BEEKEEPING PRODUCTION AND MANAGEMENT SYSTEM IN DIFFERENT AGRO-ECOLOGIES OF SELECTED DISTRICTS OF SIDAMA REGION, ETHIOPIA

M.Sc. Thesis

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DECLARATION

This is to certify that this thesis entitled "Honey Bee production and management system in different agro-ecologies of selected districts of Sidama region, Ethiopia," submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Animal Production to the Graduate Program of the College of Agriculture, Hawassa University by Abera Agensa (ID No. GPAroR 0001/2016), is a faithful work carried out by him under our regulation. The matter alive in this thesis work has not been submitted before for award of any degree or diploma to the best of our knowledge and belief.

Name of the Student: Abera Agensa _____ _____

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Signature date

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DEDICATION

I dedicate this MSc thesis to my father, Agensa Adamo, and my mother, Arshime Nuke, for nursing me with extra-ordinary tolerance, affection, love, advice, support, and hope, and for their dedicated partnership in the success of my life.

LIST OF ABBREVIATIONS

AD	After Death of Christ
CSA	Central Statically Agency
EIAR	Ethiopian Institute of Agricultural Research
ESAT	Ethiopian Society for Appropriate Technology
ETB	Ethiopian Birr
FAO	Food And Agriculture Organization of the United Nations
FAO-STAT	Food And Agriculture Organization Corporate Statistical Database
FGD**s**	Focus Group Discussions
GDP	Growth Development Program
ICIPE	International Centre of Insect Physiology and Ecology
IPM	Integrated Pest Management
KTB	Kenya's Top Bar
LGFCU	Livestock and Fish Development Coordination Unit
MEFCC	Ministry of Environment, Forest and Climate Change
MOARD	Ministry of Agriculture and Rural Development
NGOs	Non-Governmental Organizations
NTFPs	Non-Timber Forest Product
PPS	Probability Proportional to Size
SNNPR	South Nation Nationality and Peoples Region
SPSS	Statistical Package for Social Sciences
TTB	Tanzania Top Bar
UND	United Nations Development
UNDP	United Nations Development Programme
USAID	United States Of American International Development

ABSTRACT

The study was conducted in the Bilate and Gorche districts of Ethiopia's Sidama region with aim to assess beekeeping production, management practices, opportunities, and challenges across different agro-ecologies (highland, midland, and lowland). About 165 beekeepers from six peasant associations across the three agro-ecologies were purposefully selected. A combination of methods including structured and semi-structured questionnaires, key informant discussions, and honey yields data for three hive types (frame, top-bar/Ethio-ribrab transitional and traditional) were assessed. Data were analyzed using SPSS 2022 software. The majorities (98.18%) of respondents in the study area were males and only 1.18% female house households participated in bee keeping production. Majorities (53.3%) of the households were literate and they were able to read and write while 9% were illiterate. The result showed that over 40% of beekeepers had extensive experience (>10 years), while about 28% were relatively new (<5 years). Traditional hives were the most common type owned by beekeepers. On average, respondent beekeepers hold 6.92 colonies, distributed as 3.92, 8.46, and 6.95 colonies per household in lowland, midland, and highland areas, respectively. Traditional hives: Average annual honey yield varied by agro-ecologies (5.56-5.85 kg/hive).Transitional hives (top-bar and Ethio-ribrab) Yields were higher than traditional hives across all agro-ecologies (8.86-12.55 kg/hive). Highest average yields were recorded in frame hives across all agro-ecologies (10.53-12.55 kg/hive). About 70% of beekeepers reported swarming was a common occurrence. Over 91% of beekeepers reported colony absconding, with drought and shortage of food identified as leading causes. The study showed that only 28% of beekeepers practiced honey straining. Birds and ants were the most frequently reported insect pests in the study areas. Three honeybee types were identified based on color and productivity. The majority of respondents (51.52%) did not undertake internal inspection of their bee colonies. The study showed that Vernonia Spp, Croton macrostachyus, Eucalyptus spp, Persea Americana, Coffee arabica and Cordia africana were some of the major honey bee plants identified by respondents in the study districts. The major challenges of beeping were agrochemical application (herbicides/pesticides), bee predators (ant and birds), lack of market access in villages and towns , and limited market information. The main opportunities of honey bee keeping development in the study areas were existing bee colonies, extension services, abundant floral resources and water for bees, employment opportunities, and Indigenous beekeeping knowledge. Frame, top-bar, and Ethio-ribrab hives showed high honey yield potential in mid- and lowland zones. The study suggests that beekeepers in mid- and lowland areas can benefit from adopting frame, top-bar, or Ethio-ribrab hives for increased honey production. Addressing the identified challenges and promoting existing opportunities can enhance beekeeping sustainability and improve honey production in the region. Governmental and NGOs intervention, on introducing appropriate beekeeping technologies with all accessories, strengthening the management practices through training for-beekeepers is important

Key words: agro ecology, beekeepers, honeybee colony, honey production,

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1. INTRODUCTION

1.1 Background of Study

Bee plays a crucial role in smallholder agriculture by providing pollination services that are essential for the production of many crops (Gill, et al., 2016; Kleijn,etal. , 2018; Potts, et al. , 2016b). An estimated 5–8% of global crop production depends on pollination services, equating to an estimated economic value of 235–577 billion U.S. dollars(Potts *etal*., 2016) . This contribution is particularly important for smallholder farmers, who often rely on pollinator-dependent crops for their livelihoods. In addition to their pollination services, bees also produce honey and other hive products that can be a source of income for smallholder farmers (Steward *etal*., 2014).

Ethiopia is recognized as having one of the largest honeybee populations in Africa and significant potential for honey production due to its diverse ecological and climatic zones (Adgaba., 2007). It is the fourth 9^{th} largest honey producer in the world by having 6,958,004 bee hives (CSA,2020) which produced 53782 and 5790 tons of honey and beeswax respectively (FAO-STAT,2021). According to Gebremedhin *etal.* (2021), Ethiopia has an estimated 10-15 million honeybee colonies. Ethiopian honey production accounts for approximately 2.5% of world production and 21.7% of African honey production (MoARD, 2007). In Ethiopia involves the use of four types of beehives: traditional, top bar, *ethio ribrabe (chefeka),* and frame/modern hives (Awraris, *etal.*, 2012). About 95% of Ethiopian beekeepers use traditional hives made of locally available materials Kigatiira (2014). The remaining percentages of beekeepers use transitional and modern hives. The honey production capacity is different from the region to region, the most important honey producing regions are Oromia (38%), Amhara (26%), SNNPR (18%) and Tigray (7%) of total honey production potential (Bekena and Greiling, 2017). Ethiopia also have five honeybee races (Kassaye, 1990) and three category based on the color and genetic variation together with the existing environmental condition are known to affect the choice of foraging in honeybees (Pankiw and Page 2001 ; Pankiw *etal* 2002) and quantity of honey produced consequently. Honeybee colonies in the same agro-ecological zone can exhibit significant differences in their honey production, despite having access to similar forage resources. Previous study found that factors such as apiary location,

colony health, and management practices can all have a significant impact on honeybee colony performance, highlighting the importance of proper management and monitoring of honeybee colonies (Steinhauer *etal*., 2018).

Like any other parts of the country, Sidama region including Gorche and Bilate districts has a favorable suitable climate, immense natural resources, well known agroforestry practice, diversified type of vegetation, cultivated, horticultural fruit and vegetable crops which enable beekeepers to produce significant amounts of honey. Yet, the productivity is generally poor and traditional, for example, Sidama region produces about 160 t honey with 4.72 kg per hive, CSA (2002). The beekeeping practice and potentiality vary depending on agro-ecologies, abundance of honeybee flora, honeybee colonies population, availability of beekeeping equipment, skilled manpower and other facilities to run the overall beekeeping practices. In amhara region in around Gondar area there are different honey production and productivity challenges in the area such as: drought, pests and predators, pesticide poisoning, absconding, lack of modern beekeeping equipment and materials, honey bee diseases, lack of honey storage facilities, poor extension services, non-existence or poor involvement of women in beekeeping development and lack of knowledge of appropriate method of beekeeping (Birhan *eta*., 2015). However, in Bilatae and Gorche districts there are no compiled and reliable information on beekeeping production system and performance of different hive types. Therefore, the objective of this study was to assess the beekeeping production system, management practice and identify challenges and opportunities in different agro-ecologies of the Sidama region.

1.2. Statement of the Problem

The environmental condition, availability, and/or potential of the different honeybee flora in Bilate zuria and Gorche districts favor beekeeping practices in the district. The area is also a place where there is huge potential for rain-fed and irrigation-based crop production (special Bilate), which provides a potential source of different honeybee flora. Moreover, the availability of various types of improved forages and the geographical advantage of the area for transportation create a good market opportunity for the beekeepers. However, the honey production practice in the district has been affected by a wide range of technical problems in hive designs, financial constraints, traditional ways of colony management, the use of traditional beehives, the prevalence of honeybee diseases and pests (Teferi, 2018) and the lack of organized value chains and market information systems for honey and other bee products, which makes it difficult for beekeepers to access markets and obtain fair prices for their products. Furthermore, the production performances of local bee colonies and hive types, the behaviors (features) of the colonies, their production requirements, and the strengths of the local honeybee colonies in different beehive types and agro-ecologies in the area have not been studied, evaluated, or documented yet.Therefore, such an understanding of these parameters and performances is important for increasing income from beekeeping and sustaining food security in the study area.But,the existing problem ,there is no colony market in study area.

1.3 Objectives

1.3.1. General Objective

The objective of this study was to assess the beekeeping production , and management system of different agro-ecologies in Bilate and the Gorche districts of the Sidama Region.

1.3.2. Specific objectives

- To assess beekeeping production and honeybee colony management system in the different agro-ecologies of selected districts of sidam zone.
- To assess the major challenges and opportunities of honey production in the district

2. LITERATURE REVIEW

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

2.1 Geographical Distribution of Honeybee races in Ethiopia

The country's diverse flora and fauna provide an ideal environment for honey bees to thrive, and there is evidence of traditional beekeeping practices in Ethiopia dating back to at least the 6th century AD. the existence of five honeybee races: Apis mellifera jemenitica (in eastern lowlands), A.m.monticola (in the southern mountains), A.m. litorea (in the extreme western lowlands), A.m. adansonii (in the southern mid altitude areas) and A.m. abyssinica (central plateau and south western parts of tropical forest(Amssalu *etal*., 2004). In 2021, there were an estimated 102 million managed honey bee colonies worldwide (Visick. 2023), the majority being *A. mellifera*. *Apis mellifera* pollinates approximately half of all globally important crops (Klein *etal.*, 2010) .Beekeeping with the western honey bee (*Apis mellifera* L.) dates back to ancient Egypt (Crane, 2004) and is now practiced on every continent except Antarctica, in both its native (Africa, Europe and Middle East) and introduced range (Americas, Asia and Oceania).

2.2 Beekeeping Practice in Ethiopia

Beekeeping in Ethiopia involves the use of different types of hives, both traditional and modern. Here are three types of hives commonly used for beekeeping in Ethiopia (Shenkute *etal.* 2012). Log hives, these are traditional hives made from hollowed-out logs. Beekeeping plays a role in providing nutrition, economic, and ecological security as bees are valuable pollinators of both agricultural crops and natural ecosystems (Dafar, 2018). In Ethiopia, about 1.9 million farm households are involved in beekeeping, and there are about 10 million colonies out of which about 5.92 million are hived (Bihonegn & Begna, 2021) and it is estimated that the country has the potential to produce 500,000 tons of honey and 50,000 tons of beeswax per annum (Agriculture, 2013) .The commonly used by rural communities in Ethiopia due to their low cost and minimal maintenance requirements of basket hives: These traditional hives are made from

woven grass or bamboo and are also popular among rural beekeepers in Ethiopia (Sahle *etal.* , 2018 ; Guy and Legesse, 2015; Belie, 2009). They are lightweight and portable, making it easy to move from one location to another. Langstroth hives: These are modern, movable frame hives that are commonly used in commercial beekeeping operations in Ethiopia. They allow for easy inspection and management of bee colonies. However, it requires relatively expensive equipment and skilled manpower compared to the former two production systems (AAU, 2015). Top bar hives: These are hives with movable top bars that are gaining popularity among small-scale and backyard beekeepers in Ethiopia. They are relatively low-cost and require minimal equipment. Beekeepers in Ethiopia may face challenges such as limited access to markets and credit, the need for improved training and technical support, and the impacts of climate change and variability on honey production. To support the development of the beekeeping sector in Ethiopia, there is a need for increased investment in training and technical support, as well as policies and programs that support sustainable honey production and the development of domestic and export markets. A recent study conducted by Kebede, W. (2021) in the Sidama region found that beekeeping played an important role in supporting the livelihoods of small-scale farmers. The study identified the need for increased support and training for beekeepers to improve the productivity and quality of their honey, as well as the need for improved access to markets and credit (N, 2005).

2.3 Economic Significance of Beekeeping in Ethiopia

Beekeeping has been an important component of the farming system in Ethiopia for thousands of years and has been a tradition since long before other forms of agriculture were established (T, 1996). Its often integrated with other agricultural activities, such as crop cultivation and livestock rearing. Beekeeping has played and continues to play an important part in both the country‘s national economy and the subsistence smallholder farmers ‘livelihoods (Fikru, 2015). These days, it is well known that beekeeping is a sustainable and high potential activity for local communities to gain additional income through non-timber forest products (Bareke *etal*. 2018; Fikadu, 2019). Beekeeping does not require much land or high starting costs, and people from child to advanced age are able to perform this activity without advanced skills (Brad bear 2009;

ICIPE 2013). Bees do not only positively contribute to income gain by their products (honey, pollen, beeswax, propolis, royal jelly), they are also important insect pollinators and increase yields of agricultural products, and maintain biodiversity (Archer et al. 2014; Carvalheiro *et al*. 2011; Ollerton *etal*. 2011; Reilly *etal*. 2020)

In Ethiopia, beekeeping is often integrated with other farming activities, such as crop cultivation and livestock rearing. Beekeeping provides a source of income and nutrition for many rural communities, and honey and other bee products are highly valued for their medicinal properties and use in traditional medicine (Tadesse and Gebremedhin, 2017).Another additional significance of bee keeping is

Honey production: Honey, a natural product of the honeybee, is a good source of energy because it includes simple sugars that are ready for digestion as soon as they enter the intestine. Honey is in high demand on the local market since it is used to make the traditional beverage Tej'(honey mead). Much honey has traditionally been fermented in Ethiopia to make Tej.' According to Sahle *etal*. (2018) 85% of the total honey estimated to be brought for the market is used for Tej brewery, with 15% of the total honey consumed at home. Furthermore, beekeepers are estimated to earn around 360-480 million Birr per year from the total honey produced in the country (Amsalu *etal*. 2020). According to the report of FAO (2017), from the 187 tons of honey exported about a 133 million ETB birr per year was earned at a national level.

Crop pollination: In the agricultural system, bees play a critical function. Although the importance of honeybees in agricultural pollination is underestimated, they play an important role in enhancing the national food supply and plant species regeneration. Honeybees are also thought to play an important part in Ethiopia's economy by providing pollination services. An experiment was done in Ethiopia to investigate the effect of pollination on Niger (*Guizotia abyssinica*), and the results revealed that honeybees increased Niger seed yield by about 43% (Haile Michael, 2018).

Source of Immediate Cash Income: Beekeeping plays a significant role in supplementing the annual income. Honey production and value addition to its products are vital factors in sustainability of livelihood of poor people (Assefa, 2017). FAO estimated honey production to 50,000 tons in 2018, but the actual production potential is regarded to be 500,000 tons annually

(MoA and ILRI, 2013). Although the honey production rate was more or less stable over the past decade, the honey export market suffered from a decline from 2013. Reasons may include the struggling of local companies in gaining access to international markets due to increased domestic prices associated with high domestic consumption of table honey(Dong *etal*, .2016).

Job Opportunities: Beekeeping practices create job opportunities for landless men, jobless youths and women for their livelihood as it needs low capital to start (Abadi *etal*. 2016). It could also be observed that many people (intermediaries and traders) participate in honey collection and retailing (at village, district and zonal levels). Hundreds of honey processors are engaged in Tej brewing and exporters are also flourishing. It can also serve as job opportunities to local carpenters and organized youths in construction of beehive.

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2.4 Honey bee flora source

Honey bee plant is a term used to refer to plants that are attractive to honey bees and are a source of nectar and pollen for them. These plants are important for the survival and health of honey bee colonies as they provide the bees with the nutrients they need to produce honey and other bee products (Alaux *etal*. 2010). (Some common examples of honeybee plants include clovers, alfalfa, lavender, sunflowers, and wildflowers. These plants are often used in beekeeping practices to encourage bees to forage in a specific area or to provide a source of food during times of low nectar flow.

The term is used to distinguish plants that are particularly attractive to honey bees from other types of plants that may also provide nectar and pollen but are not as important for honey bee health (Klein, A.-M. *etal, 2007)*. These plants provide the bees with a source of nectar and pollen, which they use to produce honey, beeswax, and other important bee products. These

plants provide bees with a diverse range of nutrients and help to ensure that they have a balanced and healthy diet (Brodschneider and Crailsheim , 2010). In addition to providing nutrition for bees, honey bee flora can also play a role in supporting the overall health of bee colonies. Some plants, such as those in the mint family, have medicinal properties that can help support the immune system of bees and protect them from pathogens and pests.

The diversified flowering plants in Ethiopia and their blooming season greatly vary from place to place; this enables the country to sustain a large number of honeybee colonies. About 500 honeybee flora species identified by the previous study of Fitchl and Admasu (1994) with their importance for honeybees (as source of pollen and/or nectar). According to their idea honeybee plants can be categorized as major and minor source of bee forage; for instance:

Major bee plants: are those plants, which are visited by honeybees throughout their flowering season. E.g. Triffolium species. (Clover), Eucalyptus species, Acacia species, and Vernonia species.

Minor bee plants: are those plants that are visited less often by bees or only when flowers of major bee plants are not in flower. E.g. clover, Birbira, Pisum sativum and grass species

2.5 Floral calendar of honeybee plants

Ethiopia is a country with high floral diversity and bees, as well as other pollinators, benefit from hundreds of melliferous plants which are distributed over a variety of altitudes. Those variations in topography and the different climate zones complicate the development of flowering calendars. Animal pollination plays a key role in 78% of all plant species in temperate climate zones (Ollerton *etal.* 2011). A decline in bees and other pollinators impairs the harvest of many crops and consequently the income of farmers (Reilly *et al*. 2020). Especially in countries, where a great proportion of the human population depends on income from agriculture, the pollination of farming crops is crucial and keeping bees is particularly suitable for this job. Compared to many other pollinators, bees can be used systematically for places where their pollination service is desired. Further, people who provide the bees and maintain them, as well as farmers who provide the land, form a positive feedback-loop, as they both benefit from the keeping actions.

The flora calendar is a tool used by beekeepers to track the blooming times of different plants and flowers throughout the year. Having information about the potential amount of foraging

resources in specific locations, beekeepers can select and plan foraging places (Komasilova *etal.* , 2021).It provides a guide for when certain types of flora are in bloom and helps beekeepers plan their beekeeping activities accordingly. The flora calendar is important for bees because it helps to ensure that they have a consistent source of food throughout the year (Komasilova *etal.* , 2021). By tracking the blooming times of different plants, beekeepers can ensure that their bees have access to a diverse range of pollen and nectar sources throughout the year, which is essential for their health and survival. In Ethiopia, the flora calendar varies depending on the region and climate. For example, in the highlands of Ethiopia, the main honey flow typically occurs during the dry season between November and January, while in the lowlands, the main honey flow occurs during the rainy season between June and August. Authors propose two approaches when predicting (evaluating) the start of the flowering period. One method uses the known data of the sowing date and knowing historically after which period it should bloom. The second approach is using the reference plant blooming starting date. In this case, to predict the timing of the flowering of the melliferous plants, it is necessary to choose one plant from those blooming in early spring and, based on the historical records, evaluate the time after which all other melliferous plants begin to bloom. More often, coltsfoot (Tussilágo farfara) or hazel (Córylus avellana) is taken as a reference plant (Mihailova and Litvinova, 2019).

2.6 Yield Evaluation Of A Honeybee Colony In Ethiopia

2.6.1 Honey yield in different hive types in Ethiopia

Beekeeping is an important component of agriculture and rural development program of many countries (FAO, 1990). It helps to provide security in nutrition, economy and ecology besides, it does not compete with other resources in the farming system, it is income generation activity and supplement annual income for the beekeepers through sell of bee products (honey, beeswax, and bee colonies). It also serves as a healthy food for consumers (FAO, 2015). Particularly for rural households beekeeping can coexist effortless with regular farming activities (Miklyaev, M *etal* 2012) . Ethiopia is the home of diverse fauna due to its varied ecological and climatic conditions (Beyene *etal*., 2016). This is the prime reason for the availability of large colony numbers in the country. In Ethiopia, four types of beehives (traditional or cefeqa, intermediate, and improved) are known, with more than 10 million colonies, from which more than 90% are traditional hives (Mahamed *etal*., 2021) It is endowed with diverse agro-climatic zones, which are suitable for honey production. The total annual honey production in the country is estimated about 129

million kilograms of which the greater portion is harvested from traditional beehives (CSA, 2021).

