Honeybee keeping constraints and future prospects

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Abstract: Beekeeping is important for securing food, poverty reduction, health, environmental protection and plant pollination. These important practices are challenged by many biotic and abiotic factors in recent years. These factors affect honeybees and their valuable products either in combination or alone. The climatic factors like extreme temperature, relative humidity, shortage of water, deforestation of floral plants, human factors like poor apicultural practices, synthetic pesticides, diseases, and arthropod pests led to the decline of honeybee colonies and their products. But the world market demand for honey and other hive products has increased tremendously in recent decades since it is important for a wide variety of uses and applications. This review paper, therefore, was aimed at exploring these major constraints in beekeeping. It also outlines the most important cultural methods with emphasis on sanitation, maintaining bee colony vigor and some other management practices. Furthermore, from the conclusion of the review, it became important to recommend establishing specific laws and legislations that might be issued by decision makers to prevent honey adulteration. It also requires organizing honey marketing channels and raising awareness on limiting the use of pesticides in agriculture to protect the bees and the environment as well. The renovations and application of improved beekeeping technologies not only benefits beekeepers but also

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PUBLIC INTEREST STATEMENT
This manuscript addresses the challenges of the honeybee and honey production. It is important for farmers who own, produce, process, and rear honeybee for their valuable products. The review article suggests ways of managing the honeybee production problems, or challenges. Therefore, it is important to all stakeholders who are involved in honey value chains. It is also important to note the importance of honeybees beyond their valuable products that beekeepers harvest and avail for consumers. The value of honeybees is even more as pollinators of farmers' crops than the honey and related products that are directly obtained from them. Honeybees also play key role in the improvement of the diversity of flowering plants through their pollination activities.
farmers and the general public in pollinating their crops, maintaining plant biodiversity, and the ecology at large. This review, therefore, addresses the honeybee and its production constraints and puts forward some available management practices.

Subjects: Agriculture & Environmental Sciences; Zoology; Entomology

Keywords: biological agents; constraints; floral; honeybee; management measures

1. Introduction

The honeybee is a beneficial social insect. It is important for obtaining honey, securing food, reducing poverty, job employing, getting income, protecting environmental pollution, and caring for human health (AU-IBAR (Africa Union Inter African Bureau for Animal Resources), 2019; MoARD (Ministry of Agriculture and Rural Development), 2010). Furthermore, the honeybee is reared for producing honey, conserving biodiversity, pollinating crops beeswaxes, propolis, royal jelly, venom, apitherapy, and revenues. Beekeeping and honey hunting practices were begun by human beings 4500 years ago (FAO (Food and Agriculture Organization of the United Nations), 2009).

A honeybee pollinates 3/4th of the world’s angiosperm plants. It increased the yields of crops by 1/3rd that estimated to feed 1/3rd of human beings in Africa. Worldwide, honeybees were mainly kept for honey production that utilized for home consumption and sale (Aizen & Harder, 2009; Morse & Calderone, 2000). In 2011 alone, US$ 3.3 billion is obtained from naturally harvested honey (FAO 2015; Gallai et al., 2009) and played great roles in the economic growth of the producing countries (Thompson, 2012). Nevertheless, the valuable products and honeybee colonies decreased from time to time (Aizen & Harder, 2009; Van Engelsdorp & Meixner, 2010; Breeze et al., 2014; Cresssey et al., 2014; Chantawannakul & Ramsey, 2018).

This is caused by abiotic and biotic factors. The majority of these are pests, unsafe agrochemical pesticides, climate changes, and socio-economic (van Van Engelsdorp & Meixner, 2010). Over the past 15 years, they caused honeybee colony collapse disorder (Jacobo, 2019).

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 et al., 2009). These are caused by changes in honeybee population size, growth rate, and plant-pollinator network architecture. Therefore, conserving honeybee species without disturbing their natural habitats is very important (Murray et al., 2009). The United States National Agricultural Statistics authority indicated that honeybee declined from 6 million (in 1947) to 2.4 million (in 2008) hives (https://www.greenpeace.org/usa/sustainable-agriculture). Similarly, in the United states it declined from 60 to 26 from 1947 to 2008 (Ellis et al., 2010). In the last ten years, more than 30% of the annual honeybee hives declined in the United States and Europe (Wathome et al., 2013).

Generally, honeybee colony declines could threaten agricultural productivity and led to food insecurity based on the yield data obtained from 60 crop systems in 5 continents (Asia, Europe, Africa, Australia and the Americas) throughout 1983–2013 (Ghosh & Jung, 2016). However, the yield changes of essential pollination dependent crops seemed more related to socioeconomic conditions. (University of California, 2006) and Klein et al. (2007) also reported that pollinator is not required for all crops, but they affect a significant proportion of 35% of the world’s crop production amount of 87 out of 107 world-leading food crops.

The diversities of honeybees are important for stabilizing plant pollination and its yield. The pollination deficits are the main determinant of the crop yield over the diverse agronomic inputs such as fertilizer, pesticides, and fossil fuel energies (Garibaldi et al., 2016). The number of worker honeybee colonies per hectare provides a critical metric of crop health. The honeybees cannot
keep pace with the winter die-off rates and habitat loss. Hypothetically, the loss of the plant pollinators may affect the yield of the crops with varying degrees of their dependence. Insect pollinators mainly belong to the orders of Hymenoptera (bees), Lepidoptera (butterflies), and Diptera (syphid fly). There are also other pollinators of higher taxa of vertebrates like birds, bats, monkeys, etc. But honeybee (Apis sp.) is a dominant pollinators of crops (Klein et al., 2007). In contrast to this report, Garibaldi et al. (2013) claimed that the contributions of wild honeybees are higher than the domesticated honeybee plant pollinators. In contrast to this report, the honeybee was categorizing under the major pollinators of plants (Aizen et al., 2009; Kim et al., 2009). Bumblebees, mason bees, and stingless bees are important pollinators and are available commercially. If the pollinators declined, there would be the occurrence of natural environment deterioration (Thomas et al., 2004). In addition to, higher pathogen prevalence (Colla et al., 2006; Cordes et al., 2012; Forst et al., 2014) and competition between native and invasive species (Goulson, 2003), and it brought the instabilities of pollinator population, plant diversity, and climate change. The decline of pollinators caused the lowering of yield of pollinator-dependent crops and referred to as pollination crisis and subjected to different sciences like politics and economy (Jung, 2014).

The loss of honeybee species led to the losses of higher pollination efficiencies in Californian agro ecosystems (Memmott et al., 2004; Larsen et al., 2005). However, the sensitivity of particular honeybee species to a wide range of natural and anthropogenic drivers was remained unknown (Murray et al., 2009). Honey production has declined, however, the demand for honey increased. Besides this fact, many countries imported honey to fulfill the demands of their peoples, for instance, Japan and South Korea (Kohsaka et al., 2017). Korea beekeeping industry was challenged by the invasion of insect pests such as yellow-legged Hornet (Vespa velutina), small hive beetle (Aethina tumida), and degradation of black locust viability (Jung & Lee, 2018). In this country, the number of beekeepers peaked in the 1960s and 1980s. But it decreased in the early 1970s due to the of urbanization. It also peaked in 1983–1986 by adding more than 50,000 beekeepers. Then, after declined to 20,000 gradually in the early 2010s followed by the prevalent of the Sacbrood virus (Jung & Lee, 2018). In many Arabian countries, the unpropriated management of honeybee colony is the most important factor that caused honeybee decline in colonies (Al-Ghamdi, 2016). In Ethiopia, honey production is constrained by socioeconomic, cultural practices, deforestation, soil erosion, and the irreversible ecological degradation of natural environments (Bahta, 2018). While, in Mongolia, it was constrained by Varroa destructor, Nosema ceranae, viral infections, predators (like wasps, snakes, and ants), and cold conditions (Tsevegmid et al., 2018).

The transmission of honeybee diseases increased following the growth of human population size, global trade, intercontinental, and country-wise transportation (Chantawannakul & Ramsey, 2018). Torres et al. (2015) reported that in recent decades the decline of honeybee colonies is hinged, varied by honeybee age castes (egg, larvae, pupae, and adults) and pheromones that caused the slowing down of the maturation of foraging bees. The increased mortality of larvae in the absence of sufficient honeybee hives resulted in the lowering of honeybee number in the hive, the quantity of honey to produce, and food amount in the colony. Aizen et al. (2009) stated that between 1961 and 2006 the agricultural industries that depend on insect pollinators increased by 50% and 62% in developed and developing countries, respectively. This report also indicated that the loss of all pollinators can reduce agricultural products by 8%. It also stated that the loss of important animal pollinators reduced the pollinator-dependent crop yields by 15% and 42% in developed and developing countries, respectively. Most of these challenges were originated from the destruction and fragmentation of natural and semi-natural habitats along with the intensification of agricultural changes of landscapes and biodiversity of flora and fauna. These activities dramatically limited the value obtained from honeybees and their roles in the ecosystems (Abou-Shaara et al., 2017; Cane et al., 2006; Larsen et al., 2005).

The urbanization and suburban sprawl increment resulted in a combination of agricultural practices were led to the decrease of the apiary sites in the world (Arbia & Baboy, 2011). The sum of the above-discussed factors affected both the quality and quantity of honey yield and its obtained valuable
products. Generally, these factors caused the decline of honeybee, species, and their importance in the natural ecosystem in combination, or alone (Arbia & Babbay, 2011).

