasing since the park was established in the 1970s and has now reached unsustainable levels, with coincident rapid resource degradation. The park provides grazing ground for livestock herds, and a variety of non-timber forest products (NTFP) such as honey and coffee. The natural resources of the area are being treated as open access resources and use is increasing, with concomitant negative impacts such as forest destruction. Uncontrolled fire now represents a serious threat to the Erica forest and shrub, when started for example, in association with honey harvesting or slash and burn cultivation, as these fires frequently get out of control (Brown 1966). Such uncontrolled fires could potentially affect the whole forest with devastating impact.

The above scenarios entail the introduction of Sustainable Natural Resource Management (SNRM) Programmes to the protected areas in order to provide a framework for the development and implementation of sustainable natural resource. The pressure on the parks can be reduced by promoting the growing of alternatives and substitutes for park resources and by promoting revenue-generating enterprises based on the parks such as beekeeping. Modern beekeeping (both at small scale and commercial level) will helps to reduce the incidence of forest fires from wild honey hunting. Developing agro-forestry to reduce pressure on the parks for firewood, poles and timber and other tree products could in addition support beekeeping as the planted trees will serve as bee forage. These measures will support conservation through reducing pressures on the Parks.

Integrating beekeeping with managed use of resources within core areas of the national parks or in buffer zones (conservation and sustainable natural resource management areas) around them can serve as a means of defusing land-use conflicts beside the huge economic gain that comes with it. With appropriate product promotion and branding, this could substantially increase the benefits accrued by communities relying on the park for their livelihoods. This way long-term sustainability of the Parks can be ensured with the full participation of the surrounding communities and other stakeholders.
4.7 Increasing productivity of dams through demonstration of proven apiculture technologies

The technology generation and promotion are fundamental in popularizing and disseminating of improved and market oriented apiculture technologies in the country in general and degraded area around river dams in particular. This will contribute to increase production of quality bee products; contribute to poverty reduction; improve the livelihood of poor beekeepers and enhance the conservation of natural resource and rehabilitation of fragile environment around dams. Thus the project should focus on the demonstration and dissemination of improved bee keeping technologies that is very pertinent to undertake adaptation of high yielding bee forages that can contribute both for soil and water conservation and honey production. For example, the major indigenous tree species found in Tekeze and Abay River Dams are: *Sapium ellipticum*, *Acacia seyal*, *Acacia tortilis*, *Capparis tomentosa*, *Carissa edulis*, *Cordia africana*, *Croton macrostachys*, *Mimusops kummel*, *Zeziphus* spp and *Ximenia Americana*.

On top of this beekeeping integration with horticultural fruit and vegetable development programs will increase the yield through pollination and farmers can be benefitted from honey production. Among the vegetables, tomato, onion and hot pepper are grown more widely than others and these are highly pollinated by bees for better yield. These vegetables have good market access in Tigray, Wollo, Gondar and South Sudan. Perennial fruit crops like guava, mango, avocado, papaya, banana and orange can be integrated with beekeeping around in the vicinity of river dams.

4.8. Scaling up of pollination technologies for commercial crop production

Pollination is an essential ecosystem service that enables plant reproduction. This important step depends, to a large extent, on the symbiosis relation between species of the plant to be pollinated and the pollinator. The reduction or loss of either will affect the survival of both. Pollinators contribute to the maintenance of biodiversity and ensure survival of plant species including plants that provide food security to innumerable rural households. But this very important
benefit of honeybees is often poorly understood or totally unknown to most communities in Ethiopia.

The hill tracks and forests of Ethiopia host a large number of honeybee (*A. mellifera*) colonies and hence beekeeping has a great potential in raising the productivity of cross-pollinated as well as other crops that need insects for their pollination. Therefore use of honeybee pollination in vegetables and fruits and oil seed production will enhance production and quality of the seeds.

Some of the major crops investigated that need honeybee pollination in the country are niger seed, onion, apple, coffee, Avocado, orange and beans. For instance niger (*Guizotia abyssinica*) which is self-pollinated and requires bees for cross pollination and using honeybees as pollinators increased the yield by 34 % (Admassu Addi and Nuru Adigaba, 2000). Some of the major crops that need honeybee pollination in the country are listed below (Table 12).

Table 12. Percentage increase in yield of some crops due to bee pollination

<table>
<thead>
<tr>
<th>Plant names</th>
<th>Common name</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malus salvestris</td>
<td>Apple</td>
<td>18–69</td>
</tr>
<tr>
<td>Psydium gavae</td>
<td>Guava</td>
<td>10</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>Mango</td>
<td>3</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>Mango</td>
<td>3</td>
</tr>
<tr>
<td>Carica papaya</td>
<td>Papaya</td>
<td>10</td>
</tr>
<tr>
<td>Citrus spp</td>
<td>Citrus</td>
<td>7-23</td>
</tr>
<tr>
<td>Brassica spp</td>
<td>Mustard rape</td>
<td>20</td>
</tr>
<tr>
<td>Sesamum indicum</td>
<td>Sesame</td>
<td>20</td>
</tr>
<tr>
<td>Helianthus annus</td>
<td>Sunflower</td>
<td>20</td>
</tr>
<tr>
<td>Guizotia abyssinica</td>
<td>Niger</td>
<td>43</td>
</tr>
<tr>
<td>Gossypium spp</td>
<td>Cotton</td>
<td>10</td>
</tr>
<tr>
<td>Coffea arbica</td>
<td>Coffee</td>
<td>17–39</td>
</tr>
</tbody>
</table>
5. Status of honeybee forage research

5.1 Identification of bee flora

In the field of apiculture, identification and documentation of nectar and pollen source plants are the most limiting factor for honey production. The knowledge of nectar and pollen source plants is important to assist beekeepers in site selection, determination of carrying capacity and to establish appropriate colony management calendar. Based on this Holeta Bee Research Center has identified and characterized bee forages growing in different agro-ecological zones of the country. Among the numerous melliferous plants of the country, more than 1500 bee plant species were identified as honeybee forage sources, out of which 150, 140, and 300, are trees, shrubs and herbs, respectively. Of these species 500 species were published in a book entitled “Honeybee Flora of Ethiopia” (Fitchtl and Admassu 1994). Currently preparation of the second volume of honeybee forage book is under way. The new book will comprise 400 important bee forage species mostly covering arid and semiarid agro-ecologies of the country.

5.2 Pollen analysis and floral calendar

Pollen spectrum of honey and floral calendar preparation for west and east shoa zones for south west Ethiopia were studied by (Admassu & Nuru 2001). According to analysis of pollen spectrum of honey from potential districts of the Zones, more than 250 plant species were identified. In this study two honey periods were identified of which mid-October to November is considered to be the major honey flow period and from May–July is considered as minor honey flow period.

5.3 Bee forage performance evaluation

An attempt of screening major bee forage source plants has been performed on the most common herbaceous plants existing around Holeta. The species were evaluated based on germination rate, number of flower heads per plants, foraging intensity of honeybees and
duration of flowering. Accordingly, *Guizotia scabra Guizotia abyssinica*, *Brassica carinata* and *Caylusea abyssinica* were found more potential than other species in terms of number of flower heads per plant, higher number of bee visit and longer flowering period.

### 5.4 Pollination service

The effect of honeybee pollination on the yield of melliferous agricultural crops such as *Guizotia abyssinica* (Admassu, et al., 2000), *Allium cepa* (Adimasu et al., 2006), *Vicia faba* and *Citrus sinensis*, were carried out and the result anticipated (43%), (84%) and (28%) yield increments respectively for the first three, while *Citrus sinensis* showed early ripening of the fruit with quality juice when intensively pollinated by bees.

### 5.5 The role of beekeeping in natural resource conservation

The significance of apiculture in forest farming, vegetation characterization and assessing the contribution of apiculture in household livelihood improvement was studied by (Debissa 2006) to investigate the complementarities of beekeeping with vegetation conservation. Accordingly, this survey indicates that the majority of the beekeeper households (83.9%) are growing and conserving plants for their honeybees and other economic uses. There is a higher plants diversity and the honey yield has increased by 4 fold (411%) and the revenue increased by 5.76 folds (576%). From this study, it was concluded that integration of beekeeping technology with conservation of forest will enhance the income of household and encourages planting of bee forages which directly contributes for sustainable forest managements.

### 5.6 Bee forage seed multiplication

Availability of adequate perennial and annual nectar and pollen source plants is the most limiting factor for the survival and distribution of honeybees. In this regard, Holeta Bee Research Center is the only research organization in the country that has been multiplying and raising seeds and seedling of bee forages and distributing to different organizations involved in beekeeping development. The PRA study made on different parts of the country indicates that the honey
production is decreasing and the beekeepers associate this problem with the decrease in bee forage cover. As a result the beekeepers are currently requesting for bee forage seeds to grow around their apiary to minimize the feed shortage during dry periods. Hence to fill this gap, it is necessary to multiply and propagates seedling of major bee flora that adapt to different agro-ecological condition of the country including arid and semiarid habitat. Having seen this demand the center initiated this project to multiply seeds and seedling of bee forages for bee forage development in the country. The center has multiplied over 200kg of herbaceous bee forage seeds and 600,000 seedlings were distributed to beekeepers in the past five years.

6. Future direction in bee forage research and development

6.1 Identification and screening of promising bee forage for arid and semiarid agro-ecologies

Identification and screening of bee forages that can adapt to the short and erratic rainfall conditions of the arid and semiarid area could improve the food base of the local honeybees races and increases significant honey production. Therefore screening of bee forage that grow fast and having rich nectar and pollen are important for increasing and to maintain honeybee colonies during dry period.

6.2 Propagation of bee forages of best performing species

Deforestations of forest resource in the country resulted in decline of honeybee population and honey yield. These problems demand for the propagation, of indigenous trees. In response to this, there has been growing emphasis on the propagation of bee forage trees for planting for honey production and environmental rehabilitation. Some bee forages can be grown from seeds easily and others do not. For example *Schefflera abyssinica* is known honeybee forages from south west forests but it difficult to raise seedling from seeds since it needs other host plant to germinate. The same is true for *Terminalia brownie* which had a low germination rate and potential honey source plant in semiarid agro-ecologies. Therefore propagation and multiplication of these plant species using tissue culture may solve the germination problem of *Schefflera abyssinica* and *Terminalia browni* for honey production. Both species have great potential for the production of distinct mono-floral honey.
6.3 Determination of carrying capacity of the beekeeping site for optimum honey production

In many parts of Ethiopia bees and beekeepers suffer from seasonal drought, which causes a shortage of bee forage especially during the dry season. Moreover the shrinkage of natural habitat of plants also cause severe food shortage to honey bees leading to colony absconding. These conditions force many beekeepers to move their colonies from one area to another in search of better nectar and/or pollen sources and to avoid severe weather condition. In this regard, there are no directives to guide or determine the number of colonies to be placed per unit area, nor has it set out the minimum distances between two adjacent apiaries to minimize competition caused by the overlapping of foraging ranges and subsequent declines of productivity of colonies. This information is helpful to guide small or large scale investors to place appropriate colonies size in relation to population density, nectar and pollen potential of honey plants. Therefore determination of carrying capacity or stocking rate of the given area is important to increase productivity and profitability of beekeeping.

6.4 Promoting on farm demonstration of bee forages

Currently the scarcity of bee flora is rated in the top place in hindering the beekeeping development. As a result the demand for arid bee flora seed is currently increasing from time to time from different stakeholders. Hence to fill this gap, it is necessary to demonstrate promising bee forages that can adapt to different agro-ecologies. There are different species of plants that are identified and recommended by Holeta Bee Research Center as promising bee forages both for highlands and semiarid agro-ecologies of the country. For instance *Becium grandiflorum* (Tebeb, Tig.) can be grown in poor soil and produces the best honey in northern parts of the country but this plant species are not well demonstrated in other parts of the country. Similarly some introduced herbaceous plant species already tested for highlands should be demonstrated at large scale. Therefore it is essential to demonstrate promising bee forages to increase honey production and benefit the local communities and perhaps potential commercial beekeepers.

6.5 Demonstration of proven beekeeping technologies for forest conservation

Apiculture has strong contribution for enhancing the income of household and minimizing pressure on forest resources. Thus further demonstration of the beekeeping technology based on Farmers Research groups (FRG) approach should be integrated for forest conservation.
particularly in Participatory Forest Management and water shed management to increase household income from honey and for sustainable forest resource utilization.
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Tolera K (2014) Integrating Improved Beekeeping as Economic Incentive to Community Watershed Management: The Case of Sasiga and Sagure Districts in Oromiya Region, Ethiopia. Agr, Forest Fish 3: 52-57.

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Chapter 5. Colony Management and the Ethiopian Knowledge Generation and Dissemination System

1. Global Evolution of Apiculture

Apiculture is an activity in which man rears honey bees and acquires their products. Honey bees generally refer to a particular species, European honey bees, *Apis mellifera*. Human experience of beekeeping started from the earliest times in which presumably the honey bees coming to existence 5 million years ago were already 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 off tree twigs by inserting them into wild bee hives. 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 Age caves depicting honey hunting, it is certain that such types of honey hunting were in those days practiced widely across the Old World where honey bees were distributed. The development of tools and techniques for honey hunting has continued since then and the honey hunting itself is still practiced nowadays principally for collecting the honey produced by the Giant honey bee, *A. dorsata*, (distributed widely from Southeast Asia to South Asia) which is capable of producing a large quantity of honey. The products delivered by honey hunting include honey, bees wax, and larvae and pupae of honey bee, commonly called “infant bees”.

The human race is believed to have settled down about ten thousand years ago when presumably it started to invent the methods to ensure the harvest of honey to a certain extent. Actually the records on the ancient Egypt show that the so-called traditional beekeeping originated there, and based on this the date of the first domestication of honey bees has been assumed to be around 5,000 years ago (JAICAF, 2009).

The utilization of traditional beehives enables a large number of honey bees to establish their habitat in close proximity to the living environment of humans, which would stabilize the honey
production commensurate with expectation to a certain extent. The beekeeping using traditional beehives also continues to be practiced even at the present time, and diverse types of beehives exist throughout the world. Since traditional types of beekeeping concentrate honey bees in the areas close to human living environment, they possess also the effect to promote the utilization of honey bees for the purpose of pollinating agricultural crops on arable lands. However, the significance in this sense is rarely appreciated, and honey bees are essentially deemed as the means of producing honey. Among cases of traditional beekeeping, particularly in the areas where it is difficult to acquire honey bee populations, the improvement of harvesting methods allowing the reutilization of bee colonies is in progress, and the effort can be interpreted as the factor creating a situation in which honey bee colonies with a high density are present close to humans serving to facilitate the pollination of crops.

The modern beekeeping, the basic system of which emerged about 200 years ago, was perfected to assume a form resembling that of present-day in North America where the European honey bee was being reared by immigrants from Europe (JAICAF, 2009). The fundamental concept of modern apiculture is the reutilization of bee colonies for which it was called for to develop a method of honey harvesting with a lesser load on them. European honey bees construct a beehive consisting of multiple honeycombs within a closed cavity where they rear brood in the central part and store honey in the fringe portion. In the traditional beehives of hollow log, since honey is stored in the upper part and brood is kept below it, the attempt to collect honey necessarily leads to the loss of brood. Moreover, because the entire beehive is taken out and crushed to extract honey, bees have to start anew by rebuilding combs. In modern beekeeping, a beehive consists of two stages, which enables the use of the principle that the lower stage is devoted for rearing brood (brood-box) and the upper one for storing honey (honey-super). The comb frames in the upper stage are made in a smaller size and the emptied honeycombs can be easily returned to bees, thus enabling to minimize the impact due to honey extraction. The traditional beekeeping always produces beeswax as a byproduct of honey harvesting, in the modern system no byproducts other than honey can be obtained in an ordinary process of honey extraction.

The structure of beehives allowing the inspection and management of multiple frames of honeycomb individually has enabled beekeepers to carry out various management tasks including division of a colony, addition of empty frames for harvesting honey or inversely thinning out surplus frames to build a more compact colony. Thanks also to this structure of
beehives the trading of live honey bees themselves has become possible, and the beehives of a standardized size are easily mounted on transportation vehicles, allowing the movement of bee colonies for purposes other than honey harvesting, for instance, the conveyance of colonies exclusively used for pollination to the vicinity of target crops.

Modern (improved) beehives currently in use are very versatile in their function in the sense of efficient utilization of honey bees. In modern beekeeping the honey has become a product easily to be harvested whenever it is needed, and hence it has become possible to produce a particular kind of honey collected from a specifically targeted source and stored in honeycombs in a short term. Beekeepers have become able to produce a honey bearing a specific flower name, and the honey products have been diversified and the control of their quality has become possible.

The potential for honey production and success in beekeeping development projects is dependent first and foremost on the quality and quantity of bees and bee flora available. Secondly success is dependent upon the technology used in the light of local resources and economic considerations. Beehive design in itself will not influence honey production provided the hive volume is adequate. Good hive design will make management easier for the beekeeper. A moveable comb or frame hive for example enables detailed hive inspection, colony division or selective breeding and queen rearing as well as providing for ease of honey removal, and in the case of frame hives mechanical honey extractions and return of extracted combs. In the absence of management hive design will not of itself alter honey yields.

Beehive technology may be divided into three groups:

i. Fixed comb hives. These include traditional cylindrical bark and log hives and various other hives of many different forms and materials which are found throughout most of Africa and formerly also in Europe and America. Fixed comb hives also include the traditional straw skeps of Europe.

ii. Moveable comb hives. These include the Greek basket hive from which many adaptations have taken place.

iii. Frame hives. The frame hive is the most advanced of all hives and is normally used for large scale commercial beekeeping throughout the world. The Langstroth is the original
and most widely used but there are countless variations, some are good and some are atrocious.

Choice of hive technology should be based on the cost and ease of hive production and availability in relation to local honey potential and cash return, which vary according to geographical location and temperament of both bees and beekeeper. The relationship between hive technology and potential returns is summarized in Table 1.

Table 1. Relationship between hive technology, situation and potential returns.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Type of beehive and Area</th>
<th>Hive cost and ease of production</th>
<th>Honey/cash return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame hive</td>
<td>European bee in temperate region</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Frame hive</td>
<td>African bee in tropical region</td>
<td>Possible</td>
<td>Fair</td>
</tr>
<tr>
<td>Top bar hive</td>
<td>European bee in temperate region</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Top bar hive</td>
<td>African bee in tropical region</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Fixed comb hive</td>
<td>European bee in temperate region</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Fixed comb hive</td>
<td>African bee in tropical region</td>
<td>Relatively good to very good</td>
<td>Relatively good to very good</td>
</tr>
</tbody>
</table>

Source: Paterson (2000).