The honey yield results per year per hive of the colonies recorded difference honey products for different location and seasons. The (CSA, 2013) report showed the national average honey yield per hive annually reaches 19.8 kg. Furthermore, A. m. scutellata honeybee's colonies produced an average of 10.5 kg honey yield (Tadele *etal*., 2014) however, the average honey yield of for A.m.bandasii 12 kg (Zewdu, 2012; Tesfa and Kasa2019) . This production differences can be due to variations in the strain of bee and the quality of the queen in the individual colonies (Knox field, 2008). In order to exploit the country's production potential, the government has given consideration to developing the beekeeping subsector as a strategy for the reduction of poverty and the diversification of export commodities (Shapiro et al., 2015).

2.6.1.1 Traditional beekeeping

Traditional beekeeping is practiced with hives constructed from natural materials from the surrounding areas (MoARD 2007; Sahle *etal*. 2018). They are a highly simple type of beehive to make and vary greatly in shape, size and nature of construction materials (Schmolke, 2009) .The practices used for traditional beekeeping are manifold and follow the area specific culture. For example, in southwestern Ethiopia, it is common to hang log hives into trees. Only males are involved in this forest beekeeping activity (Awraris *etal*. 2012; Kenesa 2018). Reasons why women do not participate have mostly cultural origins and physical motives though, women are not totally excluded: they are responsible for product processing (e.g. tej brewing) or marketing of the bee products (Gratzer *etal.*, 2021).The hives need to be hung on 10-m-high branches of trees situated in dense forests. Climbing trees with the heavy log hives requires a certain physical strength and special skills. The work is carried out during night and is considered to be labour intense and dangerous and the beekeepers often stay in the woods for several days to maintain and harvest the hives. It is not forbidden for women to join those trips, but they prefer to not join for safety reasons and other cultural duties such as household activities (Awraris *etal.*, 2012). Though, women are not totally excluded: they are responsible for product processing (e.g. tej brewing) or marketing of the bee products (Kebede *etal*., 2018)

Beekeepers that are knowledgeable and skilled in using these hives could perform many operations with less equipment (Guy and Legesse, 2015). Forest beekeeping and backyard beekeeping are the two forms of traditional beekeeping practices. Forest beekeeping, in which some traditional beehives are hung from trees, is popular in different parts of the country, especially in the west and south. In most other parts of the country, backyard beekeeping is popular, with relatively better management. The productivity of these hives is exceedingly poor, with an average yield of only 5-8 kg per colony per year, compared to 18-30 kg per year for improved hives (including transitional hives) (Ababor and Tekle , 2018).In southwestern Ethiopia, it is common to hang log hives into trees. Only males are involved in this forest beekeeping activity (Awraris *etal.* 2012; Kenesa, 2018).Over time, various types of hives and beekeeping methods were developed in different regions, depending on factors such as climate, available resources, and cultural practices. In recent years, extensive information has been collected to demonstrate how climate change affects bees' survival and limits their ability to provide ecosystem services (Le Conte,and Navajas, 2008; Soroye *etal*., 2020)

Today, traditional beekeeping methods are still practiced in many parts of the world, particularly in rural and remote areas where modern beekeeping equipment may be less accessible or affordable (Fichtl and Admasu , 1994). The amount of honey and beeswax that can be produced by a traditional hive can vary widely depending on factors such as the size of the hive, the number of bees, and the local climate and vegetation.. According to a recent study published in the Journal of Apicultural Research, the average honey yield per colony in traditional hives in Ethiopia was found to be around 5.6 kg per year, while the average beeswax yield was around 1.3 kg per year. According to Gemechis (2016) and MoARD (2007) traditional beehives produce around 5-8 kg .

Internal inspection, providing feeding systems or swarm control is not possible (Fikru 2015; Sebsib and Yibrah 2018). The honey yield of traditional hive systems has been demonstrated to be lower than those of transitional or modern systems despite the same availability of resources within the flight radius (Beyene *etal*. 2016; Gemechis 2016; Girma *etal*. 2008). While 5–8 kg of honey can be expected from traditional Ethiopian hives, the average honey yield of transitional and modern hives ranges from 15 to 20 kg (Beyene *etal*. 2016; Gemechis 2016; MoARD 2007; Yirga and Teferi 2010).

Honey gained from traditional hives is often a mixture of wax, bee parts, honey and pollen and is therefore called "crude honey" (Awraris *etal*. 2012; Fichtl and Adimassu, 1994). Besides many disadvantages traditional hive systems also have positive aspects. The beekeepers who use them do not need special skills, the starting costs are low because locally available materials are often cheap and easily accessible, no management means less time-effort, less to no equipment is needed and bees kept in such systems produce more beeswax and propolis which can be traded at higher prices per kg compared to honey (Fikru 2015; Girma *etal*. 2008; Nuru *etal*. 2002b; Serda *etal*. 2015). Despite the higher honey quantity of transitional and modern systems traditional beehives remain dominant in Ethiopia (CSA, 2019).

2.6.1.2 Ethioribrab (chefeka)

The Ethioribebrab hive is a type of traditional beekeeping hive used in Ethiopia. It is designed to mimic the natural nesting sites of bees and is made from locally available materials such as bamboo and the exact origin of the Ethio-ribebrab hive is not known, but it has been used in Ethiopia for many centuries. Transitional system had started in Ethiopia in the year of 1976 and the types of beehives used are Kenya top-bar beehives, Tanzania top-bar beehive, Mud-block beehives and Ethio-ribrab hive. But Ethio-ribrab is commonly used in many parts of the country (Abebe, 2017).The total crude honey production from this type of hive was 497,737kg (CSA, 2017/18).

Another study The annual average of honey yield obtained from "chefeka" hive is about 20kg, while that of the frame hive is about 30kg (MoARD, 2007).These yields are generally higher than those of other types of traditional hives, but still lower than those of modern hives. It is worth noting that Ethioribebrab hives are designed to mimic the natural nesting sites of bees and are made from locally available materials. They are an important part of the cultural heritage of Ethiopia and play a vital role in providing income and food security for many rural communities. This kind of transitional (intermediate) systems are in between of traditional and modern hives and have been promoted by GOs and NGOs since 1978 (Beyene *etal*. 2016; Yirga and Teferi 2010). They are manageable, increase the safety of beekeepers that do not need to climb on trees anymore and promise higher honey yields than traditional hives. That is types are "Chefeka"

hive (Gemechis 2016). This made of locally available materials (e.g. bamboo), making it more affordable than other top-bar hive types.

2.6.1.3 Transitional (top bar hive)

A transitional system is a system between traditional and frame hive or modern system (Sisay *et al.*, 2012). It has an advantage over traditional hives in that combs containing honey can be selected during harvesting to maintain the quality of honey.

That beekeeping practice was first introduced into Ethiopia in 1976. It‘s a form of beekeeping activity that falls somewhere between traditional and modern beekeeping, and it‘s one of the better methods of beekeeping when compared to traditional methods (Dekebo *etal.*, 2019). Kenya Top Bar Hive (KTBH), Tanzania Top Bar Hive (TTBH), and mud block hives are the three types of hives used in this method (Sebsib and Yibrah, 2018). Because of its low cost and ease of construction, the KTBH has shown to be the most ideal. KTBH is well-known and widely used in different parts of the country among these hives. An ideal condition, a top- bar hive can produce approximately 50 kg of honey per year, but in Ethiopia, the average amount of crude honey produced per hive per year is 9-13 kg (Bahta, 2018).

According to a study conducted by the Food and Agriculture Organization (FAO) of the United Nations, the amount of honey and wax that can be harvested from a beehive depends on several factors, such as the size of the hive, the strength of the colony, and the length of the honey flow season. On average, a transitional beehive can produce around 20–30 kilograms of honey per year and 1-2 kilograms of wax as a byproduct of the honey extraction process (FAO, 2020). It's important to note that these yields can vary depending on the specific conditions and practices employed in beekeeping. Proper hive management, disease prevention, and feeding can all impact the productivity of a beehive.

2.6.1.4 Modern (frame) hive

The design of all modern beehives is based on the discovery, by the father of modern beekeeping, Lorenzo Lorraine Langstroth, that when bees build their combs they always leave exactly the same amount of space (the bee space) between them (Stephen, 1990). This hives are characterized by movable frames and their high management potential including honey stored in supers. Depending on the colony’s activity and status, the modern hive persists of up to four

boxes. Modern beekeeping is mostly practiced in the southwestern and in the central highland areas of Ethiopia. Popular systems include Zander, Langstroth and Dadant (Gupta *etal*. 2014; Haile Michael, 2018). Next to beekeeping, "honey hunting" is common due to the presence of feral bee colonies in Ethiopia (Fichtl and Adimassu, 1994; Gemechis 2016). (Fichtl R., & Admasu A., 1994)

The amount of honey and wax that can be harvested from a frame hive depends on various factors, such as the size of the hive, the strength of the colony, and the length of the honey flow season. On average, a healthy and productive frame hive can yield around 15–30 kilograms of honey per year and 1-2 kilograms of wax as a byproduct of honey extraction (Bee Culture, 2021).It is important to note that yields can vary depending on the specific management practices employed in beekeeping. Proper hive maintenance, disease prevention, and feeding can all impact hive productivity.

That hive is made up of properly built rectangular box hives placed one on top of the other in a tier, with the number of boxes varying depending on the size of the bee population and the season. Since 1970, around five different 13 types of mobile frame hives have been introduced in Ethiopia (Dekebo *etal.*, 2019). The improved box hive has an advantage over the others in that it produces a high quality and quantity of honey and it is east to manage the swarm by supervising the bees as they look for honeybee flowers and pollination services (Teferi , 2018).According to (Yirga & Teferi, 2010) with some hives producing annual average of honey yield up to 30 kg per year ((MoARD, 2007).

2.7 Honey Bee Management And Bee Health

African honey bees are more aggressive than European or Asian honey bees (Kastberger *etal*. 2009). For safety reasons, Ethiopian beekeepers open their hives mostly when the sun has already set to protect themselves from stings (Shackle ton *etal.* 2011). Nevertheless, climbing trees during the night to reach traditional hives is dangerous and complicated. Several survey-based studies reported that external hive inspection and cleaning of the apiary is far more common than internal hive inspection (Fikru *etal*. 2015; Kebede *etal*. 2018; Sebsib and Yibrah 2018; Serda *etal*. 2015). Latter is done by 23–33% of respondents and differs greatly between regions (Beyene 2015; Fikru 2015). Reasons for not inspecting the hives internally are the fear of

bee stings, possible triggering of absconding behaviour and lack of time and knowledge (Sebsib and Yibrah 2018).

Internal inspection of traditional hive types is not practiced as it would be accompanied by a destruction of the bees' nest (Kerealem et al. 2009). Swarming prevention is not common, which could again be associated with traditional hives (Sebsib and Yibrah 2018). Other survey-based studies focusing on South-East and East Ethiopia reported that beekeepers cut parts of brood combs, remove queen cells, add supers, or provide empty hives to prevent reproductive swarming (Fikru *etal*. 2015; Solomon 2009). In contrast to the articles surveying the most common hive management techniques, recent research articles empirically demonstrated potential improvements in hive management. A full analysis of observational survey data was conducted to identify management practices that, if adopted, were predicted to have the largest reduction in colony loss rate. The top five of these empirical best management practices (Steinhauer and Saegerman , 2020) were developed for four different beekeeper demographics (southern backyard, northern backyard, and stationary professional and migratory professional). Four of the top five empirical BMPs were the same for northern and southern backyard beekeepers.

These range from feeding regimes to cope with dearth seasons, migratory beekeeping (Kumsa *et al*., 2020), and methods to increase propolis production (Nuru *etal*., 2002), to maintain colonies.

2.8 The Honey Contribution In the Environment

Honey, which is essential for maintaining healthy nourishment and body functions of the humans, is a natural food generated by honeybees from nectar of plants or secretion of flowers, and contains 80-85% carbohydrates, 15-17% water, % 0.3 protein and trace amounts of amino acids and vitamins (Okpokiri *etal*., 2015).The honeybee is a notable pollinator for agricultural crops and wild grown plants in nature and the perfect organism is liable for one-third of herbal food production through pollution operation (Klein *etal*., 2007). There are many advantages of beekeeping activity i.e. extra revenue in shorter time period, satisfying the daily needs of the enterprise's family, contributing to the pollination and the effective use of family labor (Karadas and Kadir hanogullari, 2017), the conservation of biodiversity (Al-Ghamdi *etal*., 2017).

Due to these reasons, more studies should be conducted to ensure the sustainability of the honey related productions. Several effective predictors affecting the profitability of enterprises i.e. queen quality, floral composition, technology type, ecological conditions, beehive type, queen's age, and managerial applications in regard to honey yield per beehive should be taken into consideration (Al-Ghamdi *etal.*, 2017).

2.9. The Honey Bee Character And Their Color In Study Area

Honeybees, like all other living things, vary among themselves in traits such as temperament, disease resistance, and productivity. The environment has a large effect on differences among honeybee colonies, but the genetic makeup of a colony can also impact the characteristics that define a particular group. Beekeepers have knowledge about different genetic stocks that have distinctive characteristics, so they have utilized different strains to suit their particular purpose: whether it is honeybee pollination, a honey crop, or bee production (Meixner *etal*., 2013).

Though the color, size, and distribution of some races in the country are documented, their performance was not well studied so far (Meixner *etal*., 2013). Therefore, performance evaluation of this honeybee race in its natural agro ecological distribution is very crucial to assess the potentiality of the races (local honeybees) and to lay foundation for future selection and improvement of the local honeybees. As a country, five geographical races of honey bees and three category of colonies with respect to honey yield, dry season brooding ability, aggressiveness, absconding behavior and swarming tendency. The black colored bees, the red colored bees and mixed colors for honey production (Bogale, 2009; Kassaye, 1990)

Apis mellifera defensive behavior is a complex trait that involves individual worker behavior and a coordinated colony response with a group effect. As stated by (Guzman *etal*., 1994), genetic control of defensive behavior in honeybees and this parameter have been included in many genetic breeding programs. The African honeybees are highly defensive and much more aggressive towards humans and animals. They respond more rapidly and intensely than European bees and usually sting in larger numbers (Fletcher, 1987; Hunt *etal*., 1998; Hepburn & Radloff, 2013; Scott Schneider *etal.*, 2004). They also tend to have more aggressive behavior than their European or American counterparts, a trait which also makes them more productive and resilient at their native range

2.10. Honey Marketing in Ethiopia

Ethiopia is one of the largest honey-producing countries in Africa, with an estimated annual production of over 50,000 metric tons (FAO, 2021). Honey production is an important source of income for many smallholder farmers in Ethiopia, particularly in the southern region of the country. Shebedino district is one of the 19 districts found under Sidama zone in SNNPR of Ethiopia. It was the second highest producer of honey in Sidama Zone (124.32tone), next to Aroresa district (160.72tone) in 2015/2016. However, this amount was only 55% of the estimated potential of the district as per Sidama zone Livestock and Fish development coordination unit (LFDCU, 2015). It is also believed that honey production and marketing is an important economic activity that has great significance in terms of employment to Ethiopian rural community. According to USAID (2012) &Yetimworket al. (2015), about 1.4 to 1.7 million households are estimated to be engaged in honey production in Ethiopia. It is also believed that honey production and marketing is an important economic activity that has great significance in terms of employment to Ethiopian rural community.

2.10.1 Domestic market

In Ethiopia high portion of honey is sold for income generation. The domestic honey market starts at the smallholder bee keeper‘s level, who majorly sells crude honey to collectors in the nearest town/village markets (Assefa, 2009). Beekeepers of the country sell the largest proportion of their honey during harvest at low price mainly to meet their demand for cash to pay taxes, debts and other social obligation (Beyen and David, 2007). Similar authors notified that, the price of honey is also governed by different factors such as distance from market (28%), quality of honey (25%), consumers preference (20%), color of honey (15%,), and test of honey (12%).

About 10% of the honey produced in the country is consumed by the beekeeping households. The remaining 90% is sold for income generation and of this, it is estimated that 70% is used for tej‘brewing (ADAMTE, 2023).Honey price is differing by region and type of honey. The most expensive is Eastern Tigrays white honey, where the current retail price is ETB 170.00/kg. Lower retail prices (of around ETB 60–90.00/kg) are observed for other varieties of white honey, depending on the area and the honey’s characteristics. The retail prices for yellow honey are

around ETB 50– 60.00/kg, while the least expensive red honey is sold at a price of around ETB 45–50/kg (USAID 2012). Domestic honey consumption is increasing due to highly increasing demand for tej, increased consumption of processed table honey in most urban areas and increased demand 20 for honey in the local industries (Assefa, 2011).Honey is a popular and traditional food in Ethiopia and is used in various culinary and medicinal applications. According to a report by the United Nations Development Programme (UNDP), the domestic honey market in Ethiopia is estimated to be worth around 200 million Ethiopian birr (approximately 4.7 million USD) per year (UNDP, 2019).

In the Sidama region, honey is an important commodity and is consumed both domestically and sold in local markets. The Sidama region is known for its diverse flora and fauna, which contributes to the unique flavor profile of the local honey. There are also efforts being made to improve the marketing and branding of Sidama honey to increase its visibility and value in both domestic and international markets. The domestic market provides opportunities for beekeepers to sell their honey locally, which can help to support rural livelihoods and promote the development of the local economy.

. A recent study conducted by Kebede, (2021) in the Sidama region found that the domestic market provided important opportunities for beekeepers to sell their honey and increase their incomes. The study identified the need for increased support and training for beekeepers to improve the quality and safety of their honey and to promote the benefits of locally produced honey to consumers.

2.10.2 Export market

Ethiopia is a major exporter of honey, with the majority of exports going to markets in Europe and Asia. According to the Ethiopian Horticulture Producers and Exporters Association, Ethiopia exported over 4,500 metric tons of honey in the 2019–2020 fiscal years, with a total export value of 19.5 million USD (Addis Fortune, 2020). Honey and other apiculture products such as beeswax, propolis, pollen, royal jelly and bee venom are among the growing export commodities with good potential in many African countries (Desalgne, 2012). The developing countries get a chance of money exchange with honey and other apiculture products.

It exports honey to the countries such as Sudan, Norway, Saudi Arabia, UK, Yemen, Japan, USA and. For the first time Ethiopia exported honey to European country, U.K. was 30 tons in 2008 others (Demisew, 2016). Between the years of 2008-2011, Ethiopia exported 7,068 tons kg of honey and 6,752 tons of beeswax. As it was increasing from time to time, it reached 4252.8 tons of honey in the year 2011-2016. Currently, the export had reached up to 900 tons per annum (Demisew, 2016). Most of the world beeswax is supplied by the developing countries. China is the leading producer and exporter (Nuru, 2007). For instance, the price of beeswax exported from Ethiopia had risen from 2430 €/ton in 2003 to 3200 €/ton in 2009, with the highest 3630 €/ton in 2006, in main European ports (CBI, 2009) . Exports of beeswax from Ethiopia have increased spectacularly and reached 402 tons of beeswax (1.2% share in world market), destined to different countries (USA, Japan, Greece, Great Britain and Netherlands etc.), generating USD 936 thousands in 2003 (FAO, , 2005). After 2003, the export volume is not far from 400 tons annually (EEPA, 2010).The beeswax price at the domestic market is mostly higher than the international beeswax price which makes beeswax export less profitable in Ethiopia.

In the Sidama region, efforts are being made to improve the quality and branding of local honey to increase its value and competitiveness in international markets . The Sidama region is known for producing high-quality honey with unique flavor profiles, and there is potential for the region to become a key player in the global honey trade.

To access export markets, beekeepers must meet certain quality standards and certifications, such as organic and fair trade certifications. These certifications ensure that the honey is produced using sustainable and environmentally friendly practices and that beekeepers receive fair prices for their products. However, accessing export markets can also present challenges for beekeepers, such as meeting the required quality standards and certifications and navigating complex export regulations. According to MoARD, (2003) the most important honey and bee wax producing regions in Ethiopia are Oromia, South Nations Nationalities and People regional state (SNNPR), Amhara and Tigray (MoARD, 2003).The study identified the need for increased support and training for beekeepers to meet the required quality standards and certifications and to access export markets.

2.`11. Honey Harvesting Seasons in Ethiopia

The honey harvesting season in Ethiopia varies depending on the region and the specific flowering seasons of the local flora. The presence of a higher number of flowering herbaceous plant species from September to November is due to the availability of moisture following the main rainy season, which lasts from June to August. This is in which indicated that herbaceous honeybee forage species were the dominant honey source plants from September to November. On the other hand, the second flowering period occurs after a small rainy season, which starts from March to May, in which the majority of honey source plants were trees and shrubs in comparison to herbaceous (Gebretsadik& Negash, 2016) . For example, the tree species such as *S. abyssinica, Syzygium guineense, C. macrostachyus, and Eucalyptus spp.* are flowered in this season (Tura and Admassu, 2018).Admassu *etal.* (2014b) also stated that S. abyssinica, Syzygium guineense, and C. macrostachyus are the most important honey-producing trees and flowers from April to March to April and hence the major honey flow period in southwest parts of Ethiopia occurred during March-June. The lower number of flowering plants was observed from June to August, which is the main rainy season throughout the country and plants tends to produce more vegetative biomass rather than producing flowers and the high scarcity of honeybee forage was observed in July to mid of August (Tura and Admassu, 2018). This is in agreement with a similar study in central parts of Ethiopia (Debissa and Admassu, 2009) reported that during the rainy season, low temperatures possibly inhibit flower production.