The synthetic pesticide drifts, residues, toxicities, and persistence of them were influenced negatively against honeybee and its products. The biotic stresses like many bacteria, parasitic mites, fungi, protozoa, and viruses’ species were also caused the losses of the honeybee colony. Nevertheless, the world’s demand for honey and other hive products increased in recent decades since it was important for a wide variety of uses and applications (AU-IBAR 2019).

Generally, pollinator declines have serious effects on the world food security, just as the recent increased demand for corn for ethanol productions have had significant effects on food prices particularly those depend on pollinator-dependent crop expansion (Elobeid, 2007). Having this background information, the major important constraints of the honeybee and its products, and some important management measures of these challenges reviewed in this manuscript.

1.1. The questions for this review stated hereunder
(1) Why the numbers of honeybee hives are decline through time?

(2) What are the constraints of a honey, honeybee, and its valuable products?

(3) How possible to reduce the factors that hindered honey production systems? So, what methods are important?

(4) What are the recommendations or future directions used to improve honeybee productions?

(5) Who is responsible for mitigating honeybee problems and by what methods?

1.2. Significance of the review
This review paper is significantly important for addressing the honeybee and its production constraints and justified some available management practices.

2. Constraints of honeybee and its products
There are many abiotic and biotic factors that that weaken honeybee-keeping and its values. Among the abiotic factors, climate change is a major factor (Langowska et al., 2016). It caused the decline of honeybees by asynchronizing the season of flowering plants (Le Conte & Navajas, 2008; Hegland et al., 2009; Lever et al., 2014). Global warming due to climate change may have a substantial negative impact on the production of honey (Langowska et al., 2016). Birhan et al. (2015) reported that lack of honeybee forage, shortage of rainfalls, agrochemical poisons, pests, absconds, and lack of honey storage facilities affected honeybee production and productivity negatively in Gondar of Ethiopia. A worker honeybee preferred the nectar of one or many flower species and visited different plant species that helped to capture a higher sugar concentration of nectar. Surprisingly, if high-quality nectar is available, a forager honeybee, Apis mellifera, carried as much as 80% of their body weight (Feuerbacher et al., 2004). Those major constraint factors that related to honeybee rearing and its valuable products were justified as follows:

2.1. Poor handling practices
The poor post-harvest handling (like storing in poor containers, storing at nonnormal room conditions, exposing the storage to dust and pests without covering the storage materials, during storage and transportation) of honey, absence of market linkage between producers, retailers and consumers affected negatively the quality of honey (Bahta, 2018). Honey is widely consumed as food and medicine. So protections of honey from contamination of different factors are very important to minimize the health-related problems after consumed and medicated. This is why pesticides, heavy metals, bacteria, and radioactive materials contaminate honey and other bee products (Al-Waili et al., 2012). The honey polluted by pesticide residues caused genetic mutations, infant botulisms, cellular degradation; reduce the activity of antibiotics, and resistant immunity of human beings to pathogens. Honey may be very toxic when produced from certain plants;
therefore, it requires information such as its source, safety, origin, composition, and a clear statement that it is free from contaminants. Honey that not subjected to analysis and sterilization should not be used for infants, and not be applied to wounds (Al-Waili et al., 2012).

The behaviors of honeybees are aggressive, swarm tendency, and abscond. The migration behavior of the honeybees was a genetic foundation (Smith, 1960). Swarming is the natural means of honeybee colonies propagation. Honeybee swarms is a splitting of a honeybee and have a specific queen to from new colony. Poor ventilation of the beehive and weather conditions affected the nectar flow and contributed to the swarm of honeybees (Tew, 2004). Bees disturbed during transporting from one place to place, handling by wrapping and unwrapping beehives to protect from winter conditions, inspections, feed, placement, treatment applications, and vibrations such as the use of power mowing equipment, nuisance pests such as predatory wasps, mice (chewing), skunks, bears, and cattle. If robber bees are attracted during times of disturbance, further distress would occur. Poor controlling of honeybee pests, lacking work capitals, establishing apiary sites at distant locations from residence, or shortage of inspection, and increasing the price of beekeeping inputs could reduce the benefits the beekeepers obtained from honeybees (Biruk, 2014). (Thomson, 2012) stated that changes in the utilization of agricultural land could have profound effects against honeybee and the plant to be pollinated by it. Because it could change the nutritional value obtained from plant pollen and physiological development of honeybees. Mushonga et al. (2019) showed that in the Kayonza district of Rwanda the honeybee keeping was negatively affected by lack of education, gender bias, abscond and swarm, high costs, and lack of modern apicultural equipment.

Traditionally, beekeeping is practiced in almost all parts of Africa (Solomon, 2009). But it lacked cooperation among beekeepers, transparency, sharing of experience, skills, and knowledge. Rearing of honeybee traditional reduces the quality and quantity of honeybee products when modern with modern methods in industrialized countries (FAO, 2009).

Africa’s honey and beeswax production contributed less than 10 and 25% in the world, respectively (AU-IBAR, 2019). This low contribution endorsed by poor technology practices and a disorganized beekeeping sector. It is also characterized by low productivity, poor quality, inadequate practices technical, insufficient impact research activities, ineffective control of pests, and not yet commensurate to the potential of the apiculture sector. Despite these poor facts of achievements, Africa is the home of honeybee diversity and contributed 10% of the world’s honey demands (169,000 tons) (AU-IBAR, 2019).

2.1.1. Feeding

Beekeepers usually feed honeybee sugar syrup, cream honey, and jelly or honey juice during the cold season as supplementary food. Feeding them in such a way might be increased their tolerance to low temperatures and improves the survival rate of worker honeybees in the winter season (Abou-Shaara, 2017). Guler et al. (2018) reported that honeybee workers decreased by 4–46% because did not use glucose during the winter season. Sucrose syrup (100 liters/colony) had a positive effect to survive during the winter and wax production at 3–4% hive weight. Nevertheless, the sugar syrups prepared from monosaccharide had a negative effect (6–15%) because the honeybee colony could not use it effectively. In contrast, the sugars containing fructose and glucose had positive effects at rates of 40 and 30%, respectively ( Bee feed and Fructose-55). These positive effects had also negative impacts. For instance, the lifespan of a worker honey bees decreased over time in 100 liters/colony of all sugars syrup. In spite of this, glucose is not promoted when compared with other industrial sugars during the increment of honeybee colonies at the beginning of spring (Guler et al., 2018). The wintering ability and surviving rates of adult honeybees and broods are positively affected by feeding of sugar, fumagillin, pollen, and vitamins than unfed colonies (Akyol et al., 2006).
2.1.2. Smoking
Smoking is used for masking the alarm pheromones like isopentyl acetate that used for moving honeybees from the honeycomb in the hive during harvesting and inspecting. It interrupts the honeybee colony’s defense during opening the beehive and harvesting because it hinders the ability to sense of smell and triggers their survival response (Gage et al., 2018; https://www.fao.org/3/i0842e/i0842e06).

Smoking required a careful follow up; unless it caused the melting of the honeybee wings, burning the hive, and so on at high temperatures. Modern beekeepers use a specialized tin can with bellows. They used it with non-harmful natural materials such as pinecones, wood chips, and cartons for fuel. They doused the fire and let the cinders burn to produces a smoke that is just the right temperature. When honeybees become alarming, beekeepers had begun smoking for interfering with honeybee’s sense of smell, so that they could no longer detect the low pheromone concentrations (Gage et al., 2018) and suppressed honeybees’ aggressiveness (Babarinde et al., 2011). However, the lower quality of honey harvested traditionally because smoking could be burnt effects on honey and attributed to the low quality of honey (Babarinde et al., 2011).

2.1.3. Human factors and public services
Harvesting at night, gathering wild honey, processing crude, following inadequate techniques, or without sanitary protocols, surveillance, diagnostics, prevention, control, treatment protocols, contaminate hive, tools, equipment, and lack of care honeybee disease during movement of honey and other hive products resulted in contaminating, poor handling, disposal, and unregulated trading (Bett, 2017; Ababor & Tekle, 2018; https://www.au-ibar.org). Because the honey harvested under those circumstances, is poor and contaminated. The product from honey hunting is usually a mixture of ripe and unripe (i.e. high water content) honey, beeswax, dead bees, and other debris. Traditionally, men are responsible for honey harvested at night because they are scored of honeybees during the day (Lolika & Machangu, 2008). However, this is not to conclude that the product low value (Bradbear, 2009).

The peoples of Africa practiced traditional honey production and beekeeping, which was gradually embracing modern practices. The traditional ways of honey production resulted in relatively low honey supply, yield, and poor quality than modern (Mikhail et al., 2013; Serda et al., 2015). Among African countries, there is no competition for producing sufficiently, quality and quantity; processing technologies, accessing a good market and getting off good infrastructure. Furthermore, on the continent, there is a lack of strong organizations that represent the interest of beekeepers, inefficient marketing opportunities to utilize, poor technological exchanging among honey producers and inadequate policing direction at national and regional levels that encourage and enable honeybee keepers as a means of their source employment, income, and food value (Akangaamkum et al., 2010). Therefore, it is required to advance and strengthen the community in Africa to create a competent at regional and international market of honey and other hive products. In addition to, establishing the quality assured standard and improved coordination of institutional bodies to manage the problem of honeybee health is very important to produce honey for home consumption, domestic market, and international markets. Beekeeping in Africa is extremely fragmented and difficult to quantify accurately the actual production and growth levels (Moinde, 2016). The lack of skilled manpower, well-mannered training institutions, low leveled and high priced of improved technology, poor post harvested handles, poor extension services, absence of coordination among researchers, extensions, and farmers, shortage of recorded and up-to-date information to address the problems are the high problems of beekeepers (HBRC (Holeta Bee Research Center), 1997; Ayalew, 2001; Edessa, 2005).