2. Beekeeping and honey production in Ethiopia

2.1 History of honey production in Ethiopia and its contribution to the national economy

There is no well documented evidence that indicates when and where beekeeping practice started in Ethiopia. According to the history books, it had started in the country between 3500-3000 BC. The country has a high potential for beekeeping as the climate is favorable for growing different vegetation and crops, which are a good source of nectar and pollen for honeybees.

Ethiopia is an important honey and beeswax producing country, and the leading producer of honey and beeswax in Africa. According to report estimates, Ethiopia, with over 10 million honeybee colonies, is the country with the highest honeybee population in Africa. With a honey
production estimated at 50,000 metric tons per annum and is said to represent only 10.7% of the country’s production potential (Hussien, 2000). According to the same source, the country is on a global scale, the 4th largest producer of beeswax and is the 10th largest honey producer in the world. Ethiopia produces around 23.6% and 2.1% of the total African and world’s honey, respectively.

The country also is endowed with botanically diversified honey source plant species which supply ample food to the honeybees and for honey production. Some 800 bee plants were already identified and 500 of them are described in detail.

2.2 Honey production systems in Ethiopia

Currently, there are three production systems of bee products are underway in Ethiopia, namely, traditional, intermediate (transitional) using Kenya Top Bar (KTB) and Frame Beehive beekeeping. The critical evaluation of each production system with employed technologies, and probable productivity and quality potential of transforming beekeeping business into vibrant economic means are done under each production system as below.

2.2.1 Traditional hive production system

There are over ten types of traditional beehives made of cheap and locally available materials like clay, straw, bamboo, false banana leaves, bark of trees, logs, animal dung, grasses, wicker etc. Since the combs (brood, honey, pollen combs) are fixed on the top of the hive body, the honey can only be removed by breaking or cutting out the combs. Although the construction of the beehive is very simple and less expensive (can be constructed from locally available materials), the beehives are inconvenient for inspection and management. Moreover, the beehives are very small in size and triggers swarming, no possibilities of supering (adding extra spaces) and have no partition between brood chamber and honey chamber for quality honey harvest.

This subsistence means of production system has been practiced over many centuries in the country. About 90% of both honey and beeswax production is underway using this traditional and less productive beekeeping system. It is only yielding an average of 5.5 Kg of crude honey (honey mixed with beeswax, pollen, dead bees, etc.) and 0.55 kg of crude beeswax (unprocessed wax) per hive per annum. This production system accounts for about 64% (34650 tons) of the
current total annual honey production of the country (54000tons) (MoA, 2013/2014, expert estimation using LSIPT, 2013). An illustration of traditional beehives in Ethiopia and a model of keeping them is presented in Fig 1.

Figure... Traditional beehives and a model of keeping them in Ethiopia

### 2.2.2 Transitional hive (Kenya Top Bar, KTB) production system

The KTB is trough-shaped with sloping sidewalls covered with top bars of a specified width. This beehive can be made from timber or from any other locally available materials that is then internally plastered with mud and animal dung. It has an advantage over traditional hives in that combs containing honey can be selected during harvesting to maintain the quality of honey. The average yield collected from this system is 15kg of crude honey and 1.5kg of beeswax per hive per annum. However, the production system is less adopted and accounts only 3% of the total production system. Even, with this, the production system shares about 6% (3150 tons) of the total annual honey production (expert estimation using LSIPT, 2013), suggesting three times more productive than the traditional beekeeping system. With simple training, it is possible to construct this kind of beehives from locally available materials at low costs. Therefore, much effort is required to scale up/scale out with mainly targeting low income beekeepers.

Strategically, KTB (Fig 2) for its low cost and simplicity (easily produced by beekeeper) nature can be targeted to resource poor beekeepers either individually or in the form of cooperative.
Whereas, frame beehive, because of its high costs, required precision and demanded accessories (mainly casting mold, honey extractor) might not be affordable to most of the beekeepers. Therefore, this can be easily adopted by the beekeepers organized in cooperative. Organizing beekeepers into cooperative shall help them to intensify their production through obtaining expensive beekeeping equipment like casting mold and honey extractor that can’t be afforded individually. Furthermore, it creates big opportunity to involve in semi processing activities as well as find and develop appropriate and sustainable market for their products that is leading to reinvestment.

Figure 2. A demonstration of a top bar hive

2.2.3 Frame (improved) hive production system

This system strives for maximum output, highest productivity and optimum quality of honey. The beehive is suitable to manage bee colonies with better techniques. However, it requires relatively expensive equipment and skilled manpower compared to the former two production systems. Although this frame beehive production approach has been introduced into the country before 40 years, its uptake is so slow. This might be attributed to a number of factors. However, low level of beekeepers skill, affordability, lack of access to credit, few multipliers of the beehive etc have big contributions towards to its less adoption. As results, this production system still accounts only 7% to the total (expert estimation using LSIPT, 2013). The national average yearly yield of the beehive is estimated to be 33 Kg of centrifuged table honey and 0.33kg of beeswax per beehive. With 7% share in the production system, it accounts for about 30% (16170tons) of the total honey produced in the country.
Owing to its maximum output and quality, to date, there is a growing tendency of introducing moveable frame hives in most honey producing regions of the country. This is brought by good initiation from most of the Regional States to enhance beekeeping development of their region and make beekeeping as major means of livelihood. In fact, the initiation level varies among the regions and Tigray regional state already took beekeeping as one major activity in combating food insecurity and maintaining livelihoods.

Figure 3. Frame hives, with three supers

2.3 Perceived constraints to the development of the industry

2.3.1 Diseases, pests and predators

From a global perspective, there are several diseases and pests that are reported to affect the lives of bees and/or hive productivity. The major ones and their recommended treatments, prevention and control strategies are outlined as follows:

i. Varroa mites
Varroa destructor and Varroa jacobsoni are parasitic mites that feed on the bodily fluids of adult, pupal and larval bees. Varroa mites can be seen with the naked eye as a small red or brown spot on the bee's thorax. Varroa mites are carriers for a virus that is particularly damaging to the bees. Bees infected with this virus during their development will often have visibly deformed wings. Varroa mites have led to the virtual elimination of feral bee colonies in many areas, and are a major problem for kept bees in apiaries. Some feral populations are now recovering—it appears they have been naturally selected for Varroa resistance.

These mites are generally not a problem for a strongly growing hive. When the hive population growth is reduced in preparation for winter or due to poor late summer forage, the mite population growth can overtake that of the bees and can then destroy the hive. Often a colony will simply abscond (leave as in a swarm, but leaving no population behind) under such conditions. Varroa in combination with deformed wing virus and bacteria have been theoretically implicated in colony collapse disorder.

**Treatment**

A variety of treatments are currently marketed or practiced to attempt to control these mites. The treatments are generally segregated into chemical and mechanical controls.

Common chemical controls include "hard" chemicals such as Amitraz (marketed as Apivar), fluvalinate (marketed as Apistan), and coumaphos (marketed as CheckMite). "Soft" chemical controls include thymol (marketed as ApiLife-VAR and Apiguard), sucrose octanoate esters (marketed as Sucrocide), oxalic acid and formic acid (sold in gel packs as Mite-Away but also used in other formulations). According to the U.S. Environmental Protection Agency, when used in beehives as directed, these treatments kill a large proportion of the mites while not substantially disrupting bee behavior or life span. Use of chemical controls is generally regulated and varies from country to country. With few exceptions, they are not intended for use during production of marketable honey.

Common mechanical controls generally rely on disruption of some aspect of the mites' lifecycle. These controls are generally intended not to eliminate all mites, but merely to maintain the infestation at a level which the colony can tolerate. Examples of mechanical controls include
drone brood sacrifice (varroa mites are preferentially attracted to the drone brood), powdered sugar dusting (which encourages cleaning behavior and dislodges some mites), screened bottom boards (so any dislodged mites fall through the bottom and away from the colony), brood interruption and, perhaps, downsizing of the brood cell size.

ii. **Acarine (Tracheal) mites**

*Acarapis woodi* is a small parasitic mite that infests the airways of the honey bee. It quickly spread to the rest of Great Britain. It was regarded as having wiped out the entire native bee population of the British Isles (although later genetic studies have found remnants that did survive) and it dealt a devastating blow to British beekeeping. Diagnosis for tracheal mites generally involves the dissection and microscopic examination of a sample of bees from the hive.

Mature female acarine mites leave the bee's airway and climb out on a hair of the bee, where they wait until they can transfer to a young bee. Once on the new bee, they will move into the airways and begin laying eggs.

**Treatment**

Acarine mites are commonly controlled with grease patties (typically made from 1 part vegetable shortening mixed with 3–4 parts powdered sugar) placed on the top bars of the hive. The bees come to eat the sugar and pick up traces of shortening, which disrupts the mite's ability to identify a young bee. Some of the mites waiting to transfer to a new host will remain on the original host. Others will transfer to a random bee—a proportion of which will die of other causes before the mite can reproduce.

Menthol, either allowed to vaporize from crystal form or mixed into the grease patties, is also often used to treat acarine mites.

iii. **Nosema**

*Nosema apis* is a microsporidian that invades the intestinal tracts of adult bees and causes nosema disease, also known as nosemosis. Nosema infection is also associated with black queen cell virus. It is normally only a problem when the bees cannot leave the hive to eliminate waste
(for example, during an extended cold spell in winter or when the hives are enclosed in a wintering barn). When the bees are unable to void (cleansing flights), they can develop dysentery.

Nosema disease is treated by increasing the ventilation through the hive. Some beekeepers treat hives with antibiotics such as fumagillan.

Nosemosis can also be prevented or minimized by removing much of the honey from the beehive, then feeding the bees on sugar water in the late fall. Sugar water made from refined sugar has lower ash content than flower nectar, reducing the risk of dysentery. Refined sugar, however, contains fewer nutrients than natural honey, which causes some controversy among beekeepers.

iv. **Small hive beetle**

*Aethina tumida* is a small, dark-colored beetle that lives in beehives. The lifecycle of this beetle includes pupation in the ground outside of the hive. Controls to prevent ants from climbing into the hive are believed to also be effective against the hive beetle. Several beekeepers are experimenting with the use of diatomaceous earth around the hive as a way to disrupt the beetle's lifecycle. The diatoms abrade the insects' surfaces, causing them to dehydrate and die.

**Treatment**

Several pesticides are currently used against the small hive beetle. The chemical Fipronil (marketed as Combat Roach Gel) is commonly applied inside the corrugations of a piece of cardboard. Standard corrugations are large enough that a small hive beetle will enter the cardboard through the end, but small enough that honey bees cannot enter (and thus are kept away from the pesticide). Alternative controls such as oil-based top bar traps are also available, but they have had very little commercial success.

v. **Wax moths**
Wax moth (*Aphomia sociella*)—more often associated with bumble bees (Bombus sp.) *Galleria mellonella* (greater wax moths) will not attack the bees directly, but feed on the wax used by the bees to build their honeycomb. Their full development to adults requires access to used brood comb or brood cell cleanings—these contain protein essential for the larval development, in the form of brood cocoons. The destruction of the comb will spill or contaminate stored honey and may kill bee larvae.

**Control and treatment**

A strong hive generally needs no treatment to control wax moths; the bees themselves will kill and clean out the moth larvae and webs. Wax moth larvae may fully develop in cell cleanings when such cleanings accumulate thickly where they are not accessible to the bees.

Wax moth development in comb is generally not a problem with top bar hives, as unused combs are usually left in the hive during the winter. Since this type of hive is not used in severe wintering conditions, the bees will be able to patrol and inspect the unused comb. Wax moths can be controlled in stored comb by application of the aizawai variety of Bacillus thuringiensis spores by spraying. It is a very effective biological control and has an excellent safety record.

Wax moths can be controlled chemically with paradichlorobenzene (moth crystals or urinal disks). If chemical methods are used, the combs must be well-aired for several days before use. The use of naphthalene (mothballs) is discouraged because it accumulates in the wax, which can kill bees or contaminate honey stores. Control of wax moths by other means includes the freezing of the comb for at least 24 hours.

vi. **American foulbrood**

American foulbrood (AFB), caused by the spore-forming Paenibacillus larvae (formerly classified as Bacillus larvae and Paenibacillus larvae sp larvae/pulvificiens), is the most widespread and destructive of the bee brood diseases. Larvae up to three days old become infected by ingesting spores present in their food. Young larvae less than 24 hours old are most susceptible to infection. Spores germinate in the gut of the larva and the vegetative bacteria begin
to grow, taking nourishment from the larva. Spores will not germinate in larvae over three days old. Infected larvae normally die after their cell is sealed. The vegetative form of the bacterium will die, but not before it produces many millions of spores. American foulbrood spores are extremely resistant to desiccation and can remain viable for more than 40 years in honey and beekeeping equipment. Each dead larva may contain as many as 100 million spores. This disease only affects the bee larvae, but is highly infectious and deadly to bee brood. Infected larvae darken and die.

vii. **European foulbrood**

*Melissococcus plutonius* is a bacterium that infects the midgut of the bee larvae. European foulbrood is considered less serious than American foulbrood. *M. plutonius* is not a spore-forming bacterium, but bacterial cells can survive several months on wax foundation. Symptoms include dead and dying larvae which can appear curled upwards, brown or yellow, melted or deflated with tracheal tubes more apparent, or dried out and rubbery.

European foulbrood is often considered a "stress" disease — dangerous only if the colony is already under stress for other reasons. An otherwise healthy colony can usually survive European foulbrood. An outbreak of the disease may be controlled chemically with oxytetracycline hydrochloride, but honey from treated colonies could have chemical residues from the treatment.

viii. **Fungal diseases**

**Chalkbrood**

*Ascosphaera apis* is a fungal disease that infests the gut of the larva. The fungus will compete with the larva for food, ultimately causing it to starve. The fungus will then go on to consume the rest of the larva's body, causing it to appear white and 'chalky'. Chalkbrood is most commonly visible during wet springs. Hives with chalkbrood can generally be recovered by increasing the ventilation through the hive.

**Stonebrood**
Stonebrood is a fungal disease caused by *Aspergillus fumigatus*, *Aspergillus flavus*, and *Aspergillus niger*. It causes mummification of the brood of a honey bee colony. The fungi are common soil inhabitants and are also pathogenic to other insects, birds, and mammals. The disease is difficult to identify in the early stages of infection. The spores of the different species have different colors and can also cause respiratory damage to humans and other animals. When a bee larva takes in spores, they may hatch in the gut, growing rapidly to form a collar-like ring near the head. After death, the larvae turn black and become difficult to crush, hence the name stonebrood. Eventually, the fungus erupts from the integument of the larva and forms a false skin. In this stage, the larvae are covered with powdery fungal spores. Worker bees clean out the infected brood and the hive may recover depending on factors such as the strength of the colony, the level of infection, and hygienic habits of the strain of bees (there is variation in the trait among different subspecies/races).

There is a large volume of data on the prevalence and effects of diseases, pests and predators on the production of honey and productivity of the sector. Ethiopia, as one of the sub-tropical countries, the land is not only favorable to bees, but also for different kinds of honeybee pest and predators that are interacting with the life of honeybees (Desalegn 2001). The existence of pests and predators are nuisances to the honeybees and beekeepers. Pests and predators cause devastating damage on honeybee colonies with in short period of time and even over night. According to Kerealem (2005) ants, honey badger, bee-eater birds, wax moth, spider and beetles were the most harmful pests and predators in order of to decreasing importance. Some studies indicate that Ethiopia appears to be free from various honeybee brood diseases and at the same time at low level of adult bees’ diseases incidences. A major category of diseases which cause economic loss comprises amoeba, nosema and chalk brood (Keralen et al., 2009). Tessega (2009) also reported that diseases, pests and predators are among the reasons for a decline in bee colony numbers in the Bure district of the Amhara region. These problems may lead to poor quality honey production and inefficient utilization of the modern bee hives distributed. Lack of knowledge on the proper application of chemicals to treat diseases and/or kill pests and predators also affects product quality. Elsewhere, ants, wax moth, lice, beetles, spiders wasps, prey mantis, lizard, birds, monkey, snake(Chalaa et al., 2012) are reported to be problems that resulted in reduced bee colony numbers and reduced hive productivity. Poisoning of honey bees with
agrochemicals and pollen grains of poisonous plants (Nuru and Hepburn, 2001) is also a threat to the development of the Ethiopian honey industry.

2.3.2 Product quality

Obviously the apiculture in Ethiopia is predominantly traditional employing the traditional hive production system. In the traditional beekeeping, since normally the whole honeycomb is collected, the comb material, pollens and brood are also mixed in honey, creating an unfavorable condition for selling the product as honey. Promoting the establishment of standards and guidelines as well as establishing quality parameters for the production, processing and product differentiation of honey are critical steps that need to be taken in order to enhance national revenues and household incomes through the export of different bee products.

2.3.3 Market information and infrastructure

Of the total honey production, about 40.4% was used for household consumption, about 56.25 percent was sold, and less than 1 percent of the honey production was used as payment (wage) in the country. On the other hand, 39.95 % of the wax produced in the country was used as household consumption while 31.76 % was used for sale in the year 2013/14 (CSA, 2014). The volume of product (as percent of the total) that is supplied to market from the sector is increasing from time to time. However, the product market suffers from a multitude of problems.

According to Gezahegn (2001), the constraints to marketing of honey and beeswax in the country and these include low and discouraging price of honey and beeswax in local markets, lower quality of products, lack of market information, absence of organized market channel, transportation problem, lack of appropriate technologies for collecting, processing, packing and storage of honey to keep its natural quality, lack of government support in promoting market development, and low involvement of private sector. Because of beekeepers have limited knowledge of the preferences of their target market, they do not try to make any changes in the quality of their product. Presentation of quality honey is generally poor. Most honey come to market is un-extracted, unstrained and poorly managed. There is a need to improve marketing infrastructure in terms of provision of market information, development of feeder roads in the
high potential areas, and expansion of transportation services; improving storage and handling services; colony multiplication center; and communication media (Beyene and Philips, 2007).