In general, the honey harvesting season in Ethiopia takes place twice a year, during the main honey flow seasons, which usually fall between October and January, and again from March to May (Degaga *etal.*, 2021). In the Sidama region, the honey harvesting season typically starts in October and lasts until December, corresponding to the flowering season of various local plants such as coffee, avocado, and mango trees (Gebretsadik,& Negash, 2016). The Sidama region is known for producing high-quality honey with a unique flavor profile, which is attributed to the diverse flora and fauna in the region. During the harvesting season, beekeepers in Ethiopia and the Sidama region typically inspect the hives to assess colony strength and honey stores and harvest the honey using various methods, such as smoking the bees to calm them and using a honey extractor to remove the honey from the comb.

2.12. Constraints of Honey Bee

Despite the potential for honey production in Ethiopia and the Sidama region, there are several constraints that can limit the productivity and profitability of beekeeping enterprises. Some of these constraints include: Lack of access to modern beekeeping equipment and technology Limited access to extension services and training for beekeepers Pests and diseases that affect bee health and productivity land use conflicts that can limit access to forage and beekeeping sites Climate change and environmental degradation that can affect the availability of nectar and pollen sources (Kerealem, 2009).

The decline of honeybee populations poses a great negative threat to agricultural production (Grossman, 2013). It is followed by the loss of important plant species, honeybee diversities, and disturbance of the natural ecosystem (Murray *etal*., 2009). These are caused by changes in honeybee population size, growth rate, and plant-pollinator network architecture. Efforts are being made to address these constraints through various initiatives, such as improving access to training and extension services, promoting sustainable land use practices, and investing in research and development to address pest and disease issues.

It has been reported that several biological and environmental factors acting alone orincombinationhavethepotentialtocauseprematurecolonymortality(Genersch,2010;Vanengelsdor pandMeixner, 2010;Vanengelsdorpet al. 2013).Therefore, conserving honeybee species without disturbing their natural habitats is very important (Murray *etal*., 2009).

2.12.1. Swarming incidence

Swarming incidence refers to the natural process by which a colony of bees divides into two separate colonies. It occurs when the existing colony becomes overcrowded and the queen bee leaves with a portion of the worker bees to establish a new colony. Swarming typically occurs during the peak honey flow season, which can vary depending on the region and the specific flowering seasons of local flora.

The swarming tendency of the colonies were evaluated by counting the number of queen cells constructed from all colonies under the study and number of swarms produced during the normal honeybees' reproduction season. These counted cells were removed immediately to avoid double counting. Africanized honey bees swarm at a rate far greater than European honey bees. They

typically produce six to twelve swarms per year (Camazine and Morse, 1988). The A.M Weyi gambella race queen cells in January, which was maximum number of queen cells observed month in most colonies and not at all in some colonies, like March and June (Melkam *etal*., 2017). The high swarming tendency was observed in October and November than any other seasons during the study period (Tesfa and Kasa, 2019).In Ethiopia, swarming can occur between February and May, and again between September and November (FAO, 2021).Swarming can have both positive and negative impacts on beekeeping operations. On the one hand, swarming can lead to the creation of new colonies and increase overall hive productivity. On the other hand, swarming can also lead to a decrease in honey production in the short term, as the existing colony focuses on rebuilding its population.

2.12.2 Absconding incidence

Absconding incidence refers to the phenomenon where a colony of bees abandons their hive and leaves their honey and brood behind. This can occur for a variety of reasons, such as disease, pests, lack of food or water, or environmental stressors (Edessa, 2005). Absconding can occur at any time of the year, but it is more common during the dry season or when environmental conditions are unfavorable. In Ethiopia, absconding can occur between November and February, which is typically the dry season (FAO, 2021).Absconding can have a negative impact on beekeeping operations, as it can result in the loss of honey and brood as well as a decrease in colony population. Beekeepers can take steps to prevent absconding by monitoring hive health and addressing any issues that may arise, such as providing adequate food and water, and controlling pests and diseases.

2.12.3 .Seasons of colony absconding and its control methods

Colony absconding can occur at any time of the year, but it is more common during the dry season when environmental conditions are unfavorable and food and water sources are scarce. In Ethiopia, colony absconding is more likely to occur between November and February, which is the dry season (FAO, 2021). This was most prevalent for some weak hives which couldn't be kept strong enough throughout the year especially during prolonged dearth periods in relation to the availability of bee forage.

Moreover, informal personal communications with local beekeepers around the study area has also supported our observation and summarized results. Besides, higher absconding tendency was most observed at the midland and lowland than the highland representations, which might be associated with the difference in the length of dearth period among the agro ecologies.

An absconding was the release of colony to leave the nest and searching to another in A.M weyi gambella around 26% from a total colony leave their nest at the time of pollen and nectar shortage mainly at the end of May to July (Melkam *etal.*, 2017).There are several methods that can be used to control colony absconding, including: Providing adequate food and water: Ensure that the bees have access to enough food and water, especially during the dry season. Addressing pest and disease issues: Regularly inspect hives for signs of pests and diseases, and take appropriate measures to control them. Requeening replacing an old or failing queen with a new one can help to improve colony health and reduce the likelihood of absconding (Gela *etal.*, 2017).Creating favorable hive conditions: Ensure that the hive is well-ventilated, free from drafts, and has a suitable layout to promote optimal bee behavior. Providing shade: Providing shade for the hive during the hottest parts of the day can help to reduce stress on the bees and prevent absconding. Additional another control method is a recent study conducted in Ethiopia found that the use of traditional hives, which are made from locally available materials, can help to reduce colony absconding compared to modern hives. The study also found that beekeepers who receive training in hive management and beekeeping practices are more likely to have successful and sustainable beekeeping businesses (Tadesse and Gebremedhin, 2021).

2.12.4. Pests of honeybee

2.12.4.1 Rodents: honey badgers, birds, and other mammals

Honey badger is a small strong mammal that caused considerable damage to beehives, honey, and other hive products. To control them, beehives are required to keep in cemented houses, hanged, or suspended to a tree. European foulbrood demand dying larvae curled upwards; brown or yellow, melted or deflated with tracheal tubes more apparent, or dried out and rubbery. The infection could be self-healed when good beekeeping management practiced. Birds, wild animals, and other vectors that scavenging honeybees like the skunks and bears predators. Skunks are insectivores and often attack beehives and consumes large quantities of honeybees

during the night (Wakgari & Yigezu, 2021).Among the mouse were the most serious rodents after entered the honeybee hives.

The principal method of damage prevention is the use of electric fencing for bears and traps for skunks as well as establishing the apiary at safe sites where they are not able to climb and drop inside the fence. Besides, using a piece of chicken wire at the stapled bottom board and stretched in front of the beehive to discourage skunks and other animals. Exclusions, killings, mowing grasses, and inspecting at regular period are the best means of resolving mouse problems in the beehive (Sarwar, 2016; Tesfaye *etal*., 2017). Birds managed by hanging off the repelling videotape, selecting the proper apiary site, hanging of beehive in the dappled sunlight to minimize their entrance under cool weather conditions

2.12.4.2 Agro-chemical

The use of agrochemicals in agriculture can have negative impacts on honey production in Ethiopia, including in the Sidama region. Agrochemicals such as pesticides and herbicides can be toxic to bees and other pollinators, and can also contaminate honey and other hive products. One of the main challenges facing beekeepers in Ethiopia is the lack of awareness about the potential risks of agrochemicals. Many farmers are not aware of the negative impacts that these chemicals can have on bee health and honey production, and may use them indiscriminately. Insecticides and herbicides had been reported as significant causes of the death of the colonies and absconding (Melaku *etal*. 2008; Desalegn 2014; Melissa *etal*. 2016; Krystyna *etal*. 2017; Guesh *etal*. 2018)

To address these challenges, there is a need for increased awareness and education about the impacts of agrochemicals on honey production, as well as stronger regulation and enforcement of pesticide use. Beekeepers can also take steps to mitigate the impact of agrochemicals, such as by locating their hives away from areas where pesticides are being used, and working with farmers to promote the use of alternative pest management strategies. Many mitigation measures are already mandated on the pesticide product label or in governmental guidance documents (Sud, 2020). Within the European Union at least, following. Farmers within the European Union also report high levels of compliance with pesticide regulations pertinent to protecting bee health (Straw *etal*. 2023).

In many cases, measures may be suggested as part of advice or guidance given to farmers in addition to what is written on label guidelines. A few notable measures include optionally applying pesticides outside of pollinator foraging activity hours, and taking practical measures to protect managed bees such as covering colonies during application (Moffett *etal.* 1977, Moffet *etal.* 1979,.Given the scale and impact of pesticide usage, it is important that mitigation measures used are effective (Randall *et al.* 2015).

In many countries of the world, agro-chemicals have played major roles in increasing agricultural production dramatically but not without leaving their adverse effects on the environment. Population growth and land degradation contribute most to the increasing risk of food insecurity and famine in Ethiopia. On top of these obvious factors, the average crop loss due to pests is estimated to reach between 30 and 40% annual (Negash *etal*., 2020). The use of agro-chemicals in agriculture can have both direct and indirect effects on honey production. Agro-chemicals such as pesticides and herbicides can contaminate nectar and pollen sources, which can lead to the accumulation of these chemicals in honey and other bee products. This can impact the quality and safety of honey, and can also have negative effects on bee health and colony productivity. In addition, the use of agro-chemicals can also impact the availability and diversity of nectar and pollen sources for bees, which can impact the quality and quantity of honey produced. A recent study conducted (Assefa and Yirga, 2021) in Ethiopia found that the use of agro-chemicals was a significant concern for beekeepers in the country, and identified the need for increased support and training for beekeepers to adopt alternative pest and disease management strategies..

2.13 Opportunities of Honey Production Systems in The Study Area

2.13.1 Availability and existence of strong bee colonies and wide experience

Ethiopia has a longer tradition of beekeeping than other country in the world during time of king Ezana, around the 3rd century AD; wax was needed for religious ceremonies and honey for nobility and the social elite for making traditional beverages .In the study area, most beekeepers start beekeeping by catching the swarm from the environment followed by gift from their parents and by buying bee colonies. This is because of the reason that, catching swarm obtaining from the environment is more advantageous both for cost and colonies alternatives.

This is because of the reason that, catching swarm obtaining from the environment is more advantageous both for cost and colonies alternatives. This explains that, the environment has good access to honey bee resource. The contrast agro-ecological conditions and availability of diverse floral resources make Ethiopia as one of the very conducive place for the existence of 10 million of honeybee colonies (Ayalew, 2001), of which farmers keep about seven million in hives and the remaining exist as wild in forest and caves (Shenkute *etal*., 2012).According to CSA, the major honey and beeswax producing regions in Ethiopia are Oromia (41%), SNNPR (22%), Amhara (21%) and Tigray (5%) however, the country is suffering from the ecological degradation of its natural resources and this means the basis for any honey production is threatened and affected. In many regions of the country, beekeeping is considered as one of the income-generating activities for resource-poor farmers including women, youth and the unemployed sectors of the community (Kassa *etal*., 2020). Ethiopia has the potential to produce 500,000 tonnes of honey per year and 50,000 tonnes of beeswax per annual, but currently production is limited to 43,000 tons of honey and 3,000 tones' of beeswax (Faji & Begna, 2017).

2.13.2 Biodiversity conservation

Biodiversity plays a critical role in honey production in Ethiopia, including in the Sidama region. The country's diverse flora provides a wide range of nectar and pollen sources for bees, which can result in different types of honey with unique flavors and characteristics (Picknoll *et al*., 2021). In addition to promoting honey production, biodiversity conservation is also important for maintaining healthy bee populations. Bees rely on diverse plant communities for their survival, and the loss of biodiversity can have negative impacts on bee health and productivity. Conservation measures such as the protection of natural habitats, the promotion of agroforestry, and the use of organic farming practices can help to promote biodiversity and support healthy bee populations. For example, planting a variety of flowering plants, trees, and shrubs can provide a diverse range of nectar and pollen sources for bees, while also promoting soil health and reducing erosion.

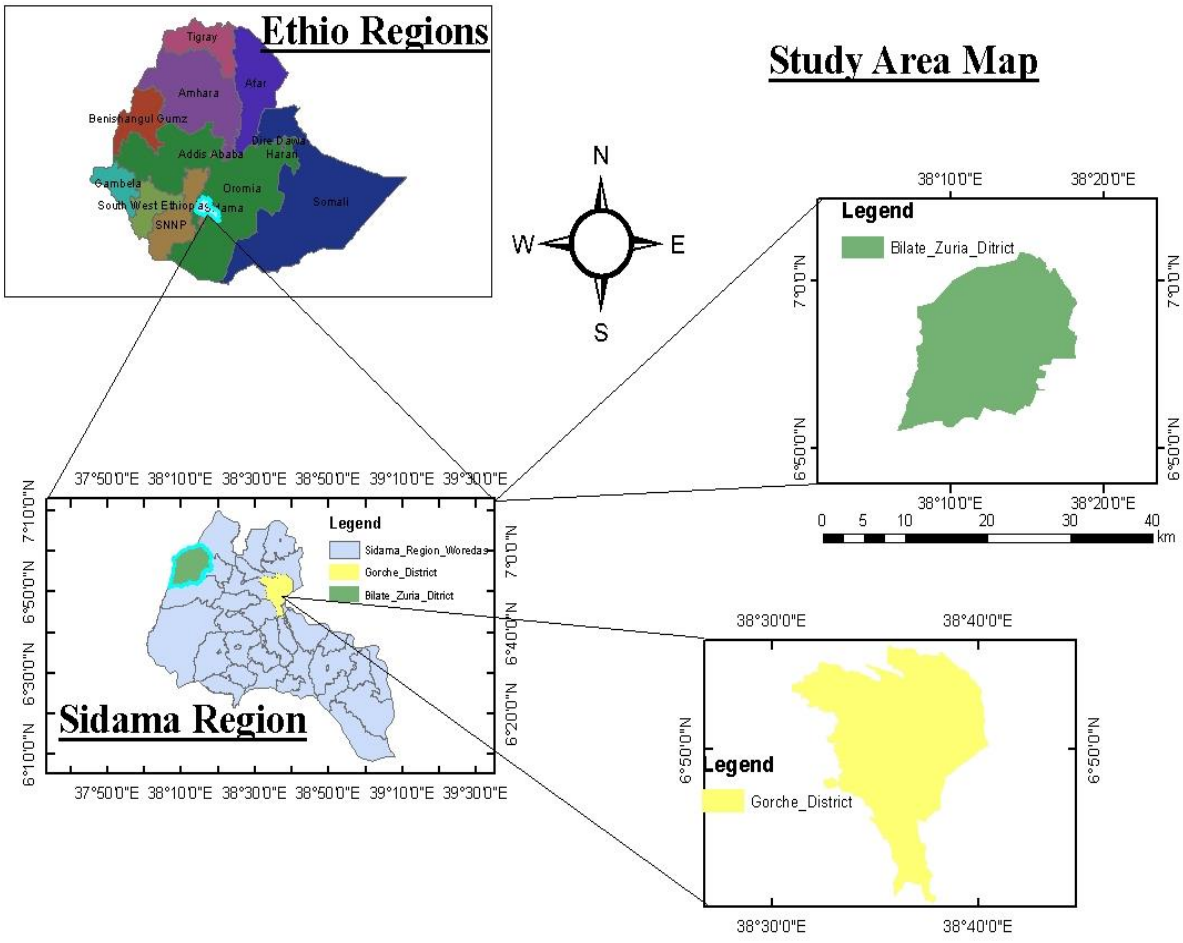
Biodiversity conservation can also *have broader* environmental and social benefits, including the preservation of ecosystem services such as pollination, water regulation, and carbon sequestration. A recent study conducted in Ethiopia found that the promotion of biodiversity conservation can have significant benefits for honey production and beekeeping livelihoods. The study identified (Abdullah and Shemelis, 2020). The need for increased awareness and education about the importance of biodiversity conservation, as well as the need for policies and programs that support sustainable land use practices.

3. MATERIALS AND METHODS

The study was conducted in Bilate Zuria, and Gorche districts of the Sidama regional state, Ethiopia located at 331 km and 317km, respectively, from Addis Ababa. Bilate District is located north of Siraro District woreda in the Oromia region, south of Darara District, west of the Woliat zone, and east of Boricha District. The District comprises 19 kebeles, among them seventeen rural and two urban kebeles. The District is located approximately at its geographical location, which extends from 6º 46'N and 38º 04'E to 7º 01'N Latitude and 38 East Longitudes (Bureau of Finance and Economic Development (BOFED, 2016). Bilate District has a total population of 450,260, of whom 225,524 (50.1%) are men and 224,736 (49.9%) are women; 10,402 (4.16%) of its population are urban dwellers. The majority of the inhabitants were Protestants, with 77.9% of the population reporting that belief; 8.94% were Catholic; 8.22% were Muslim; 1.81% observed traditional religions; and 1.14% practiced Ethiopian Orthodox Christianity the 2%has not follow any religion. (Boni, 2020). The District has a suitable climatic condition for agricultural products mainly Avocado, Enset,Coffee and others like Corn, teff and other crops and cattle breed is the Arsi siraro woreda and wolaita zone cattle. The District is classified into Kola (42.1%) and Woina-dega (57.89%) agro-climatic zones. Soil types are mainly clay and siltis dominant. Soil analysis revealed that the soil of the study area is clay loam in texture (24% sand, 40% silt and 36% clay).

44 km from Hawassa, this is the capital city of the Sidama region. The district is subdivided into 21 rural and 3 urban totals of 24 kebeles (Gorched district bureau of agriculture, 2019). According to the 2007 census, the projected total population number of the district is 105,472, of which 53,484 (50.7%) are males and 51,988 (49.3%) are females. The district situated between 6.41º–6.61'N latitude and 38.44º– 38.98' E longitude (Siyoum *etal.* 2020). The area is woyna dega (25%) and dega (75%) agro-ecological zone receiving bi- modal rainfall with mean annual rainfall of 1200mm (ranges between minimum 900 mm and maximum 1500 mm rainfall). The mean annual temperature of the district were 19.5 0 c and ranges between minimum and maximum temperature of 12 – 27 0 c respectively ((Hawassa metrological station, 2019 G.C) .The area is predominantly Nitosols, Andisols and Vertisol soil type mostly good to fairly good fertility with acidic and slightly acidic property. Study animals related information on each tested

cattle (such as sex, age, body condition score, breed and location) were recorded at the time of sample collection. The cattle in this study area were mainly local breeds which are categorized under Sanga breed group. The ages and body condition scores were scored according to De Lahunta and Habel (Alexander *ital.*, 2017) and (Nicholson and Butterworth, 1986), respectively.



Source: Ethio_ shape files 2021

Figure.1 The Map of Study area

3.1. Sampling Techniques and Sample Size Determination for the Survey

In order to collect data related to the research problems and research objectives, the researcher followed the multiple-stage technique of sampling. The Bilate and Gorche Districtas have a total of 19 and 24 kebeles, respectively. Out of them, six (6) kebeles were selected for research purposes, including Shamana godo, Dila Anole, SadamoCala, and Boroshawala from Bilate, Muranchoguco, and Hora kebeles from Gorche district, based on beekeeping potential and accessibility. A total of 165 respondents were selected using a proportional random sampling procedure based on the proportion of households in each kebeles; among them, 80 households was selected in the middle, and 43 and 42 households was selected in the highland and lowland, respectively. The sample size for beekeepers was determined based on Yamane (1967) as follows: the sampling units are households that have honey bee colonies. Probability proportional to size approach (Kothari, 2004) formula is used to determine the number of sample households from beekeepers, the formula is **Pi = ni/N. Where:** pi= proportion of producer households in stratum, ni = total sample size and N= Total number households which have one and above years of beekeeping experience.

Table 1. Beehive number and bee keeper in the study districts

Kebele	Woreda	Total HHs[1]	Total beekeepers [1]	HHs which have 1 and above years experiance[1]	Proportion	Sample HHs
Shamana godo	Bilate	1025	234	125	0.19	40
Sadamo caala	Bilate	1228	256	163	0.19	40
Dila Aanole	Bilate	1324	294	174	0.19	25
Boro shawala	Bilate	995	211	94	0.19	17
Muranchoguco	Gorche	1221	267	115	0.19	27
Hora	Gorche	956	185	99	0.19	16
Total		6749	1447	770	0.19	165

Table.2: The total population were selected in the three agro-ecology of population .

Highland	Midland	Lowland	Total
285	310	265	860

Pi=165/860=0.19.

$n=N/1+N(e^2)$

Where n=sample size determination

N=total population; e^2 = acceptable sampling error (7% or 0.07)

$n=860/1+860(0.07)^{2=}165$

Therefore, the total sample size for this study was 165. In the third stage, the proportional size of respondents from each stratum is selected using the probability proportional to size (PPS) sampling method to ensure that there is no over- or under-representation in the sample.

3.2. Data Sources and Methods of Collection

This study was employing a mixed-methods approach that integrates quantitative and qualitative methods. In this study, both primary and secondary sources of data were used. Primary data was collected from sample household beekeepers through a structured and semi-structured questionnaire, focus group discussions, key informant interviews, and field observation. Secondary data was obtained from the reports of the Office of Agriculture and Rural Development in the respective districts, the Regional Bureau, NGOs, and other published and unpublished materials. To gather information, enumerators were recruited and trained. Prior to the survey, pre-testing of the questioner was done.

3.2.1 .Focus Group Discussions (FGDs)

The objectives of the FGDs were to obtain in-depth information on the role of productive safety net programs. The discussions were conducted with three groups. A group consists of three to six purposefully selected members, and on average, the discussions were finished within four hours.

The discussions were moderated by the principal investigator. It was held in a private and quiet environment. The discussions were fully tape-recorded, and notes were taken at the same time.

3.2.2 .Field observation

Prior to and in parallel with FGD, field observation was made three people to understand the beekeeping production system.