2.1.4. Inadequate period of inspection and sanitation of honeybee hives
The hive requires frequent inspection and sanitation per season of the year. Otherwise, the pests of honeybee such as predator mites, insects (ants, bugs, beetles, etc.), birds, rodents, mammals, pathogens, and environmental conditions like rainfall, drought, abnormal temperature, etc. were caused a loss of honeybee colony and value obtained from honeybee rearing. Therefore, time-
based inspection and sanitation of the honeybee hive environment are very important to strengthen the honey colony, the status of increased the amount of honey to produce, number of broods, etc. per hive (FAO, 2009; Kinati et al., 2012; Teferi, 2018). Besides, the plant grew near the honeybee hive is harboring pests and helping for its buildup in the environment. Therefore, pruning, cutting, mowing/suckling, removing the spider webs, putting ash around hive stands, and clearing outside of the hive and internal of the hive to protect the intensity of honeybee losses due to diseases, predators, environmental stress, and other honey baggers. Unless their management they brought the decline of honeybee colonies (Saville & Acharya, 2001; Tesfaye et al., 2017). The plants grown near the beehives served as the shelters, food, feeder, and reproduction of honeybee predators. Therefore, it required time-based management and inspection to curb the problems they preceded to the honeybee, physical of the beehive, and its valuable products.

2.2. Temperature and relative humidity
Temperature and relative humidity affects the homeostasis of the honeybee colony in the hive (Abou-Shaara et al., 2017). Collins (2015) stated that the percentage increment of temperature, relative humidity, wind speed, and intensity affected honeybees negatively. As the temperature rose beyond the optimum ranges the activities of honeybee decreased, phenologically flowering plant is varied to collect pollen and nectar or mismatch or of asynchrony to give good outputs. Langowska et al. (2016) showed that the yield of honey decreased in the summer season as the temperature increased in the United Kingdom. In this season the most of the annual floral plant species become dry or unavailable due to a shortage of moisture in the soil, while others found dormant, except the evergreen plants. In the spring season, the honeybee phenology had a strong negative relationship with temperature (Langowska et al., 2016). Similarly, in this season the flowering plants exhaustively available for foraging than the other season of the year.

In Sub-Saharan African countries, a high yield of honey harvested in the late spring and early months of the summer season. Thus, this yield related to the rising of temperatures during late spring up to late summer. In the winter season, honeybee colonies and mass of worker honeybees in spring appeared mostly on the flowering plants like oilseed rape (Kołtowski, 2002). However, in the winter season, the flower occurred to collect pollen and nectar, but it is not sufficient. This stimulates honeybees to swarm (founding new colonies by division) seriously and reduces the amount of honey to harvest. After completion of the winter season, the honeybee colony performs the phenological sign of cleansing flight activity in the spring depending on the late winter temperature variables (Langowska et al., 2016). In addition, the higher temperatures that occurred in the spring season could shorten the flowering period of individual plants and advanced the flowering date of both early and late spring plant species (Sparks et al., 2011). A warmer temperature in the later spring boosts the number, yield and extends the beekeeping season and exploration of new flowers. But it reduced the harvested percentage of the first annual yield of honey. The effect of temperature on the honeybee and its production values are higher than relative humidity or precipitation. These were consistent with flower phenology by hastening the end of flower nectar production and honey, soil water deficit, and low honeybee activity or damaged flowers (Langowska et al., 2016). Generally, climate change brought weather-related seasonality of honeybee migration and water stress. These caused by the change of factors following climate change such as drought, deforestation, and degradation of the environment. For instance, deforestation leads to insufficient floral pollen and nectar collection, or malnutrition to honeybees.

2.3. Water availability and its provision
Water availability strongly affects the honeybee colonies. It is used for maintaining the amount of moisture evaporation from the hive, fluid homeostasis of adult bees, producing glandular secretions, diluting honey for feeding the brood, relieving brood nest, hyperthermia, cooling or buffering their colony against future extreme water stresses or desiccation of the stored brood crops in the combs of the hive (Human et al., 2006; Nicolson, 2009; Ostwald et al., 2016). A honeybee collected water with nectars or pollens and moistens the environmental surfaces of the wetland areas (ponds, canals, near river water basin and ditches) (Seeley, 1997), guttation dropping from plants (xylem fluid excrete droplets along with the edges of the plant leave) and an axial leaf of plant surfaces (Joachimsmeier
Honeybees did not distinguish between dew, rain, and guttation droplets. However, they often observed by scanning the leaf edges (Joachimsmeier et al., 2012). Casey (2018) reported that honeybees collected water from many undesirable sources. It collected moisture from rainwater gutters that choked with decayed organic matter, on the puddles that form on the top of cow dung and sewage effluent, rather than from a source of clean water. In the absence of water, the honeybee colony migrates or swarms from its hives particularly during the dry season or drought happened (Birhanu, 2016). Therefore, the artificial provision of water is important for honeybees during the drought season. On the other hand, beehives need a safe place to stand or plant. During the provision of water for honeybee artificially, avoiding a steep-sided container or water that flows quickly. Therefore, filling the saucer or bucket with marbles or stones, corks, sponges, sticks, straw, or anything that floats over water in order to avoid easily drown of the honeybee to water. In addition, beekeepers have devised all kinds of bee watering stations (Burlew, 2020).

The amount of moisture collected with nectar during foraging from plant surfaces by honeybee could be estimated to 35–85% (Seeley, 1995). There are also times when the colony’s nectar collection is scanty during cold weather, the dearth of nectar-bearing flowers, and high water consumption. The water demand for brood consumption is stored in the combs in watery fluid form. It also used for buffering the rising of colony thirst in the hive. The honeybee colonies do not maintain the large water stores in their nests or hives (Eksteen & Johannsmeler, 1991). The worker honeybees stored water in their crop, or honey stomach and diluted nectar on the periphery of a colony’s brood nest after intense water collection. A water collector honeybee becomes active when they intensely begged for fluid during their crops empty of moisture, or thirst response. However, they do not activate water collectors, under high temperatures in their hives. Because often it stimulates to fetch water even without heating stress and rearing of brood colony intensively, but lowering the ambient temperatures to prevent the honeybees from collecting water (Seeley, 1995; Lindauer, 1955). The water deficit in the environment affects all the beneficial aspects of the beekeeper, honeybee, and its products.

The water collected in the spring season is primarily used for diluting the stored honey, while the water collected in summer is important for the regulating of temperature and relative humidity (Winston, 1987). Furthermore, the availability of water throughout the year is required for the preparation of larval food and minerals supply (Piscitelli, 1959).

### 2.4. Beehive

#### 2.4.1. Types of beehive
The honeybee hive categorized into modern, intermediate (Kenya Top Bar), and traditional (MoRAD (Ministry of Agriculture and Rural Development), 2008). Traditionally, beehive constructed from whatever materials that locally available like clay, cow dung, ash, hollowed-out log, and thick bamboo stem. The second type of beehive is the European box and Lang troth, or built from Lang troth in 1852. Lang troth had more advantages than European countries (Kassaye, 2008). It introduced and distributed for farmers in countries like Ethiopia. But it is limited in its effectiveness in the case of the Ethiopian honeybee race due to their ecological adaptation difference, when compared with European bees, despite its cost to purchased and operated. These modern beehives made from pinewood, which is not available in the market, or introduced illegally to Ethiopia and caused environmental degradation (Gallmann & Thomas, 2012). In Kenya, top bar beehives are simple in design and can be constructed from locally available timber and bamboo. In addition to these types of beehives under natural conditions, the honeybees build a nest in stone piles, hollow trees, ground holes, and others to protect themselves from the wind, rain, fire, and natural enemies (Bahta, 2018). The beehive exposed to rainfall followed by drought and damage to the beehives. Poor handling of the beehive leads to poor quality of honey production. In modern beehives, the combs can be lifted from the beehive and then replaced and examined the honeybee colony without harming it. Honeycombs could have to be removed from the beehives for
harvesting without disturbing combs that containing brood and honey harvesting that was free from contaminating of pollen, or brood (Logan, 1990).

Vural and Süleyman Karaman (2010) reported that the increment of traditional or the old type of beehives by 1% could be decreased by 0.29% of honey production; while the 1% increment of modern, or new type of beehives it increased by 0.47%. The traditional beehive is not more important than the top bar or the modern beehive (Babarinde et al., 2012) Ononye and Akunne (2017) also reported that traditional beekeeping is associated with several limitations such as low productivity, loss of honeybee colonies, and poor processing of hive products.

Mcmenamin et al. (2017) reported that among the traditional log hives, Langstroth hives, and Kenyan top-bar hives, the Langstroth hives were the most attractive for migrating or swarming, followed by Log hives, while Kenyan top-bar hives were the least preferred.