2.3.4 Issues related to the agricultural education, research, extension and development continuum

2.3.4.1 Agricultural education with special emphasis on apiculture
The role of education to transform a given sector through provision of skilled human power that efficiently support the processes of innovations is pivotal. The Ethiopian universities that have agricultural colleges or faculties have been feeding the agricultural sector with trained personnel to improve the performance. Beekeeping is one of the disciplines which suffered and is suffering from the lack of skilled human resource, appropriately skilled trainers, training materials and training institutions. Majority of the beekeepers lack the knowledge of appropriate methods of beekeeping. In the country there is no concerned college or university which does provide diploma or certificate level course in beekeeping except the new training inception by Bahir Dar University at a postgraduate level. Holetta Bee Research Center is the only institute that provides basic trainings to farmers, technicians, and experts. However, this doesn’t meet the ever increasing demand of trained manpower in the country.

2.3.4.2 The research and extension scenario
Technical change to increase food production is the most pressing need for addressing economic growth, alleviating poverty and arresting environmental degradation in most of sub-Saharan Africa (Byerlee and Heisey, 1996). Ethiopia is trying to pull itself out of that state of poverty by making efforts to bring about accelerated economic development. The focal economic policy known as Agricultural Development Led Industrialization (ADLI) puts the role of agricultural development as instrumental to foster economic growth through its contribution to food security and industrial transformation. The policy anticipates economic growth focusing on improving the performance of the agriculture sector. Consequently, promotion of agricultural innovation through generation and adaptation of new technologies received due emphasis (Ashenafi, 2011). Allocation of a sizeable volume of public finance from the country’s GDP to agricultural
research and extension unlike other developing countries (Byerlee et al., 2007) is indicative of the magnitude of the policy focus on agriculture. Establishment of agriculturally-oriented Technical and Vocational Education Training (TVET) colleges for the training of Development Agents (DAs), and establishment of kebele level Farmers’ Training Centers (FTCs) are important policy outcomes for capacitating the agricultural sector.

However, very little empirical evidence is available on the impact of public extension services on farm performance and household welfare that could justify these investments (Egziabher et al., 2013). Transforming Ethiopian agriculture from its current subsistence orientation into market orientated production system forms the basis of the agricultural development strategy of the country. The agricultural extension service is one of the institutional support services that have a central role to play in the transformation process. Poor institutional arrangements has limited the technology generation options and hence there are limited available, beekeeping processing, packaging, quality testing, value addition etc that helps increasing competitiveness of the country’s bee products both at local and international markets.

Generally, these technical and socioeconomic factors has characterized apiculture subsector of the country as low productive and poor quality affecting the beekeeping industry development and competitiveness, which are calling for policy attention. Ethiopia, with the applications of improved beekeeping technologies and techniques can increase productivity and quality that substantially has influences over cost and hence increase price competitiveness and quality competitiveness.

Recently, apart from Holeta, regional livestock research centres at Sekota, Pawae, Andanssa, Sinana, Adami Tulu, Yabello, Bako, Bonga, Jinka, Mekele and Srinka have started work on beekeeping. However, there is acute shortage of trained manpower and facilities. The slow uptake of modern beekeeping methods indicates that so far research has contributed less to real innovation in beekeeping in the sense of turning knowledge into improved productivity and incomes. Therefore, future research that focussed on developing technical packages which can be rapidly taken up by Ethiopian beekeepers should be designed. In most cases, this will mean adapting productivity and quality improving modern technologies to the constraints that
beekeepers face.

To ensure this focus, this strategy calls for targeted research activities with specified outcomes. Priority is given to research which will yield rapid results. Poor extension systems (absence of coordination between research, extension and farmers), lack of credit service, shortage of records and up-to-date information, shortage of reading materials regarding to beekeeping, and lack of research stations to address the problems related to apiculture (Keralem et al., 2009). This section of the document looks at the existing scenario of the agricultural extension system in Ethiopia focusing on the balance between the crop and the livestock subsystems and the perceived situation on the success of the ATVET program as it relates to the performance of the system with particular emphasis on apiculture development.

The Ethiopian economy has grown and food security has significantly improved over the past two decades. Agricultural growth has been a key part of this progress and will need to be maintained if the country is to build on this past success and sustain rapid overall growth while sharply reducing poverty in both rural and urban areas. Research into agriculture and food security can further this objective by informing effective policymaking (Dorosh and Rashid, 2012). Model simulations suggest that if agricultural growth can be maintained at 6 percent per year, an additional 3.7 million people would be lifted out of poverty by 2015, as compared with a business-as-usual scenario (Dorosh and Rashid, 2012). Achieving this high rate of agricultural growth will require considerable effort. However, land and water constraints will make it difficult to achieve either crop or livestock production gains in the highlands regions, where most Ethiopians live, without major investments in productivity-increasing technologies such as improved seeds and veterinary services, extension, and small-scale irrigation.

The agricultural extension system is blamed for being tied to the conventional top-down approach which is not participatory and learning based (Ashenafi, 2011). The extension system lacks to be demand driven, inclusive (of the relevant actors), learning based and targeted at bringing about successful and sustainable innovations in the sector. Nonetheless, there is an observed shift in the picture of the extension service with emphasis being shifted to the use of the newly established Farmers Training Centers (FTCs) to serve as hubs for the transfer of improved technologies and knowledge, skill development, and the provision of other institutional support.
services. Although the country is following market oriented agricultural development strategy, we find that the extension service that has been organized for achieving food security objectives has not yet been adapted (both in capacity and organizational structure) to provide extension service required for transforming subsistence agriculture to market oriented agriculture. Major problems of the extension system include top–down and non-participatory approach, primarily supply driven, low capacity of experts and development agents, low morale and high turnover of extension staff, and shortage of operational budget and facilities (Berhanu et al, 2006).

With due emphasis on improving the performance of the apiculture sector, the then Ethiopian Agricultural Research Organization, now Ethiopian Institute of Agricultural Research, the coordinating organ for agricultural research in the country, drafted a bee research strategy (EARO, 200) with a strategic focus on the following:

- Increase the production of honeybee products by alleviating management and related constraints which cause low productivity;
- Identify the natural apicultural resources base, conserve and tap the honeybee genetic potential and resources available;
- Generate development and processing technologies that would enhance the development programme;
- Organize and build apicultural research capacity and capability; among others.

However, the successful implementation of the planned activities is reportedly constrained by resource (both physical and human) limitations. Though new startups have been recently reported in several other centers, bee research works have literally been left to be dealt by Holetta Bee Research Center with all its limited resources.

- Development of disease resistant honey bee races through organized selection and breeding processes—both for diseases and chemicals—evidences are there.
- Collaborative research attempts to select/breed/develop drought resistant bee flora that have wider adaptation

**Identified Research gaps**

Based upon the current scenarios, the following are identified as apiculture research gaps

- Honeybee Genetics
- Proper bee Management
- Apiculture Economics and Livelihoods Contribution
- Honeybee health
- Bee flora and honey calendar
- Bee products diversification and value addition
- Bee products quality

**Honeybee Genetics**: Ethiopia, having wide range of topography, climate and vegetation many species of honeybee races is expected to exist. Not all Ethiopian races of *Apis mellifera* have been identified, and the productivity and management characteristics of those which have been identified have not been analysed. To select and breed improved races suitable for the different Agro Ecological Zones (AEZs), this needs to be done. To solve the problems of bee colony shortages and to develop colonies with desirable characters, selection and breeding with technologies for the large-scale multiplication of honeybee colonies have to be refined in a short term plan and should be well adapted to local circumstances.

With continued identification of land races, works like evaluation, selection and breeding has to start. Hence, having local honeybee breeding plan or program towards improvements of their performance is one of the priority areas to be addressed in this strategy. Therefore, the following two major activities will be aimed towards the improvements of local bee races.

1. **Land race identification**: for each AEZ, identification of all races of *Apis mellifera*, and other honey-producing bee species;
2. **Selection and breeding**: for the most important races, comparison of their productivity and management characteristics in between races and an assessment of the potential to develop improved races for commercial production.

This research requires on station and controlled experiment, and it is long time taking in nature. However, in the shorter term, the research will concentrate on evaluating how available genetic material can perform in their localities adapted to fit with. Base parameters like behavior, productive performances, resistances to diseases and pests, response to different queen rearing and artificial insemination methods will be adequately evaluated and documented. These are
bases for future selection and breeding the best performing among the local bees. In this work, strategically located research centers listed under “technology development” will involve to evaluate the honeybee races existing at the AEZs of their respective centers. However, as these centers are lacking trained manpower and facilities, it requires targeted capacity development consideration.

**Honeybee Forage:** A lot of work remains to be done to register the entire melliferous flora of Ethiopia, to assess it for sources of nectar and pollen, and to establish flowering calendars. The pollination requirements of major food crops are not known and the resultant yield and quality increment is not yet assessed. Ways to conserve and rehabilitate indigenous sources of honeybee forage have not been developed. As land is cleared for agriculture, high-quality bee forage is lost. This is particularly evident in the northern and central highlands of the country. Ways to mitigate this is not yet established. This work is long-term in nature.

Improved bee management: Traditional bee management systems in the different AEZs are broadly understood but not systematically recorded. Some work has been done to adapt improved methods to Ethiopian circumstances. The slow uptake of improved methods indicates that a lot of work is needed to complete these processes. A complete package of recommendations is required at least for major beekeeping production systems.

Beekeepers should know the interaction between bee colony development and the environment and should develop skill in managing his/her bee colonies in accordance of the interactions. The beekeepers can get knowledge and skills of this kind through regular hand of training on seasonal bee management and keeping record on the brood development, nectar hording capacity (honey yield), colony behaviour, age and egg laying performances of the queen. Bee management is one of the major intervention areas to enhance productivity and quality of product.

**Apiculture economics and livelihoods contribution:** Little work has been done on the costs and benefits of beekeeping and on quantifying its contribution to rural livelihoods and poverty reduction. The relative value to the producer of crude honey and high-quality table honey will be a critical factor in the uptake of improved methods, but it has not been thoroughly analysed.
There are few estimates of the additional cost, including opportunity costs, of adopting improved methods and few direct comparisons, under controlled circumstances, of yields under traditional and modern management.

**Honeybee Health**: Although the country is thought to be free from the major bee diseases like American and European foul broods, the recent report on the occurrences of varroa mite in different parts of the country has dismissed the disease free country contemplation. Honeybee diseases and pests may become meantime development issues for the producers and fear exists nonexistent diseases may inter into the country. Similarly, agro-chemicals are not widely used but they are increasing. Therefore, with high-priority, regular surveillance work is needed to identify news and assess the importance of the diseases and pests that do exist. Furthermore, legislation and regulation that enforces the non-importations of live bees and used bee equipments and strong quarantine that strictly implements prohibition of these acts must be in place with awareness creation on the potential danger of importing live bees and used bee equipments. Freedom from disease and chemical contamination will be particularly important for Ethiopia’s entry into export markets.

**2.3.4.3 The balance of focus on crops versus livestock with emphasis on apiculture**

Over two-thirds of world’s 1.3 billion impoverished people live in rural areas and rely on agriculture for a significant part of their livelihoods (Reddy *et al.*, 2003). Livestock are important assets of this group and play a critical role in both sustainability and intensification of agricultural productivity in most farming systems. Increasing human population and changes in dietary habits associated with urbanization and higher incomes are causing increased demands for foods of animal origin. Agricultural intensification through crop and livestock integration is the future of agricultural development in Ethiopia (Byerlee *et al.*, 2007; Diao and Prrat, 2007). Research packages should aim at maximizing output per unit area of land. This would be achieved by the generation and productive use of agricultural technologies and knowledge with multiple uses and a better rate of uptake by the end users. This requires a multidisciplinary approach taking into consideration the farming circumstances along with new ways of institutional, policy and learning processes by involving a wide array of stakeholders – professionals of diverse specialties, policy makers, farmers, NGOs, community-based
organizations, etc. with a common understanding and focus on sustainably improving the performance of the agricultural sector.

There is a concern among professionals that the transfer of livestock production techniques to farmers by extension services in developing countries has been neglected by both policy makers and researchers due to the marginal position of livestock extension (Morton and Wilson, 2000). Transmitting information on livestock production has rarely been a priority for centralized extension services in developing countries. National agricultural extension services are usually designed around the need to transmit information on annual crops, while livestock ministries and departments are dominated by vets and animal health concerns (Morton and Matthewman, 1996). Though the agricultural development policy of Ethiopia gives reasonably equal emphasis to both sub-sectors its implementation is dictated more by the production of enough grain in an effort to terminate the cycle of starvation overlooking even the contribution of livestock for crop production. This resulted in a skewed focus towards crop production. For a successful adoption of a technology, popularization is a crucial step as it promotes better social inclusion in the use of the technology. This could be achieved through demonstrations and training. Organizing farmers’ field days is one of the mechanisms to demonstrate a technology to end users. These are particularly important in the Ethiopian condition where the education level of farmers is considerably low. However, the proportion of farmers that participate in these processes is very small and the issues for training and demonstration are dominated by crops as compared to those of livestock (Ashenafi, 2011). A similarly low level of participation in livestock packages and training as compared to that of crops’ has been reported by EEA/EEPRI (2006).

Apiculture, as a component of the livestock subsector in the Ethiopian agriculture, is considered as nonfarm activity by several authors. This magnifies the severity of relative neglect of the enterprise added to the general scene of the livestock subsector. It is believed that the low performance of apiculture/ honey industry as compared to the potential is partly attributed to the magnitude of emphasis it has received in the agriculture system. This can also be witnessed by the absence of skilled personnel proper in the area of apiculture at lower levels of the structure of the extension service.

The picture of the apiculture extension system as a component of the large agricultural and that of the livestock extension system has been a subject of considerable neglect for decades except...
the recent attempts which is primarily reflected by the number of improved hives distributed. However, apiculture extension means a lot more than a mere distribution of improved hives. The focus should also include the provision of all the necessary beekeeping equipment, assigning trained personnel at different levels following the extension structure nationwide, particularly in high honey production areas, to properly support the apiculture development endeavors. The apiculture sub-sector has been suffering from critical shortages of honey production and processing equipment. The results of the exploratory survey conducted confirm that the shortage is critically hampering the efficiency of honey production in almost all areas of the south and southwestern (the dominant honey producing) areas of the country. The success of the apiculture extension service is also affected by high capital investment requirements and limited credit facility designed for the sector (Ayalew, 2008).

Appropriate credit schemes are important for purchasing the necessary inputs including bee colonies. A number of NGOs are operating in many parts of the country including apiculture development as one of their intervention areas with the aim of poverty reduction at both household as well as national levels. However, their efforts have not been coordinated and sometimes their supports to producers or their groups take a form of a charity where the sense of ownership of the interventions by farmers has been negatively affected. The process of credit provision needs to be supported with training on the proper use of resources and close monitoring on the feasibility of planned activities and implementation of the same in a sustainable and profitable manner before the beneficiaries are pushed to a condition where they cannot pay their debts back and even go into a worse household economic situation. A case in point is a cooperative in Bonga which failed to pay its debt and subsequently suffers from serious hurdles to execute its functions as planned.

Harvesting and storage of honey is being conducted in an unskilled manner which have got serious implications on the market value of the product in addition to significant loss as a result of spoilage. Problems associated with access to market information and transportation are critical limitations for producers to sell their products at a better price. Most of the producers sell honey to local traders and tej makers at low rates. Absence or limited number of honey processors adds to the magnitude of the problem.
2.3.4.4 Agricultural Technical and Vocational Education Training (ATVET) college trainees and their contribution to strengthen the extension system

The four major components of the Ethiopian extension system are the Participatory Demonstration and Training Extension System, Farmer Training Centers, Agricultural Technical and Vocational Education (ATVET) and Institutional Coordination under the overall management of the Extension Service Directorate of the Ministry of Agriculture.

The development of extension agents (usually referred to as Development Agents) was aggressively started in 2002 in Ethiopia. This development initiative is being implemented parallel to the establishment and expansion of Farmer Training Centers throughout the country. Since 2007, the Rural Capacity Building Programme (RCBP) of the Ministry of Agriculture has been the major contributor of the success of this massive scale-up of human and infrastructure resources for agriculture. In particular, focus was given to the development of human resources capacity of the ATVETs and supporting FTCs with physical infrastructure, agricultural research, and institutional capacity building.

The rapid expansion of ATVET in the last ten years in Ethiopia has resulted in an increase in the number of ATVET colleges to 25. There are five federal and 20 regional ATVET colleges. These colleges provide a 3-year training programme to produce middle level work force by admitting people who complete the general education (grade 10) in the Ethiopian education system. The success of the graduates as they employed as Development Agents (DAs) with Ethiopian farmers justifies the investment made in the expansion of Ethiopian ATVET institutes. The ATVET colleges have so far trained around 72,000 DAs who are employed by the government to provide extension services to farmers at the lowest level of the administration (kebele). Currently, the ratio of Development Agents to farmers is about 1:200. It is widely believed that Development Agents contributed a lot to the improvement of agricultural production and productivity at national level. Farmers are usually willing to receive the advice of the DAs and in doing so the livelihoods of farmers have changed considerably (NEPCA, 2013).
Farmer Training Centers are established at the lowest administrative units (kebele) as a critical resource needed to enable extension delivery. These centers serve as focal points for farmers to receive information, training, demonstrations and advice, and include both, classrooms and demonstration fields. They serve as a node between extension services of the DAs and farmers. FTCs are managed at the kebele level, but funding for capital, operational, and salary costs come from the upper second administrative unit (woreda) level. In each of the FTCs, there are usually three DAs at each FTC (one from plant science, animal science, and natural resources management) and one Animal Health and one Cooperative DA are shared between 3 to 5 FTCs in the vicinity. These FTC are instrumental in facilitating the cross learning between farmers through experience sharing among model farmers. Furthermore, each DA is expected to train 120 farmers per year in his/her field of specialization. The DAs provide training to 60 farmers every six months in their respective areas of specialization.