3.2.3. Key informant interview

In each of the selected kebeles, discussions with key informant development agents and experts from various NGOs were conducted at the district and zonal level with kebeles administrators, elder groups, leaders, and development agents. Information related to the current beekeeping production system, challenges, and efforts made will be assessed using checklists.

3.2.4 Household survey

Prior to the actual survey, a visit was made to the districts, and secondary information relevant to the study was gathered from all possible sources. An informal survey and group discussion was conducted to gather information about the district and to get insights from community members who was directly or indirectly involved in the beekeeping production system. Group discussions were held with elders, key informants, and development agents working at the site and district levels. The discussion was focused on household socio-economic characteristics, honey production systems, marketing systems, beekeepers' indigenous knowledge and practices, potential, constraints, and opportunities for beekeeping in the area.

The information gathered through the above process was summarized and used as a basis to design other data collection tools. A structured questionnaire was designed to obtain data on the honey production system; the questionnaire was including both closed (single response) and open (multiple responses) questions. A pre-test of the questionnaire was made before the actual data collection, and appropriate modifications and corrections were made. Enumerators was recruited and trained on the methods of data collection and interviewing. Six Kebele was selected based on the agro-ecologies of the district. From the selected kebeles, a total of 165

households possessing beehives at the moment were selected at random, and interviews was conducted. Prior to the interview, the objective of the survey was explained and discussed with the informants in order to ensure their cooperation.

For the study, both qualitative and quantitative data was collected, which includes:

Socio-economic characteristics of households: sex, age, marital status, family size, education level, land holdings, livestock, off-farm activities, crop production.

Honey production and management systems: honeybee type and behavior, hive holding, bee colonies, type of hives used and cost of hives, beekeeping equipment, honey flow and dearth period, amount of honey harvested, cost of production of honey, honey and bee colony marketing situation, and market prices.

Bee keepers' indigenous knowledge and practices: place of keeping hives (site), hive inspection, methods of swarm control, swarm catching experiences, control of absconding, harvesting time and methods, honey storage facilities, and postharvest management of honeybee pests and predators and control methods; potential honeybee plants and flowering time; poisonous plants; tree and bee interaction and management.

Potential, constraints, and opportunities of beekeeping in the area: potential honeybee plants, honeybee pests and predators, insecticides and other chemical applications, availability of credit and extension services, market system

3.2.5 Survey on the beekeeping production system

3.2.6 Yield evaluation of different bee hives

To undertake the yield performance, four different bee hives, such as modern, transitional, and locally made ethioribrab and traditional hives, from three agro-ecologies were selected and evaluated. During the study period, data was collected on honeybee colony strength, honey yield, and production cost of each beehive type during selection Ifour bee colony observed from each agro-ecology. Honeybee colony strength was simply assessed as strong, medium, and weak based on honeybee population estimation during the study period due to the limitations of traditional hives in manipulating detailed internal observations like measurements of brood area

and pollen stored. In this study, colonies was considered strong when the honeybee population is full of the hive, medium if more than half, and weak when they cover less than half of the hive volume, including the combs, during the honey harvesting season. Moreover, data on honey and beeswax productivity (yield performance) of each of the four beehive types was recorded and compared in major honey flow seasons. Data on honeybee behavior (e.g., aggressiveness, swarming, and absconding tendencies) was gathered. The datacan be recorded by asking

3.2.7 Method of data analysis

The collected quantitative data through a questionnaire was coded and entered into the computer using Statistical Package for Social Sciences (SPSS) Software Version 22. The analysis techniques were performed using descriptive statistics such as frequency, percentage, mean, and standard deviation. Furthermore, inferential statistics such as independent and dependent samples, chiefly Chi-square, and small amounts of data were used in one-way ANOVA and income of honey annual per house hold analyses by Excel.

The results were presented using tables, figure and pichart. Qualitative data that was collected through the interview key informant interview and group discussion was analyzed qualitatively using narration for the purpose of triangulation.

4. RESULTS AND DISSCUSSION

4.1. Demographic and Socio-Economic Characteristics

The majorities (98.18%) of respondents in the study area were males and only 1.18% female house households are participating in bee keeping production. The survey result revealed that, beekeeping activity in the study area was dominated by male households. The limited number of female participation might be due to the fact that, beekeeping is considered as male workloads in the study area. This result is similar to the report of Juher (2020) and Tamiru (2017) in the east Denbiya district, Amhara region, Ethiopia and Gololcha district, Bale Zone, Oromia Regional State, Ethiopia. Both reported that most of the apiculture activities were dominated by men headed households. This may be due to traditional belief that beekeeping activities are done by men. Also results are in line with the findings of Abebe, 2008; Adebabay *et al.*, 2008; Haftu and Gezu, 2014; K. Ejigu et al.,2009) a reported that, cultural barrier would hamper women to undertake beekeeping activities. As the number of bee colony increases, the labor required in watching and during swarming times, beehive construction, honey extraction and colony multiplication increases (Guesh *et al.*, 2015). Majority (63.03%) over all age of the respondent household heads were in the active and productive age group which ranges between 20- 60 years (Table 3). The dominance of active and productive heads of households in the study area has direct bearing on increased availability of able-bodied labor for production and ease adoption of apiculture related innovations which have great potentials for increasing apicultural productivity and production (Table 3). The distribution of the age of household heads was fairly similar across all locations. The average productive age groups of the study area were in line with the result of Kalayu *et al.* (2017) who reported the same productive age group in their study. Moreover, (Baynes, 2013), Guesh (2015) and also reported similar mean economically active age group. Thus, availability of high labor potential for beekeeping contributes for the beekeeping activities and in most cases; people at younger age are actively engaged in the district. As it is shown in Table.3 below, the marital status of household heads in the study area showed a high level of homogeneity in the distribution due to the similarities in cultural and religious practices. From the total respondents, 88.3% were married. With regard to religion, all of the respondent household in the study area were protestant (Christians) followers.

The level of education of respondents is depicted in Table 3. Majority (90.91 %) of the

households was literate and they were able to read and write (grades 1-12). The result also revealed that, the respondents who were between grade 5 to 8 have significantly ($p<0.05$) they are ability to can write and read than the lower literacy levels. Thus, educational level can have significant importance in identifying and determining the type of development and extension services that need to be designed for the area. Higher literacy level may also enable to access relevant information that will enhance honey production. The result is in line with findings of Alemayehu (2016) who reported more than 60% of educated respondents in Amhara region, Sekota district.

As it is shown in Table .3 below, the marital status of household heads in the study area showed a high level of homogeneity in the distribution due to the similarities in cultural and religious practices.

Table 3. The response of respondents on gender, educational level, marital status, age and religious status

Variable		Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	df	p
Gender of house	Male	43(100)	77(96.25)	25(31.25)	162(98.18)	3.247	2	0.197
	Female	0	3(3.75)	0	3(1.818)			
	Total	42(100)	77(100)	42(100)	165(100)	165		
Age of respond	0-19	22(51.25)	25(31.25)	3(7.1428)	50(30.3)	33.441	4	0.000
	20-60	21(48.83)	44(55)	39(92.857)	104(63.03)			
	61-80	0	11(13.75)	0	11(6.6)			
	Total	43(100)	80(100)	42(100)	165(100)	165		
Education	Illiterate	8(18.60465)	3(3.75)	4(9.523)	15(9.0919)	52.452	4	0.000
	Primary	21(48.83)	45(56.25)	0	66(40)			
	Junior	14(32.5)	28(35)	42(25.5)	84(50.909)			
	10+3-degre	0	4(5)	0	4(2.4)			
	Total	43(100)	80(100)	42(100)	165(100)			
Marital status	Married	38(90.476)	63(78.75)	32(76.19)	133(80.6061)	1.744	2	0.418
	Single	3(7.143)	12(15)	6(14.286)	21(12.73)			
	Divorse	1(2.381)	3(3.75)	2(4.762)	6(3.636)			
	Widow	1(2.381)	2(2.5)	2(4.762)	5(3.03)			
	Total	43(100)	80(100)	42(100)	165			

The average land holding for plowing or farm, backyard, grazing, plantation and total land of the sample respondents during the study year were recorded. About40% of the interviewed households have between 0.25 and 0.5 hectare of land. From the total respondents, about 24.24% of them have land holding of 0.25and less than 0.25 hectare. This indicates that, majority of respondents have very small lands which limits the self-sustainability of the farmers in the study area. The result of colony holding revealed that, high colony holding is related with limited land holding (Table 4). This is due to the fact that, beekeeping practices does not bring matter farm size is small or large. Thus, involvement of beekeeping activity is one of the alternative options for the respondents so as to improve their food security status (Alemayehu, 2016; Bihonegn, 2017).This finding was the line with ((Brad bear 2009; ICIPE 2013) reports beekeeping does not require much land or high starting costs, and people from child to advanced age are able to perform this activity without advanced skills except modern bee keeping activity.

Table 4 clarifies that, Teff and wheat is the dominant crops grown in the lowland and midland of the study area, respectively; whereas in the highland, cereals (Barley) and legumes (pea and bean) are dominantly produced by the respondents. More importantly, cereals are the most widely cultivated crops in the area. Teff and wheat were the two top cereal crops grown by the sampled farmers. The dominance of cereals in the area may be related to the food or dietary habits of the community and the local climate which favored its production and productivity. Inset also adapted more highland and midland and coffee can be adapted most time midland and highland agro-ecology but it also can resist lowland. Most of these crops important for dietary for human and honey bee flora.

Table 4. Land holding, types of crops grown, and colony holding of the respondents

variables		Highland F(%)	Midland F(%)	Lowland F(%)	Overall F(%)	X^2	Df	P
The land holding	**≤0.**25ha	**0**	40(50)	0	40(24.24)	140.671	8	0.0001
	0.25to0.5h	35(83.3)	25(31.25)	6(14.29)	66(40)			
	0.5to1ha	6(13.95)	5(6.25)	12(28.57)	23(13.94)			
	1to1.5ha	2(4.65)	7(8.75)	0	9(5.45)			
	≥1.5ha	0	3(3.75)	24(57.14)	27(16.36)			
	Total	43(100)	80(100)	42(100)	165(100)			
Types of crops grown		Highland F(%)	Midland F(%)	Lowland F(%)	Overall F(%)	X^2	Df	P
	Inset	2(4.76)	7(8.75)	0	9(5.46)	86.259	12	0.0001
	Maize	0	18(22.5)	7(16.67)	25(15.15)			
	Pea	3(6.98)	1(1.25)	1(1.25)	5(3.03)			
	Bean	3(6.98)	4(5)	3(7.14)	10(6.061)			
	Coffee	2(4.65)	18(22.5)	2(4.762)	22(13.33)			
	Teff	2(4.65)	10(12.5)	15(35.71)	27(16.36)			
	Barley	31(72.1)	0	0	31(18.79)			
	Boloqe	0	12(15)	4(9.52)	16(9.697)			
	Wheat	0	10(12.5)	10(23.81)	20(12.12)			
	Total	43(100)	80(100)	42(100)	165(100)			
Colony holding	Traditional	6.95	8.46	3.92	6.92		2	0.0001
	Transitional	2.19	2.7	1.67	2.3			
	Frame	1.63	2.73	1.43	2.11		2	0.001
	Ethioribrab	1.66	1.91	1.8	1.75		2	0.366

4.1.2 Beekeeping practices in the study area

Number of hive types across the agro-ecology is not significantly ($p>0.05$) different, but it was statistically (*$p<0.05$)* significant within agro-ecologies. The mean total numbers of colonies possessed by the respondent beekeepers was 6.92 and colony holding of lowland, midland and highland were 3.92, 8.46 and 6.95 per household, respectively. The mean number of transitional (2.3) and moveable (2.11) and ethioribrab (1.75) beehives owned by the respondents were very low compared with the traditional (8.46) beehives per house hold (Table 6). The higher averages number of beehives in the traditional production practices may be related to the availability of beehive any local material and conducive climate and available any person without advanced skill local own material which is suitable for beekeeping practices especially in the midland agro-ecology. The average colony holding of beekeepers in this study is comparable with the findings of Alemayehu (2016) who reported an average of 9.10 colonies per household in Siltie district southern Ethiopia. The study revealed that, there were three types (traditional, transitional and movable frame) of beehive production practiced in the study area. However, the major share of colony was recorded by traditional production practices which account 88.49, 87 and 82.8% in mid land, low land and high land, respectively (Table 6).

The greater number of traditional hives across the three agro-ecologies could be due to the easy of constructing the hives from locally available materials. This is in line with the reports of FAO (1986) and (Kebede, 2011) who said that, Africa has the oldest tradition of beekeeping in the tropical region. This type of practice uses traditional techniques of harvesting honey and beeswax using various traditional styles of hives and equipment. Moreover, similar findings were also conducted in Northern, South Western and Central parts of Ethiopia and they reported that, traditional beekeeping is the

predominant practice (Kebede and Lemma, 2007; Kerealem *et al*., 2009; Alemayehu, 2016). In contrary to this, only 25% traditional production practices were reported in Eastern Tigray region by Kiros and Tsegay (2017).

Table 5. Different types of hive and colony holding owned by the respondents

Hive types with colonies	Highland Mean	Midland Mean	Lowland Mean	Overall Mean	Sum Square	Df	Mean Square	F	P
Traditional	6.95	8.46	3.92	6.92	566.232	2	283	11.098	0.0001
Transitional	2.19	2.7	1.67	2.3	30.204	2	15.102	5.69	0.007
Frame colony	1.63	2.73	1.43	2.11	59.754	2	29.877	7.879	0.001
Ethioribrab	1.66	1.91	1.8	1.75	3.884	2	1.942	1.012	0.366

Table 6. Number of honey bee colonies in different hive types owned by the respondents

Traditional Colony	High land F(%)	Mid land F(%)	Lowland F(%)	Overall (%)	X^2	Df	P
1-5 hive	25((58.14)	16(20)	35((83.3)	76(46.06)	50.0126	4	0.0001
6-10 hive	13(30.23)	55(68.75)	7(16.67)	75(45.45			
11-40 hive	5(11.91)	9(11.25)	0	14(8.49)			
Total	43(100)	80(100)	42(100)	165(100)			
Transitional							
1-4hive	25(31.25)	25(31.25)	30(71.43)	80(48.49)			
5-10hive	4(9.302)	43(53.75)	0	47((28.49)	54.372	6	0.0001
11-25hive	0	3(3.75)	1(2.381)	4(2.42)			
Frame							
1-2hive	10((23.26)	24((30)	2(4.76)	36((21.82)			
3-6hive	11(25.58)	35(43.75)	6(14.29)	52((31.52)	67.938	8	0.0001
7-15hive	0	12(15)	0	12(7.28)			

0	22(51.16)	8(10)	31(73.81)	61(36.97)			
Total	43(100)	80(100)	42(100)	165(100)`			
Ethioribrab							
1-2hive	4(9.3)	18(22.5)	8(19.05)	30(18.182)			
3-10hive	8(18.61)	50(62.5)	5(11.91)	63((38.182)	84.838	6	0.0001
11-20hive	0	9(11.25)	0	9(5.46)			
0	31(72.09)	3(3.75)	29(69.05)	63(38.182)			
Total	43(100)	80(100)	42(100)	165(100)			

4.1.2 Beekeeping experience of the respondents

The more percentage share of beekeeping experience (11-20 and above years) were obtained from high land (23.25%), low land (14.29%) and mid land (43.75%) agro-ecologies. Accordingly, more (41.21%) of beekeepers had more than 10 years of experience. The recently engaged beekeepers that have less than 5 years of experience were only 27.88% of the total respondents (Table 7). That indicate significance variation (*p*0.05more experienced beekeepers have better understanding and they are more curious about their colony management, such as pest and predator prevention, shelter preparation, provision of dearth period supplementary feeds, swarm management, quality honey Production and other seasonal management. It is also evident that beekeeping is a discipline that is based on experience and interest.

Differences in experience might be responsible to influence the attitude and adoption of new beekeeping technologies (Hussien *et al.*, 2015). Moreover, experienced could predict the future outcome of production with some probability by considering performance of the past. This indicates the existence of a long standing tradition of beekeeping in highland location than the low and midland, which is associated with the conducive weather, flora and moisture potential of highland area which encourage beekeepers in terms of the higher output of hive products. This result was also in line with Alemu (2015). However, this result is greater than the findings of Alemu (2015) and Alemayehu (2016) who reported 41.1% and 45.1% experienced beekeepers in South Wollo and Wag Himra zones and Siltie district in south region, respectively.

Table 7. Beekeeping experience of the respondents in the study area

	Highland F(%)	Midland F(%)	Lowland F(%)	Over all (%)	X^2	Df	P
1 to5year	24(55.81)	16(20)	6(14.29)	46((27.88)	39.514	4	0.0001
6 to10year	9(20.93)	29(36.25)	30(71.43)	68(41.21)			
11to20year	10((23.25)	35(43.75)	6(14.29)	51(30.91)			
Above							
Total	(43(100)	80(100)	42(100)	165(100)			

4.1.3. The source of honey bee colony

The majority of the respondents (60%) in the study area get their starter bee colony by swarm catching followed by gift from their parents (33.33%) and others(6.67%) of the farmers started and source of starter honey bee colonies is mainly swam catching in highland (90.69%) , lowland (80.95%) while in midland (61.25%) was from family gifts? because most of midland and lowland beekeeping through training supports like Governmental and None governmental organization (Figure 2). This result is similar with the finding of Fikiru (2015) who reported 71.43%, 14.29% and 14.29% from catching swarms, gift from parents and buying, respectively. Furthermore, during interview with respondents, it was discovered that the capture of natural swarms is a traditional and common technique which was practiced almost by all beekeepers in the study area as a source of colony for colony expansion. From the discussion made with farmers, the main reasons the beekeepers practice swarm catching was that it is cost free, convenient to keep in traditional beehives and lack of knowhow of artificial means of queen rearing techniques. Colony multiplication as means of getting new swarm is not introduced and practiced by any of the beekeepers in the study area. This finding agreed with Chala (2010), Alemayehu (2016), Teklu and Dinku (2016) and Alemayehu and Abera (2017) who reported that, majority of beekeepers initiated beekeeping through swarm catching in Burie district of Amhara region, Gomma district of Oromia Region, Gedeo zone, Southern Nation, Nationalities and Peoples regional state and Sude Woreda, Arsi Zone Oromia region, respectively. According to the discussion, newly engaged beekeepers get their starter colony from their parents has more experience than started from training or by their motivation. Where people are actively engaged in helping older beekeepers from an early age, they accumulate experience from fellow beekeepers and gradually become independent beekeepers (Adebaby *et al.*, 2008).

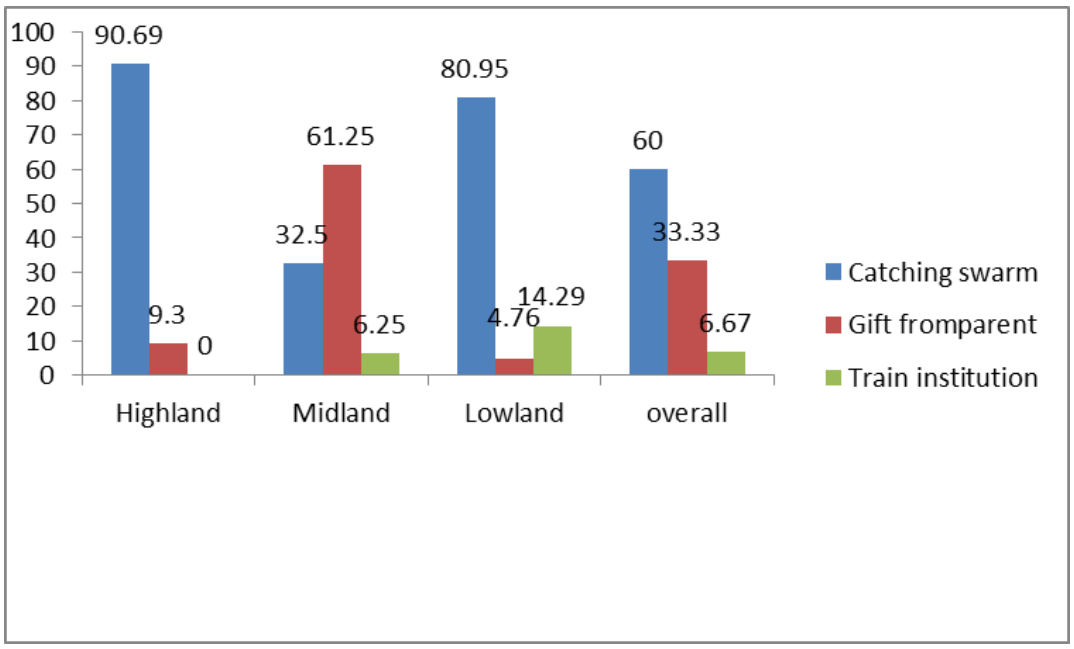


Figure. 2 shown the place of honey bee

Figure. 2 shown the place of honey bee

4.1.4 Honey bee colony population and honey yield trend

Despite the potential of the study areas with good market price, the respondent reported that the colony and honey yield was decreased by 56.97% due to different threatening factors. The respondent reported that, among the possible causes of decreasing colony and honey yield in the study area, lack of forage (47.88%) was the predominant cause followed by use of pesticide and herbicide (41.25%) and pest and predator (42.86%) (Table 8). This result is almost in agreement with Tamiru and Dinku (2016) who reported more that 50.6% decreasing trends in Ambo District, Ethiopia. Moreover, Tewodros (2010) and) (Bihonegn, 2021) also reported the same result in Bure, Sekota and South Wollo and Wag-himra zones, respectively.