2.5. Deforestation
Deforestation contributed to losses of honeybee diversity, the value obtained from the honeybee, and floral plants. This is why the forest provides an excellent resource for honeybees and beekeeping in the ecosystems. Conservation of the forest is, therefore, an imperative for sustainable beekeeping and its valuable products (Mustafa et al., 2015). Nevertheless, the impacts of deforestation on honeybees are poorly considered. In the short forest, conservation helps to conserve honeybee and their values and vice versa. The forest ecosystem is a home or shelter, and sources of food where different indigenous honeybee races are found. Honeybee gets pollens, nectars, shelters, and water from the forest. However, in the past in general and recent decades in particular the overexploitation of tree resources had been caused by a significant reduction of honeybees elsewhere in the world (FAO, 2009). This is why deforestation highly treating to local honeybee populations and leads to excessive hunting pressure (Oldroyd & Nanork, 2009). In addition, the long-term decline of the honeybee colony caused the decline of pollinator ecology of the forests and exacerbates deforesting and wood harvesting.

2.6. Floral availability
The availability of various floral resources and its species concerning nectar, sugar contents, and pollen are very important for brood rearing (Rucker et al., 2002). Honeybee must be accessing the adequate sources of carbohydrates, proteins, lipids, vitamins, minerals, and waters that collect from the nectars, pollens, honey reserves, and other water supplements. The honeybee is malnourished if exposed to only one source of pollen crops for an extending period in their success of reproduction and overwintering under stress conditions. Worker honeybee collects pollen and nectar from a single source predominantly. These encountered imbalances in nutrition in the colony. Foragers preferred the complementary diet. The nutrition of honeybee that sourced from a diverse floral plants are important to sustain the homeostasis and balanced diet at the colony level. (Hendriksma & Shafir, 2016). Thus, therefore, the honeybee colonies attempted to foraging nutrients from a diversity of plants for striving of malnutrition. However, bias their foraging towards pollen substitutions of a balanced diet can overcome the nutritional deficits of the colony (Behmer, 2009; Hendriksma & Shafir, 2016; Simpson & David Raubenheimer, 2011). Honeybees and bumblebees served as a model organism for studying the relative uptake of proteins and carbohydrates from the collected pollens and nectars, respectively. Pollen choice by foragers seems unlinked to nutritional values, though non-nutritional pollen traits could induce foraging preference (e.g., color, odor, concentration, pH, or grain size) (Hanley et al., 2008; Nicholls & Hempel de Ibarra, 2014).

Nectar is a source of honey, heat, and energy for honeybees, while pollen provides protein, vitamins, fatty substances, and other nutrients. Therefore, a direct consequence of nutritional deficiency (pollen shortage) has resulted in a decrease in a honeybee colony. The nurse honeybee physiology and its ability to tolerate parasites depend on the quality of the pollen. Pasquale et al. (2016) reported that pollen diet diversity had no effect on the nurse of honeybee physiology and
it's healthy to survive. Nevertheless, it increased the live longevity of honeybee than honeybee fed on monofloral pollens unless a protein-richest monofloral pollens. The survival period of healthy honeybees correlated to alkaline phosphatase activity and phenol oxidase activities. The quality and diversity of pollen can shape honeybee physiology and land-use intensification of agriculture on honeybee nutrition and health (Pasquale et al., 2016). The presence of quality pollen is a central parameter. It influences the development of honeybee colonies and brood rearing. Besides this, the consumption of high-quality pollen induces the development of an important component of larval food known as the hypopharyngeal glands in young honeybee workers (Keller et al., 2005).

The floral availability varied during the dry and rainfall seasons. It is high during the spring than in the winter, summer, and autumn. Moreover, the availability of honeybee forage is high from August to November. However, it becomes decreases and shortens from late December to mid of March. The shortage of floral pollen could have to be solved by planting a drought-resistant flora species (Kebede & Gebrechirstos, 2016; Teklay, 2011). These indicated that the ample pollen and nectar source of honeybee forage is available following the rainfall season.

The amount of honey produced during the dry season was low due to the scarcity of pollen and nectar. Honeybees pollinate both cultivated and wild flora. During the decline of flowering plants, a deficiency of nutrients occurred, affected the physiology of developing honeybees, and increased the probability of attack by parasites and diseases (Thompson, 2017).

The time and duration of the blooming season of flora, environmental factors, and the carrying capacity of the area could be hampering the maximum honeybee yield production (Rajan, 1980). However, assembling a floral calendar for a specific area is time-consuming. It requires complete observation of the seasonal changes in the vegetation patterns. These observations could be an agro ecosystem of the area, the foraging behavior of the bees, a how the honeybee colonies interact with their floral environment. The accuracy of a floral calendar and its practical value depends solely on the careful recording of the beginning and end of the flowering season of the plants (FAO, 1990; Kebede & Gebrechirstos, 2016).

2.7. Pests of honeybee

2.7.1. Rodents: honey badgers, birds, and other mammals
Honeybadger 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 dead and 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 (Mayer, 2019).

The rodents such as mice, rats, and squirrels, shrews, moles, skunks, raccoons, and opossums were the pests of a honeybee (MAAREC (Atlantic Apiculture & Extension Consortium), 2004; BMPHH (Best Management Practices for Hive Health), 2019). Among the mouse were the most serious rodents after entered the honeybee hives.

Sarwar (2016) reported that several amphibians, reptiles, birds, and mammals feed on honey and honeybee. They considered the most damaging group of pests. Honeybees and colonies have lacked the immunity used against their predators which caused predation, destruction of the combs, physical dismember ships, and colony hungry. 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 et al., 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 (Sarwar, 2016).

2.7.2. Diseases
The survey conducted in Austrian indicated that beekeepers frequently suffered severely because of honeybee colony losses by three major brood diseases (Varroosis, Chalkbrood, and Sacbrood) particularly in the winter season (75%) (Morawetz et al., 2019). The high risks occurred in Austria in July followed by infesting of high varroa mite and weakening of honeybee colonies in summer. The risks of suffering in winter increased due to the high infestation level of varroa mite in September in general and old queen honeybee colonies are more suffering in particular. However, the effects varroa mite in September had by far greater than winter (Morawetz et al., 2019).

Honeybee colonies and their products are also vulnerable to various pathogens and parasites such as viruses, bacteria, and fungi (Genersch, 2010b). Their infections were fatal to honeybees. Nosema apis and Melipigamoeba mellificae are a common disease agent of honeybees in Ethiopia (Begna & Bezabeh, 1999; Gezahgen Tadesse & Bezabeh, 1991). A chalkbrood disease affected the growth and development of brood (Begna & Bezabeh, 2006). FAO (2018) reported that the occurrence of diseases in honeybees depends on three factors. These are 1) honeybees (genetic): the hygienic behavior, the genetic heritage of the queen bees and ability of the colony to resistant to against various diseases, 2) Pathogens (presence, infectious load, and virulence), and 3) favorable environmental conditions (temperature, relative humidity, and presence of nectar plants). Factors that promoted the occurrence of honeybee diseases are weather-related seasonal, mobile, contact of healthy with infected and susceptible colonies, presence of infected native honeybee populations, malnutrition, water stress, harvest and gather wild honeybees during the night. In addition, crude processing of contaminated, poor disposal of infected materials, unregulated trades, contaminated of the beehive, inadequate of sanitary products, scavenged by birds, wild animals, and other predators, and inadequate surveillance, diagnostics, prevention, control, and treatment protocols, lack of pest assessments and reports (Brosi et al., 2017; Joseph & Joshi, 2019).

The American foulbrood (AFB) (Paenibacillus larvae) and European foulbrood (EFB) (Melissococcus plutonius) is the most economically important diseases of honeybee colonies (Forsgren, 2010; Genersch, 2010a; Arbia & Babbay, 2011).

2.7.2.1. Fungus. Fungal diseases transmitted by spore contaminations among honeybee colonies. The chalkbrood (Ascospheara apis) and Stone brood (Aspergillus spp) are the well-known fungal diseases of honeybees (AU-IBAR, 2019). A. apis infected honeybee brood, larvae, and pupae (Aronstein & Murray, 2010). It infected the gut of the larvae of 3–4 days old (FAO, 2006). Its entrance means is through mouthparts during feeding, starving, and contacting of the body surface. It’s occurred in Asia, Europe, Africa, and America and common in countries like Ethiopia (Begna & Bezabeh, 1999, 2006). In general, it was highly problematic in temperate regions of the world (FAO, 2006). The symptoms of the dead larvae have swelled the size of the cell, covered with whitish mycelia, mumified, hardened, shrunken, and brattled, appeared chalk-like, and turned into black colors. It also consumes the rest of the larval body and appears white and chalky or mummies at the entrance of the hive (FAO, 2006). These microorganisms have a certain preference for larvae and pupae, where they induced distinctive symptoms, in comparison with adult honeybees seemingly not affected (Arbia & Babbay, 2011).

2.7.2.2. Nematodes. Very few nematodes species were honeybee parasites; however, there were no records of whether they live freely in honeybee colonies or attacked honeybees therein are not well known (Morse & Flotum, 1997; Morse & Hooper, 1985). Most of these parasitic nematodes are the family of Mermithidae (Morse, 1955).
2.7.2.3. Bacteria. The bacterial disease is contagious and remains dormant for more than 50 years (FAO, 2006). For instance, American foulbrood (AFB) and European foulbrood (EFB) are the two well-known epizootic bacterial diseases of honeybee brood that threaten the economics of apiculture globally (Matheson, 1993). Both of the pathogens affected honeybee larval and pupae. They caused an eponymous foul-smell, weaken, and death of the bee colony (Genersch, 2010a).