Apart from the acclaimed contribution of the ATVET programs and their graduates to the success of the agricultural extension system (NEPCA, 2013), the following points are cited to be challenges:

- Limited public and private funding to provide quality training;
- Low quality of training as some DAs lack practical skill and experience;
- Low motivation/lack of proper incentive mechanisms/lack of good governance/lack of facilities/harsh working environment, extra engagement of DAs outside of the formal or anticipated commitments. The exploratory field survey results inform that the magnitude of turnover goes even beyond the stated percentage. Most DAs reside in the townships and study in subjects other than agriculture as an exit strategy out of the profession.
- DAs high staff turnover, approx. 10-15% per annum;
- Trainers work overload due to self-contained training delivery system, continuous assessment, industry-extension service, development of curriculum, preparation of teaching, training and learning material, etc.;
- Shortage of training resources at FTCs due to limited budget;
- Weak linkage between stakeholders in particular the limited participation of the private sector and lack of collaboration among ATVET colleges;
- Unwillingness of some stakeholders to engage in training;
• Occupational Standards for some fields do not consider the indigenous knowledge of farmers.

3. The way forward

1. Improving the production from and productivity of the sector

Successful bee management entails the skillful application of knowledge and practices that will fully utilize the productive capacity of the honey-bee colony, with productivity favorably balanced against capital, operational, and labor costs. Because there are individual colonies in most apiaries that produce three to four times more honey than the average colony, the opportunities for improving colony management are at least threefold. Management costs for low-producing colonies usually equal and often exceed those for the best colonies because they require more labor to correct deficiencies that should be avoided. By raising the average yield to equal more closely that of the higher producing colonies, the beekeeper is also likely to improve productivity of his best colonies.

The honey-bee colony is highly adaptable to a wide range of climatic conditions and is usually productive wherever man successfully cultivates forage, fruit, and vegetable crops. There are many areas where the natural vegetation provides abundant pollen and nectar resources that equal or exceed those present in cultivated areas.

The object of colony management is to coordinate the colony’s development with all the natural plant resources available in order to have the maximum number of foraging bees when the major nectar producing plants are in blossom. Every colony will have its own maximum population and production level, but efficient management requires that the beekeeper recognize the different levels of productivity in honeybee stocks and keep only the best. The principles of productive colony management are similar in all areas where bees are kept. Management problems in different regions vary only in the timing of colony development to coincide with the location’s nectar and pollen resources as influenced by the climate and plant species available, including their abundance and period of bloom.

The place to start to ensure the necessary strong population for honey production is a young queen. Young queens can boost honey production in a couple of ways. Queens less than a year old produce more brood than older queens. In addition young queens are less likely to swarm.
This is a factor of bee biology. A first year queen is genetically programmed to focus her efforts on building a colony and storing honey for winter. It is not until the second year that they reproduce or swarm. A good comparison is a biannual plant that stores resources in its first year and then produces seeds in its second year.

Placing the bees in an area that has a diverse community of plants available over an extended period of time contributes to the large population and hence a higher yield. Water supply and afternoon shade can contribute to a more productive population. In the first case the bees travel a shorter distance and therefore expend less time and energy locating water. Shade means less time and energy spend trying to maintain the proper temperature within the hive. Time and energy expenditures mean less stored honey.

Increasing the productivity of existing colonies by effectively dealing with identified research gaps, improving input delivery (improved beekeeping equipment and other supplies) is an essential avenue to promote apicultural development in the country. Moreover, putting in place an efficient and effective extension/demonstration/training service targeted at improving the performance of individual colonies - improving the efficiency of colony management - is imperative to achieve set targets. Transforming the traditional forest system into a backyard system of production and promoting multiple harvests in high potential areas are the other viable options to improve productivity.

The traditional hives in Ethiopia account for 94.4% and about 91% of the total hive number and honey production, respectively (CSA, 2014). Therefore, it is very critical to assume a significant level of improvement in terms of volume of production and productivity from traditional hives through making appropriate/scientific interventions and inputs. There was a 26% increase in honey production in Ethiopia from 2005 to 2010 (USAID/CIAFS, 2012) and it is essential to assume that more of the increase was coming from the traditional production system.
2. Promoting new engagements

*Engaging organized women and youth groups, increased private actor involvement and commercialization*

In developing countries, the migration of rural people to urban areas constitutes the main cause of impoverishment there and hence the factor enabling the production for ready cash earning has an aspect to prevent the exodus of population. In this regard, the apiculture can be seen as a type of economic activity likely to produce an immediate result for regional development (JAICAF, 2009).

One of the essential merits of apiculture as an industry is that it creates lucrative job opportunities. This aspect of the industry/sector is particularly important for countries like Ethiopia where the urban centers are being overwhelmed by permanent and temporary poor migrants from the rural areas in search of employment and better life. Moreover, the Government’s initiatives in developing watersheds which also involves intensified tree planting exercises in the process of soil and water conservation attempts has a big potential of absorbing a large number unemployed engaged in honey production/processing thereby contributing to the success of the poverty reduction efforts.

Past conservation efforts in Ethiopia have only concentrated in developing watershed conservation programs without addressing the socioeconomic of watershed communities. Community ownership and participation in conservative initiatives is critical to sustainable conservation of watersheds (Lietaer, 2009 as cited by Tolera *et al.*, 2014). Therefore, integrating improved beekeeping technologies and natural resources development offers a pathway that guarantees sustainable watershed management.

Moreover, increasing the number of hived colonies through promoting large scale/commercial bee farming along with efforts of colony multiplication and increased efficiency of swarm catching are suggested. Nonetheless, efforts of commercialization should include making the investment environment conducive.
Integration of beekeeping with existing/future agricultural production systems

According to Chamberlin and Schmidt (2011), the proportion of moisture reliable areas (both highland and lowland) estimated for the year 2007 was 40% inhabited by 71% of the total population while that of drought prone highland and lowlands was 30% the rest 30% being occupied by pastoralists contributing to 6% of the population. Rain-water harvesting and tree planting are among the recommended strategies for addressing the challenge of climate change on pastoralist livelihoods in East Africa (Oxfam, 2008). Although tree planting isn’t a new phenomenon, it is being undertaken in some arid areas in a much more comprehensive way. The integration of beekeeping with the tree systems is a viable option for diversifying livelihoods in pastoral communities and helps them withstand recurrent economic shocks as a result of droughts.

There is also an immense potential for integrating honey production with many flowering crops in the moist agro ecological zones of Ethiopia. Although honey and crop productions are naturally complementary, use of chemicals, particularly, pesticides and herbicides in crop production is severely damaging the bee colonies. This requires making a strategic selection between commodities based on the potential of a specific target zone. Moreover, following a systematic way of applying the agrochemicals without seriously impacting the survival of bees, productivity of hives and quality of the products is recommended. The shift to the use of available labor instead of applying herbicides could be a way out of the danger of applying herbicides to the bees and their products.

Most major bee poisoning incidents occur when plants are in bloom. However, bees can be affected in other circumstances as well. The following are the general advice to avoid pesticide poisoning given by Lowore (2013):

- Choose pesticides which are not the most toxic;
- Apply pesticides before the crop is in flower;
- Apply pesticides at night, when honey bees are not foraging; and
- Beekeepers can temporarily confine their bees to the hives by closing the entrances - but this can only be done for a short time and where there is no risk of colony overheating.

Sanford (1993) also advises to keep the following suggestions in mind when applying pesticides:
• Use pesticides only when needed;
• Do not apply pesticides while crops are in bloom;
• Do not contaminate water; and
• Use less toxic compounds.

3. Product diversification and value addition
Apart from honey and beeswax, bees also produce pollen, propolis, royal jelly and bee venom. There are international markets for all these products, but production and marketing are specialised. Although there a proven technologies and techniques, propolis production is little known in Ethiopia and production of pollen and venom requires technology innovation and/or adoption. Commercial and small holder producers using modern methods are likely expected to be able to capitalise on these products to maximize their income from single unit of beehive. In the long run, research is needed to develop Ethiopian bee products value addition and assess whether the country would have a real comparative advantage in this regard.

Unifloral (monofloral) honeys represent a sizeable and well-paid portion of the European honey market. Their production depends on management through site selection and selective harvesting. Increasing consumer knowledge and appreciation of honey is developing a particular market niche for honey identifiable by a characteristic color and flavor, and originating from one or few sources of flowers. Differential pricing sometimes makes the production from rarer floral sources very attractive. Even in some developing countries, honeys from certain areas are preferred, though not always directly for reasons of floral origin, but sometimes for quality, liquidity, color or simply because it looks and tastes the way the most commonly available honey tastes (FAO, 1996). The techniques to produce unifloral honeys are based on the possibility of separating honey of one floral period from earlier and later nectar flows on an economically interesting scale. The most commonly used technique is based on migratory beekeeping.

Monofloral honey is a type of honey which is valued because it has a distinctive flavor or other attribute due to its being predominantly from the nectar of one plant species. While there may never be an absolute monofloral type, some honeys are relatively pure due to the prodigious
nectar production of a particular species, such as citrus (Orange blossom honey), or there may be little else in bloom at the time.

An increasing number of farmers all over the world are shifting to organic farming, since it provides numerous benefits over conventional farming due to its positives such as increased price of honey and increased marketability, among others. The standards for organic honey production are much different than those for producing other organic livestock products. Managing honey bees is very difficult, so the general rules applicable for other livestock cannot be implemented in the case of organic honey production. Organic certification: Certification is a procedure by which written assurance is given that a product, process or service is in conformity with certain standards. Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. In addition to these, undertaking organic production has advantage of selling the products at high price than the conventional produce. In this regard apiculture in the country has great advantage over other agricultural products.

Apiculture potential areas of south and southwest parts of the country less practice farming of agricultural crops, which don’t necessitate the applications of agricultural chemicals (herbicides and insecticides). However, it requires institutional arrangement that will take the leading role in delineating organic apiculture development areas with the areas bee products certification.

Although the country has great potential of natural forest areas where beekeeping is undertaken naturally that can of course meet requirements for organic making, no institution has taken a mandate to delineate and register accordingly. As well, the country is endowed with different flora from which specialty honey can be produced. Even if, coffee honey, Schefflera abyssinica (Geteme honey), Syzygium guineese (dokma honey), Vernonia honey, Croton macrosachus honey, Becuim glandiflorum honey are so far identified as specialty honey by HBRC, strategy to enhance its production and further promotion is lacking. Furthermore, lack of marketing organizations/associations, poor bee product outlet to foreign markets, lack of market and market information, lack of bee product production and processing plants, inadequate infrastructure and
high costs of bee equipments and its inadequate supply are issues deserving attention for institutional arrangements.

While most of the primary products from beekeeping can be consumed or used in the state in which they were produced by the bees, there are many additional uses where these products form only a part of all the ingredients of another product. Because of the quality and sometimes almost mystical reputation and characteristics of most primary bee products, their addition to other products usually enhances the value or quality of these secondary products. For this reason, the secondary products, which partially, or wholly, can be made up of primary bee products, are referred to as "value added" products from beekeeping. Many of the primary beekeeping products do not have a market until they are added to more commonly used, value added products. Even the value of the primary products may increase if good use is made of them in other products, thereby increasing the profitability of many beekeeping operations (FAO, 1996).

The past apiculture research and extension efforts were focussed mainly in promoting honey and beeswax. However, the future apiculture research and development strategies which could develop/identify procedures that could assist the Ethiopian beekeeping industry to actively participate in other apiary products like pollen, royal jelly, bee venom and propolis. Ethiopia has a marketing advantage in this areas compared to many other countries because of our freedom from significant honeybees disease and pests that necessitate medication. Therefore, mechanisms should be designed to support and encourage beekeepers with an insight into further diversification options.

Propolis and pollen collection and processing mechanisms have been designed at Holeta Bee Research Centre (HBRC). But, technologies for commercial production and processing of royal jelly and bee venom do not exist in the country and have to be either generated or adopted to tap the resources. On the other hand, there is an opportunity to scale-up technologies of propolis and pollen collection to the farmer beekeepers at large to produce for export purpose. Because of the increasing health awareness and the high esteem of bee products in various forms, the use of honey and other products has increased in many countries. To this fact, there is increasing trends worldwide on the usage of propolis, royal jelly and bee venom to inclusion in cosmetic preparations and medicinal uses. Hence, diversification with value-added products offers an opportunity to strengthen local markets which then permit a more solid beekeeping production to
expand from a broad base into exportation. Therefore, investigations on the development of end products for each product are necessary, so that their use in nutrition and therapeutics can be popularized in the country.

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Chapter Six. Quality Assurance of Ethiopian Honey for Export and Local Market

1. Introduction

National food safety & quality policy with a clearly defined goal is crucial to develop a sustainable, integrated food safety & quality system for the reduction of health risk along the entire food supply chain of a country. For effective regulation of food safety and quality, the mandates and responsibilities of different relevant ministries as well as all responsible bodies at various levels need to be clearly defined. However, effective food control has been undermined in Ethiopia due to the existence of fragmented legislation, multiple authority, and weaknesses in quality control, surveillance, monitoring and enforcement. As a result, strengthening of national food quality assurance system and quality control infrastructure is mandatory because of the increasing existing challenges of food control which include:

- Increasing burden of food-borne illness and new emerging food-borne hazards;
- Rapid economic development of the country
- Rapidly changing technologies in food production, processing and marketing;
- Developing science-based food control systems with a focus on consumer protection;
- Increase in type and volume of imported and exported food items; and
- Growing consumer awareness on food safety and quality issues.

Although laboratories are an essential components of a food quality assurance system, their establishment requires considerable capital investment and they are expensive to maintain and operate. Therefore, due consideration should be given to analytical quality control laboratories based on the scope and volume of analytical work expected form the laboratory to achieve the most effective coverage of the food analyses to be performed. The Food quality control laboratories have to have adequate facilities for physical, microbiological and chemical analyses as well as qualified and skilled analysts so that it can issue accurate and reliable analytical results. It is also essential that some laboratories are equipped with all the necessary analytical equipments for reference analyses. As these analytical results will be used as evidence for various decisions which have great impact on import & export of food items, it is necessary that
utmost care be taken to ensure the efficient and effective performance of the laboratory. This can be achieved by the establishment of quality management system and accreditation of the laboratories to the ISO 17025 by a recognized accreditation agency.

The incidences of contamination of coffee bean exported to Japan with pesticides, contamination of various spices exported to EU countries with some pathogenic microorganisms and aflatoxins as well as the recent issues related to the quality of honey (adulteration), all of which were detected after being exported, have to be considered as a forewarning for the country`s food items for export in the future. Lack of laboratories which can analyze these samples and identify root causes of such problems is an overwhelming condition.

Since the current food quality control laboratories in the country are not capable of performing the most critical quality control test parameters on honey and other food stuff for export, capacities of both private & government food testing laboratories were assessed. Overall quality assurance systems in place were also looked into with the objective of identifying where special attention shall be given by the government in order to establish and implement comprehensive & reliable quality assurance system at national & regional level.

2. Quality standards & Regulations
All countries have legislations to regulate safety and quality of food stuff imported. The standards of Codex Alimentarius commission is the international reference standard for control of food items. For honey quality generally refers to its genuineness, natural quality and the absence of adulteration, residues, damage from heat during storage & transportation and fulfilling other desired qualities.

Quality control measures in honey are useful to define sensory values (taste, odor, & appearance), set limits for moisture content, diastase, pollen, sugars, acidity and proline. It also limits the presence of residues from antibiotic and pesticides. Furthermore, it can minimize the level of hydroxy methyl furfural (HMF). The limits for these quality components are usually indicated in Codex Alimentarius commission standards as well as importing countries national standards.
**Codex Alimentarius commission standards**

Codex Alimentarius (CA) has seven sections & an annex; sections 1 & 2 define the scope of the standard and descriptions respectively. The other remaining sections focuses on, quality, safety, hygiene, and labeling requirements.

Essential composition and quality factors

The essential composition and quality factors require that honey sold as such shall not have added to it any food ingredient, including food additives, nor shall any other additions be made other than honey. Honey shall not have any objectionable matter, flavour, aroma, or taint absorbed from foreign matter during its processing and storage. The honey shall not have begun to ferment or effervesce. No pollen or constituent particular to honey may be removed except where this is unavoidable in the removal of foreign inorganic or organic matter.

Honey shall not be heated or processed to such an extent that its essential composition is changed and/or its quality is impaired. Chemical or biochemical treatments shall not be used to influence honey crystallization. Essential composition and quality factors for honey as per the codex standards are shown in Table 1.

<table>
<thead>
<tr>
<th>Ser No</th>
<th>Test parameter</th>
<th>Requirement</th>
<th>Test Method</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOISTURE CONTENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Honeys not listed below</td>
<td>NMT 20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Heather honey <em>(Calluna)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NMT 23%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SUGARS CONTENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Fructose and Glucose Content <em>(sum of both)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Honey not listed below</td>
<td>NLT 60 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Honeydew honey, blends of honeydew honey with blossom honey</td>
<td>not less than 45 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Sucrose Content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Honey not listed below</td>
<td>NMT 5 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Alfalfa <em>(Medicago sativa)</em>, Citrus spp., False Acacia <em>(Robinia pseudoacacia)</em>, French Honeysuckle <em>(Hedysarum)</em>, Menzies Banksia <em>(Banksia menziesii)</em>, Red Gum <em>(Eucalyptus camaldulensis)</em>, Leatherwood <em>(Eucryphia lucida)</em>, Eucryphia milligani</td>
<td>NMT 10 g/100g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hygiene

1. Has to comply with the recommended International Code of Practice; such as
   - General Principles of Food Hygiene recommended by the Codex Alimentarius Commission (CAC/RCP 1-1969),
   - Other relevant Codex texts such as Codes of Hygienic Practice and Codes of Practice.

2. Should comply with any microbiological criteria established in accordance with the Principles for the Establishment and Application of Microbiological Criteria for Foods (CAC/GL 21-1997).

Labeling

The following are stated as labeling requirements in the standard with regard to the name of the food.
All provisions of the general standard for the labeling of pre-packaged foods in the CODEX Standard have to be met. The naming of the food as honey is to be specified based on its conformity with requirements of this standard. Accordingly it may be labeled as/by either;

- the term “blossom” or “nectar”
- the term “honeydew”
- “a blend of honeydew honey with blossom honey”
- the name of the geographical or topographical region
  - if the honey was produced exclusively within the area referred to in the designation
  - but the name of the country where the honey has been produced shall be declared
- According to floral or plant source
  - if it comes wholly or mainly from that particular source and has the organoleptic, physicochemical and microscopic properties corresponding with that origin
  - but the common name or the botanical name of the floral source shall be in close proximity to the word "honey"
  - but the name of the country where the honey has been produced shall be declared
- Extracted Honey, Pressed Honey or Drained Honey
  - according to the method of removal from the comb
- Honey may be designated according its styles:
  - Honey which is honey in liquid or crystalline state or a mixture of the two;
  - Comb Honey which is honey stored by bees in the cells of freshly built broodless combs and which is sold in sealed whole combs or sections of such combs;
- Filtered honey
  - If it has been filtered in such a way as to result in the significant removal of pollen

Labeling of non-retail containers
All Information on labeling specified above shall be given either on the container or in accompanying documents, except that the name of the product, lot identification and the name and address of the producer, processor or packer shall appear on the container.