On the other hand, (18.7%) of the respondents have replied that the trends of colony and bee products have increased. These respondents assumed the increased trend to be getting of additional colonies (30.91%), good market price (1.82%), adoption of improved beekeeping practices (38.79%) and afforestation programs (28.49%). On the other hand, (18.79%) and (11.52%) of the respondents perceived the trend to be constant and no harvest respectively that indicate by not harvest means they

donot harvest honey at the time of dearth period(Table 8).

Colony and honey yield trend	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
Not harvest	4(9.3)	10(12.5)	5(11.9)	19(11.52)	17.757	6	0.007
Increasing	4(9.3)	19(23.75)	8(19.05)	31(18.7)			
Decreasing	35(81.14)	39(48.75)	20(47.62)	94(56.97)			
Stable	0	12(15)	9(21.43)	21(12.73)			
Total	43(100)	80(100)	42(100)	165(100)			
Cause of increasing							
Use of new technology	5(11.63)	33(41.25)	26(61.91)	64(38.79)			
Increase colony number in the area	20(45.512)	31(38.75)	0	51(30.91)	43.503	6	0.0001
Afforestation of more bee forage	18(41.86)	13(16.25)	16(38.09)	47(28.49)			
Good market price in the area	0	3(3.75)	0	3(1.82)			
Total	43(100)	80(100)	42(100)	165(100)			
Cause of decreasing							
Pest and predator	8(18.61)	10(12.5)	0	18(42.86)			
Use of herbicide and pesticide	29(67.44)	34(42.5)	5(11.905)	68(41.21)	47.729	4	0.0001
Lack of forage	6(13.95)	36(45)	37(88.09)	79(47.88)			
Total	42(100)	80(100)	42(100)	165(100)			

Table 8. Honeybee colony population and honey yield trend of the respondents

Source: Survey result (June 2023 to December 2024).

4.5. Honey Bee Management Practices

Among the honey bee management, placement of hives in appropriate site; keeping them disease free, guarding from external predators and maintaining/increasing bee population and honey production are the most important points. This indicated that, backyard is the most preferred place for hive placement across the three agro-ecologies (high land (54.14%), low land (52.38%) and mid land (62.5%)). Some beekeepers were also reported in the study area that placed their hives hang on trees near homestead and hang on trees in forests. This indicates that, backyard is the most common practice of honey production

in the study areas followed by under the eaves of the house (Table 9). This could be due to the appropriateness of the sites for daily follow-up of the beekeeping activities. The result was in agreement with the findings of (Negash, 2019)), Haftu (2014), Alemu (2015), Fikiru (2015) and (Mussa, 2021) who reported that, the major beekeepers at each of their respective study districts were kept their colonies around the backyards of their homestead. Moreover, (Kum *etal.*, 2023) notified that, backyards are easier for frequent inspection and other hive managements (including swarm prevention, pest and predator control and honey production quality and quantity)compared with free apiaries.

The respondents reported that, movable beehive has higher (13.15±7.276) service year (durable) in midland followed by low land (12.88±7.522) agro-ecologies. However, transition beehive was higher (6.3±3.369) service year in mid land agro-ecology and ethioribra (chefeka) was3.02±2.90. This indicates that traditional beehives are less durable than the other beehives. Although service years of moveable frame hive is usually more than 14 years in the two agro-ecologies, the adoption rate of the technology is very low. This might be due to the distribution of movable hives without training and improved beekeeping accessories.

Low adoption and disseminations of moveable frame bee hive is attributed to many factors like weak extension services, initial high costs, demand for its own seasonal management techniques and other accessory equipment, poor economic background of the beekeepers, lack of knowhow, and so on (Beyene and Verschuur ,2014; Geberetsadik andNegash,2016and Kalayu*etal.*,2017).

Table 9. Placement of honey bee colonies by the respondent households

Parameter variable	High land F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2 F (%)	Df	P
Back yard	25(54.14)	48(60)	22(52.38)	97(58.79)			
Eaves of house	3(6.976)	4(5)	2(4.762)	9(13.3))			
In the forest	5(16.28)	18(22.5)	1(2.38)	24(15.76)	18.652	6	0.005
Hang on the tree	10(23.26)	10(12.5)	17(40.476)	37(22.42)			

Total	42(100)	80(100)	42(100)	165(100)

F=frequency, df=degree of freedom, x2=chi-square, p=significant level

Table 10. Response of household on mean service year of different hive type

Service year of hive types	Highland	Midland	Lowland	Overall	mean square	Df	Mean square	P
Traditional	2.911±1.306	2.89±1.389	2.86±1.299	2.88±1.336	0.54	2	0.27	0.001
Transitional	6.02±3.44	6.3±3.369	5.88±3.604	6.12±3.432	5.394	2	2.697	0.797
Ethioribrab	3.05±2.903	3.14±0.67	1.6±0.627	2.72±1.706	71.662	2	35.831	0.000
Modern	12.88±7.522	13.15±7.276	11.6±7.071	12.68±7.275	68.875	2	34.437	0.524

SD=standard deviation, df=degree of freedom

4.6 Inspection of honey bee

The survey result revealed that, about 57.58% of respondents practice external inspection sometimes while 26.06% of the respondents rarely inspect their hives externally (Figure 3)> About 51.52% of the respondents do not undertake internal inspection of their bee colonies (Figure 3). The respondents claimed that, bee will be disturbed if internal inspection is very frequent as did in external inspection. Such limited awareness could cause the low percentage of internal inspection in the study area. Though, inspection of hives and apiary is indispensable to safeguard honeybee colonies from different natural disasters and various hazards (pests, diseases and chemical poisoning), respondent beekeepers believe that visiting the apiary and the hive externally or internally during rainy season causes diseases. For this reason, during

rainy seasons the respondents are covered their beehives with grasses which may intern serve as a hiding place of honeybee pests. Experiences show that external colony inspection can be done at any season but internal inspection during rain seasoncause disease or ill so not recommended rain season to inspect internal. The result is lined with (KirosandTsegay, 2017) who reported more than 72.5% external inspection in Eastern Tigray, Ethiopia. This result agreed with the findings (Sebsib and Yibrah, 2018) and Tekilu and Dinku (2016) who reported little common internal beehive inspection due to the difficulty of traditional hives for internal inspection (fixed combs attached to the body of traditional beehive). Thus, all these researchers confirmed that, internal hive inspection of traditional hive is not very common or non-existent at all in their respective study areas.

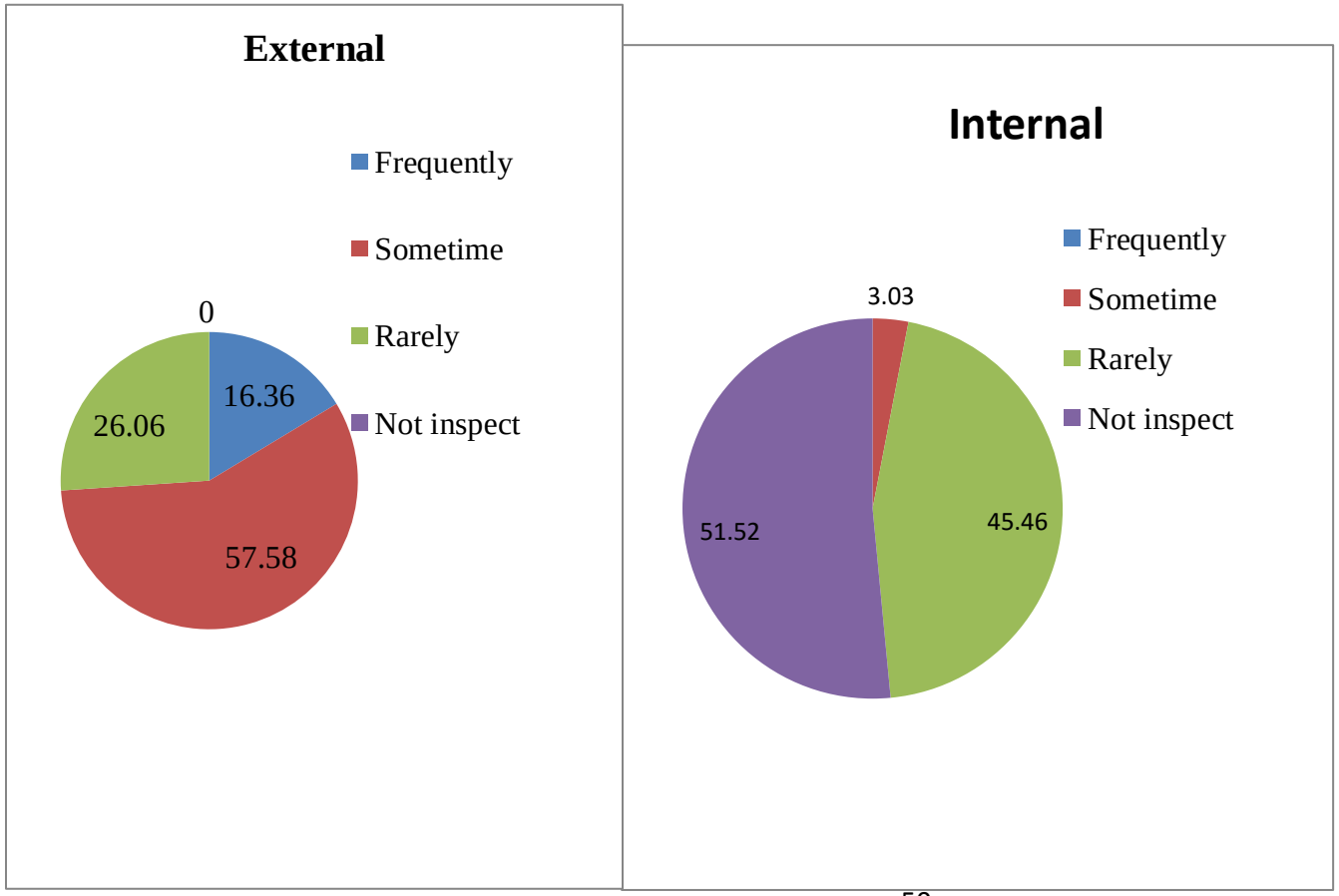


Figure .3 Summarize the hive inspection types in study area

4.7 The Supplementary Feeding Types of Honey Bee

Shortage of food for honeybee is directly associated with off flowering period of major honey bee forages. Thus, to overcome the problem, supplementary feed is required. In this study, about 87.3% of the respondents' were not providing supplementary feed for their honeybees (table11). They also reported that, supplementary feed was provide mainly during March to May (33.3%) followed by December to February (52.519%) and Sugar syrup (25.46%) and honey plus water (1.82%) were the major feeds which were provided by the respondents as a supplement. The main reason few amount of honey given they said that they saved income.

The existence of more bee forage results in high honey production provided that other factors are suitable for honey production. However, in this there was no improved bee forage promotion. This result is agreed with the findings of Kiros and Tsegaye (2017) who reported that, about 62.5% of beekeepers feed their colony when there were shortages of feed in Eastern Tigray. In contrary to this, Alemayehu (2016) reported that out of the sampled respondents only 36.3% were practice feeding supplementing feed to their bee colonies and their honey bee colonies were naturally sustaining and produce honey by foraging natural and cultivated crops in all possible radiuses from their nests.

Supplementary given?	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
Yes	5(11.63	10(12.5)	6(14.29)	21(12.73)	0.142	2	0.931
No	38(88.37)	70(87.5)	36(85.7)	144(87.3)			
Total	43(100)	80(100)	42(100)	165(100)			
Supplementary							
Sugar syrup	3(6.98)	3(3.75)	4(9.52)	10(6.06)	3.732	8	0.714
Honey plus water	2(4.65)	2(2.5)	0	4(2.42)			
Besso	2(4.65)	5(6.25)	2(4.76)	9(5.45)			
Not given	36(83.72)	0(87.5)	36(85.71)	142(86.06)			
Total	43(100)	80(100)	42(100)	165(100)			
Supplementation Month							

December to February	10(23.26)	70(87.5)	30(71.43)	110(66.67)			
march to may	33(76.75)	10(12.5)	12(28.57)	55(33.3)	52.519	2	0.0001
Total	43(100)	80(100	42(100)	165(100)			

Table 11. The response of respondents on supplementary of honey bee

4.8. The Source Of Water Honey Bee In The Study District

According to respondent responses the honey be can be get water from different water harvesting structure. But in the case of figure .4 explanation majority of water can be fetch by nearby apiary site watter(54.55%),followed by(30.3%)pond ,(10.91%)lake and(4.24%)from lake and river respectively.

Honeybees use large quantities of water to dilute their brood food and to cool the hive by evaporation during dry seasons. Honeybees elapse most of their time in collecting water for major purpose of rinsing the collected nectar and keeping the micro-climate of their hive. In the study area even if the water fetching distance is different for each agro-ecologies water is 100% available and the sources were illustrated in Figure .4. In many literatures, water is mentioned as equally important as bee forage to the honeybees (Jones, 1999; Paterson, 2006).

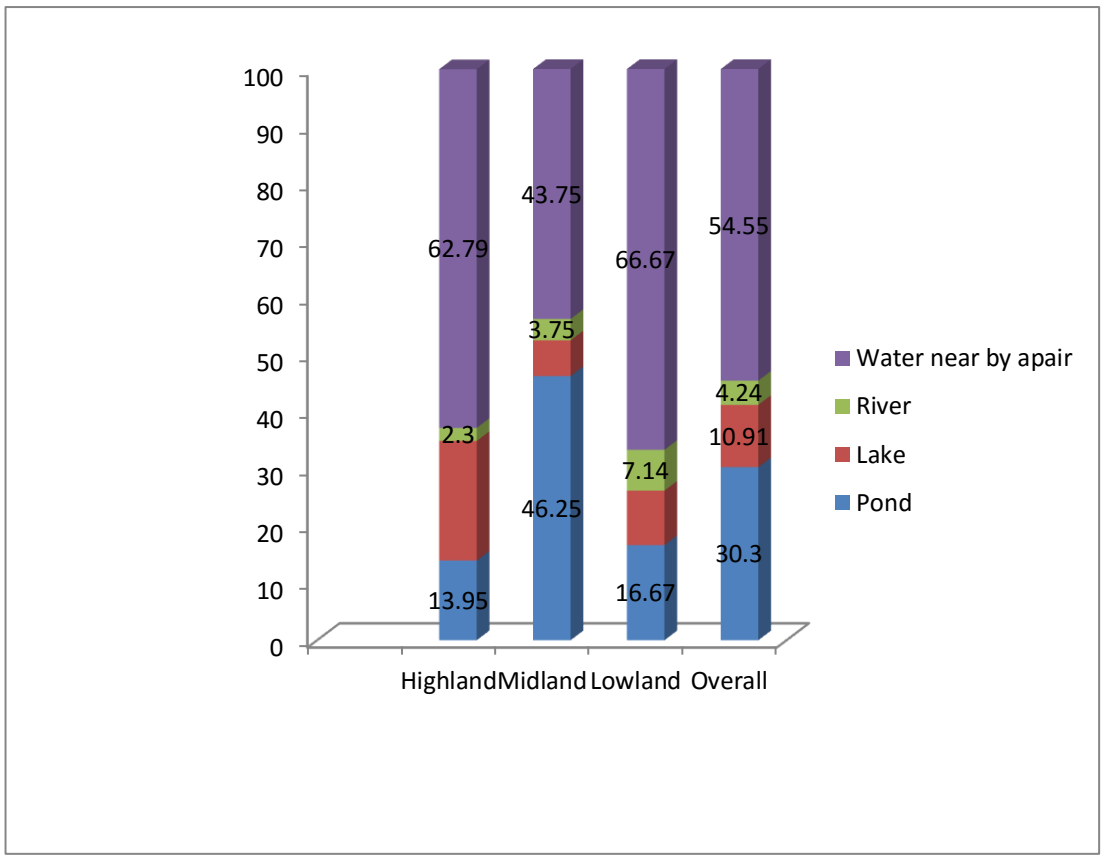


Figure .4 shown water harvesting place of honey

4.9. Swarming Incidence

About 70.19% of the respondents reported that swarming phenomenon appears in honeybee colonies of the study area (Table 12). The respondents also mentioned that, the frequency of swarming was depending on the availability of honeybee's flower and season of the swarming occurrences. In the study area the most frequent swarming was observed in traditional hives (75.15%) attributed to overcrowding effect of its small volume and the temperature maintenance quality of the hives which are constructed locally. This result is similar to the findings of Awraris *et al.* (2012), Alemayehu (2016) and Tekilu and Dinku (2016) who reported more than 90% of the occurrence of reproductive swarming in their study area.

Swarming is more prominent management techniques in honeybee which is practiced from Pagumie (Ethiopian leap year) to October in Ethiopia. The respondent also reported that, every year swarming (70.19%) frequency was dominantly practiced in the study area followed by once in two years swarming. Moreover, majority (56.36%) of respondents in this study were agreed that, swarming is advantageous to increase the number of colonies for bee keepers (Table 12). This is the line (Sebsib and Yibrah , 2018) also reported the same findings in Bonga areas. According to (Hossametal., 2021) construction of a new nest with wax requires a sufficient amount of food and larger number of bees. However, the discussion made with beekeepers in the study area suggested that, this scenario cannot be easily activated by a small group of bees. Hence, beekeepers kill the successive swarms after catching the first 1 up to 3 strong swarms.

Beekeepers in the study area use different kinds of swarm control techniques so that the honeybees cannot escape out of their control/produce only honey. From the data presented in Table 12 it is evident that, the incidence of swarming is majorly controlled by the removal of queen cells before they hatch (81.82%) followed by reuniting back to mother colony by killing the queen (4.24%) and supering (13.94%). That indicate swarming controlled significant indifferent agro-ecology ($p<0.05$).This finding is in line with the results of (Taye and Mekonen, 2021) who reported the same practices of swarm

control at Burie district. Beekeepers traditionally believed that, the bees will become sterile and honey producer, if they treated with smokes of different ingredients; like white 'Adrus', mule bone, 'kosso' tree flower smokes. Although very few beekeepers tried 'Adrus' did not show expected results but they believe about it. Further research is required to verify this indigenous knowledge and practices.

As reported by 53.3% of respondents, water was the major attractant material followed by smoking of wax and some smelling tree (14.7%) and throwing the dust (16.697%). About 86.05%, 91.25%and 71.43% of the sample respondents from three agro-ecology have experience on catching and using different production techniques and only 13.95%, 8.75% and 28.57% respectively new for swarm catching practice. This result agrees with the report of Tessega (2009) and Tekilu and Dinku (2016) who recorded more than 84% catching swarm experience in Burie district of Amhara region and Keffa and Gedeo zone. In addition, respondents use different attractant tools by rub or clean the hives and fumigate them with a mixture of leave and bark of different plant species. These are burning of garbicho, ejersa (weira), dawowessa and others.

Table 12. Response of informants on swarming and swarming controlling

Parameter	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2 F (%)	Df	P
Removal of queen cell	27(62.79)	70(87.5)	38(90.48)	135(81.82)			
Re-unite back to mother colony	6(13.95)	0	1(2.38)	7(4.24)			
Suppering	10(23.26)	10(12.5)	3(7.14)	23(13.94)	20.087	4	0.0001
Total	43(100)	80(100)	42(100)	165(100)			
More swarming occur type of hive							
Chefeka	5(11.63)	7(8.75)	3(7.12)	15(9.091)			
Traditional	23(53.49)	68(85)	33(78.57)	124(75.15)			
Transitional	13(30.23)	3(6.98)	5(11.9)	21(12.73)	20.22	6	0.003
Frame	2(4.65)	2(2.5)	1(2.4)	5(3.03)			
Total	43(100)	80(100)	42(100)	165(100)			
Bee swarming continues?							
Yes	19(44.18)	65(81.25)	33(78.57)	117(70.91)			
No	24(55.8)	15(18.75)	9(21.43)	48(29.1)	20.229	2	0.0001
Total	43(100)	80(100)	42(100)	165(100)			
Swarming attractant	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2	Df	P
Water spraying	17(39.53)	59(73.75)	12(28.57)	88(53.3)			
Throwing dust	8(18.61)	11(13.75)	9(21.43)	28(16.97)	29.604	4	0.0001
Smoking of wax and smelling tree	18(41.61)	10(1.25)	21(50)	49(29.697)			

Total	43(100)	80(100)	42(100)	165(100)			
Swarming is advantages?							
Yes	12(27.91)	60(75)	21(50)	93(56.36)			
No	31(72.09)	20(25)	21(50	72(43.64)	26.146	2	0.0001
Total	43(100)	80(100)	42(100)	165(100)			
Catching swarm experience							
Practiced	37(86.05)	73(91.25)	30(71.43)	140(84.85)			
New	6(13.95)	7(8.75)	12(28.57)	25(15.15)	8.481	2	0.014
Total	43(100)	80(100)	42(100)	165(100)			

4.10. Absconding Incidence

More than 91.52% of the beekeeping respondents across the three agro-ecologies revealed that, occurrence of absconding was practiced immediately. Reason of absconding varies across the three agro-ecologies. Draught (41.2%) is the major reason of absconding followed by shortage of food. Shortage of food (23.03) is the major reasons in three agro-ecology followed by pestand predator (20.93); whereas it was very high in high land agro-ecology (Table 13). The report by (showed Asaminewetal., 2023) also that same reports. (Taye andMekonen , 2021)and Abadi *et al.* (2016) also supports these findings as the main causes for colony absconding were incidence of pests, poor management, bad weather and others. Moreover, the sampled beekeepers and bee expert of the district indicated that the highland area is not suitable for movable frame hive as it is too cold and the honeybees cannot resist the cold.