The adult honeybee can be recovered from the AFB infection, but larvae and pupae could not be recovered (FAO, 2006). It caused spore-forming (Paena bacillus) to larvae. Its spore could spread over the brood caps of fully closed or unsealed. It looks decay, darker, and sunken, and often punctured. The infected brood also looked dead, dull, dark brown, or almost black and soft during touch and has a brittle texture (FAO, 2006). These bacteria could remain viable for more than 40 years in honey, beekeeping equipment, and have the capacity to resist desiccation extremely (AUIBAR, 2019).

EFB is less virulent than AFB. It is a gram-positive bacterium pathogen called Mellissococcurs pluto. It has a lanceolate shape. It is mostly occurring singly and does not form spores. It caused damage and decays to 4–5 days old larvae. It produced shiny white to pale yellow and brown on the infected larvae. It has a rubbery texture scale and produces a sour odor of the decayed larvae (FAO, 2006).

2.7.2.4 Virus. Viruses pose a serious threat to the health and well-being of honeybees. It caused a disease called Colony Collapse Disorder (CCD); for example, in the USA and Israeli acute paralysis virus (vanEngelsdorp et al., 2009; Chen, 2011). Diseased larvae by virus fail to pupate after 4 days of infection. It changed its color from white to pale yellow and finally turned to dark brown and black color. The larvae infected by the virus looks like watery sac or contents of larvae (FAO, 2006).

Deformed wing virus (DWV) caused abdominal bloat, paralysis, rapid mortality of emerged adult honeybees (Lanzi et al., 2006). Whereas, the wing and body deformations of an adult honeybee induced by the heavy of an infestation of varroa mite (Genersch, 2010a; Mockel et al., 2011). DWV is part of complex virus strains. Serologically it related to the Kokugo virus (Varroa destructor), and Egypt honeybee virus (Ball and Bailey, 1997). The deformities on honeybees are produced when the pupae parasitized by V. destructor. Those adult honeybees infected remain symptom-free, behavioral changes, and have reduced life expectancy. Most adult honeybees carry symptomless viral infections (Chen & Siede, 2007; Riberie, 2010). However, under conditions of stress, it caused diseases following the occurrence of poor nutrition, extreme weather, or parasitism by V. destructor or N. apis (Yang & Cox-Foster, 2005), viral infection can overpass the non-detectable threshold, causing symptoms in adult honeybees.

2.7.2.5 Protozoan. Nosema disease (Nosemosis) is a microsporidian in the form of spores. It invades the intestinal tracts of adult honeybees and produces dysentery symptoms (Nabian et al., 2011; Papini et al., 2017). N. apis, is known to infest the guts of adult honeybees. It caused dysentery and the early decline of adult workers, especially when the infestation is at the highest level. It is the most destructive adult of honeybee castes (worker, queen, drones), particularly the worker honeybee by making them paralysis to flies and crawls (FAO, 2006). It reduces honeybee population size and causes significant losses in honey production (Papini et al., 2017). This pathogen also caused a shortened life span, deteriorated hypopharyngeal glands; water lost from the body, impaired protein nutrition of the honeybee metabolism, and weakened the overall strength of the colony and their productivity. Nosema infection is also associated with the black queen cell virus. Normally, it is a problem when the honeybees cannot eliminate the waste in their hive during an extension of a cold spell. The movement of adult honeybees, honeycombs, apicultural equipment, and other apiculture products are mostly responsible for the spread of this disease. Nosema and Amoeba diseases are the most commonly known honeybee diseases in Ethiopia (Begna & Bezabeh, 1999, 2006).
2.7.3. Insect pests of honeybee
Wax moth of the species Achoria grisella and Galleria mellonella were damaging the beehives and hive products (Egelie et al., 2015; Ellis et al., 2013; Kwadha et al., 2017). These insect pests did not attack the honeybee directly but they feed on the wax of the honeycomb. The larva of the wax moth hatched from the laid eggs in the beehive cracks and build grayish webs that used for protects themselves against predators, pathogens, and weather extremes. They make tunnels in the combs and contaminate honey with their excreta. Active bees at times can reduce the wax moth infestation but the population can build to unmanageable levels if left unchecked.

The wax moth species are the greater wax moths (G. mellonella) and lesser wax moths ((Achoria grisella) F), (Lepidoptera: Pyralidae) that destroys the wax combs by feeding on the cost of larval skins and stored food in, or outside of the beehives (Ellis et al., 2013; Kwadha et al., 2017). Wax moths invade weak colonies. Inside the hives, it can be controlled by boosting the strength of colonies or using specific traps (Abou-Shaara, 2017).

Ants (Dorylus fulvus) eating the comb and its contents, pollens, and brood. They kill honeybees first; robbing their products, and initiating aggressiveness in honeybees that lead to absconding of honeybees (Begna & Bezabeh, 2006). It is well known across tropical Africa (Adgaba et al., 2014).

Aethinatumaidea (Aethina tumida murray; Coleoptera: Nitidulidae) is a small hive beetle species that attracted to honeybee colonies to reproduce but they can also survive independently outside the bee hive. This insect pest is endemic to sub-Saharan Africa (Gonthier et al., 2019). The adult female beetle is capable of producing up to thousands of eggs over its lifespan, thus being able to colonies almost all beehives and honeybee colonies within a wide radius by flying up to 6–13 km from its nest site; it is capable of dispersing rapidly and directly invading new beehives. It invades honeybee colonies and their larvae feed on the stored food and wax of honeycombs. The larvae pupate in the soil (Froke & Tubbs, 2009).

2.7.4. Parasitic pests of honeybee
In the Asian continent, the mites are the most serious enemies of honeybees and their products. For instance, Varroa mite that cause Varroasis is a native parasite of A. cerana throughout Asian countries. It is found throughout the world, except Australia and New Zealand South Island. It was introduced to beehive from the external environment during nectar collection. Its infestations are high in the temperate regions of the world. It also hindered the success of A. mellifera and A. Cerana colonies in the tropics. It caused the absconding of honeybee from the hive and invited a multi-factorial disease (FAO, 2006).

V. destructor is microscopic but it is quite larger than the other mite species in causing damage to honeybees. Acarapisosis’s infestation caused tracheal problems to adult honeybees e.g., by Acarapis wood and spread by direct contact from a single adult honeybee to another. Tropilaelaps psclareae, and T. mercedesae are species of mites. They were ectoparasite that affects honeybee brood (Pettis et al., 2017). Their infestations occurred mostly by direct contact among adult honeybees during their movement and through infested honeybee brood. V. destructor and V. jacobson caused the Varroasis of honeybees. They feed on the body fluids of honeybees in all their stages. They are visible to our naked eyes and looked like a small red or brown spot on the honeybee’s thorax. Varroa mites can lead to the virtual elimination of feral honeybee colonies in many areas. However, the African bee can control infestation through its behavior of self-grooming and resistance.

V. destructor is distributed globally while Tropilaelaps mercedesae has remained largely in Asia. Tropilaelaps mites are the most problematic. In areas where this occurs, Tropilaelaps and Varroa threaten beekeepers of A. mellifera aggressively. They are outcompeted and controlled because they are aggressive to resist or against Tropilaelaps (Pettis et al., 2017). Rosenkranz et al. (2010) reported that the parasitic mite (V. destructor) infests brood cells and lives on the adult honeybees.
Under heavy mite infestations, an accelerated rate of death becomes obvious among the colonies. This report also indicated *V. destructor* was a parasitic mite that threatens honeybee health and vectors or carriers of the deformed wing virus. The parasitic *V. destructor* mite appeared to be the most harmful to honeybee colonies globally and affected negatively every life stage of honeybees from larva to adult (Anderson & Trueman, 2000). The beekeeper in the United State ranks parasite mite as a bigger threat to their honeybee colonies than Colony Collapse Disorder (CCD) (Williams et al., 2010).

Bee louse (*Braula coeca*) is a parasite of bees across Africa. The larvae hatched in the wax and then spoil the combs. The adult louse is found on the thorax of honeybees in general and the queen in particular. The braula fly does not damage or parasitize any stage of the honeybee life cycle but the adults do compete for food from bees and larvae. Phorid fly (*Apocephalus borealis*) was parasitizing bumblebees and infected honeybees and eventually leading kills in North American apiculture (Core et al., 2012). This report also indicated that the parasitized caused honeybee abandonment behavior, leaving their hives at night and dying shortly thereafter.

2.8. Agrochemicals

Agrochemical exposures hindered beekeeping and its production (Sanchez-Bayo & Goka, 2016). The agrochemicals are killing honeybees by disrupting their neuronal activity; its molting process or another specific metabolism. The term biocide, reserved for broad-spectrum poisons that kill any organism. The fatal agrochemical incidents are not limited to target pests, but also affects beneficial insects like the honeybee and its products. Continuous contamination by insecticides and herbicides caused the low quality of honey (Oliver, 2012). Some of the negative impacts of agrochemicals or pesticides on honeybees and their products discussed here as follows.