The EU Requirements

To ensure food safety, the EU has laid down strict safety requirements for all food imported into the EU. Above all, the food products must meet safety requirements that are at least equal to those required in the EU. The EU’s food policy is comprehensive and one of the strictest in the world. It requires that food should be traceable throughout the food chain, from the farm, where the food is grown, to the tables, where the food is consumed by EU consumers (so-called ‘farm-to-fork’ reproducers and exporters in developing countries, have to be involved in making sure that only safe food enters the EU Market.

Nowadays food legislation in Europe is mostly EU legislation and only partially national legislation, i.e. there is a harmonized legal framework for the EU internal market. As a result, they have a food safety system that automatically alerts all member countries about rejected shipment to prevent re-entering of the rejected food stuff through another port. The standards for honey are laid down in the EU Honey Directive; the Council Directive 2001/110/EC. It has provisions with regard to the term honey, labeling requirements, composition criteria (as annex) and methods adoption to permit verification of compliance with the directive.

Labeling requirements

1. The term ‘honey’ shall be applied only to the product as defined below.

   “Honey is the natural sweet substance produced by Apis mellifera bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature.”

2. It defines the main types of honey according to:

   (a) origin:
blossom honey or nectar honey: - Honey obtained from the nectar of plants;

honeydew honey: - Honey obtained mainly from excretions of plant sucking insects (Hemiptera) on the living part of plants or secretions of living parts of plants;

(b) mode of production and/or presentation; as comb honey, chunk honey or cut comb in honey, drained honey, extracted honey, pressed honey or filtered honey based on the additional processes used prior to bring it to the market.

3. Baker's honey: - Honey which is (a) suitable for industrial uses or as an ingredient in other foodstuffs which are then processed and (b) may have a foreign taste or odour, or have begun to ferment or have fermented, or have been overheated.

Labelling requires that the product names referred above shall apply only to the products defined therein and shall be used in trade to designate them. These names may be replaced by the simple product name ‘honey’, except in the case of filtered honey, comb honey, chunk honey or cut comb in honey and baker's honey. However,

a) in the case of baker's honey, the words ‘intended for cooking only’ shall appear on the label in close proximity to the product name;

b) except in the case of filtered honey and baker's honey, the product names may be supplemented by information referring to floral or vegetable origin, regional, territorial or topographical origin, or specific quality criteria;

c) where baker's honey has been used as an ingredient in a compound foodstuff, the term ‘honey’ may be used in the product name of the compound food instead of the term ‘baker's honey’.

4. The country or countries of origin where the honey has been harvested shall be indicated on the label. However, if the honey originates in more than one Member State or third country that indication may be replaced with one of the following, as appropriate: ‘blend of EC honeys’, ‘blend of non-EC honeys’, or ‘blend of EC and non-EC honeys’.

5. In the case of filtered honey and baker's honey, bulk containers, packs and trade documents shall clearly indicate the full product name, as filtered honey, and bakers’ honey respectively.

Methods for Verification of Compliance
It describes that “The Commission may adopt methods to permit verification of compliance of honey with the provisions of this Directive. These methods shall be adopted in accordance with the procedure laid down in Article 7(2) of this directive; i.e. Articles 5 and 7 of Decision 1999/468/EC shall apply. Until the adoption of such methods, Member States shall, whenever possible, use internationally recognized validated methods such as those approved by Codex Alimentarius to verify compliance with the provisions of this Directive.

Composition Criteria for Honey

It defines that honey consists essentially of different sugars, predominantly fructose and glucose as well as other substances such as organic acids, enzymes and solid particles derived from honey collection. The color of honey varies from nearly colourless to dark brown. The consistency can be fluid, viscous or partly to entirely crystallised. The flavour and aroma vary, but are derived from the plant origin.

When placed on the market as honey or used in any product intended for human consumption, honey shall not have added to it any food ingredient, including food additives, nor shall any other additions be made other than honey. Honey must, as far as possible, be free from organic or inorganic matters foreign to its composition. With the exception of baker’s honey, it must not have any foreign tastes or odours, have begun to ferment, have an artificially changed acidity or have been heated in such a way that the natural enzymes have been either destroyed or significantly inactivated.

Without prejudice to filtered honey, no pollen or constituent particular to honey may be removed except where this is unavoidable in the removal of foreign inorganic or organic matter. When placed on the market as honey or used in any product intended for human consumption, honey must meet the following composition criteria (Table1).
Table 1: Composition criteria for Honey

<table>
<thead>
<tr>
<th>Ser No</th>
<th>Test parameter</th>
<th>Requirement</th>
<th>Test Method</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sugar Content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Fructose and Glucose Content (sum of both)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blossom Honey</td>
<td>NLT 60 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Honeydew honey, blends of honeydew honey with blosson honey</td>
<td>NLT 45 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Sucrose content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general</td>
<td>NMT 5 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>False Acacia (Robinia pseudoacacia), Alfalfa (Medicago sativa), Menzies Banksia (Banksia menziesii), French Honeysuckle (Hedysarum), Red Gum (Eucalyptus camaldulensis), Leatherwood (Eucryphia lucida, Eucryphia milligani), Citrus spp.</td>
<td>NMT 10 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lavender (Lavandula spp), Borage (Borago oficinalis)</td>
<td>NMT 15 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Moisture content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general</td>
<td>NMT 20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heather (calluna) and baker’s honey general</td>
<td>NMT 23%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baker’s honey from heather (calluna)</td>
<td>NMT 25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Water insoluble content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general</td>
<td>NMT 0.1 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pressed honey</td>
<td>NMT 0.5 g/100g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Electrical Conductivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Honey not listed below and blends of these honeys</td>
<td>NMT 0.8 mS/cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Honeydew and chestnut honey and blends of these except with those listed below</td>
<td>NMT 0.8 mS/cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Strawberry tree (Arbutus unedo), Bell Heather (Erica), Eucalyptus, Lime (Tilia spp), Ling Heather (Calluna vulgaris) Manuka or Jelly bush (Leptospermum), Tea tree (Melaleuca spp).</td>
<td></td>
<td></td>
<td>Exceptions</td>
</tr>
<tr>
<td>5</td>
<td>Free Acid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general</td>
<td>NMT 50 meq acid per 1000g</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baker’s honey</td>
<td>NMT 50 meq acid per 1000g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Diastase activity &amp; Hydroxy methyl furfural content determined after processing &amp; blending</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Diastase activity (Schade scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general except baker’s honey</td>
<td>NLT 8 Schade units</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Honey with low natural enzyme content (e.g. Citrus honey and an HMF content of NMT 15mg/kg</td>
<td>NLT 3 Schade Units.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>HMF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general except baker’s honey</td>
<td>NMT 40 mg/kg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Honeys of declared origin from regions with tropical climate and blends of these honeys</td>
<td>NMT 80 mg/kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other EU requirements
Monitoring for presence of drugs, pesticides heavy metals, throughout the whole process of production, collection and processing as well as a system in place to ensure traceability of any source of these contaminations is an additional requirement that makes the EU market stringent. Therefore there has to be a residue monitoring plan that enables the exporting third countries to prevent contamination of honey and to trace the source when it is encountered.

3. Quality Standards and Regulatory issues in Ethiopia

Ethiopian standards
During the preparation of the Ethiopian Standard references have been made to the Indian Standard 4941-1 974 specification for extracted honey and Codex Standard for honey. It has seven sections and annexes which describes the test methods. Sections 1 to 3 are general which describes the scope, normative references and definitions of terms used to describe honey. Section 4 is general quality requirements for honey (table 2) where as sections 5 and 6 describe hygiene and packing and labeling requirements. Section seven is general sampling requirements and details of sampling techniques. The test methods to be followed to evaluate compliance of honey with requirements of the standard are addressed as annexes. As a result, it incorporates majority of the composition requirements & labeling requirements laid down by Codex Alimentarius food standard as well as EU directive for honey.

Table 2: General Quality requirements for honey

<table>
<thead>
<tr>
<th>Ser No</th>
<th>Test parameter</th>
<th>Requirements</th>
<th>Test Method</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apparent reducing sugar( as invert sugar), % by mass min</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Apparent sucrose content % by mass, max</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Water insoluble solids content % by mass, max</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mineral content(ash), % by mass, max</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Acidity meq acid per kg</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Diastase activity, 1% starch solution hydrolyzed by enzyme in 1 gram of honey in 1 hour at 40 °c, min</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hydroxy methyl furfural content mg/kg</td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Limitations of Ethiopian standard
As compared to Codex Alimentarius standard and EU requirements, it lack clarity with regard to the limits for the water insoluble solids content. The general requirements mentioned under section 4 (4.1.3 & 4.1.4) requires that pressed honey and extracted honey shall not contain water insoluble solids more than 0.5% and 0.1% respectively where as the water insoluble solids contents % by mass maximum 0.1% indicated in the table did not specify the type of honey. In addition, it does not set the limits for moisture content rather it indicates the grades of honey based on its moisture content. It does not set maximum residue level for Pesticides and no requirements for residue level of antibiotics residue.

**Regulations**

There are various proclamations and regulations in the country in relation to food safety and quality control. There are also different departments that are organized under different ministries and with direct or in direct responsibilities in ensuring food safety and quality in general. Some of the institutions and regulations in relation to regulating quality of honey and other bee products include

**Regulation 728/2011**

Regulation 728/2011 which is to provide for the veterinary drugs and feed administration & control has provisions in relation to registration, certification of registration, post market surveillance as well as prescription and dispensing of veterinary medicines. Clause 6 sub-clause 2, of the proclamation addresses the use of veterinary drugs “any veterinary drug shall be available for use in accordance with the guidelines issued by the authority to ensure judicious use of veterinary drugs. However, it does not clarify whether use of antibiotics honey bee treatment is permissible or not.

**Proclamation 674/2010 to provide pesticides control**

**Proclamation 661/2009**

Proclamation 661/2009 is a proclamation to provide for Food, Medicine and Health Care Administration Control has addressed some of the critical issues related to food safety and quality. According to the definition of terms in this proclamation (clause 2 sub clause) food means “any raw, semi-processed or processed substance for commercial purpose or to be served for the public in any way intended for human consumption…” Issuing, renewal, suspension and
revoking of certificate of competence (Clause 4 sub clauses 2) for food processing plants, quality control laboratories, importers, exporters, storages and distributors of food as well as issuing import and export permits (clause 4 sub clause 7) for food is the mandate of the executive organ established to enforce this proclamation. It also requires that food manufacturing, import, export, storage, distribution, transportation or making available for sale or use to the public needs permit from an appropriate organ (Clause 6 sub clauses1).

With regard to the quality standards, it declares that “No food or its raw material, additive or packaging material shall be put into use unless it complies with the international and national safety and quality standards”.

The labeling requirements were addressed under Clause 8 sub clause 1 that “Any producer, importer, distributor or retailer of packed food shall not supply it to the market or distribute it otherwise unless it is duly packed and labeled”. In this proclamation issuance of safety certificate for export is not mandatory as it clearly states that “The executive organ may issue safety certificate for export food that needs the same (Clause 10 sub clause 2).

Regulation 299/2013, the council of ministers regulation to provide for Food, Medicine and Health Care Administration Control has also some additional detailed provisions of the critical issues related to ensuring food safety and quality. The general provision of the regulation is No food unfit for human consumption or not complying with appropriate safety and quality standards may be manufactured, imported, exported, stored, distributed, transported or made available for sale or use to the public. It also addresses the requirement of permit from the authority for manufactures to sale or distributes food in more than one regional state or for export market. It also prohibits to addition or mixing (adulteration) any substance to any food so as to increase its bulk or weight, or make it appear better for any other similar purpose. It prohibited presenting any food as if it is produced by the real manufacturer or affecting quality and safety by imitating its package identification, trade mark, trade name or any mark. There are also requirements (Clause 6) regarding food transportation; that “any food manufacturer, exporter, importer or distributor shall store, display, pack or transport perishable food at appropriate temperature or cold chain”. It prohibits storing, loading or transporting any food together
with contaminated food, waste food, poison, any harmful substance, animal or any other contaminant.

**Proclamation No. 660/2009**

A proclamation to provide for apiculture resources development has few provisions that have impact on quality assurance of honey at the grass root level since it addresses issues related to conservation of the biodiversity of honey bee races and honey source plants.

**Some relevant initiatives**

The draft regulation for honey has addressed some critical issues that have direct or indirect effect on quality assurance of honey. It states that “fertilizers and pesticides shall not be applied in areas delineated to organic honey production”. It also requires that “extreme care shall be taken while applying pesticide to protect loss of honey bee colonies”.

There shall be competency assurance system for processing plants and product health, quality and safety certificate for exporters of bee products will be issued by federal supervising authority. Sale or transfer of adulterated or blended honey bee products for human consumption and other uses is prohibited. It has also provisions for any person or bee keeper organization registration by supervising authority. And the person or the organization has to post his/her certification number in a prominent place in his /her apiary. Distinctive mark or brand has to be also attached on hives and appropriate handling of honey bee colonies infested with curable diseases and honey bee pest. But did not indicate means of treatment; whether antibiotics are prohibited. Responsibility of honeybee products exporters in the cases of compliant from importing countries on quality and safety of exported honey and responsibility to be inspected. Record keeping showing the collection processing transportation and distribution operation and production of bee keeping as well as importance of inspection, retaining relevant documents are well addressed.

The organic certification internal control system (ICS) manual for hive products has addressed some of the important components of traceability and labeling requirements.

The other activity which can contribute to the quality assurance system is the residue monitoring plans prepared on annual basis for honey products exported to Europe. The seventh RMP( RMP 2014) of the country has shown that low capacity honey production and processing methods, hygiene, packaging technology, and lack of accredited laboratories for verifying the quality &
safety of raw & processed honey are the major constraints affecting the apiculture sector in Ethiopia.

**Standards & regulatory systems of lead exporters**

Desktop benchmarking has shows that the regulatory systems and standards of these lead exporting countries is based on the requirements of the importing countries.

**4. Quality Control laboratory services**

**Existing laboratories capacities and gaps**

The existing capacities and gaps of only three relevant food testing laboratories which are believed to have the capacity or potential to carry out full parameters tests on honey and the Holeta Honeybee Research Center laboratory were included in this assessment. This assessment is a brief account of the present performance of these food testing laboratories & honey research laboratory. Thus it covers only the premises, equipment, staff and status of laboratory accreditation; which were in place for food testing (with special emphasis on honey) at the time of the assessment (annex 1). Therefore, it does not include details of other testing or research activities undertaken by these laboratories as well as the future planning of the individual laboratories and institutes.

**Ethiopian Conformity Assessment Enterprise laboratory**

The Ethiopian Conformity Assessment laboratory is one of the oldest laboratories in the country which has been providing quality control service organized under the previous Ethiopian Quality &Standards Authority (EQSA). The enterprise is established by the “Ethiopian Conformity Assessment Enterprise Establishment Council of Ministers Regulation No. 196/2010” to provide certification services. It has chemical testing and microbiology testing laboratory sections for food analysis as well as laboratories for other electromechanical items.

It has sufficient laboratory space and dedicated areas for various activities performed in the laboratory. There were dedicated areas for samples store, chemicals stores, and sample testing areas. However, there was no environmental monitoring; which is one of the requirements by ISO/IEC 17025:2005 for accredited laboratories. ISO/IEC 17025:2005 requires that “The
The laboratory shall monitor, control and record environmental conditions as required by the relevant specifications, methods and procedures or where they influence the quality of the results”.

The laboratory has sixteen (16) technical staff working in the chemical section. Majority of them have BSc degree qualifications and two have MSc degree in various fields of science including chemistry, food science and plant science. They have varying years of work experience in the analytical laboratory. Three staffs have seven to nine years of experience, four staffs have only six months experience and the rest have about four years of experiences.

The lab has adequate number and types of apparatuses for carrying out most of the standard test parameters that needs to be performed on food samples. It is also equipped with advanced analytical equipment such as HPLC, AAS, and LC-MS, GC. However, performance verification checks are not done on schedule basis since most of these equipments are not in use. Majority of the tests undertaken by the laboratory are mainly classical test methods such as gravimetric and volumetric analysis. Atomic absorption and UV-Visible instruments were also in use by the lab for quality control purposes. However, other laboratory equipment such as High Performance Liquid Chromatography, Liquid chromatography hyphenated with Mass spectroscopy (LC-MS-MS), and Gas Chromatography were not in use for analysis of food samples. The main reason for not using these advanced analytical equipments was lack of experience to use them and due to priority given to the number of samples tested and reported by analysts rather than spending some time for the staff to familiarize them with the equipment. The major problems of the laboratory, according to the top management opinion were, failure to use advanced analytical equipment, shortage/lack of laboratory chemicals (reported as bottleneck), and equipment maintenance problems. For example two detectors of the HPLC, equipment in the laboratory, which are the major component of the equipment, were out of service at the time of the visit. Even though the enterprise has a maintenance team, they do not have experience and training on such specific analytical equipment and are not capable to fix the problem.

Test methods and specifications

Currently the laboratory utilizes ISO, AOAC, ASTM, WHO and Ethiopian standards to test quality of various samples. Analytical methods verification or validation is performed only for few test methods. There was serious problem regarding sourcing of reference standards and certified reference materials which are the most critical inputs for analytical laboratories. It was
observed that the laboratory participates on some (proximate analysis) proficiency testing schemes on a regular basis.

The laboratory is ISO 17025 accredited by the Ethiopian National Accreditation Office (ENAO) on majority of tests; including salt iodine content test, nine test parameters for edible oils, proximate analysis for majority of food samples as well as water analysis. The laboratory has a plan to be accredited for aflatoxins test until July 2015.