As shown in Table 13, beekeepers in the study area tried to control absconding majorly through feeding (76.36%) followed by frequent inspection (23.64%). This finding indicate the rate of hive absconding is reported to be high, especially following harvest (Gebremedhin, 2020). Moreover, bee strains like *Apis cerana* and tropical *Apis mellifera* were much more prone to absconding.

Table 13. Absconding incidence, cause and control method

Do you know absconding?	Highland F(%)	Midland F(%)	Lowland F(%)	Over all F(%)	X^2	Df	P
Yes	38(88.37)	74(92.5)	39(92.86)	151(91.52)			
No	5(11.63)	6(7.5)	3(7.14)	14(8.49)	0.744	2	0.689
Total	43(100)	80(100)	42(100)	165(100)			
Reasons to absconding							
Drought	16(37.21)	40(50)	12(28.57)	68(41.2)			
Shortage of food	18(41.86)	20(25)	0	38(23.03)			
Pest and predator	9(20.93)	10(12.5)	0	19(11.52)	81.485	2	0.0001
Queen failure	0	10(11.25)	30(71.43)	39(23.64)			
Total	43(100)	80(100)	42(100)	165(100)			
Controlling method							
Feeding	39(90.69)	60(75)	27(64.29)	126(76.36)			
Frequent Inspection	4(9.3)	20(25)	15(35.7)	39(23.64)	8.372	2	0.015
Total	43(100)	80(100)	42(100)	165(100)			

4.10 .Honey Bee Character Described by Beekeepers in the Study Area

Beekeepers claimed that there was a strong positive relationship between characteristics and productivity of bee. Based on their indigenous knowledge, beekeepers have their own methods of categorizing their honeybees, mostly based on the color of the bees. According to respondent responses there were three color types owned which are identified as red (Shimbrie) which is nearly yellow (18.79%), black also known as haadicho diisho (57.88%) and Wanzie sometime called mixed color (23.64%). The black (haadicho) is the dominant honeybees in the all agro-ecologies. Beekeepers further described the behavior of the honeybees that the red ones are more aggressive, productive and smaller in size and have less absconding and swarming behavior than the black ones, this might be the aggressive bee was defensive to their territory than docile counterparts, while the Wanzie honeybees are preferred by beekeepers might be due to their assumption that this variety has gentle or docile behavior. The black (haadicho) honeybee was characterized as tolerant to starvation or dearth problem as the other types of honeybees with big body size. This finding was similar to the results of (Awraris *etal.*, 2012) and Kiros and Tsegay (2017) who reported that, red honeybees were more aggressive, productive and smaller in size and have less absconding and swarming behavior than the black and Wanzie honeybees.

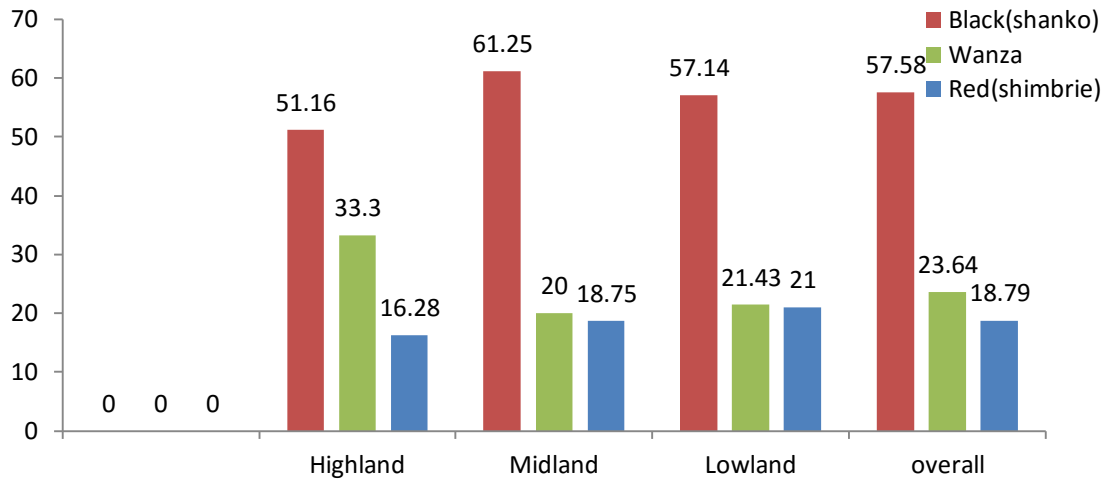


Figure.5 Characterization of honeybees by their color

4.11. Hive products harvesting

Two honey harvesting periods were understood from the study area; the main harvesting period was during October to November and the second was between May to June. The respondents further explained that, little amount of honey products are harvested in second harvesting and depends on the nature of yearly rainfall condition. Most traditional beekeepers are also determined harvesting periods of honey through the experience they developed in their respective areas. The different indicators used by beekeepers for identifying honey ripening were: smelling of honey, accumulation of bees around the entrance of hives, end of flowering season and assessing weight of the hive/full of hive. Honey produced in traditional and transitional hives is usually harvested at night in order to avoid the aggressiveness of honeybee during day lightbut in modern hive honey can be produced day or night . However, it is not easy to work well in the dark. Light must be provided and this definitely requires an extra hand to assist in the operations. Smoke is blown into the opened hive so that the bees leave the honey combs. Out of respondents, higher use of smoke (36%) of them used worn out cloth and straw grass the rest for smoke in 12.12% inset product and 15.15% cow dung all agro-ecologies during honey harvesting due to its length of smoking (Table 14).

In contrary to this, reported that, smoky fire employed while harvesting honey may dust the honey with ash and the honey may absorb the smoke which might cause contamination to the honey produced(Kebede ,2016)and (JOY, 2023). Such honey tastes could be bitter and smoky and cannot meet standards of international markets. During honey harvesting from traditional hives, beekeepers cut and pull the fixed combs one by one. Pollen, brood and honey combs were removed and kept in a container and covered with a lid. While in the case of top bar hives or chefeka the beekeeper selects combs which contain ripe honey covered with a fine layer of white beeswax, usually those nearest to the rear part of the hives. Combs containing pollen and developing bees are left undisturbed. During harvesting the honeybees are brushed from the combs with a brush made from dried grasses.

During harvesting the honeybees are brushed from the combs with a brush made from dried grasses. About 83.03% of the respondents were leave 1-2 honey comb and the other 16.97% of the respondents harvested all of the honey combs (Table 14). In case of movable frame hives, beekeepers indicated that during honey harvesting, frames are removed from the boxes and uncapped with the fork. The empty honeycombs are then returned to the hive. Because the combs are recycled, bees put effort into honey production rather than beeswax comb building. During the study, beekeepers using movable frame hives reported to have shortage of honey extractor and lack of access to strainer. The respondents in the survey

revealed that, honey is the major type (70.3%) of hive products harvested in the study area; whereas the other 28.49% and 21.2% is covered beeswax and honeybee colony but honey bee colony to establish another colony (Table 14). The reasons for non-involvement in wax production were: lack of processing skill (56.36%), lack of market (19.39%) and lack of processing material (24.24%). This finding is higher than that of (Tessema *etal.*, 2017) who observed underutilization of wax by 39.3% of beekeepers as they don't know the value as income source in Amhara region, Gubalafato.

Table 14. Honey harvesting time, method and smoking material used in the study areas

Smoking materials	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2	Df	P
cow dung	1(2.32)	15(18.75)	9(21.43)	25(15.15)			
Worn out cloth	14(32.56)	42(52.56)	4(9.5)	60(36.36)			
Straw/grass	24(55.8)	15((18.7)	21(50)	60(36.36)	36.352	6	0.0001
Inset product/Haanxe	4(9.3)	8(10)	8(19.05)	20(12.12)			
Total	43(100)	80(100)	42(100)	165(100)			
Harvesting method							
Leave1-2comb	35(81.395)	74(792.5)	28(66.67)	137(83.03)			
Harvest all comb	8(18.6)	6(16.97)	14(33.3)	28(16.97)	13.155	2	0.001
Total	43(100)	80(100)	42(100)	165(100)			
Hive product harvested							
Honey	28(65.12)	50(62.5)	35(90.48)	116(70.3)			
Beeswax	13(30.23)	30(37.5)	4(9.52)	47(28.49)	16.593	4	0.002
Honey bee colony	2(4.65)	0	3(4.76)	5(3.03)			
Total	43(100)	80(100)	42(100)	165(100)			
Non involve wax production							
Lack of processing skill	31(72.09)	4o(50)	22(52.38)	93(56.36)			
Lack of market	12(27.91)	20(25)	0	32(19.39)	33.54	4	0.0001
Lack of process material	0	20(25)	20(47.62)	40(24.2)			
Total	43(100)	80(100)	42(100)	165(100)			

$X^{2=}$chi-square, df,=degree of freedom and p=statically significance level

4.12. The Measurement of Honey Yield

The major proportions of household honey products from low land (47.62%), high land (66.67%) and mid land (17.5%) harvest less than 50 kg followed by the range of 51 to 100 kg. Thus, the major shares of honey production across the three agro-ecologies were less than 50 kg per household. The result also further indicated that, honey production and productivity per hive were decreasing in the study area (Table 15) which is in contrary to (Sebsib and Yibrah , 2018) who showed an increasing trend in the country even though the beekeepers were using traditional beehives and low productive systems. However, the result is in line with the findings of (Gebremedhin, 2020) chena district, kaffa zone, southern nation, nationalities and peoples region.

The amount of honey produced from one bee hive per year varies from places to places, which in most cases is determined by the existences of plenty of pollen and nectar source plants and the level of management and input applied. The survey result revealed that, movable beehive recorded the highest honey production/hive/year from mid land (20.26 kg), high land (18 kg) and lowland (17.47kg) agro-ecologies. On the other hand, the overall mean average honey productivity from traditional beehives was 6.26 kg/hive/year which is very low compared with the movable beehives that is similar with (Table 16)and contrary with(table 15). The respondents further explained that, depending on seasonality and size of the beehives, some farmers indicated that a well-managed traditional beehive can produce up to 10 kg of honey/year/hive. Even though the product volume and quality is lower compared with the other beehive types, beekeepers were preferred traditional hives for its low input price, low wage rate, convenience to construct, quantity of wax produced and less dependency on external inputs and convenient to be used as a bait hive. This is strongly agreed with the findings of (Abera ., 2023), Tessega (2009), (Alemayehu *etal.*, 2021) and The highest productivity of honey was recorded from movable/frame hives across the three agro-ecologies and its overall productivities were ranges from 15 to 25 kg/year. Whereas the lowest productivity was recorded from traditional beehives and transitional beehives were in between the two and chefeka hive was between top bar and frame hive. Thus, the overall mean maximum and minimum amount of honey harvested from traditional, Ethioribrab, transitional and movable frame hive were ranges between 1-15, 8-18 kg and 15-25 kg/hive/year, respectively (Table 15).

This result is similar with (Gebremedhin, 2020) range of reports. However, the findings of transitional and movable hive products were greater than the finding of Fikiru (2015) who reported 8 and 9 kg from transitional and movable beehives in Jigjiga zone, Ethiopia, respectively. However, it is lower than the result reported from Central Tigray region (Haftu et al., 2014). In addition, traditional hive's honey production in this study is lower than the result obtained from Kilte Awlealo district of Tigray region and the national average ((Yetimwork *etal.*, 2015); (Teshome and Getu ,2016)). The main reasons for low adoption rate or challenging for having the transitional and modern hive were lack of awareness and initial capital limitation. Similarly (Mewcha Berhe1, 2016)) in their study reported that, lack of know-how on how to operate modern hive and lack of awareness about its benefits were the main reasons for the dependence of traditional hives than the modern hives.

Table 15 Average annually honey yield per household

Annually honey yield/house hold(kg)	High land F(%)	Midland F(%)	Lowland F (%)	Over all F (%)	X^2	Df	P
≤50kg	28(66.67)	14(17.5)	20(47.62)	62(37.58)	33.416	4	0.0001
51-100kg	10(23.25)	36(45)	7(16.67)	53(32.12)			
101-180kg and above	5(11.63)	30(37.5)	15(35.7)	50(30.3)			
Total	43(100)	80(100	42(100)	165(100)			

Table 16. The mean honey yield annually in different hive types in different agro-ecology

Agro ecology		**Traditional**	**Transitional**	**Frame**	**Ethioribrab**
Highland		5.56±3.018	9.6±4.147	10.53±5.382	11.42±5.675
Midland		5.85±3.218	10.02±4.808	12.44±7.076	11.73±6.348
Lowland		5.74±2.795	8.86±4.852	12.55±6.612	11.02±6.218
Over all		5.75±3.048	9.62±4.563	11.97±6.573	11.47±6.116
P		0.881			

Table 17. Frequency of honey harvesting in the study area

Parameter	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
Once	23(53.49)	50(62.5)	21(50)	94(56.97)	2.14	4	0.71
Twice	16(37.21)	25(31.25)	17(40.48)	58(35.15)			
Three times	4(9.3)	5(6.25)	4(9.524)	13(7.88)			
Total	43(100)	80(100)	42(100)	165(100)			

Based on the results of this study, honey was harvested once or twice, and in some cases even three times which indicates that the study area has a high potential for honey production which might be attributed to provision of supplementary feed for their bee colonies during the dry season, and to the seasonal follow up as well as proper colony management practices.. This result is in contrary to Tamiru and Jinanus (2016) who reported 13% once, 76% twice and 11% three times per year in Ambo District, West Shoa zone, Oromia Regional State, Ethiopia. In addition, it was also in contrary to the findings of Kiros and Tsegaye, (2017) who reported more honey harvesting frequency in modern hive than in the traditional hive in Eastern Tigray region, Ethiopia. (Dinka,& Kumsa, 2016)

4.13. Post-Harvest Handling of Honey

It is evident from Table 18, beekeepers in the study area do not process honey before they sale. However, the basic processing practice is to chunk the comb honey into a liquid mixture using direct heating and sunlight to melt honeybut most time sunlight is not enough to use electric or fire heat to put honey comb on the equipment. The survey result revealed that, more than 71.51% of the respondents had no straining practice and only 28.48%have straining practice. The respondent who strained honey in the study area explained that, using hand were the major (65.46%) materials which were used for straining the honey. The respondent further explained that, the reason for not straining honey was more due to the lack of knowledge (36.36%) followed by lack of straining materials (26.06%). This result is in agreement with the reports of (Kebede, 2011) who reported the same result in his study.

Table 18. Response of households on honey storage and processing material

Do you strain honey?	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
Yes	12(27.91)	30(37.5)	5(11.91)	47(28.49)	8.867	2	0.12
No	31(72.1)	50(62.5)	37(88.095)	118(71.52)			
Total	43(100)	80(100)	42(100)	165(100)			
Reason of strain							
Consumer preference	19(44.12)	30(37.5)	12(28.57)	61(36.97)	15.66	10	0.11
Get high price	24(55.8)	50(62.5)	30(71.43)	104(63.03)			
Total	43(100)	80(100)	42(100)	165(100)			
Reason for not straining							
Lack of material	11(25.58)	18(22.5)	16(38.09)	45(27.27)			
Lack of Knowledge	14(32.56)	28(35)	16(42.86)	58(35.15)			
Consumers preference	3(6.98)	12(15)	3(7.14)	18(10.91)			
Consumer not prefer	0	1(1.25)	0	1(0.6)			
Amount of honey will have reduced	6(13.95)	3(3.75)	5(11.9)	14(8.49)			
Get high price	9	18	2	29(17.58)			
Total	43(100)	80(100)	42(100)	165(100)			
Material used for straining							
Honey extractor	2(4.65)	9(11.25)	2(4.76)	13(7.88)	14.227	8	0.078
Clothes	16(37.22)	15(18.75)	6(14.29)	37(22.42			
Sieve	0	2(2.5)	0	2(1.212)			
Decantation	0	4(5)	1(2.38)	5(3.03)			
Using hand	25(58.14)	50(62.5)	33(78.57)	108(65.46)			

Total	43(100)	80(100)	42(100)	165(100)

4.13.1 The reason of honey harvesting and storage material

Honey is mostly harvested prior to the harvesting period of major food and cash crops to satisfy their immediate cash need to cover taxes and fertilizer loan. The result indicated that, majority (67.27%) of the respondents sell their honey products immediately after harvest. Only 9.7% of the respondents were reported to store their honey products more than one year. This value is greater than the finding of Alemayehu (2016) who reported 36.2% in Silte district.

Some beekeepers who have no pressing problems, keep their honey for prolonged period time to get better price. About 56.97% of the respondents stored their honey products in plastic containers followed by earth pot (22.42%). However, except for the stainless steel containers, most storage materials aforementioned are technically not appropriate storage containers as they result in serious quality deterioration even in the study area most of bee keeper store their honey in plastic container (Table 19). Beekeeping respondents reported that, the major purpose of storing honey in storage was for medicine (43.63%) and the other respondents were for saving more currency (13.3%), for beverage (26.06%) and home consumption (16.97%). Furthermore, the survey result indicated that about 65.46% of respondents were practiced honey crystallization (Table 19).

Table 19. Response of households on honey storage period, honey storage material, reason of honey storage..

Honey storage period	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2 F (%)	Df	P
Sell immediately harvest	31(72.09)	50(62.5)	30(62.5)	111(67.27)			
One to six months	4(9.3)	25(31.25)	5(11.91)	34(20.61)	24.894	6	0.0001
Seven to twelve months	8(18.61)	1(1.25)	7(16.67)	16(9.7)			
One to three years	0	4(5)	0	4(2.42)			
Total	43(100)	80(100)	42(100)	165(100)			
Storage material/container used							
Gourd	2(4.65)	5(6.25)	0	7(4.24)			
Earth pot	7(16.28)	30(37.5)	0	37(22.42)			
Tin/ stainless steel/	0	24(30)	0	24(14.55)	81.528	8	0.0001
Plastic container	34(79.07)	21(26.25)	39(92.86)	94(56.97)			
Animal skin	0	0	3(7.143)	3(1.82)			
Total	42(100)	80(100)	42(100)	165(100)			
Reason of honey store?							
Medical purpose	1(2.3)	41(51.25)	30(71.43)	72(43.64)			
Home consumption	0	16(20)	12(28.57)	28(16.97)			
To save more currency	12(27.91)	10(12.5)	0	22(13.3)	94.268	6	0.0001
For beverage	30(69.76)	13(16.25)	0	43(26.06)			
Total	43(100)	80(100)	42(100)	165(100)			
Honey crystallization?							
Yes	32(74.4)	60(75)	16(38.1)	108(65.46)			

No	11(25.58)	20(25)	26(61.91)	57(34.55)	18.655	2	0.0001
Total	42(100)	80(100)	42(100)	165(100)			

4.14. Marketing of Hive Products and Colony in the Study Area

Table 20 indicated that, although the potential for honey production in study area is high, there is a limited supply of honey due to low yield and poor production practice. About 7.27% of the sampled beekeepers sold their products in major market place followed by home (52.73%) and nearby market place (40%). This idea is in line with (Gemechis 2016) reports about 90% of the honey production is sold either collectors (near village/town markets), or the beekeepers associate to form cooperatives for production and marketing to control and develop their businesses or The remaining 10% are consumed by the beekeeping households (Serda et al. ,2015). Thus, honey is more commercialized in the district. This result agrees with the findings of (Benyam *etal.*, 2021), (Chala Kinat *etal.*, 2013). Although both women and men were involved in honey marketing, the major (93.3%) responsibilities were covered by men and the remaining 6.67% were covered women. Alomst half of honey buyers in the study area were tejhouses (49.1%). This might be due to the lack of formal market linkage between all other market actors and as a solution; honey producers could sell their products for individual consumers and 'Tej' brewery at lower price. Similarly, in Bilate and Gorche districts of Sidama region, half (49.1%) of honey producers were sold their products directly to their tej houses (Table 20). About 43.03% of respondents reported that, season of the year were the major honey price factor in the study area. The price of honey in the study area was reported to vary depending on seasons of the year, color, taste and purity.

According to the interviewed respondents, the most demanded honey was light (white) in color, sweet in taste and pure. Honey was considered to be pure if it had fewer amounts of impurities (wing of honeybees, wax, dead adult bees and brood). Distance from market is the other factor which affects the price of honey to a lesser extent in the study area. Based on color, honey in the study area is classified into three types: white, yellow and red. The respondents further reported that, honey price always decreases during main harvesting season (November to December) and increase in the other months of the year. Moreover, there was no defined links and proper market channels established so far in the study area (Table 20). The respondents revealed that, the price of honey in the study area is increasing from year to year due to increasing demand of honey, increasing consumer number and slower growth rate of honey production. The average price of honey during production season of the study period (2023 and 2024) was 150-200 ETB/kg for honey from traditional hives, and 350-400 ETB /kg, for honey from transitional and movable

hives, respectively. The price of bee colony is much more not familiarized in Bilate and Gorchedistrict. But it also showed that bee colony selling or buying is uncommon most of the respondent but there were some respondent beekeepers that started beekeeping by buying bee colony. The price of one bee colony ranges of ETB750-800 birr in Bilate and Gorche district. This finding agree with Tessega (2009) ,(Gebretsadik *etal*., 2012) reports that majority of beekeepers initiated beekeeping through swarm catching in Burie district of Amhara region and Gomma district of Oromia Region, respectively. This fact may be attributed to decrease in trend of honeybee colonies due to environmental degradation, intensification of agriculture, poisoning of honeybees and increased attention/demand to beekeeping sub-sector by the government and involving of non-beekeepers through improved beekeeping practices. Table 19 honey market place and customers in the study area.