2.8.1. Pesticides

Pesticide exposure contributes to honeybee colony losses by lethal toxicity (Krupke et al., 2012; Pettis et al., 2012; Tapparo et al., 2012). It also altered the behavior of honeybees (Aliouane et al., 2009; El Hassani et al., 2005). Besides, it increased the susceptibility level of honeybees to nosema parasite as well as queen failure (Vidau et al., 2011; Pettis et al., 2012). The neonicotinoid is an insecticide that caused pollinator losses of honeybees (Blacquiere et al., 2012; Gill et al., 2012). This insecticide has less acute toxicity to blooming plants and considered safe to honeybees after application (Legard et al., 2001). The miticides used to control varroa mites' contaminate combs and food stores of honeybees in the comb cells than fungicides (Mullin et al., 2010). The honeybee are also exposed to pesticides in some routine practices of farmers. The worker adults of honeybee contacts directly with applied pesticides in the field during the collection of pollens and nectars (Thompson, 2012). Honey could be contaminated with pesticides from the environmental drifts before, during, and after applications. The pesticide stored and applied by contaminated equipment is harmful to human health (Al-Waili et al., 2012). Honey harvested from natural vegetation is safer than those harvested from exposed to pesticidal residues in the environment (Choudhary & Sharma, 2008).

Honeybee existences in the environment could also be used for monitoring the environmental pollution by agrochemicals. Agrochemical can influences the agricultural practices and environment positively or negatively (Tillman et al., 2001). Their accumulations can be measured in honeybee products and pollens they forage (Chauzat & Foucon, 2007). Insecticides, herbicides, fungicides, and bactericides applied to control crop pests to increase their yields. Instead of its benefits, agrochemicals have long and short-term negative outcomes on agro ecology and biodiversity. Honeybee face agrochemical related problems during the collection of pollen, nectar, and water or moisture from their natural environment after applied. Because of its drifts in the air, water, and soil (Oliver, 2012).

The consumption of applied pesticides causes carcinogen effects on honeybee during and after the collection of pollens, nectars, and water in their hives due to its drifts, residues, and persistence.
(Kiplimo, 2017). All the life cycle stages of honeybees are negatively affected by the applied pesticide exposures. However, certain pesticides do not have any effects on adult honeybees though it may have on larval stages (Evans & Schwarz, 2011). The contaminated beeswax primarily affects the brood after direct contact with its cell wall due to grayanotoxins. The adult honeybees exposed to pesticide exposures directly through over-spraying, flying along the spray drift or consumption of contaminated pollen and nectars in the field. The applied pesticide enters the body of the honeybee through open parts of the exoskeleton and respiratory organs or the ingestion system. The larvae are primarily exposed to the pesticide residues in brood food (Thompson, 2017). The pesticide residues collected with nectar and pollen from the main and cover crops, or weed flowers buildup within the comb or stored food. The degrees of toxicity to honeybees varied based on the variation of chemical product groups, formulations, application rates, active ingredients, and environmental conditions like temperature. Honeybee killed outright or showed signs of poisoning subsequently led to weak colony.

2.8.1.1. Herbicides. : Herbicides are another group of pesticides that are popularly used for weed control. Balbuena et al. (2015) reported that glyphosate is herbicides that affect honeybees negatively. The honeybee ingesting this herbicide in their hive had impaired the cognitive capacities needed to retrieve. It has also long-term negative impacts on the honeybee colony. It hindered an integration of the spatial information for returning to the hive successfully, and affected the gustatory responsiveness and learned performance in harnessed honeybees. The foreign substances like herbicides accumulation in the hive brought the contamination of stored nectar and pollen that affected the honeybee activity in the hive for short or long-term periods. Thus, these negative impacts are impairing reproduction, individual behaviors, and social organization for the long term (Devillers & Pham-Delegue, 2002; Giesy et al., 2000; Kirchner, 1999).

Balbuena et al. (2015) reported that the honeybee imposed to feed the glyphosate herbicides did not indicate the problem of locomotive activity after foraged the sucrose solution contaminated with it artificially. Herbert et al. (2014) reported that glyphosate accumulation in the hive and its acute exposure caused sub-lethal to olfactory, decreased short-term memory, and impaired associative learning in foragers. Glyphosate also affects the cognitive and sensory abilities of young hive bees and delays brood development (Farina et al., 2019). The herbicide reduces the harvestable and availability of nectar and pollen via the killing of floral host plants of bees before reaching the stage of flowering (Bohan et al., 2005).

2.8.1.2. Bactericides. : Beekeepers apply antimicrobial drugs to control bacterial and microsporidia diseases (Johnson et al., 2013). American Foulbrood (AFB) is a deadly bacterial disease affecting pupae and larval stages of honeybees by forming endospore-forming bacterium Paenibacillus larvae (Collins et al., 2019). Propolis consisted of caffeic acid esters, which are a product of bee foraging. It is a resinous substance derived from botanical substances found primarily in trees. Propolis has antibacterial activity against Paenibacillus larvae. Because have a Caffeic acid isopropenyl ester, caffeic acid benzyl ester, and caffeic acid phenethyl ester. These were the most effective in inhibiting and killing of Paenibacillus larvae cell growth when used alone and in combination with minimum inhibitory concentrations (MICs) at 125 µg/mL and minimum bactericidal concentrations (MBCs) at the rate of 31.25 µg/mL. These compounds inhibited bacterial growth through a bactericidal effect, which revealed cell killing but no lysis of Paenibacillus larvae cells after 18 hours of applications (Collins et al., 2019). This report also indicated Caffeic acid esters are potent bactericidal compounds against Paenibacillus larvae and eliminate bacterial growth through an oxidative stress mechanism. The bee forage able thyme product terpenes (mainly from pollen) were an antibiotic that reduces the growth of bee disease-associated with bacteria effectively. This is a further step forward in understanding the complex pathen-pollinatator-plant network (Wiese et al., 2018).

2.8.1.3. Insecticides. : Insecticides are essential tools for preventing or minimizing insect damage to crops, increase the quality and quantity of crop yields, and improves the life status of human
beings, domestic animals, and livestock and their products (BASF, 2016). There are more than 20 different mechanisms, or modes of action, by which various commercial insecticides control insects. Its mode of action is via disrupting specific vital biological processes like the nervous system but most of them are not specific to insect pests. Despite its positive effect, it had also negative impacts on beneficial insects like the honeybee. Besides this, Eiri and Nieh (2012) reported that neonicotinoids affected honeybee gustatory sensitivity and their dance maneuvers negatively. Gauthier (2010) also reported that a neonicotinoid insecticide acts on cholinergic pathways of insect synaptic transmission, affected the capacity to return to the beehives (Bortolotti et al., 2003) and impairs the memory helps to retrieval to their hives during exploratory orientation of flights (Fischer et al., 2014). Melisie et al. (2016) reported that 48.3% of the beekeepers abandoned beekeeping due to insecticide application. Moreover, high rates of insecticides are affecting honeybees and the quality and quantity of their products. According to A. Tadesse and Asferacchew (2008), honeybees and other pollinating insect populations have been declining in the current era by synthetic pesticide application in agricultural activities, which resulted in the poisoning of the beneficial insects. Most of the farmers spraying insecticides without considering their negative impacts on honeybees, duration, and recommendation rates to apply. It can be overlapping with the period of honeybee foraging flowers nectar and pollen. These activities increased the danger of honeybees after insecticides are applied (Melisie et al., 2016). Hunt (2000) also reported that applying insecticides during the flowering stage can increase the risk of toxicity to honeybee colonies. The degree of this toxicity varied based on their active ingredients and species of organisms, for example, endosulfan (third/endorsed) is extremely toxic to fish but is safe to honeybees, while dichlorvos is extremely toxic to honeybees. Stanley et al. (2015) also stated that thiamethoxam, dichlorvos, profenofos, and chlorpyrifos could cause mortality to honeybees up to 100%. However, acetamiprid and endosulfan did not cause any repellent effects on honeybees. Whereas, the flubendiamide, methyl demeton, imidacloprid, and thiamethoxam caused mortality of honeybees highly after direct exposure (Stanley et al., 2015).

2.8.1.4. Fungicides. : Fungicides applied to manage flowers, leaves, stems, roots, and fruits diseases of many crops infected by fungi worldwide. These fungicides are either non-toxic or are practically toxic to adult honeybees extremely (Adaskaveg et al., 2012). Degrandi-Hoffman et al. (2015) reported that fungicidal exposure to honeybees resulted in the reduction of brood rearing, queen loss, increased malnutrition, weakened colonies and made them more vulnerable to parasitic pathogens. Besides, the agro-fungicides caused respiratory inhibitors; fed fungicide-treated pollen had lower ATP concentrations and higher virus titers (Degrandi-Hoffman et al., 2015). Fungicides may enter the beehive when applied to nearby flowering crops and foraging with nectars and pollens. Acaricides, antimicrobial drugs, and fungicides are highly toxic to honeybees in their combinations than alone (Johnson et al., 2013). Stanley et al. (2015) reported that carbendazim, mancozeb, chlorothalonil, and propiconazole wasn’t safer to honeybees.

2.8.1.5. Other agrochemicals. : Honeybee keepers applied acaricides to control V. destructor (Johnson et al., 2013), which could also kill honeybees. The application of organic manure is better than the application of conventional synthetic fertilizers. When nitrogen fertilizer input was low, the abundance of honeybees declined with vegetation cover (Ramos et al., 2018).