As per the ECAE top management explanation; currently the laboratory has the capacity to perform the following QC tests on honey samples:

- Moisture content
- Total ash
- pH
- Water
- Insoluble matter
- HMF
- Electrical conductivity
- Optical rotation

**Coffee Quality Control laboratory**

The laboratory is established in response to the problem of contamination of exported coffee with DDT. Hence, it is currently working mainly on residue testing on coffee beans for export purpose. It was understood that the laboratory has been in the process of standardizing the testing activities and currently it is carrying out pesticide residue testing on coffee.

The types of quality control testing services provided by this laboratory are very limited both in the type of food items tested as well as the types of tests performed. It is mainly monitoring level of pesticides on coffee beans and hence it can provide only chemical test service. The laboratory’s operations rely on project funds & it is currently operating with the support of Japan International Cooperation Agency (JICA) at the time of the visit.

**Ethiopian Food, Medicines & Healthcare Administration and Control Authority (EFMHACA) Laboratory**
The Ethiopian Food, Medicine and Health Care Administration and Control Authority (FMHACA) is a regulatory agency established under Regulation No. 189/2010 and authorized by Proclamation No. 661/2009 to protect the health of consumers by ensuring food safety and quality as well as safety efficacy & quality of medicines. The authority is responsible to regulate among others food manufacturers, distributors and sale of food to ensure that products for dietary consumption are safe and comply with prescribed specifications and standards.

The food safety and Quality Control laboratory of EFMHACA has been organized under the Product Quality Assessment Directorate (PQAD), which is well equipped, has competent staff, established, implemented and maintained Quality Management System. As a result, it has been ISO 17025 accredited laboratory for seven major tests of pharmaceuticals since September 2011. The Food safety and Quality Control laboratory of EFMHACA has adequate facilities (in terms of space) for physical, microbiological and chemical analyses, however there are gaps in the number and types of equipment as well as professional mix of well qualified and skilled analysts.

**Human resource**

The EFMHACA Food Quality Control laboratory is at its early stage and in the process of strengthening its food testing capacity. The pharmaceuticals quality control laboratory is one of the oldest laboratories in Africa, and it has adequate competent staff with ample experience in the area of quality control procedures including high tech instrumental analysis. However, there are gaps with regard to the number as well as professional mix of qualified and skilled analysts working in the food QC laboratory. The total number of technical staff working in the EFMHACA`s food quality control laboratory are eleven with relevant professional mix and qualifications. These include BSc in chemistry /pharmacy (4), MSc in food science, microbiology and pharmaceutical analysis (5) and Laboratory technicians (2).

**Premises & Laboratory equipment**

EFHACA laboratory has basic lab equipment including HPLCs that are necessary to undertake physicochemical, microbiological, and micronutrient analysis from different food products. However, there is a problem of various laboratory supplies such as chemicals, microorganism’s culture media and glass-wares etc. Although there are sufficient space/premises for both food
microbiology and physicochemical testing activities, it has to be renovated to give the expected test results.

Types of food analysis parameters
EFMHACA has been trying its best to strengthen the food safety and quality control laboratory while utilizing other food research laboratories & QC laboratories for its regulatory purposes. As shown in Table 4 the laboratory has the capacity to carry out most of the test parameters recommended for honey as essential quality components but it has not yet been fully realized due to various minor limitations such as chemicals and short term staff training on this specific product testing. The types of test parameters that can be carried out and the gaps of EFMHCA lab are shown in Table 4.

Holeta Honeybee Research Laboratory
The laboratory was established in 1957 E.C, and its main purpose is to conduct research on honey bee. Currently it provides, among other services, support to agriculture extension workers, training on technology transfer and dissemination. It also serves as a model research laboratory which provides training for experts and researchers. The major areas of the research include bee biology, product laboratory and bee health protection research. The laboratory works mainly on health aspects of honey bee, management, and product postharvest & value addition. It has also a workshop for developing new utilities (hives) for improving production of honey & other bee products. Since the laboratory is essentially working on honey bee breeding, bee predators, pests and some pesticides impact on honey bee, its focus is on improving the production of bee products and less attention was given to the quality assurance of the products. One of the peculiar natures of the center is all-inclusiveness, unlike research institutes in other countries. It was noted that the center has no problem of human resource both in number and qualifications (majority are MSc. graduates and three PhD) for the activities currently undertaken. It was observed that the major problem of the center is lack of up-to-date laboratory equipment and apparatuses. However, the laboratory was contributing its best by using the few available apparatuses and by using modified & locally made apparatuses. There are three main laboratories at the center; bee health, bee products and botany laboratory. The center is selected to be a satellite site in the East African region to work on bee health.
**Bee products quality control activities at the center.**

Even though the laboratory does not have most of the analytical equipment for quality control of honey, it receives sample test request from different clients. Quality control test requests received by the laboratory include investigation on honey samples reported to be adulterated. The laboratory performs some physical tests & organoleptic checks to verify the quality of honey. The current focus of the center is on improving the production of honey rather than establishing quality assurance systems.

**Bee Biology laboratory**

The major activities of the Bee Biology laboratory are to carry out research on bee breeding, race, characterization, behavior and productivity.

**Product Laboratory**

This section performs some tests on honey and bee wax. It categorizes the different types of honey (already identified 9 specialty honey) produced in the country. It also identify whether a honey product is adulterated or not and determines the shelf life of honey based on physical changes like formation of crystals & visual inspection of retained honey products.

**Major laboratory Equipment**

The equipment available in the bee product laboratory will enable it to perform only few physical checks. Besides the limited types of equipment, some were out of service at the time of lab visit. Equipment/apparatuses in the lab were:

- Refractometer (out of service)
- Microscopes (some out of service)
- Polarimeter
- UV-Visible Spectrophotometer
- Melting point apparatus
- Color Grader
- Centrifuges
Balances

**Bee Protection Laboratory**
This laboratory conducts research on honey bee disease, predators & pests, chemical pesticides and carries out identification and diagnostic surveys.

**Bless Agri Food Laboratory Service**

Bless Laboratory has been providing analytical services previously through the sister laboratory Hilina Food Laboratory Business Unit, later on transformed into an independent Bless Agri Food Laboratory Service for agricultural & food products. It is a private owned laboratory which was established in July 2014, by Ethiopian and French shareholders. It has a plan to provide three major services in relation to food safety and quality. These are research and development, laboratory testing services and training. The focus of the research wing will be on product development, nutrition program support and risk assessment. The role of training wing will be to provide tailored trainings on food safety and production technologies.

**Laboratory services**

The main analytical services which are provided by the laboratory include macro nutrient and proximate analysis, aflatoxins, ochratoxins tests, etc. and 12 different types of microbiological analysis for different types of food products. It also provides both chemical & microbiological testing on a variety of Agricultural, & Water Products and Soil samples.

The laboratory is accredited as per the International Standards Organization (ISO) requirements for testing laboratories; ISO/IEC/ 17025:2005. Its scope of accreditation encompasses aflatoxin, acratoxin, proximate analysis and 7 different microbiological tests. The laboratory also performs few chemical tests on honey samples. The types of test parameters and methods used are as listed here under.

Table 3: Quality control tests that can be performed by Bless laboratory
<table>
<thead>
<tr>
<th>Ser No</th>
<th>Type of test parameter</th>
<th>Method used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HMF in honey</td>
<td>HPLC/Spectrophotometric</td>
</tr>
<tr>
<td>2</td>
<td>Water insoluble matter in honey</td>
<td>Gravimetric</td>
</tr>
<tr>
<td>3</td>
<td>Acidity of honey</td>
<td>Titrimetry</td>
</tr>
<tr>
<td>4</td>
<td>pH in Honey</td>
<td>Potentiometric</td>
</tr>
</tbody>
</table>

**Laboratory premises**

It has sufficient laboratory spaces and dedicated areas for various activities performed in the laboratory. There were dedicated areas for samples store, chemicals stores, and sample testing areas based on the type of analysis. However, there was no environmental monitoring in chemical testing laboratories; which is one of the requirements by ISO/IEC 17025:2005 for laboratories providing accredited works.

**Laboratory equipments/instruments**

The laboratory has most of the apparatuses necessary for food testing laboratory and some major analytical equipments such as HPLC system, with RID, Fluorescence and UV-visible detectors one GC with FID and ECD detectors. It was noted that the HPLC is usually in use conditions testing aflatoxins. There were also some new equipment in the laboratory waiting for installation like atomic absorption spectroscopy and GC-MS. The microbiology laboratory is well equipped with all apparatuses and equipments for microbiological tests. However, there were limitations in relation to as equipments qualifications (IQ & OQ) performance verifications on regular schedule.

**Conclusion**

Although there are various efforts being made by all the assessed laboratories none of them can perform full quality control tests on honey samples. Table 4 indicates the major quality components for honey and the gaps of the laboratories included in this assessment.

Table 4: Types of standard tests required as essential quality component for honey & gaps at different food testing Laboratories
<table>
<thead>
<tr>
<th>S/N</th>
<th>Test parameter</th>
<th>Laboratories current/near future capacity</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ECAE</td>
<td>EFMHACA</td>
</tr>
<tr>
<td>1</td>
<td>Moisture Content</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>2</td>
<td>Sugar Content</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>2.1</td>
<td>Fructose and Glucose Content (sum of both)</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>2.2</td>
<td>Sucrose content</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>3</td>
<td>Water insoluble solids content</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>4</td>
<td>Determination of Sugars added to Honey (Authenticity)</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>4.1</td>
<td>sugar profile</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>4.2</td>
<td>stable carbon isotope ratio analysis</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>5</td>
<td>Heavy Metals</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>6</td>
<td>Residues of Pesticides and Veterinary Drugs</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>Free Acidity</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>7.1</td>
<td>Diastase activity</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>7.2</td>
<td>hydroxymethylfurfural content</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>8</td>
<td>Electrical Conductivity</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

5. Other Quality Assurance mechanisms

Producers
There are various initiatives being undertaken by different groups in different regions of the country in order to assure quality of honey at various levels of value chains of honey for export. However, there are no standardized procedures made available to farmers’/small scale producers regarding how to assure quality of honey produced by farmers. There are many factors which could have negative impact on the quality of honey produced, such as honey bee predators, various honey utensils and storage containers, and types of nectar or pollen used by the honeybee. Therefore, there has to be standardized procedures and enforceable laws with regard to quality of honey produced by farmers and coding system to trace the possible sources of contamination or adulterated honey when necessary. There is no quality control system in place to check the quality of honey for market at various levels of the supply chain.
Honey processors and Surveillance mechanism
There are weak or no regular surveillance mechanisms in place to ensure that honey meets all the required safety and quality standards at producers and processing levels.

Monitoring at ports of export
Export quality Control, inspection and certification including ensuring implementation of residue monitoring plans to ensure food safety of the honey meant for export to all countries at all ports of exit is being carried out by the veterinary service directorate of the Ministry of Agriculture. It was noted that the certificates are provided based on the requirements of the importing countries. The certificates are issued based on evaluation of the products by visual inspection & use of packaging materials. However if it is to be exported to EU countries it has to be tested by recognized laboratories (in Germany or Uganda) as per the EU requirement for its composition and certificates of analysis attached. Sometimes farmers may use containers which are labeled as “dangerous goods”. The other problems which were usually encountered include contamination of honey with foreign taste or odour (perfumes & garlic). Some of the major honey exporters are providing awareness creation & appropriate containers to the farmers to alleviate the problem of packaging. There is regular inspection of major honey exporters to check compliance with the HACCP requirements.

Transportation
One of the causes for contamination of honey with foreign taste & odor has been reported to occur during transport. In addition, it will fail to fulfill limit set for HMF if the honey is exposed to excessive heat during transport.

Proposed Quality assurance system

Strengthening Quality control infrastructure
Laboratories premises, competent staff, analytical instruments/equipments, test methods, specifications and various lab supplies are among the major critical resource required by analytical laboratories so as to issue accurate and reliable analytical test results. These results can be used as a basis for law enforcement, research & development outcome, to accept or reject food products by importing countries. Therefore, utmost care has to be taken to ensure competence of testing laboratories. This can be achieved by the establishment of laboratory
quality management system and accreditation of the laboratory by an appropriate accreditation agency.

Establishing or strengthening the existing food testing laboratories indifferent parts of the country to provide food quality control service will play a crucial role in ensuring quality of honey as well as other food products throughout its value chains. The existing branch laboratories of EFMHACA (five branches) & ECAE Braches (six branches) can be strengthened and shall provide QC testing service to the honey processing companies located at different regions of the country. This will reduce unnecessary cost incurred for transporting honey / bee products that does not comply with the quality standards. Laboratories at the federal level shall provide testing service for honey exports and shall also serve as reference laboratory for these branch laboratories and private testing laboratories. Competent private testing laboratories can also be encouraged to participate in such quality control testing activities provided that they are accredited to ISO/IEC 17025:2005 by appropriate accreditation body.

**Strengthening existing quality control laboratories**

The existing laboratories can be strengthened in terms of human resource, laboratory premises, instruments, laboratory chemicals etc and be utilized for ensuring quality of different food items both for export and domestic consumption. Since majority of the laboratory equipments, apparatuses, chemicals and human resource can be used for majority of food items testing, it will be wise to establish or capacitate existing laboratories to provide quality control tests on all food samples.
**Personnel**

The analysis of contaminants in various food products including honey requires competent laboratory personnel who have appropriate qualification, experience and training in analysis of contaminants in trace level and residue monitoring. Presence of competent and productive human resource is the key element for the existence of any organization. Therefore, there should be a mechanism for recruiting, creating & retaining competent laboratory personnel. Hence, although the required number of personnel depends on the volume of work, the proposed professional qualifications, responsibilities and retention mechanisms to improve and maintain staff competency recommended as minimum at the different levels of laboratories are as shown in annex 2.

**Establishing new laboratories**

Major cost for establishing new quality control laboratory includes expenditure for construction of laboratory premises, procurement of advanced analytical equipments, different apparatuses, chemicals and reagents. Furthermore it may take extended time (three to five years) to start
testing service in new facility. The budget required depends on the types of food quality control tests to be undertaken by the laboratory and the volume of work. This may require a budget which ranges from 500 million to 2 billion birr, based on the size of laboratory to be established. Hence, strengthening the existing quality control laboratories and setting up appropriate networking, alignment of work and referral linkage among these laboratories would be wise way of utilizing limited resource.

**Proposed Mechanisms to improve QA system of honey supply chain**

**Labeling requirements & Traceability**
Designing appropriate labeling procedures & establishing a reliable traceability mechanism in the value chain for honey and other bee products play the basic role in establishing honey quality assurance system at country level.

Therefore, there shall be a directive or guideline at national level for quality assurance of bee products in relation to the types of nectar and pollen the bees use to maintain the Ethiopian organic honey. These might be handled by the national bee research laboratory. But the research center needs to be strengthened and get appropriate capacity building in relation to quality assurance and importance of establishing quality management systems.

**Individual Farmers**

- Registration of farmers, code for each hive, proper training, regular inspection & surveillance
- Provide proper packaging materials and labels
- Customized standard operating procedures
- Visual inspection
- Sanctions on those who do not comply

**Small scale commercial producers**

- Registration of producers, code for each hive, proper training, regular inspection & surveillance
- Provide proper packaging materials and labels
• Customized standard operating procedures
• Sanctions on those who do not comply
• Visual inspections, Sampling & testing

**Large scale commercial producers**

• Registration of producers, code for each hive, proper training, regular inspection & surveillance
• Provide proper packaging materials and labels
• Customized standard operating procedures
• Sampling & testing (all critical Test parameters)
• Sanctions on those who do not comply

**Cooperatives**

• Registration of companies, proper labeling requirements, proper training, regular inspection & surveillance
• Relicensing, revocation of license as necessary
• Encourage to establish & implement Quality Management systems
• Customized standard operating procedures
• Sampling & testing at regular intervals (all test parameters)

**Strategic plan to implement & sustain Quality Assurance system**
<table>
<thead>
<tr>
<th>Strategic objective</th>
<th>Measures</th>
<th>Target</th>
<th>Implementation period</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve good practices in the honey supply chain</td>
<td>Percentage of export consignment complying with the standards</td>
<td>100%</td>
<td>85% 90% 95% 98% 100%</td>
<td>Good agricultural, hygiene and distribution practices</td>
</tr>
<tr>
<td>Improve quality control infrastructure</td>
<td>No of laboratories ISO 17025 accredited to test major food items for export</td>
<td>3</td>
<td>1 1 1 1</td>
<td>ECAE, EFMHACA &amp; Bless food QC laboratories</td>
</tr>
<tr>
<td>Increase companies implement Quality Management Systems &amp; HACCP</td>
<td>Percentage of companies complying</td>
<td>95%</td>
<td>85% 90% 95% 98% 100%</td>
<td></td>
</tr>
<tr>
<td>Improve inspection &amp; surveillance system</td>
<td>Percentage of inspection coverage</td>
<td>100%</td>
<td>75% 85% 90% 95% 100%</td>
<td></td>
</tr>
<tr>
<td>Increase no of certified honey exporting companies</td>
<td>Percentage of exporter companies granted certification of competency</td>
<td>100%</td>
<td>85% 90% 95% 100%</td>
<td></td>
</tr>
</tbody>
</table>
Annex 2: Recommended Staff qualification, responsibility & retention mechanisms of staff at different levels of QC laboratories

Central Reference Laboratory

<table>
<thead>
<tr>
<th>Staff position</th>
<th>Responsibility</th>
<th>Qualification</th>
<th>Retention mechanisms</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory technicians</td>
<td>Perform simple tests</td>
<td>Diploma chemist, &amp; laboratory technician</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assist analysts &amp; senor analysts</td>
<td></td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td>Analysts (different levels)</td>
<td>Perform majority of the Food QC tests</td>
<td>BSc &amp; MSc in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Train technicians</td>
<td></td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td>Senior Analysts</td>
<td>Perform complex samples testing</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training other staff</td>
<td></td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td>Supervisors</td>
<td>Supervise technicians &amp; junior staff</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participate in investigative and research work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Managers</td>
<td>Overall Management of the laboratory</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provide technical advice to supervising authority regarding food quality &amp; safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Assurance manager &amp; officers</td>
<td>Establish, implement &amp; maintain laboratory QMS ( accreditation)</td>
<td>BSc &amp; MSc in chemistry, microbiology, food science &amp; additional trainings on QMS</td>
<td>Housing &amp; transportation allowances</td>
<td></td>
</tr>
<tr>
<td>Laboratory equipment Maintenance engineers</td>
<td>laboratory equipments preventive maintenance, in-house calibrations &amp; curative maintenance</td>
<td>Electrical Technicians &amp; electrical or biomedical engineers</td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
</tbody>
</table>
## Other Central Laboratories