Table 20. Response of households on honey market place, honey customer, honey price

Honey market	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
At home	16(37.21)	45(56.25)	26(61.91)	87(52.73)	8.718	4	0.067
Nearby market	25(58.14)	29(36.25)	12(28.57)	66(40)			
Major market place	2(4.65)	6(7.5)	4(9.52)	12(7.27)			
Total	43(100)	80(100)	42(100)	165(100)			
customer's	Highland	Midland	Lowland	Over all	X^2	Df	P
Whole sellers	4(9.3)	0	4(9.52)	8(4.85)			
Tej houses	9(20.93)	34(42.5)	38(90.48)	81(49.1)			
Direct consumers	24(55.8)``	39(48.75)	0	63(38.18)	64.378	8	0.0001
Middle men	0	4(5)	0	4(2.42)			
Retailers	6(13.95)	3(3.75)	0	9(5.46)			
Total	43(100)	80(100)	42(100)	165(100)			
Honey price Factor	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)	X^2	Df	P
Season of the year	28(65.12)	31(38.75)	12(28.57)	71(43.03)			
Quality	8(18.61)	16(20)	4(9.52)	28(16.970			

Color and test	3(6.98)	5(6.25)	11(26.19)	19(11.52)	27.196	6	0.0001
Distance from market	4(9.3)	28(35)	15(35.7)	47(28.49)			
Total	43(100)	80(100)	42(100)	165(100)			
Honey trade including	Highland	Midland	Lowland	Overall	X^2	Df	P
Men	37(86.047)	78(97.5)	39(92.86)	154(93.3)			
Women	6(13.95)	2(2.5)	3(7.14)	11(6.67)	5.917	2	0.052
Total	43(100)	80(100)	42(100)	165(100)			

Where x^2=chi-squares, df=degree of freedom and p=significant level

The survey source June 2023 to December 2024

4.14 Honey Bee Colony and Income

Honeybee colony marketing is not known practice in the study district. Basically colonies were not carried to market and it is not done at village level when a beekeeper household decides to get their own colony for catching swarm (Tessega (2009). Honey and bees-wax are the two main products harvested by the interviewed beekeepers.

The survey result indicated that, the major income (43.75%) , (47.62%) and 16.28 obtained from hive products in the mid land , lowland and highland agro-ecology were 1,001-6,000 birr but in case of less than 1000birr most of bee keeper in high land agro-ecology.The10000birr and above income in highland(4.65%),midland(7.5%)and lowland(19.05%).

Thus, the overall average annual gross income of the interviewed respondents from beekeeping was ETB 4746.573 /household (birr /year) (Table 21). This result is higher than the finding of (Kebede, 2011) who was reported that Birr 2472.30 /household in Siltie district Southern region, Ethiopia.

Table 21. Response of households on annually honey yield per household per agro-ecology

Income category	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2	Df	P
≤1000birr	30(67.77)	12(15)	6(14.29)	48(29.09)	53.099	6	0.0001
1001-6000birr	7(16.28)	35(43.75)	20(47.62)	62(37.58)			
6001-10000birr	4(9.3)	27(33.75)	8(19.05)	39(23.64)			
≥10000birr	2(4.65)	6(7.5)	8(19.05)	16(9.696)			

Total	43(100)	80(100)	42(100)	165(100)
Mean income annually per household	2346.548	5337.225	6021.548	4746.573

Where x^2=chi-square, df=degree of freedom and p=significant level

4.15. District's Honey Bee Flora

Beekeeping is a livestock production that has provided honey and other bee products for thousands of years (Coline Kochiner , 2019). Survey conducted in Bilate and Gorche district showed that, the cultivated and natural honey flora potential of the area makes it very favorable for beekeeping. In general, naturally growing plants occupy quite a large variety and proportions than cultivated crops (Dinku and Bereket, 2019). In the district the major honey flow season is from October to November and the minor flow season is from May to June, and it depends upon the availability of bee forage that in return depends on the amount of rainfall. Interviewed beekeepers were asked to list major honey plants in their localities. Some important honeybee plants of the study areas mentioned and described by respondents are recorded in vernacular (common) and scientific names with their flowering calendars (Table 22). The scientific names were determined using reference books of (Gebremedhn and Teame, 2015). However, the respondents indicated that, even though there were different types of bee plants in honey flora seasons, there is a shortage of bee food during the dry seasons especially in lowland areas where ground and surface water resources are scarce. They also reported the current declining trend in bee forages as compared to the past period due to the degradation of forest and expansion of cultivated lands in the area. To alleviate the shortage of honey flora, protection and conservation of natural vegetation and plantation of bee forage in farm boundaries and homestead, using multipurpose bee forage species need to be promoted. Moreover, the positive impact of grazing area enclosures needs to be encouraged.

Table 22. Response of households on the common flora types in the study area

Common name flora	Scientific name flora	Type of the plant (tree, shrub or herbs)	Flowering time/month	Source(pollen and nectar)
. Gerawa	*Vernonia Spp*	Tree	December	Pollen and nectar
Masincho	*Croton macrostachyus*	Tree	May	Pollen and nectar
.Adal-bole	*Bidens spp*	Herbs	October	Pollen and nectar
.Avocado	*Persea americana Mill*	Tree	September-December	Pollen and nectar
Mango	*Mangifera indica*	Tree	September-December	Pollen
Duume bahiriza	*Eucalyptus camaldlensis*	Tree	March-June	Pollen and nectar
.Buna	*Coffe arrabica*	Tree	January-February	Nectar
.wadicho	*Cordita Africana*	Tree	June-july	Pollen and nectar
Rejicho	*Vernonia figiera olive*	Tree	May	Pollen
.Badala	*Zea mays*	Crops	June-august	Pollen
.Waacco	*Acacia albida*	Tree	May	Pollen and nectar
Bakela	*Vicia faba*	Crops	September-November	Pollen and nectar
.Mashila	*Sorghum bicolor*	Crops	September-November	Pollen and nectar
.Gomen	*Brassica carinata*	Crop	June-November	Pollen and nectar
.Sesbania	*Sesbania sesban*	Crop	November-January	Pollen and nectar
.Xaddo	*Rhamnussp*	Shrubs	March-April	Pollen and nectar
Atar	*Pisum sativum*	Crops	September-November	Pollen and nectar
.Hooncho	*Juniperus procera*	Tree	May	Pollen and nectar

.Maaxe	*Euphorbia abyssinica*	Shrubs	September-November	Pollen and nectar
.Chat	*Catha edulis*	Tree	July-October	Pollen and nectar
.Ejersa	*Olea Africana*	Tree	September-December	Pollen and nectar
.Hadda	*Guizotia scabra sub sp*	Herb	Year round	Pollen and nectar
Warka	*Piscus Species*	March	March	
.Dinich	*Cicerarietinum*	Crops	September-November	Pollen and nectar
.Muzi	*Musa paradisca*	Tree	September-October	Pollen and nectar
.Papaya	*Carica papaya*	Tree	September to November	Pollen and nectar
.Zeyitonia	*Psidium sp*	Tree	March	Pollenand nectar

4.15.1 Honey Bee Enemies and Poisons in Study Area

4.15.2 Pests and Predators

It is a known fact that, like all living things honeybees are attacked by various enemies directly as predators, or indirectly by disturbing the life of the colony in various ways at all stages of their development. The most important of these enemies are those that destroy the combs, the stores, the hive itself and some predators attack foraging worker bees as they leave the hive. The most common enemies reported in the study area were ants, birds, wax moth, lizard, spider, wasps, honey badger (shelemtemate in Amharic), beetles, bee lice and prey monts.

The occurrence of honeybee pests for all agro-ecologies (lowland, midland and high land) were similar, except for prevalence of wax moth in mid land and to some extent in low land area of the district. According to the respondents ranking, birds were number one predators (1^{st}) followed by ants (2^{nd}) which attack the bees mainly during the rainy seasons when there is no grain to feed the bees that rank worked based population responses of frequency (Table 23). Almost all of the farmers reported that pests and predators attack results in a considerable amount of honey loss

and absconding of colonies. The result of the present study is in line with the findings of Meseret and Abera (2018) who reported ants, honey badger, bee-eater birds, wax-moth and spiders as the major honeybee pests and enemies in Adet district Amhara region. The result was also supported by the study of Gidey *et al*. (2012), Tekilu and Dinku (2016) and Gebrewahd *et al.* (2018) who reported bee pests, predators and absconding were the major constraints affecting honey sub-sector in northern Ethiopia. In the study area, some of the methods used by the respondents to prevent enemies were: keeping the apiary clean from under growth, avoiding scattering combs around the apiary site, application of ash around the hive stand, plastering the hive stand with plastic materials, finding and killing predators like bee-eater birds and the queen of ants. None of the interviewed beekeepers responded for the availability of bee diseases in the area which could be due to its absence/lack of awareness symptoms of bee diseases.

Table 23. The pests and predator of honey bee in the study areas

Honey bee enemies	Highland	Midland	Lowland	Overall	X^2	Df	P
Ants	0	17(21(	10(23.81)	27(16.36)	81.554	18	0.0001
Birds	14(32.56)	32(40)	10(23.81)	56(33.94)			
Wax moth	10(23.26)	0	0	10(6.06)			
Lizards	0	5(6.25)	8(19.05)	13(7.88)			
Spider	0	5(6.25)	8(2(4.762)	7(4.24)			
Badger	1(2.3)	4(5)	5(11.91)	10(6.06)			
Wasps	0	5(6.25)	4(9.52)	7(4.24)			
Beetles	3(6.98)	4(5)	3(7.14)	10(6.061)			
Bee lice	6(13.95)	2(2.5)	0	8(4.85)			
Preymonts	9(20.93)	6(7.5)	0	15(9.09)			
Total	43(100)	80(100)	40(100)	165(165)			

Honey bee enemies	Rank
Birds	1st
Ants	2nd
Preymonts	3rd
Lizard	4rth
Wax moth, Badger and beetle	5th
Beelice	6th
Spider, wasps	7th

4.1 5.3 Poisonous plants in the study area

The beekeepers were asked whether their bees get incidence of poisoning or not. About 51.52% of the respondents used herbicides and pesticides to control crop and livestock pests and diseases. About 91.2.0% of the interviewed households reported that, bee poisoning occurs due to the use of agro-chemicals mainly for weed control and the other 4.24 % notified that honeybee poisoning occurs due to the use red flower. The time of application varied but was usually between June and September. Majority of beekeepers appeared to be aware of the toxicity of insecticide and herbicides to bees. None of the beekeepers, however, are taking any measures to protect their bees from the sprayed chemicals. On the other hand, several plants that are traditionally used as source of pollen and nectar in the area are declining from time to time due to application of herbicides.

Therefore, it is of paramount importance to employ integrated pest management techniques and use of lesser hazardous chemicals to control pests and predators as well as increase soil fertility and agricultural productivity whilst enhancing forage resources for bees and livestock. In the study area, it was observed that the knowledge of beekeeper regarding the damage caused by poisonous bee plants on honey bees was comparatively very limited. Only deaths of field bees were reported under or around the suspected plants by beekeepers like *Bisan (Croton macrostachys), Semiza (Justitia schemperina) and Kulkual (Euphorbia spp. The level of poisoning honey bee it kills with any place and found to dead bee without any reason.*

Table 24. Response of households on the poisonous of honey bee

Source of Poisons to honey bee	Highland F(%)	Midland F(%)	Lowland F(%)	Over all	X^2	Df	P
Herbicide and pesticide	39(90.69)	78(97.5)	41(97.62)	158(95.75)	18.21	4	0.001
Red flower	4(9.32)	2(2.5)	1(2.38)	7(4.24)			
Total	43(100)	80(100)	42(100)	165(100)			
Agro-chemical poisonous honey bee?	Highland F (%)	Midland F (%)	Lowland F (%)	Over all F (%)			
Yes	39(90.69)	75(93.79)	37(88.09)	151(91.52)	9.238	2	0.01
No	4(9.3)	5(6.25)	5(11.91)	14(7.88)			
Total	43(100)	80(100)	42(100)	165(100)			

4.16 .Locally available beekeeping equipment in the district

Local equipment such as a smoker, and knife and water sprayers were produced by beekeepers in the study area by local way at the moment of honey harvesting. Among which, smoker (89.69%), knife (91.7%), hives (83.9%) and bee brush (80.6%) were predominately made locally as compared to other bee equipment. Bee brush was the least equipment which can be made by bee keepers and queen catcher cannot be made locally and they are not known how to make. As it was mentioned in the group discussion, some equipment such as casting mold and honey extractor are not made locally. These are either purchased or donated by government and non-governmental organizations. During the study period there were no honey extractors and casting molds within Bilate and Gorche district but other equipment either made local or government donated belongs in the hands of beekeeper. This finding indicated that majority of the beekeepers face limitation to access of casting mold and honey extractors, in addition queen catcher also not distributed all beekeeper, unfortunately responsible body should take responsibility and dispensable to these equipment because consider improved beekeeping practices cannot be successful unless and otherwise. The major reasons behind the limited use of beekeeping accessories by the respondents were their unavailability and high cost which were found to be the key limiting factors.

Therefore, the adoption of improved beekeeping practices also relies on the supply of these basic materials. It is evident from Fikiru (2015) effective colony management requires the use of appropriate equipment and accessories. The growth of the apiculture sub-sector in terms of efficiency and productivity is mainly dependent on technology inputs. Similar findings were reported in Ethiopia by (Tewodros, 2015), Kebede (2011) and Kiros and Tsegay (2017) in Sekota districts of Amhara, Siltie district of SNNPRS and Eastern Tigray, respectively

Table 25. Response of households on local available honey bee equipment

	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2 F (%)	Df	P
Do you make smoker?							
Yes	38((88.37)	74(92.5)	36(85.7)	148(89.69)			
No	5(11.63)	6(7.5)	6(14.29)	17(10.3)			
Total	43(100)	80(100)	42(100)	165(100)			
Do you have queen catcher?							
Yes	26(60.46)	54(67.5)	24(57.14)	104(63.03)	1.432	2	0.489
No	17(39.54)	26(39.54)	18(42.24)	61(36.97)			
Total	43(100)	80(100)	42(100)	165(100)			
Do you make honey Extractor and casting mold?							
Yes	-	-	-	-	Constant		
No	43(100)	80(100)	42(100)	165(100)			
Total	43(100)	80(100)	42(100)	165(100)			
Do you make bee brush?							
Yes	23(53.48)	30(37.5)	20(47.62)	72(43.64)	3.159	2	0.206
No	20(46.5)	50(62.5)	22(52.38)	92(55.76)			
Total	43(100)	80(100)	42(100)	165(100)			
Do you make bee brush ?	Highland F(%)	Midland F(%)	Lowland F(%)	Overall F(%)	X^2	Df	
Yes	32(74.4)	75(93.75)	26(61.91)	133(80.6)	19.291	2	0.0001
NO	11(25.58)	5(6.25)	16(38.09)	32(19.39)			

Total	43(100)	80(100)	42(100)	165(100)			
Do you construct beehive ?							
Yes	39(90.69)	71(87.75)	35(83.3)	145(87.8)	1.192	2	0.552
No	4(9.3)	9(11.25)	7(16.67)	20(12.12)			
Total	43(100)	80(100)	42(100)	165(100)			
Do you make Knife?							
Yes	33(76.74)	60(75)	31(73.81)	124(75.15)	12.578	2	0.001
No	10(23.25)	20(25)	11(26.19)	41(24.85)			
Total	43(100)	80(100)	42(100)	165(100)			

4.16 .Access To Credit, Beekeeping Extension and Training

Access to credit, extension and training are the most important factors that promote beekeeping development and thereby increase income of the producers. According to the respondent's opinion, the effort made so far in facilitating the beekeepers access to appropriate technologies by provision of credit services was minimal. All of the sampled households pointed out that they need credit for honey production activities but not give credity any organization about honey production how ever get other agricultural activities like distribution of plote during agricultural working. This result is completely disagreed with the finding of Fikiru (2015) who reported that 14.3% beekeeper got credit access in Jigjiga Zone, Somali Regional State of Ethiopia. The main reasons for poor beekeepers in need of credit service were due to the poor extension services in the study area. Therefore, establishing a sustainable provision of extension system for credit as seed money to the resource poor beekeepers should be given due attention in devising apiculture development programs in the study area. The study revealed that, majority (91.52%) of the respondents has not had any contact with extension agents but some of them has contact with extension agent (Table 26).

Which indicates the extension service was not playing adequate roles in promoting the apiculture sector in the study area. Moreover, the extension workers themselves need to be well equipped with skill and knowledge in beekeeping technology to give effective services for the beekeepers. The extension services delivered to the beekeepers in the study area were provision of inputs (like smoker, hives, beeswax, extractor, and casting mold), field observation, training and follow up, provision of starter colony and money. The above result showed that the beekeeping extension service delivered is still at infant stage or the service was professionally biased to other field of studies. The results of this study were different from the findings of Yetimwork (2015) who reported about 75% beekeepers who received beekeeping extension service. However, it was similar with the result of Adebabay *et al.* (2013) who reported only 33.2% respondents had the chance of getting extension service delivery in their study area.

Beekeeping training develops the beekeepers' self-confidence in the technology and increases the productivity of the hive products. The study indicated that, only 15.15% have taken beekeeping training from the agriculture, livestock and fishery office and some concerned nongovernmental on bee management, bee feeding, harvesting and honey handling, selecting

apiary site and handling, properties and uses of bee products. However, about 84.85% of the respondents have no access to training in the area of beekeeping (Table 24). As a result, the majority of the beekeepers were only using their indigenous knowledge for beekeeping activities. This result agreed with the findings of Kebede (2011) who reported only 36.25% respondents who had got training services, respectively. However, the result was in contrary to Kiros and Tsegaye (2017) who reported that 80% of beekeepers got training in Eastern Tigray, Ethiopia. The respondents further explained that, about 96.1% of them were in need of beekeeping training in the study area. The trained beekeepers explained that the training has helped them to improve the management of bee colonies and maintain the quality of their products. Besides, newly engaged farmers were encouraged to buy frame beehive after training because of the increased understanding about the importance of framed hive (Table 26).

Table 26. Response of households on the credit access, training and extension services

Extension	Highland F(%)	Midland F(%)	Lowland F (%)	Overall F(%)	X^2	Df	P
Yes	0	8(10)	6(14.29)	14(8.49)	6.043	2	0.049
No	43(100)	72(90)	36(85.7)	151(91.52)			
Total	43(100)	82(100)	42(100)	165(100)			
need training	Highland F(%)	Midland F(%)	Lowland F (%)	Overall F(%)	X^2	Df	P
Yes	43(100)	69(86.25)	38(90.48)	38(90.48)	6.411	2	0.041
No	0	11(13.75)	4(9.52)	4(9.52)			
Total	43(100)	80(100)	42(100)	42(100)			
Training	Highland F(%)	Midland F (%)	Lowland F (%)	Overall F (%)	X^2	Df	P
Yes	10(23.26)	9(11.25)	6(14.29)	25(15.152)	3.169	2	0.205
No	33(76.74)	71(88.75)	36(85.71)	140(84.85)			
Total	43(100)	80(100)	42(100)	165(100)			

4.17. Opportunities of Honey Production Systems

4.17.1 Availability and existence of strong bee colonies and wide experience

In the study area, most beekeepers start beekeeping by catching the swarm from the environment followed by gift from their parents and by buying bee colonies. This is because of the reason that, catching swarm obtaining from the environment is more advantageous both for cost and colonies alternatives. This explains that, the environment has good access to honey bee resource. Even though the minimum honey bee colonies holding per household in the district is one, the maximum honey bee colony holding is 70. According to the survey result about the highest (37.8%) percentage of households possess 6-10 honey bee colonies; whereas 32.8% of the households have 1-5 honey bee colonies and the rest 29.4% household have 11 up to 70 colonies. This result is in line with the finding of Alemayehu (2016) and EIAR (2017).

Table 27. Response of households on the colony holding in the study area

Colony amount	Highland F (%)	Midland F (%)	Lowland F (%)	Overall F(%)	X^2	Df	P
1-5 colony	16(37.21)	20(25)	18(42.85)	54(32.73)	5.579	4	0.233
6-10 colony	22(51.16)	50(62.5)	22(52.38)	94(56.97)			
11-70 colony	5(11.63)	10(12.5)	2(4.762)	17(10.3)			
Total	43(100)	80(100)	42(100)	165(100)			

4.17.2 Availability of honey bee floral and water resource

The survey result showed that, the cultivated and natural honey flora potential of the area makes it extremely favorable for beekeeping. The availability of multipurpose trees and shrubs in the study area has been identified not only as major sources of pollen and nectar for honeybees but also provide different services to the community. Very recently, establishment of apiaries in rehabilitated areas (closure and religious areas) are a common practice in the study area. Thus, beekeeping farmers also understood that, such activities have values for floral resources for

increased honey production and survival rate of the honeybee colonies in the study area. In the district, there are some natural spring waters and small rivers. Bilate are the perennial rivers crossing many kebeles.

4.17.3 Employment opportunity

Beekeeping sector can be done with relatively low startup capital and minimum land requirements and thereby offers high potential for outreach programme for safety net beneficiaries. Cooperative-based production schemes offer opportunity for the landless and youth on communal lands. The non-labor intensive aspects of bee-keeping are favorable for women. For those beneficiaries engaged in other types of farming, bee-keeping can complement already-existing crops by increasing production through pollination while promoting biodiversity. Honey is also a stable commodity with a relatively long shelf life, and may serve as a risk mitigation strategy and as an additional income stream (Abadi *et al.*, 2016).