2.9. Honeybee preference

Foraging honeybee are exposed to rewarding and aversive events, providing a selective advantage for maximizing the former while minimizing the latter. The honeybee preference scents, locations, and visual cues that influenced by inter-individual and aversive stimuli variation (Finkelstein et al., 2019). Sucrose response of honeybees reduced if foraged from scented rather than unscented sources. Honeybee preferred the sites of high quality and non-aversive floral (Finkelstein et al., 2019). Honeybees preferred angiosperm plants. The behavior choice is based on the spatial achromatic flower properties of visual signaling for plant-pollinator interactions (Howard et al., 2019). Honeybees can thrive in natural or domesticated environments, though they prefer to live in gardens, woodlands, orchards, meadows, and other areas where flowering plants are abundant.
Within their natural habitats, honeybees build nests inside the tree cavities and under the edges of the objects to hide from predators (https://www.orkin.com). Honeybee preferred the habitats that have no water shortage and floral limitations. Honeybee preference was highly correlated with sugar production per floret and purple florets to cream or yellow colored with high nectar production than yellow florets of alfalfa in the fields (Pankiw, 1967).

Carroll et al. (2017) reported that despite a greater abundance of older stored pollen cells on brood frames, honey bees preferred fleshy stored pollen cells for consumptions. Nevertheless, these consumption preferences for freshly stored pollen occurrence have no clear developmental advantage.

3. Management of honeybee production constraints

3.1. Cultural practices
The honeybee beekeepers could manage the American Foulbrood (AFB) culturally through destruction of the infected combs; avoiding contamination of the honeybee with fungi spores, drying combs that has no hold brood, burning old beehives by with gas flame burner; keeping honeybees in the dark places for several days, and clean the beehives are a few to mention (FAO (Food and Agricultural Organization of the United Nations), 2006).

The European foulbrood (EFB) disease managed by stimulating the hygienic behavior of honeybees, removing the brood combs, replacing the old queen with the new queen, changing the hygiene the behavior of honeybee genetically enhancing egg laying ability of the queen in order to increase the colonies ability to diseases resistance and destroying the infected larvae in the beehive (FAO (Food and Agricultural Organization of the United Nations), 2006).

Ascospheara apis fungi infects the brood honeybee severely. It can be minimized by removing the infected brood from the hive, stimulating hygienic behavior, ventilating the hive, removing the accumulation of moisture from the hive, feeding sugar-syrup/sugar water, cleaning the beehive from the spread of spores within the colonies (Palacio et al., 2010).

Nosema disease can be minimized by removing stress, providing adequate ventilation, and protecting from cold, humidity, and changing of the combs once per two years (FAO (Food and Agricultural Organization of the United Nations), 2006). In most European countries, AFB and EFB are also controlled through the burning of symptomatic colonies and avoid the spread of the infectious agent to uninfected hives (Forsgren et al., 2018).

The parasitic honeybee mite managed by removing the A. cerana male brood combs and splitting honeybee colony in the hive (Pettis et al., 2017). It could be managed by providing supplemental nutrition, improving the honeybee health, applying sanitation measures like cleaning the beehives and well ventilating (Gochnauer et al., 1975), replacing or exchanging the beehive and brood combs annually can minimize the transfer of parasitic mites from combs to combs (Flores et al., 2005). In addition, the practices of sanitation of beehive can reduce the continual source of fungal spore infection on all surfaces of a beehive.

The best cultural practices utilized to manage arthropod pests to boost honey products from beekeeping is by maintaining colonies strength by keeping bottom boards raising above the ground, removing debris from around the bottom of the hive and using ant barriers around the colonies, or placing single colonies on stands through oil or sticky traps in its surrounding. For instance, to control honeybee predatory wasps can be controlled by using baited traps with meat or other attractants (HPMSP, 2008). This report also indicated that SHB effects minimized by storing honey for a short period before extraction by keeping the comb and its eggs in a location with less than 50% relative humidity. This would be protecting the SHB eggs from hatching by using traps (corrugated plastic or pit traps), freezing honey, or installing hot lights in honey houses to burn
grubs. Ants (Dorylus fulvus) may be protected by placing an inner tube, smoothing iron sheet, and tinning filled with used engine oils around the wooden or metallic stand supporting hives and covering the hive environment with ash.

3.2. Biological agents
Breeding biocontrol agents are the most promising, safe, eco-friend management options of honeybee pathogenic and parasitic pests. This relies on the exploration of beneficial microorganisms that antagonize honeybee pathogens and/or eco-friendly natural products (Arbia & Babbay, 2011). These methods include the use of disease-resistant bee strain lines. Rondeau et al. (2019) reported that Thymovar and oxalic acid was effective against varroa mite populations, while the predatory mite (Stratiolaelaps scimitus) (Womersley) was ineffective in Eastern Canada.

Antibiotics, fungicides and anti-mites are some of the earliest strategies implemented for the control of pathogens and parasites that are threatening honeybees. But it has numerous limitations such as low number of available molecules, lack of specificity in terms of action, and quick development of resistance (Arbia & Babbay, 2011).

AFB diseases can be controlled by the application of Tetracycline antibiotics such as oxytetracycline hydrochloride (OTC). But the development of resistant strains has been reported from the USA, Canada, and Argentina (Alippi et al., 2007; Miyagi et al., 2000). Hives treatment with oxytetracycline hydrochloride may mask disease signs for several months, while P. larvae spores have still found in the honey. The oxytetracycline hydrochlorides has been used against M. plutonius infection. Though there is still a lack of information regarding its use. It is approved for controlling the causal agents of respiratory diseases in farm animals, including gram-positive bacteria, mycoplasma, and some gram-negative bacteria (Shryock et al., 2002).

Predatory mites, parasitoids, entomopathogens, nematodes, protozoa, viruses, bacteria (Bacillus thuringiensis), rickettsiae, and fungi have a lethal effect on Acari (Chandler et al., 2010). Entomopathogenic fungi (Metarhizium anisopliae and Beauveria bassiana) have great potential against Varroa mites under laboratory and field condition (Garcia-Fernández et al., 2008; Shaw et al., 2002). It has no negative impacts on immature (Ahmed & Abd-Elhady, 2013; Meikle et al., 2008) and queens (Kanga et al., 2002) after dusting or coating with fungal conidia (Kanga et al., 2006), and thus can be applied as spore solutions in beehives (Hamiduzzaman et al., 2012) during no or low brood is present in the honeybee colonies (Kanga et al., 2006). Fortunately, it has no negative impacts on colony health (Meikle et al., 2008), or immature and mature stages of bees (Ahmed & Abd-Elhady, 2013).

In Europe, Chelifer cancroides is interesting in predatory species in beekeeping (Schiffer, 2017) and showed the most promising roles for the biological control of Varroa (Read et al., 2014). Rangel and Ward (2018) reported that predatory mite (Stratiolaelaps scimitus; Mesostigmata: Loelapidae) could control Varroa under laboratory and field conditions.

The parasitoids (Bracon hebetor (Say,)) and (Apanteles galleriae (Wilkinson) (Hymenoptera: Braconidae)) have potentially negative effects to wax moths (Kwadha et al., 2017). In fact, these two parasitoids attacked the wax moth and its larvae in stored combs outside of the beehives or inside empty beehives. When there was no crowded of adult honeybees in the beehives, honeybees prevented them from accessing inside of the hives. The wax moth larvae usually occurred within the wax combs and couldn’t be easily detected by the parasitoids, while honeybee found crowded inside of the hives. But the Bt could be used under this type of beehive conditions (Abou-Shaar & Staron, 2019). The small hive beetles (SHB) can be attacked and reduced by baits (Arbogast et al., 2007) and irradiation (Downey et al., 2015).

Aspergillus niger and A. flavus (Richards et al., 2005), storage mite (Caloglyphus hughesi) (Strauss et al., 2010), ant (Pheidole megacephala), larvae predator (Torto et al., 2010a), and protozoan
(Wright & Steinkraus, 2013) could be controlled by the SHB. Mortality of SHB increased when \textit{B. bassiana} and \textit{M. anisopliae} variety \textit{anisopliae} used, using spore suspension bioassays. SHB larvae were susceptible to entomopathogenic nematodes (\textit{Heterorhabditis megidis}, \textit{Steinernema carpocapsae}, and \textit{S. riobrave}).

The utilization of microbial organisms for Varroa mites is difficult. Because regulating the beehive temperature is not an easy task to make detrimental effects of the fungi against immature stages of the mites, difficult to produce the virulent and persistent fungal spores in mass to use (James, 2009). In addition, pests that have part of their life cycle outside the beehive, such as small hive beetles, may be more amenable for biological control (James, 2009). According to HPMSP (2008), fungi, and nematodes could control SHB but are not available for commercial use.