<table>
<thead>
<tr>
<th>Staff job position</th>
<th>Responsibility</th>
<th>Qualification</th>
<th>Retention mechanisms</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory technicians</td>
<td>Perform simple tests</td>
<td>Diploma, chemist, &amp; laboratory technician</td>
<td>Short term &amp; long term</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assist analysts &amp; senor analysts</td>
<td></td>
<td>Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td>Analysts (different levels)</td>
<td>Perform majority of the Food QC tests</td>
<td>BSc &amp; MSc in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Train technicians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior Analysts</td>
<td>Perform complex samples testing</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training other staffs</td>
<td></td>
<td>Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td>Supervisors</td>
<td>Supervise technicians &amp; junior staff</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participate in investigative and research work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Managers</td>
<td>Overall Management of the laboratory</td>
<td>MSc &amp; PHD in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liaison with branch and referral food QC laboratories</td>
<td></td>
<td>Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td>Quality Assurance manager &amp; officers</td>
<td>Establish, implement &amp; maintain laboratory QMS (accreditation)</td>
<td>BSc &amp; MSc in chemistry, microbiology, food science &amp; additional trainings on QMS</td>
<td>Housing, transportation, chemical hazard allowances</td>
<td></td>
</tr>
<tr>
<td>Laboratory equipment Maintenance engineers</td>
<td>laboratory equipments preventive maintenance, in-house calibrations &amp; curative maintenance</td>
<td>Electrical Technicians &amp; electrical or biomedical engineers</td>
<td>Short term &amp; long term</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trainings on schedule basis</td>
<td></td>
</tr>
</tbody>
</table>
Branch Laboratories

<table>
<thead>
<tr>
<th>Staff job position</th>
<th>Responsibility</th>
<th>Qualification</th>
<th>Retention mechanisms</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory technicians</td>
<td>Perform simple tests</td>
<td>Diploma chemist, &amp; laboratory technician</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assist analysts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>analysts (different levels)</td>
<td>Perform majority of the Food QC tests that can be</td>
<td>BSc &amp; MSc in chemistry, microbiology, food science &amp; biotechnology</td>
<td>Housing, transportation, chemical hazard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>performed at branches</td>
<td></td>
<td>allowances</td>
<td></td>
</tr>
<tr>
<td>Laboratory managers</td>
<td>Overall Management of the laboratory Liaison with</td>
<td>BSc or MSc chemistry, microbiology, food science &amp; biotechnology</td>
<td>Short term &amp; long term Trainings on schedule basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>other central and referral food QC laboratories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Assurance officers</td>
<td>Establish, implement and maintaining QMS</td>
<td>Diploma or BSc in chemistry, Biology, food science &amp; additional trainings on QMS</td>
<td>Housing, transportation, chemical hazard</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>allowances</td>
<td></td>
</tr>
</tbody>
</table>

Annex 3: Recommended tests, instruments/equipments, test methods and specifications, premises and accreditation

<table>
<thead>
<tr>
<th>Type of laboratory</th>
<th>QC test services</th>
<th>Equipments</th>
<th>Test methods &amp; specifications</th>
<th>Laboratory premises</th>
<th>Laboratory accreditation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central referral laboratory</td>
<td>Referral services for QC tests on all food items</td>
<td>Hi tech analytical equipments</td>
<td>accepted at international level</td>
<td>Adequate area for physical, chemical and microbiological routine tests and research</td>
<td>Must be accredited by internationally recognized accreditation body (Full ILAC member)</td>
</tr>
<tr>
<td></td>
<td>investigation and research related to food safety &amp;</td>
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<td></td>
<td>quality</td>
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<tr>
<td>Central other laboratories</td>
<td>Major QC control tests on all food items</td>
<td>Major analytical equipments</td>
<td>accepted at international level</td>
<td></td>
<td>Must accredited by internationally recognized accreditation body (Full ILAC member)</td>
</tr>
<tr>
<td>Branch laboratories</td>
<td>Simple QC tests &amp; organoleptic checks</td>
<td>Equipments for simple QC tests</td>
<td>accepted at international level</td>
<td></td>
<td>May or may not be accredited</td>
</tr>
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Chapter Seven. Strategic Directions and Projections for Transforming the Ethiopian Apiculture

Summary and Conclusions

Potential of the Apiculture Industry

There is not only large natural endowment for apiculture but that endowment is being enlarged. Moreover, the Potentials of apiculture are not only consistent with the grand objectives of the Ethiopian government, but has the feature of meeting simultaneously different and sometimes conflicting development objectives, which should have been an attractive industry to a government which is pursuing an 'inclusive growth'.

Recognizing the fact that the Ethiopian government is pursuing growth objectives and income distribution objectives, it is rare to find a sector that contributes equally to all these objectives. Developing and promoting a productive apiculture at farm household level, equally contributes to poverty reduction and employment creation and by same token to export earning and diversification.

Apiculture reconciles the conflicting interests of the present and future generations, because it is both green, sustainable and growth enhancing at the same time. Developing an apiary site enhances productivity of beekeeping and rehabilitates the environment at the same time. The more rehabilitated a given site is the more productive would be for beekeeping. In this regard, promoting apiculture in the preserved areas like the national parks would reconcile the interest of the surrounding communities and that of these preserved areas.

Thus, apiculture should have been and should be a preferred and priority industry in Ethiopia.

Drivers of Global Competition

Global competition sets the conditions of entry and survival of Ethiopian apiculture in the global market. There are multiple major drivers of global competitiveness including quality and meeting the minimum health and safety standards, price competitiveness, volume(quantity) of supply that justifies efficient and economic procurement, prompt delivery of export orders, and related others.
This calls for simultaneous achievement of highly productive production system of quality products, at lower selling prices, with consistent and predictable delivery and upgrading into high value products over time.

**Why marginal export participation?**

So far the contribution of Ethiopian apiculture towards the country's export earnings has been persistently negligible. Ethiopian exports were characterized by:

- Low capacity to supply because of low production capacity, which is attributed to low productivity
- Shortage of supply in the domestic market has increased domestic prices which discourages exports, which also means low price competitiveness of Ethiopian bee products. This can easily be addressed through increasing productivity and product differentiation.
- Traditional packaging, storage and transportation leading to quality deterioration of honey, which are not acceptable in the global market.
- Weak regulatory body and absence of laboratory services to undertake necessary tests, and adulteration which is tarnishing the image of the country. One of the major root causes for lack of accountability for such adulteration practices is the difficulty to trace back the supplier. This is in turn is attributed to low productivity, low production, high collection cost from diverse sources of beekeepers. If indeed, productivity is increased, the size of the supply from each beekeeper could be large enough reducing unit collection cost and creating the condition for traceability.

Thus directly or indirectly, the major reason for low export earning and for that matter to poverty alleviation is the low productivity and low product differentiation capacity of the country.

**Opportunities for Developing the Ethiopian Apiculture**

The opportunities for developing the Ethiopian apiculture include a number of factors.

1. Obviously the existing large current potential and the fact that this potential itself is getting larger over time is a natural resource endowment, which the country needs to give prior attention.
2. There is large potential to grow organic products, which is becoming the mainstream market in major global markets.
3. There is large political commitment to bring about sustainable socio-economic development that is anchored on both poverty alleviation and at the same time promoting green economy, which could be defined as green poverty alleviation, or commonly known in the literature 'green growth'.

4. Beyond federal decentralization, and even district level decentralization, there is already established large and extended institutional arrangement with an effective highly vertically coordinated structure that reaches every farm household, three extension workers at every kebele, FTC at each kebele, Kebele association, an organization of farmers one-to-five, an organization of 20 involving five groups. Every effort should be made to enhance the effectiveness of this extended outreach to every farm household, through which miracle can be achieved.

5. There is large physical infrastructure outreach in terms of feeder roads, almost many kebeles have an access road, every district is accessed through all weather roads. There is high and increasing distribution of mobile telephone even in rural Ethiopia.

6. There is large potential for mobilizing international resources for promoting apiculture, because of its unique feature of being an agent of growth and sustainable development simultaneously.

7. Apiculture is relatively less resource intensive but rather more sensitive to knowledge, which however is acquirable with relatively less resource. It is a sector of the poor. We won't be presumptuous if we say the cost of one sugar or textile industry could transform the Ethiopian apiculture which, however, could bring about immense advantage in terms of poverty alleviation, employment creation, export generation (both direct and indirect) and at the same time ensure sustainable socio-economy transformation.

Challenges for Developing Ethiopian Apiculture

The other side of the coin of development initiatives is to recognize possible challenges that may hinder the rate of achievement. The challenge that the Ethiopian apiculture is facing include the following:

1. There has been low policy attention has been given to apiculture.
2. There has been a mindset that apiculture cannot be a sole source of income, which is the result of 'low productivity trap', which in turn is the cause for low policy attention and for low private investment.

3. Another challenge is the fact that there are multiple government vertically structured organizations with weak horizontal communication, operating as organizational silos.

4. There has been very weak linkages between academics and industry, and in particular very weak relationship between research, extension and the producers (farmers, business operators).

5. There is low motivation, low training and high turnover of agricultural extension workers, which may compromise government plans and strategies or reduce the degree of success in the future.

6. One of the prime challenges of the Ethiopian apiculture is the weak quality assurance system. Indeed one of the drivers of global competitiveness is high and stringent quality requirements which involve health and safety standards.

**Strategic Directions**

The strategic direction should be on promoting productivity and product differentiation for which knowledge generation and developing strong quality assurance are fundamental determinants of global competitiveness. Generally, the strategic direction should focus on making dramatic productivity improvement and product differentiation and upgrading strategies. The product improvement involves two directions:

- Developing and managing apiary site, which would ensure sufficient and sustainable forage for the bees. This is the only means to create the possibility of equally productive multiple harvesting.
- Hive selection and colony management

**Development and Management for each apiary site**

Productivity basically can be achieved through enhancing the yield per harvest per colony and through multiple harvesting over the year. Apart from selecting and managing bee hives, productivity of beekeeping depends upon the resourcefulness of an apiary site. Multiple
harvesting calls for developing a beekeeping calendar, which is designed, planned and managed flowering calendar of different bee forages.

Each apiary site needs to be designed, developed and managed. The design and development activities include to identify the possible endogenous mix of bee forage, considering diversity, mix with herbs, shrubs, trees and their blossoming calendar, moisture requirements, soil requirement, soil and water conservation, rainfall harvesting, composting, seed collection and developing of nurseries.

The allocation of land for commercial beekeeping should be governed by these factors and issues.

The extension system should start to focus on this issue of designing, developing and managing apiary site. If an apiary site is well designed, developed and managed, then it is possible to consider bee keeping as an alternative sole source of income for many farm households who have marginal lands, and for rural unemployed youth.

**Bee Hive Selection and Colony Management**

One of the factors that determine productivity is selection of bee hive technology. In selecting the bee hive technology the criteria should be primarily productivity and product differentiation. So instead of comparing the traditional, transitional and frame hives on the basis of their costs and recommend for a mix of the three, we suggest that the prime selection criteria should be the productivity gain from the adoption of the hive technology.

If indeed, financial criteria should be relevant, then instead of comparing the costs of alternative hives, the comparative analysis should be between the alternative policy intervention areas to alleviate poverty in the country. We believe promoting the productivity of Ethiopian apiculture would be an efficient and sustainable way of alleviating poverty. This becomes more relevant in highly degraded areas, with low potential for sustainable cereal production.

*There is a new, modern, fourth type Ethiopian new innovation of bee hive from Becho, Illu Aba Bora, Oromia, which may be named after the name of the person or the Woreda, Becho.*

The standard recommendation so far has been to promote traditional, transitional and frame hives. Indeed, the third hive, the vertically supered(structured) hive, commonly called as modern
hive is more productive than the other two and this should be disseminated aggressively in order to make dramatic change in the productivity of production of honey and beeswax.

Yet, we are convinced that there is great potential with the recent innovation of Ato Mohamed Fiseha's model which is being under the process of patenting. From the outset, it seems that this new Ethiopian innovation is more likely to be more productive than the Frame hive. It is likely to be acceptable because essentially it involves a mixture of the merits of the vertically structured frame hive and the transitional hive. The major advantage is the fact that it is more suitable for inspection and harvesting compared with the vertically structured hive, which has wider implications on productivity of honey and beeswax. According to the owner of the innovation, Ato Mohamed Fiseha, this new innovation has the special merit of producing both honey and beeswax. Thus, the study team urges the government to speed up the legal process of establishing the patent ownership of the innovation. The existing system of patent seems to be tuned to the educated innovator who can manage with the paper work and engineering specifications and blue prints, not suitable to the non-educated farmer who lives in far distant areas like in Becho Woreda in Illu Aba Bora Zone, Oromia. For the study team, the issue is not merely all about protecting the interest of the individual innovator. This improved hive is being promoted in different zones of Oromia, which means it is accessible to anybody, which means it can be stolen and get the patent outside Ethiopia. By then it is not only the individual who is losing, but the country at large. More importantly, we believe that this new Ethiopian hive can achieve the government objective of poverty alleviation and employment creation as well as export promotion more than the existing three hives. Even if this new innovation is not patented (evaluating and checking the genuineness of the claim is someone else's responsibility and authority) for whatever reason, still, the government should consider seriously the choice of this technology, which we believe can contribute to enhance productivity. Here, the selection of a given technology may involve certain procedures, like experimenting and validating procedures. These procedures if they are let be managed through the normal bureaucratic procedures, definitely, this may take years. If the government seriously considers this it should take a year to validate and standardize and develop the production capacity along each region. Innovations, innovations ideas and for that matter clues are very scarce resources to be subjected to bureaucratic procedures and time management.
Yet, the human factor matters most than the hardware. There has been an increasing trend of distribution of frame hives, which was not accompanied with commensurate improvement in productivity of the production of both honey and beeswax. Ethiopia so far remains in low productivity of honey production. Thus, the prime strategic direction should aim at disseminating and creating the necessary knowledge and skills on beekeeping and efficient use of frame hives or an alternative better hive.

**Upgrading Strategies: Product Differentiation**

The analytical frame work is the global value chain analysis, which suggests that the change should be comprehensive enough to address all bottlenecks along the entire chain from farm level beekeeping, supply of standard inputs, ensuring the right packaging, storing and transporting.

The other implication of the global value analysis is the fact that the strategic direction should be to develop clear upgrading strategies through different means of product differentiation. There is ample space for product differentiation in apiculture.

There is a space one can play in producing organic bee products playing with color, odor, and other attributes that are sensitive to cultural contexts of different market segments.

There is wide room for producing specialty honey, which are preferred mono-flora honeys, which fetch higher prices than poly-flora honey types. Ethiopia can go a long distance in boosting its export sector through promoting more than nine specialty honeys.

Furthermore much foreign exchange can be earned through the promotion of the high-value bee products, including propolis, royal jelly, bee venom, pollen.

**Beekeeping as Sole Source of Income for the farm household**

There are good reasons for giving farmer beekeeping prior attention. First of all, so far nearly 100% of production goes to farm household beekeeping. So transformation of the Ethiopian apiculture should center on transforming the Ethiopian farm household. Moreover, the government's prime objectives of poverty alleviation of absolute poverty is household based.
The potential of apiculture in general and particularly of Ethiopian apiculture can be realized if and only if the industry is recognized and developed to become sole source of income for the farmer and an attractive business venture for the private sector. This can be achieved through enhancing productivity, and through product differentiation, which should, therefore, be the major strategic directions. With the existing level of productivity, beekeeping can only be a supplementary source of income and business line, not a main occupation.

Essentially productivity can be achieved through developing and managing apiary site as well as managing the beekeeping practice, which involves the management of the bee hive and the bees.

It is more feasible in marginal land, sloppy areas, highly degraded areas than cereal production and open-grazing based livestock development. This is so because it is more economical and less demanding to grow honey bee forages than cereal crops or for that matter livestock forage. The depth of top soil and its content, the volume of and frequency of water required to cultivate bee forages of different endogenous types is relatively smaller than required for cultivating cereal crops. This is because wild and weedy plants that are bee forage are resilient to various biotic and abiotic stresses. The annual required labor for maintaining bee forages is by far lower than cereal production which could make it preferred option for women-headed and old-person headed families, and small-size families.

But this can be achieved if the focus on making dramatic changes in productivity. From the experience so far, the focus should not be on mere distribution of hives. The distribution of frame hives in Ethiopia has been increasing at a rate of about 30% but without any visible contribution to change the trend in productivity of honey production. The strategic direction should aim at boosting the productivity of honey and beeswax production. Thus the focus, should be on creating the human capital, creating the knowledge of how to develop and manage an apiary site and bee hiving. The extension system should make sure that everyone who buys this new Ethiopian hive should be well trained and tested for his/her comprehension and closely monitored during both the dearth period and harvest period. This is because the human capital is more important in determining productivity of bee products than the knowledge embodied in the hard ware.
Then if indeed, Ethiopian apiculture is to contribute to poverty alleviation and export earnings, then the government should plan to how many households that the development should target.

For instance, if there are 800 districts in the country, and if the government aims to transform the lives of 1000, 1500, 2000, 3000, 4000 household per woreda, the required number of Becho/frame/hive would be determined by such targets.

**Private Investment in Apiculture**

One can anticipate two types of private investment. First is an entirely new investment which starts with beekeeping and recognized as an investment in beekeeping. This requires the allocation of adequate size of land, with ample forage resources or there is economic possibility of developing such site. The site selection should be managed through joint consultation of different stakeholders, definitely involving the investor. Since there are only few commercially operating beekeepers in the country, there is no much data that one can use for projecting such investment in the country.

The second is an integrated apiculture in already established commercial farms and Preserved Areas. There is no need for allocation of land for this type of investment. It only requires awareness creation. First of all, potential investors should be motivated by the potential increment of productivity gain from honey bee pollination.