4.17.4 Indigenous knowledge

In the study area, beekeeping practice has a long history, as a fact, the beekeepers have developed indigenous knowledge which was transferred from generation to generation. The major indigenous knowledge of the respondents in the study area were, hive construction from locally available materials, swarm catching, and construction of hive fumigation materials, swarming season identification, identification of important honeybee floras, the medicinal value of honey and identification of adulterated honey in study area bee keeper can be honey adulteration by looking, handle and eating that can done only experienced person. Presence of long standing beekeeping practices and indigenous knowledge is very important to improve the existing practices than introducing new practices. Thus, their indigenous knowledge could be used as a possible entry points for intervention strategies aimed at improving.

5: SUMMARY, CONCLUSITION AND RECOMMENDATION

5.1. Summary

The Sidama Region boasts a rich beekeeping history and abundant resources for honey production. Bee keeping is an integral part of other agricultural activities. However, current honey yields remain low. This study was carried to assess the honeybee production practices, management, opportunities, and challenges across different agro-ecologies Bilate and Gorche districts of the Sidama region. A total of 165 beekeepers were purposely selected from six peasant associations of Bilate and Gorche districts. The study showed that a significant gender gap among participants, with 98.18% being male and only 1.18% female households engaged in beekeeping. Moreover, 53.3% of households demonstrated literacy, capable of reading and writing up to grades 1-12. On average, each household owned 6.92 colonies, distributed as 3.92, 8.46, and 6.95 colonies per household in lowland, midland, and highland areas, respectively. Experience levels in beekeeping varied, with 41.21% of beekeepers known over a decade of experience. The majority of respondents (60%) acquired their initial bee colonies through swarming catching. Backyards emerged as the preferred hive placement locations across all agro-ecologies, accounting for 54.14% in highland, 52.38% in lowland, and 62.5% in midland areas. Notably, a significant portion of respondents (26.06%) rarely conducted external hive inspections, while 51.52% neglected internal hive inspections. Moreover, 87.3% of respondents did not provide supplementary feed for their honeybees. In the study areas, swarming incidents were reported by 70.19% of respondents, while over 91.52% of beekeepers practiced familiarize absconding. The study showed that two main honey harvesting periods were occurred, such as from October to November and May to June. Interestingly, 71.51% of respondents did not strain their honey, choosing to sell it immediately after-harvest. Only 9.7% of respondents stored honey products for more than a year, predominantly in plastic containers (56.97%), gourds (4.24%), earth pots (22.42%), or tin/stainless steel containers (14.55%). In the study areas, honey sales were mainly conducted at home (52.73%) or nearby marketplaces (40%), with a minor proportion (7.27%) sold in major marketplaces. Insect pests such as ants, birds, wax moths, lizards, spiders, wasps, honey badgers, beetles, bee lice, and preymonts were commonly reported. The majority of respondents (51.52%) did not undertaken internal inspection of their bee colonies. The study showed that *Vernonia Spp, Croton macrostachy, Eucalptus spp, Persea Americana, Coffee arebica and Cordia africana* were some of the major honey bee plant

identified by respondents in the study districts. The major challenges of beeping were agrochemical application (herbicides/pesticides), bee predators (ant and birds), lack of market access in villages and towns , and limited market information. The main opportunities of honeybee keeping development in the study areas were existing bee colonies, extension services, abundant floral resources and water for bee, employment opportunities, and Indigenous beekeeping knowledge. Frame, top-bar, and Ethio-ribrab hives showed high honey yield potential in mid- and lowland zones.

5.2. Conclusion

Despite a long history of beekeeping and abundant resources, honey production in the Sidama region remains low. This study identified several areas for improvement, such as increased adoption of modern beehives (frame, top-bar, Ethio-ribrab) with higher honey yields, especially in mid and lowland areas. Improved beekeeping practices such as regular hive inspections to identify and address problems like swarming and absconding. Supplementary feeding during resource scarcity, honey straining for better quality and marketability. Utilizing appropriate storage containers to minimize spoilage. Used red flower, herbicides and pesticides to control crop and livestock pests and diseases honeybee poisoning occurs due to the use. The most common enemies honey bee reported in the study area were ants, birds, wax moth, lizard, spider, wasps, honey badger (shelemtemate in Amharic), beetles, bee lice and prey monts. Gourd, stanless steel, plastic material, earth pot and animal skin are locally honey storage for bee keepers. The movable beehive recorded the highest honey production/hive/year from all agro-ecology than other types of the hive. there were three color types owned which are identified as red (Shimbrie) which is nearly yellow, black also known as shanko and Wanzie sometime called mixed color.

5.3 Recommendation

Based on our study, the following recommendations are suggested for improving beekeeping practices in the study areas:

- The problem of pest particular ant should be managed using various methods.
- Enhancing the productivity and production of honey by improving the management of the traditional hives and introducing improved beehive technologies, increasing the productiveness of bee colonies by improving bee forage and providing feed and water and introducing bee plants is very important.
- Participation of women in apiculture production system should be encouraged through various support e.g. training, and credit services
- To address the knowledge and skill gap of bee keepers on colony management and hive products, practical training should be given.
- Governments and NGOs should support farmers with beekeeping business through credit service, cooperative formation, input supply and market facilitation.
- Improved beekeeping technologies with adequate practical skill should be promoted..
- Further study on honey quality and effects of agro-chemical should be examined.

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Appendix Table 1. List of respondent Questioner in the study area

9. What are your major goals' of beekeeping? a. home consumption[ ] b. for source of income/money [ ] c. for medicinal value [ ] d. for social and cultural value [ ] e. other (specify)

10. Where did/do you keep your bee colonies?

a. backyard [ ] b. under the caves of the house [ ] c. hanging on the trees near homestead [ ] d. in area enclosure[ ] e. other (specify)----------

11. Which one is more profitable to you among above?

a. Back yard [ ] b. Forest [ ] c. Under the caves of house [ ] d. Apiary site [ ] e. Others---------

12. Why you mostly choose to keep your hives in this area?

a. Easy catching swarm bee [ ] b. Good in honey production since have flora vicinity

c. Preferred by bee colony [ ] d. to protect bee from ant by placing on long tree [ ]

e. No cause damage on both man and animal [ ] others [ ] (specify) ----------

13. For how many years your bee colonies remain or stay in the hive once occupied in hive?

Traditional:		Intermediate:		Movable-frame:	
Minimum years	Maximum years	Minimum years	Maximum years	Minimum years	Maximum years

14. If you do not have modern hive what factors limit you to own it?

a. high price[ ] b. lack of information [ ] c. absence of hive in area [ ] d. difficult to work with it[ ] e. high damage by honeybee enemies[ ] f. require more management [ ] g. frequent absconding after transferring[ ] h. lack of working materials [ ] i. other (specify

15. What are the sources of beehives in your area?

No	Items	Traditional	Transitional	Movable
1	Constructed by himself/herself			
2	Constructed locally and bought			
3	Bought from market			
4	Supplied by governments			
	On credit basis			

	Free of charge			
5	Supplied by NGO's			
	On credit basis			
	Free of charge			
6	Price of one hive (ETB)			
7	Service time (years)			

16. Is it possible to make hive from all trees that locally found? a. Yes [ ] b. No [ ]

17. If your answer is no in question number 18, which tree is preferred? ----------
---

18. And why? a. Easy to make [ ] b. It used for year than others [ ] c. Based on bee colony preference [ ] d. It is good for honey production [ ] e. Easy to transport [ ] f. others specify----

19.Have you ever taken training in bee keeping?

A, yes B, No

2o. If yes your response in No19 who trained you?

A, GO B, NGO C, others

21. Did you get that the training is useful?

A. yes B. NO

22. DO You take credit?

A. Yes B,NO

23. Are you a cooperative member?

A, Yes B, No

Vegetation, honey plants and water availability

1. What is (are) the most common bee forage in your area?

No	Local/common name	Flowering months	Current distribution condition of plant		
			Excellent	Good	Poor
1					

2					
3					
4					

2. In what month the limitations of bee forage is/ are observed? ----------

3. Is there any poisonous plant to bees in your area? a. Yes [ ] b. No [ ]

4. If yes, please mention these poisonous plants and their flowering time.

No	Local/common name	Effect on bee colony	Flowering month
1			
2			
3			
4			

5. Did you plant bee forage species purposely for your bees? a. Yes [ ] b. No [ ]
6. If yes list them (1) ---------- (2) ---------- (3) ----------
7. Does water available for your honeybees at all the time? a. Yes [ ] b. No [ ]
8. If yes, what is/was the source?
   a. Rivers [ ] b. Lakes [ ] c. Ponds [ ] d. Water harvesting structure [ ] e. Others: specify ---
9. If your response is no, how do you provide water to your bee colonies? ----------
10. Did you feed your honeybee colonies? a. Yes [ ] b. No [ ]
11. If yes, when do you feed your honeybees? (Months): ----------
12. What kind of feed you offer to your honeybees?
    a. *Besso* [ ] b. *Shiro*[ ] c. Sugar syrup[ ] d. Honey + Water[ ] e. Others (specify) ----

13. Why do you hang hives on tall trees?
i. to protect theft
ii. to avoid vermin attack
iii. To make visible for swarming bees
iv. To ease pollen collection for bees v. Other

V) Competition of honey production with other forms of forest use
1. What is the effect of forest coffee production on honey production?
i. No effect ii. Slashing of undergrowth and vines decreases bee forage
iii. Coffee flowers give good honey production and stimulation of coffee growing increases bee forage
iv. People cultivating forest coffee do not allow beehives on their lands
v. Anti-fungi used for coffee are poisonous for bees
vi. Coffee generate better income than beekeeping and therefore replaces it
vii. Other, specify

14. Can you handle enset production and beekeeping on the same land use at the same time?
i. Yes, there is no any problem Yes, But _____
ii. No, Bees prevent frequent visits to home yard 75 Enset don't provide fodder It invites more ants Undergrowth cleared
iii. Other specify

15. Do you know any other crop that negatively or positively affect honey production practice? If yes, mention which crop/s and how does it affect?

VIII) Perception on the role of forest in honey production

1. Do you think forests are important for beekeeping? 1=yes; 2= no Yes (explain why) No, because 76
2. Do you think that the disappearance of forest has a negative effect on honey production?
i. Yes, why? ii. No, why?
3. Do you think that beekeeping does stimulate forest conservation? i. If yes, in what way? ii. If no, why
4. Who do you think much affected if this forest has gone?
i) Honey collector
ii) Government
iii) Cereal farmers
iv) Livestock owners v) Other

Swarm catching of Indigenous knowledge in area.

1. What mechanism do you Quse to attract the scout bee? ----------

2. Do you use different color to catch bee swarm? a. Yes [ ] b. No [ ]

3. If yes which types of color do use to attract bee colony?

a. Red [ ] b. Black [ ] c. Yellow [ ] d. White [ ] e. green [ ] f. Brown [ ]

4. Do you smoke the hive to attract the scout bee? a. Yes [ ] b. No [ ]

5. If yes list type of local tree or material used to smoke hives as attracting means?

No	Types of tree to smoke	Rank	Part of plant used
1			
2			
3			
4			

6. List the local materials, which do you, use to clean hives internally? ----------
----------7. What materials do you use for plastering hives?

a. culm sheaths of bamboo [ ] b. leave [ ] c. grass [ ] d .bark [ ] .e other; specify ----------

8. What enfolding materials do you use during plastering or covering externally your hive?

---

9. Assume that; if you placed ten hives in the forest out of those, how many hives can gate the chance of bee colony around your vicinity? ----------

10. How many hives occupied by bee colonies if you are participated in transportation of movable swarm catch area / migratory beekeeping practice? ----------

11. Is it possible to hang hive on the tree by direct hive entrance in all direction?

a .Yes[ ] b. No [ ]
12. If no which direction is preferred? ----------

13. What are the main factors, which govern direction of hive entrance? ----------
---

Occurrence of colony swarming and its Control
1. What is the frequency of swarming occur in your colonies or locality?
a. Every seasons [ ] b. once per year [ ] c. Twice per year [ ] d. Once at two years [ ] e. Others, -
2. When does swarming occur more frequently? (Months) From---------- to ----------
3. Is swarming advantageous to you? a. Yes [ ] b. No [ ]
4. If yes, describe the reason(s)
a. To increase my number of colony [ ] b. To sale and get income [ ]
c. To replace non-productive bee colonies [ ] d. Others specify:_____
5. Do you control / prevent/ swarming? a. Yes [ ] b. No [ ]
6. If yes, what methods do you use to control / prevent/ swarming?
a. Removal of queen cells [ ] b. Harvest or cut honey combs [ ]
c. suppering [ ] d. Using large volume hive [ ] e. Others, specify:_____

Bee Colony Management practice in area

1. What are major management practice do you offer to your bee colony?

a. Routine colony inspection [ ] b. Apiary management [ ] c. Division making [ ] d. Swarming control [ ] e. Colony feeding [ ] f. Pest control [ ] g. Others----------

2. If do inspect your colony which types inspection routine do you perform to your colony?

a. Internal [ ] b. External [ ] c. Both [ ]

3. How many times do you inspect your hive?
a. Every day [ ] b. Every2 or 3 days per a week [ ] c. Once per month [ ]d. Other (specify)---
4. At which season special care do you give for your bee colony?

a. Rainy season [ ] b. Dearth season [ ] c. At honey flow [ ] d.Early winter [ ] e. Early summer [ ] f. Others specify-
---

5. What are special care do you offer for your bee colony before honey harvesting to increase colony production potential?

a. Strengths colony by feeding [ ] b. Uniting Weak colony [ ] c. Change old hive cover [ ]

d. Cleaning and smoke to hive [ ] e. Transport colony to adequate be flora area [ ]

f. Discard old honey comb [ ] g. Control swarm by remove queen cell [ ] h. Make free from enemies attack [ ] i. Other specify----------

6. What is / are management taken place after honey harvested to bee colony? ----------
---

7. Is possible to transfer bee colony from tradition hives to other when it got old? Yes [ ] No [ ]

8. If yes in which month ----------

9. And how?----------
---

10. Do you have the knowledge of splitting one hive colony in to two or more hives to increase the number of your colony? Yes [ ] No [ ]

11. If your response yes in question 11, how do you perform it? ----------
---

Beekeeping Work schedule in area

No	Work activities	In month of year
1	Bee hive making	
2	Plastering hive	
3	Hang plastered hive to catch swarm	
4	Migrate empty hive to catch swarm	
5	Return back occupied hive	
6	Colony transferring in area	
7	Colony swarming	
8	Honey harvesting months	
9	Deficiency of bee flora	
10	Colony absconding month	
11	Others; specify.	

Honey harvesting in area

1. Are all honey comb and brood in the hive is harvested? a. Yes [ ] b. No [ ]

2. If no at number 1 at which parts of hive it left? ----------

3. Is there any division in traditional hive internally? a. Yes [ ] b. No [ ]

4. If yes at number 3 where? ----------

5. And what is purpose of this division? ----------

6. Is possible to harvest honey twice or more at one major bee flora? a. Yes [ ] b. No [ ]

7. If yes at number 6, how? ----------

8. Is there any technique to initiate bee colony to construct comb rapidly? a. Yes [ ] b. No [ ]

9. If yes at number 8, how it can be achieved? ----------

10. What are the mechanisms that used to determine optimum time of honey harvesting, as your experience? ---------
---

11. If honey contain brood it harvest together with honey? a. Yes [ ] b. No [ ]

12. If yes, do you think this have no any risk on both colony population and honey production?

a. Yes [ ] b. No [ ]

13. What are your major hive products?

a. Strained honey [ ] b. Crude honey [ ] c. Crude wax [ ] d. Pure wax [ ] e. propolis [ ] f. others---

Characteristics of bee colony

1. What are the characteristic features of your honeybees?
a. Behavioral. Docile [ ] 2. Aggressive [ ] c. Very aggressive [ ]
2. Color: 1. Black [ ] 2. Red[ ] 3 Grey [ ] 4. Mixture [ ]
3. Size: 1. Big [ ] Medium [ ] Small [ ]
4. Which one is productive? Behaviors: ----------, Color----------, Size--------

Honey marketing in area

1. Do you sell your honey? a. Yes [ ] b. No [ ]

2. If your response is yes, how much amount per year?

Amount honey sold in KG	Amount honey consumed directly in kg	Amount saved for medicinal value in kg	Free charge to relatives in Kg

3. Do you sell honey and wax separately? a. Yes [ ] b. No [ ]

4. If your response is yes in number 3, how you can differentiates it? ----------

5. Do you store or sell your honey immediately after harvesting?

a. Immediately sell [ ] b. Store based on price situation [ ]

c. Store only which used at home [ ] d. Others----------

6. What type of material do you use to store the honey for marketing purpose?

No	Types of honey storage Materials	most of the time	use to some extent	use rarely
1	Earthen pot			
2	Animal hide and skin			
3	Sack			

4	Plastic			
5	Jar			
6	Tin			
7	Buket			
8	Others (specify)			

7. Where do you sell your honey?
a. In your home [ ] b .Nearby market place [ ] c. Major honey market place [ ] d. Beekeepers cooperatives [ ] e. Other (specify) ----------
8. how far from you? ----------

9. How do you transport the honey to the market?
a. By using human labor [ ] b. By using animal labor [ ]

c. By using vehicles [ ] d. state if others -[ ]

10. Who are your customers?
a. Tej' houses [ ] b. Middlemen [ ] c. Retailers [ ] d. Wholesalers [ ]
e. Individual consumers [ ] f. Beekeepers co-operative [ ] g. Others/specify/_____
12. Did you get current market information before you sale your honey? Yes [ ] No [ ]

13. If your answer is yes, where is your source of information?
a. From radio [ ] b. From ministry Livestock and Fishery development [ ]
c. From District Livestock and Fishery development office [ ]
d. From honey market cooperative [ ] e. From neighbors [ ]
f. From nearby market [ ] g. state if there are other source [ ]
14. How is the price trend of honey in your locality?

a. Increasing [ ] b. Stable [ ] c. Decreasing [ ]

15. If your response is increasing in number 14, what reason behind? ----------

16. Is there difference on price of harvested honey? a. Yes [ ] b. No [ ]

17. If yes at numbers 16, what are causes of difference? ----------

18. Are there differences in honey price based on honey colors? a. Yes [ ] b . No [ ]

19. If yes, can you rank based on preference of costumer and price of honey respect to their categories?

Honey color White Dark/ black Red

Price per kilo or local materials in ETB

20. Honey is sold in kilos or local container? ----------

21. What is relationship between kilos and this container? ----------

22. Are you satisfied at market related to relationship between kilos and local container's honey price? a .Yes [ ] b. No [ ]

23. If your response is no, what are problem do think as kilo related?

---

24. Have you experience to differentiate your honey into pure and wax for selling purpose?

a. Yes [ ] b. No [ ]

25. If your response is yes at 24, how? ----------

26. What are the most problems of honey marketing in your area?

a. Lack transport facilities [ ] b. lack market information [ ] c. lack of structured market center [ ] d. Honey broker [ ] e. low honey price [ ] f. lack of market center nearby [ ]g. others (specify)----------

27. What are the best opportunities related honey marketing at your area? ----------

Challenges and Opportunities of beekeeping in area,

1. Constraints of beekeeping

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

1.2. What are the major pests and predators found in the area that affect your colonies?

Pests/Predators	**Rank**	**Local control methods**
Ants		
Wax moth		
Beetles		
Spiders		
Wasps		
Prey mantis		
Toads		
Lizard		
Snake		
Monkey		
Birds		
Hamagot		
Others		

1.5. What is (are) the cause (s) of absconding do you know?

a. Lack of feed [ ] b. poor management [ ] c. Migratory behavior of bee colony [ ]

d. Ant [ ] Doe to poisonous plant [ ] e. predators [ ] f. Drought [ ] g. Others ----------

1.6. Is there a problem of weather condition on honeybee production? Yes [ ] No [ ]

2. Opportunities of honey production in the area

2.1. What are conducive situation/opportunities for bee keeping in your area as yours tangible evidences?

Determinants condition	Rank based on their availability in area			
	Excellent	Very good	Good	Poor
Bee flora and availability of water				
Weather condition				
honey marketing situation				
Availability of bee colony				
Experienced beekeepers Participation				
Locally available materials to make bee hive				
Behavior of bee colony				
Beekeeping equipment and protective cloths				
Infrastructure and input for modern apiary				
Credit service in woreda				
Financial support				
Involvement of NGO in area				
Availability of Demonstration site				
Others specify				

Beekeeping equipment and protective

1.Which of the following beekeeping equipment and protective materials you have or available to you when ever required?

Materials	Home made	Locally made and purchased	Provide on credit (purchased)	Donated by GO or NGO's	Price (ETB)		Service period (years)
					Rent	Purchase	
Smoker							
Hives							
Gloves							
Overall							

Boots							
Water sprayer							
Bee brush							
Queen catcher							
Queen excluder							
Chisel							
Knife							
Embeder							
Frame wire							
Honey presser							
Beeswax (pure)							
Casting mold							
Honey container							
Other (Specify)							

Appendix Figure 1. Bee Keeping Placement in the Study Area

Figure .2 Storage equipment of honey after harvest

Appendix Figure .3 Honey storage equipment in the study area

Appendix Figure .3 Smoking equipment during honey harvesting time of study area

Appendix figure 4. Honey and honey storage material in the study area

Appendix figure 5. focus group discussion in study area

AUTHOR BIOGRAPHY

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