### 3.3. Chemical

The bacterial diseases could be fighting off by chemotherapeutics application of antibiotics or sodium sulfoisoxazole to minimize its multiplication in the infected honeybee hives or combs within a short period of time intervals (FAO, 2006). Nosema disease reduced by feeding the fumagillin antibiotics @ 25 mg/1Litre of sugar-syrup during the long rainfall season and fumigating the beehive was important (FAO, 2006). Organic acids, ethereal oils, synthetic pyrethroids, amitraz, lactic acid, oxalic acid, fluvalinate, flumethrin, Pakistan, klartan, and formic acid could have the toxicity used to suppress the \textit{V. destructor} and its damage (FAO, 2006). There are many products that are used for managing mites in worldwide. These products posed negative impacts on natural environmental conditions. This mainly works for volatile compounds (Pettis et al., 2017). The formic acid product and Mite-Away Quick Strips\textsuperscript{R} was the only commercially available products that significantly reduce the mite population within 8 weeks after application. These chemical pesticides have also no side effects on honeybees. Sulfur-containing chemicals are also used for reducing mite populations. However, both sulfur and Hopguard\textsuperscript{R} influenced honeybee adults in its growing colony (Pettis et al., 2017). Fumigation of beehive equipment with lactic, formic, and oxalic acids were used to combat the mite (Dodologlu & Emsen, 2009). But somewhat it has less effective in controlling mites and even cause direct toxicity to honeybees. HPMSP (2008) reported that SHB (\textit{Braula coeca}) managed by the application of Cournaphos (Checkmite+) and permethrin (Gardstar).

Chemotherapeutic compounds have the ability to control honeybee diseases. Most of these products were promising in terms of controlling pathogens that grow in either culture or honeybee colonies, but none of them have eradicated the diseases (Lodesani & Costa, 2005). However, depending on the synthetic pesticides and antimicrobials it could be leading to a general deterioration of the honeybee colony and the environment in general. It is advisable to minimize the use of pesticides inside and outside of honeybee colonies (Bogdanov et al., 2004; Frazier et al., 2008).

### 3.4. Genetic resistance

Genetically, improving the resistant lines of honeybee could be made against the disease challenges like chalkbrood. This could be achieved by improving the genetic stock; hygienic the behavior of honeybees, improving the ability of honeybees to detected and removed the diseased or parasitized brood (Aronstein & Murray, 2010). The genetic basis of hygienic behavior involves several gene lines, which interacted within complex ways, demonstrated and increased the genetic diversity of honeybees to reduce the likelihood of honeybee disease outbreaks (Goode et al., 2005; Evans & Spivak, 2010; Lapidge et al., 2002).

### 3.5. Other management practices

To cope up and avoid the main constraints that hindered beekeeping measures such as development, reforestations are important for managing droughts, deforestations of floras, conservation of the existing vegetations, integrating beekeeping with agroforestry, crop production and increasing the distribution of moveable frame hives (Birhan et al., 2015).
HPMSP (2008) indicated that the protection of the apiary location from the wind and slope could help in reducing the disturbance of honeybees and water drains. This report also indicated that provisions of clean water sources within a quarter-mile of the honeybee yard to maintain the adequate thermoregulation, cool and hot environment of the honeybee colony during the hot and cold months of the year are also very important to increase the production and productivity of honeybees. Beekeepers fall into four categories based on the number of bees they keep: hobbyists (one to five), small scale (five to 50), sideliners (50 to 300), and commercial beekeepers (300 or more) (HPMSP, 2008).

In early to mid-summer, supers are added to encourage surplus honey production. Finally, in the late summer and early autumn, beekeepers should replace the queen (if necessary) to treat mites and diseases before the entrance of the winter season are also advisable. The status of honeybee colonies should be checked three to five times during the spring season (HPMSP, 2008). Swarming of honeybee is prevented either by reversing repeatedly the bodies of a beehive or by using the Demaree method, which involves segregating the queen at the bottom of the beehive in a brood chamber with an empty combs. If the honeybees are prepared for the swarm, queen cells removed or destroyed, and splitting of the colony by using the Demaree method.

Honeybee colonies should not be allowed for disturbing during the major nectar flows, except for quick inspections to add honey supers. A queen excluder is added to keep the queen from laying eggs in honey storage areas. During the summer, one or two inspections are very important to assess honey production and prevent or control diseases and parasites. Summer is also a good time to evaluate the honeybee colonies' performance, such as for honey production, tendency to rear brood and adjust rearing to nectar flows, and gentleness. Honey supers should be removed and cleared by honeybees by shaking and brushing the workers from the frames or by using a honeybee repelling, honeybee escaping, or bee-blowing. The honeybee colony that provided with the supplemental sugar food content during inadequate stores and flower plants inadequately available under unfavorable conditions to protect the queen’s healthy and pests from the honeybee colony. The old queen in the beehives of honeybee colonies should be renewed with the new queen at least every two years for maintaining honeybee colony health. Stimulatory feeding with pollen supplementation in late January can help survival and encourage the honeybee colony to buildup.

3.6. Insect sterilization techniques
The gamma irradiation with a Cobalt-60 source used to sterilize contaminated beekeeping equipment effectively (Hornitzky & Willis, 1983). It is achieved after the bee wax and honey are irradiated (Wootton et al., 1985). At the optimum level of irradiation, it had no negative impacts on the wax composition, except physicochemical alterations of honey such as decreasing of its enzymatic activities and changing of color (Baggio et al., 2005). However, it was limited due to a shortage of the accessibility of radiation facilities to run this technology. Instead, the sterilization of honey using heat might be efficient with some of its limitations.

Microwave heating reduces the rapid buildup of the yeast. Nevertheless, infrared heating is not as rapid as microwave heating to achieve the result. Membrane processing is a thermal process and very effective for the complete removal of the yeast cells from honey; while microfiltration and ultra filtration could produce enzyme-enriched honey besides clarifying the honey (Subramanian et al., 2007). Little et al. (1987) reported that a microfiltration membrane with a pore size of 200 nm would remove the viable microorganisms completely in honey-like sterilization.

4. Conclusion
Beekeeping is important for many purposes. It is used for securing food, reducing poverty, improving human health, protecting the environment, pollinating plants, and maintaining biodiversity. However, in the developing world, the role of apiculture in poverty reduction and economic growth is not well appreciated. This led to poor or inadequate protection of the honeybee flora and
hence honeybee colonies. Habitat deterioration by deforestation, forest fire, agrochemicals and honeybee diseases and insects and other pests are reducing honeybee colonies across the globe at an alarming rate. The decline of honeybee populations threatens not only honeybee products but also global agriculture and the world biodiversity. Honeybee are major pollinators of many cultivated crops and some are exclusively pollinated by honeybees. The naturally occurring plants diversity is also maintained by pollinating activities of honeybees and in fact other pollinators as well. Therefore, it necessary to reconsider the modern agricultural practices that heavily depend on agrochemicals the safety of which is not well tested for honeybees. Combinations of protected area networks and honeybee-friendly habitats within agriculture is important for honeybee conservation.

Scientific approaches of managing abiotic and biotic factors are very important to increase the production of honey, honeybee colonies, and other honeybee products. Cultural methods of apiary management coupled with safer honeybee protection techniques can be used to prevent honeybee diseases, insects and other pests. The major cultural methods include removing the infected brood, stimulating hygiene, ventilating, feeding sugar-syrup, provision of water, and maintaining the relative humidity and temperature of the hive. In addition, changing the old combs per two years, burning of symptomatic colonies, and avoiding the spread of infectious agents among the bee hives are very important to manage honeybee colony losses. Genetically, improving the resistant lines of honeybees are important for improving the status of honeybee against the honeybee pathogens like chalkbrood. Gamma irradiation by 60 cobalt source, microwave, infrared heating (not as rapid as microwave heating), microfiltration and ultrafiltration were effective to sterilize the contaminated beekeeping equipment.

Biological control agents like predatory mites, and honeybee disease antagonists are the safe methods of honeybee protection. At the worst, application of antibiotics of pathogens, mites and predatory mites can be used to control the honeybee pathogens and parasites that are threatening honeybees and their valuable products. Chemically, it could be managed by application of pesticides like chemotherapeutics with antibiotics or sodium sulfathiazole and synthetic pyrethroids, amitraz, lactic acid, oxalic acid, fluvalinate, flumethrin, Pakistan, klartan, and formic acid. There are many products that are used for mite management worldwide. Nevertheless, their effects are not the same across the variability of environmental conditions.

In the future, establishing natural honeybee habitats, host-specific predators, parasitoids, and/or microbial biopesticides against pests of the honeybee is required. Searching for more specific and effective biocontrol agents is very essential, especially under future climate change challenges, which can greatly impact honeybees.

5. Recommendation or future directions
The potential of the beekeeping sector in the economy of the developing world is unquestionable. This is demonstrated by the demand for honey and other hive products in the world market. Besides, the role of honeybees is beyond the provision of honey and other hive products by the fact that the majority of crop plants are pollinated by honeybees and some are inseparably linked to honeybee pollination. This indicates that the agenda of honey bee conservation should not be limited to beekeepers alone as crop producers should be concerned about losses of bee colonies. At present, as relatively higher honeybee colonies are available in the developing tropics, hiring beehive for pollination is not yet known and the benefits of honeybees and other pollinators are not appreciated.

Beekeepers, researchers and other stallholder in the apiculture sector could make chains of networks and associations that may enable them access information regarding honeybee health. Improved technologies available in different parts of the world. Improved hive tools, biological control agents, at the worst safer antibiotics are available against bacterial, fungal and protozoan diseases.
Therefore, awareness creation on the role of honeybees and honeybee health to all stakeholders including governments in framing policies for conservation of habitat is necessary. The testing of the safety of agrochemicals that are used in crop production are on forefront. Besides, it requires policies that regulating pesticide handling like, marketing, storing and applications. Training one of the tools in creating awareness on honey and honeybee colony marketing as well.

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