As part of the pollination service, it is possible to double or triple the existing production capacity and hence the exportable quantity of honey and beeswax by introducing beekeeping as an integrated agriculture in the existing commercial production of crop, oil seeds, fruit and vegetables. Simple exercise can show that the scope of the possibility. If there is 100,000 hectares of commercial plantations of coffee, and if we conservatively assume, 20 colonies per hectare, and further assume two supers per colony, producing only 15kg per super, the total production capacity that can be produced using these two million colonies will be 60,000 tons of honey, which is higher than the existing annual average production of 50,000 tons of honey. It is possible to think of at least double harvesting in the existing situation alone, one during the main harvesting period, which one can harvest multi-flora honey and the other during the time coffee
blossoms its flowers. Given the sheds of coffee plantations, and the possibility of promoting other bee forages in different sites of the plantations, it is possible to harvest 4-6 times per year.

The main challenging block is the capacity to manage multiple apiary sites, which, however, can be and should be addressed if we are serious about the development of the sector. The real task is to convince investors to go for integrating apiculture with their former agricultural business. Genuinely it is not financial resource that binds this decision. Awareness creation and intimate discussion and negotiation with respective individuals could shed more light as to how to deal with investors in different commercial agricultural production.

Promoting apiculture aggressively in the existing enclosures and preserved areas (national parks and natural forest areas) can further double or triple the existing bee products, honey and beeswax. In such places, it is more likely to find rich bee forage resources. If not it is possible to have such resources with little effort, if indeed apiculture is recognized as a reconciling industry, that reconciles the interest of the surrounding communities with the interest of the administration of these preserved areas.

**Creating, reinvigorating the knowledge generating and dissemination system of the country**

One of the strategic direction is to create and/or strengthen the national knowledge generating infrastructure.

It is timely to establish research centers that specialize in every major agro-ecology who are closely related with the extension system and the beneficiary group, the farm household.

Moreover, there should be strong institutional responsiveness towards innovations, innovative ideas and clues by farmers. There are ample cases that call for developing an institutional arrangement which would identify, recognize, follow and develop beekeeper's innovations, innovative ideas and clues.

Whatever research results and innovative ideas they may be generated, their dissemination strongly depends not only on the existence and outreach but on the effectiveness of the agricultural extension system of the country. So special attention should be given to the motivation and human capital of the agricultural extension workforce.
Supplying Standardized inputs of beekeeping

One of the problems of the sector has been the lack of standardized supply of beekeeping inputs. The supply system is quite weak in reaching all parts of the country. Moreover, there are different standards of input supply which have an impact on quality and productivity of beekeeping in the country.

Develop a strong quality assurance system

One of the strategic directions for developing the Ethiopian apiculture should be to develop a strong quality assurance system.

Strengthening extension system, focusing on the human capital of the beekeeper in addition to distributing the latest innovation of bee hive and supplying standardized inputs would contribute to enhance productivity which facilitates traceability of every production and supply of bee products.

On the other hand strengthening the regulatory body and establishing or strengthening the laboratory centers in the country would ensure the prevalence of the rule of law and discourage the incentives for adulteration of bee products and other negative behaviors.

Projections

In order to project into the future three scenarios are developed on the basis of certain adopted assumptions and facts.

1. **Strategic directions in summary:**
   a. The strategic directions would be tailored to hive selection and colony management, design, development and management of apiary site, product differentiation and the development of the necessary quality assurance system along the entire value chain, and knowledge generation and dissemination system across the diverse agro-ecologies of the country.
   
   b. **Hive selection and colony management**, the focus should be on the human capital not on mere distribution of the hives, which has been the case so far in the country. We urge the government to seriously consider the selection and promotion of the 4th type of hive. The government should and can manage the necessary procedures in validating the
choice and promotion of the bee hive, instead of giving it up to the bureaucratic procedures which is consuming a lot of time.

c. **Design, development and management of apiary site** aiming for equally productive multiple harvesting. Apiary site development mechanisms may involve, soil and water conservation, rainwater harvesting, composting and application of a mix of organic and inorganic fertilizers, selection of the mix of bee forage, playing the mix with herbs, shrubs and trees.

d. **Product differentiation and upgrading.** This requires to develop market orientation of beekeepers. Once beekeepers improved productivity per super, per harvest, and manage with multiple harvesting, then the extension service should promote the idea of market-based production, which aims to exploit the scope for product differentiation and upgrading in the industry.

2. **Major facts and assumptions:**
   - World average of 45kg an average of the last 10 years, 2003-2012.
   - China's average of 51kg as of year 2012.
   - Ethiopian average productivity of frame hives 20kg per year
   - Individual Ethiopian cases of 40-50 kg per harvest (not per year) through double harvesting in a single harvest period, by a farmer beekeeper in Tigray through developing homestead apiary site
   - Individual Ethiopian case in Addis Ababa of 80kg per harvest, involving double harvesting in one harvesting season
   - Productivity per frame, 3-4 kg, giving 30kg to 40kg per super. There is no such data in the country. These are expertise opinion. There are opinions of 2kg per frame. However, with the opinion of 2kg per frame it is difficult to conceive of global and China's average productivity nor is it possible to understand the individual success stories. Thus we rely on the professional opinion of 3-4kg per frame.
   - Occupancy rate of frames per hive 50% per super. Expertise opinion suggest that bees do not fill in every frame with honey. Broods and pollen share some of the frames. Still there is no such data in the country. Thus, we had to settle down with professional opinion of a conservative estimate of 50% of the frames filled with honey of 3kg for the present projection.
• Assuming, 1 super, 2 supers, 3 supers, which are possible and experienced in Ethiopia, the experience with 3 supers being rare. Yet, we need to recognize the fact that using 3 supers is rare because there has not been a tradition of developed and managed apiary site. The success cases we have are the innovative initiatives of individual beekeepers. If we introduce in our extension system of designing, developing and managing apiary site, identify, select and develop nurseries for bee forage in the country, it is possible to create the situation where using 3 supers will be the norm rather than the exception.

• Multiple harvesting: the existing data is between 1 and 2, but it is possible to think of 4 to 6 harvesting, if there is well developed and managed apiary site and well-thought of flower calendar. Development of an apiary site, involves cultivating a mix of different types of bee forage, to keep the diversity and considering and aiming for those forages with different flowering calendar. With soil and water conservation works, harvesting rainfall, compost preparation, application of mix of organic and chemical fertilizers in the moisture stressed areas would enable mixed harvesting up to 4 times. There are success stories of double harvesting during the main season if the apiary site is resource full. Through water harvesting, it is possible to think of at least one more harvesting immediately after the main harvesting period by cultivating different herbs that mature in short period or those who have the nature of multiple flowering in a given year. Moreover, it is possible to harvest during April-June from those plant trees which naturally blossom in these months. The trick is in developing and managing the flower calendar of a given site. In those areas where the natural endowments are better, harvesting of 4 to 6 times is possible at less effort. If we do this, then apiculture can play an important role in simultaneously alleviating poverty and increasing export earnings.

• So far there has not been meaning full study on carrying capacity of a given density of vegetation. Without such study, it is difficult to exactly determine the optimal size of a beekeeping. In general, there has been ample experience of under-stocking except in one case of overstocking in Tigray, by Ato Alem, the largest bee keeping so far in Ethiopia. Though a valid issue that prior attention be given into the future, carrying capacity is not an actual problem at present. There is rather under-stocking
rather than overstocking problem in the country. Yet it would be far sighted move if one promotes the study of this issue of carrying capacity of each vegetation site and for that matter each type of bee forage along the different agro-ecologies of the country.

- It is recognized that the base, or the queen's chamber is not harvested.
- It is assumed that with increased distribution and effective use of modern (Becho type and/or frame) hives, production would increase such that domestic prices would fall and the gap between domestic and export prices would narrowed down to zero. It is estimated that selling price would adjust downwards to Birr 40, which is equivalent to USD 2 per kg and remain the same throughout the projection period. This price would make Ethiopian exports price competitive. It is possible to argue for higher prices but, instead of playing with prices, it is advisable to focus on productivity gain which would define the lasting competitive position in the country.
- Target population that could benefit from the transformation of the apiculture sector. Assuming about 700 districts in the country, and if the government aims to transform the lives of additional beekeeper farm households of 500 each in the first and second years, 1000 for the third year, 2000 households each for the 4-6th plan years, per woreda, the required number of Becho/frame/ hive would be determined by such targets. The number of household beekeepers from each woreda will be about 8,000, with about 32,000 colonies in each woreda at the end of the 6th year of the plan period. We considered a learning period of 2 years, when 500 households are made to be new beekeepers. Yet we cannot increase the number of beekeepers, as the carrying capacity of a given area would set the limit.
- **Share of export from total production:** It is assumed that the 50% of production from farmer beekeeper will be exported and 100% of production from the private sector will be exported. The assumption is that with dramatic change in productivity, the domestic demand would only consume 50% of the production capacity.
- Despite the higher sales value of beeswax, we did not incorporate planned figures for beeswax. The production of beeswax as a main product line involves a trade off production with honey. Some expertise opinion is the fact that the production trade
off is 1kg of beeswax for 7 kilos of honey. In the face such trade off, it would be wise to live it to be timely and operational decision instead of a plan target of the GTP.

- It is advisable that the government promotes the production of high value bee products like propolis, royal jelly, venom and pollen in due time by developing the necessary infrastructure and human capital. There is no base line data to estimate the possible production of each of these high value products.

3. **Scenarios for developing Ethiopian apiculture as poverty alleviation instrument:**

   a. **Low Scenario:**

   - Taking the existing average productivity of frame hive of 20 kg per hive per harvest; and double harvest per year, giving 40kg per hive per year, which generates an income of Birr 40*40=1600 per hive per year.
   - To generate an annual income of Birr 24,000, it requires a household to have 15 colonies. The challenge would be to develop an apiary site that would carry that number of colonies. But the main problem is the fact that it is not targeting at productivity improvement, rather based on allocating more resources to transform the lives of poor farmers in the country. The underlying assumption is the past average performance shall persist and which means we do not have the will and/or capacity to transform the low productivity trap we have been operating with.

   b. **Medium scenario**, conservative strategic commitment that aims at alleviating poverty of millions and generating meaningful contribution to export earnings of the country.

   - We need to aim at the Chinese average of 51kg per hive per year, as a reference point. Yet aiming at an average figure of about 50kg implies that we should set targets higher than the average.
   - Assumed super productivity is 3-4 kg per frame, settling for 3kg instead of 4kg and assuming further a conservative 50% of frames are filled with honey and the rest half are filled with brood and pollen, would give 15kg per super per harvest.
We assume the farm household would develop its apiary site such that there will be adequate resource to feed two supers in each harvest period, giving 15kg per hive per colony, the hive productivity would then be 15kg*2 =30kg.

It is assumed that if indeed, the farm household is depend entirely on beekeeping, then it has to develop the apiary site such that it can harvest four times of equal productivity instead of two. This would give 30kg*4=120kg per hive per year.

Earning per hive per year at Birr 40 per kilo = 120*40=4800

In order to alleviate household poverty: 5 hives per household, giving an annual income of Birr 4,800*5=24,000, which would give a monthly income of Birr 2000 per household. This is at the existing exchange rate of Birr 20 per 1USD, USD 1200 per year, which would mean a daily income of USD 3.30 per household, which would graduate a family from absolute poverty.

The challenge in this scenario is the capacity of the farm household to develop an apiary site that can nurture at least 5 colonies for the entire year, which require water conservation works and supplementing the soil through conservation, composting and other mechanisms. If a farmer has to cultivate his/her cultivable land every year, then the beekeeper needs to design, develop and manage his/her apiary site. In fact, the level of effort required to develop an apiary site is quite small compared with the effort required to cultivate crops every year.

c. **High scenario:**

- The assumed productivity of frame is assumed to be 4kg, giving productivity of a single super to be 40kg. We can assume the productivity of frames to be 80%, suggesting that 8 frames will be filled with honey and 2 will be filled with brood and pollen. This will generate 4*8=32 kg per super.
- It is assumed that the beekeeper will develop his/her apiary site such that it enables the use of 3 supers in each hive, through the development of the human capital in managing the colony and developing the apiary site. This implies 32ks per super *3= 92kg per hive per harvest
The apiary site will be developed such that it enables harvesting of 4-6 times harvesting of equal productivity through apiary site development. If we settle for 4 harvesting time, then the annual production of honey would be 92*4=368ks, which at Birr 40 per kilo would generate an annual income of Birr 14,720 per hive per year.

- If this is managed then the having 2 colonies would alleviate the poverty of a poor household.
- The highest scenario is possible but by far demanding in terms of the required human capital. Thus, even if some individuals may be passionate with beekeeping and capable to do, there are many factors that may contribute to lower productivity. So we decide not pursue this scenario.

4. Suggested recommendation: The medium scenario appears to be more realistic and visionary at the same time. The criteria for selection of a given scenario should be realism and hence its achievability and vision to transform the existing reality. The low scenario involves most realistic assumptions and hence it is indeed achievable. But this scenario is less visionary and cannot serve a strategic thinking. On the other hand the high scenario is less realistic but most visionary that would have enabled poverty alleviation with only 2 colonies. Even if achievable, it would be quite challenging to transform the Ethiopian farmer (Beekeeper) to achieve this level of performance. On the other hand, the medium scenario seems to compromise both reality and vision. Moreover, it should be manageable for a farmer beekeeper to develop an apiary site for 5 colonies, which should be possible even for those families who have less human resources, like female headed and aged headed families.

5. **Private investment** may lead to a short cut to double and even triple production and export of honey and beeswax and the commencement of higher value bee products, which are scale sensitive compared with the production of honey and beeswax. Considering for integrated investment in commercial farms, if we assume for 200,000 hectares of say coffee plantations for promoting an integrated agriculture which use pollination service and simultaneously produce bee products, assuming 10 colonies per a hectare, 15kg per super and assuming 2 supers per hive, annual production would be about 60,000 tons.
   - target this with 30%, 50%, 65%, 85% and 100% in the five year plan period.
• For the GTP 3, period no additional investment is assumed because of the concern of carrying capacity.

• It is assumed the private sector will export the entire production.

6. Potential Direct Impact

a. Poverty alleviation of 8000 farm households from each woreda, and a total of 5.6 million households in the country. These benefit however does not include all other direct and indirect benefits that can be generated from specialization in different activities, the possible income from integrated agriculture once apiary sites are developed, the immense environmental impact.

b. The projected export earnings of the first plan year of 2016 is about USD 210 million and the projected export earnings would be USD 4.8 billion. Again this does not incorporate the direct and indirect benefits from pollination (which is immense estimated by any method), from the possibility of upgrading to high value bee products in due course of the development of the industry, the employment opportunity of the private investment, etc.

7. Binding constraints that may frustrate the transformation of the Ethiopian apiculture

a. The critical factors of success are productivity performance indicators which essentially depend upon colony management and apiary site development. If each beekeeper is committed to develop his/her apiary site, then the momentum is set. The dynamism and potential impact of the sector depends upon designing, developing and managing the apiary site. Then beekeeping can be a dependable, sustainable and preferred sole source of income for a poor rural and even urban household or can support millions of unemployed youth organized as associations and cooperatives.

b. Lack of coordination among the different stakeholders in general and the number of government organizations involved in the development of apiculture in particular.

c. Lack of developing and assigning agricultural extension workers at Kebele level.

d. Failure or weakness to ensure the motivation and full commitment of the assigned extension workers.
e. Failure of the knowledge generation system to generate adequate knowledge on issues like:
   i. for instance, carrying capacity of different apiary sites, which depends upon knowledge about the pollen and nectar production capacity of each bee forage and the required mix for an optimum apiary site development to avoid both under-stocking and over-stocking risks.
   ii. Failure or weakness of the knowledge generation system to generate adequate knowledge and data on frame productivity, on super productivity, on hive productivity in each agro-ecology that could be used to plan commercial investment in different parts of the country
   iii. Bee health, sub species (queen and race) selection, etc.

f. Failure to develop the quality assurance system and the risk of loss of image in the export markets, due to adulteration.

g. Availing detailed feasibility studies and required performance and productivity indicators for upgrading the sector into high-value products, and establishing agro-industries like pharmaceuticals, cosmetics, sweets, beverages and others.
|                          | GTP 2 Period |             |             |             |             |             |     | GTP 3 Period |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |
|--------------------------|--------------|------------|------------|------------|------------|------------|     |--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|             |             |             |             |
|                          | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10   |
| 2016                     |     |     |     |     |     |     |     |     |     |     |
| Number of woredas        | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 |
| Target farmer beekeeper population per woreda | 500 | 500 | 1000 | 2000 | 2000 | 2000 | 0   | 0   | 0   | 0   |
| Number of modern hives distributed taking medium scenario, 5 colonies with 2 supers per household (1000) | 350,000 | 350,000 | 700,000 | 1,400,000 | 1,400,000 | 1,400,000 | -  | -  | -  | -  |
| Honey Production, medium scenario, 15kg*2*4=120kg (in tons) | 210,000 | 210,000 | 420,000 | 840,000 | 840,000 | 840,000 | -  | -  | -  | -  |
| Cumulative production, medium scenario, annual production, in ton | 210,000 | 420,000 | 840,000 | 1,680,000 | 2,520,000 | 3,360,000 | 3,990,000 | 3,990,000 | 3,990,000 | 3,990,000 |
| Annual export value taking USD 2000/ton (52/kg), assuming 50% of production (in 1000 USD) | 210,000 | 420,000 | 840,000 | 1,680,000 | 2,520,000 | 3,360,000 | 3,990,000 | 3,990,000 | 3,990,000 | 3,990,000 |
| Private investment apiculture integrated with large commercial plantations & Farms) | Learning period | 60,000 | 100,000 | 130,000 | 170,000 | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 |
| Honey production at 10 colonies/hectare & 60kg per hive/year, (in tons) | 0   | 36,000 | 60,000 | 78,000 | 102,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 |
| Cumulative production from private sector, in tons | 36,000 | 96,000 | 174,000 | 276,000 | 396,000 | 396,000 | 396,000 | 396,000 | 396,000 | 396,000 |
| Annual export value taking USD 2000/ton (52/kg) (in 1000 USD) | 0   | 72,000 | 192,000 | 348,000 | 552,000 | 792,000 | 792,000 | 792,000 | 792,000 | 792,000 |
| Grand Total of Exports of Bee Products (1000 USD) | 210,000 | 492,000 | 1,032,000 | 2,028,000 | 3,072,000 | 4,152,000 | 4,782,000 | 4,782,000 | 4,782,000 | 4,782,000 |