

In partnership with



Assessment of Honeybee Colony Carrying Capacity in Sidama, South and Southwest Ethiopia



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List of Acronyms

A	Abundance
X ²	Chi - square
EOHY	Expected Optimum Honey Yield
ETB	Ethiopian Birr
J	Evenness value
FBC	Frame Honeybee Colonies
FGD	Focus Group Discussion
Ha	Hectare
HBC	Honeybee colonies
ICIPE	International Center of Insect Physiology and Ecology
IIRR	International Institute of Rural Reconstruction
IPM	Integrated Pest Management
Km	Kilometer
MaYEA	Mass Youth Employment in Apiculture
M	Meter
MEL	Monitoring Evaluation and Learning
N	Nectar
%	Percent
P	Pollen
P	Probability
RA	Relative abundance
H	Shannon Index
H ^I	Shannon – Wiener diversity index
Km ²	Square kilometer
M ²	Square Meter
Σ	Summation
ORDA	Organization for Rehabilitation and Development in Amhara – Ethiopia
PAM	Partitioning around medoids
PCoA	Principal coordinate Analysis

$H_{\max}$	The maximum value of Shannon – Wiener diversity index
S	The number of species
Spp	Species
P_i	The proportion of individuals or the abundance of the i^{th} species
TDBC	Traditional Honeybee Colonies
TRBC	Transitional Honeybee Colonies
USD	United States Dollar
Yld	Yield

Executive summary

Apiculture remains the primary economic activity for Mass Youth Employment in Apiculture (MaYEA)'s youth partners in Ethiopia, and estimating the honey flow period is essential for effective beekeeping operations. Identifying and understanding the distribution and flowering patterns of bee forage plants enables beekeepers to synchronize colony management practices with the peak availability of nectar and pollen to achieve increased honey yields and improved quality of honey. Thus, optimizing floral resource use and ensuring sustainable honey production require a clear understanding of vegetation-based honey production potential and an area's honeybee colony carrying capacity. In response to this need, the International Centre of Insect Physiology and Ecology (*icipe*), in collaboration with the Mastercard Foundation, Ethiopian Relief Organization (ORDA Ethiopia), International Institute of Rural Reconstruction (IIRR), and other implementing partners, conducted a comprehensive assessment in 20 MaYEA intervention woredas located in the South, Southwest, and Sidama regions of Ethiopia.

The study identified 32 and 68 bee plant species per woreda, with one to three optimal honey harvesting seasons mapped across sites. Estimated annual honey yields varied significantly, from 71.515 tons in Sodo Zuria to 1545.7 tons in Bita Woreda. Across the entire study area, the optimal honey yield was projected at 7,203 tons, while current production stands at only 2,273 tons, indicating that just 32.1% of the potential is being realized.

Honeybee colony numbers across woredas were well below optimal carrying capacity, ranging from 911 colonies in Baka Dawla to 36,419 in Benatsemay. An exception was Tello Woreda, where colony numbers exceeded optimal capacity by 2,257, resulting in increased competition for floral resources and reduced yields per colony.

Potential for apiary site development also varied widely: Benatsemay could host up to 240 sites, while Wonsho had the lowest potential at 11 sites. Forest ecosystems offered the highest colony carrying capacity per site, up to 393 transitional hives or 320 frame hives in the South, and up to 900 transitional or 733 frame hives in the Southwest and Sidama regions. Agroforestry systems followed, supporting up to 148 transitional or 121 frame hives in the South, and up to 500 transitional or 407 frame hives per site in the Southwest and Sidama regions.

The analysis estimates that up to 76,206 youth could be newly engaged in beekeeping enterprises across the intervention areas, presenting a significant opportunity for rural employment and economic development.

Key constraints/challenges identified across the woredas include:

- Limited access to quality training and extension services
- Unregulated use of agrochemicals
- Colony absconding
- Inadequate access to finance
- Seasonal forage shortages
- Pest and predator pressures

These challenges, while varying in severity by location, must be addressed to unlock Ethiopia's apiculture sector's full potential and ensure its contribution to sustainable livelihoods and rural development.

1. Introduction

The International Centre of Insect Physiology and Ecology (*icipe*) is an international scientific research institute, headquartered in Nairobi, Kenya that works towards improving lives and livelihoods of people in the tropics. *icipe* in partnership with the MasterCard Foundation, IIRR, ORDA Ethiopia, and implementing partners is implementing the Mass Youth Employment in Apiculture (MaYEA) program. The program is aimed to transform Ethiopia's apiculture industry by enabling 1,050,000 young people (80% women) to access wage and self-employment through skilling and access to financial services in 135 Woredas (districts). These Woredas are organized into three implementation hubs: Central, South and Southwest Ethiopia sub national Hub (Oromia, Sidama, Central, South, Southwest, and Gambella regions), North and Northwest Ethiopia sub national Hub (Amhara, Afar, Tigray and, Benishangul Gumuz regions), and Program Coordination Hub. From these, 11 Woredas of South Ethiopia were addressed by this study. The implementing partners, led by IIRR, ORDA Ethiopia, and *icipe*, will work together to establish a success story in the value chain through a well-coordinated consortium approach.

MaYEA aims to transform the apiculture sector and allied value chains to triple the current annual honey production by 2028 by creating employment opportunities to 300,000 new beekeepers, increasing the production and productivity of 350,000 existing young beekeepers, and engaging additional 350,000 young people in integrated value chain activities according to relevant climatic, economic and market orientation of the location.

Apiculture remains the primary economic activity for MaYEA's youth partners. Ethiopia is renowned for its high diversity of plant species (Hedberg, 2009; Kassa et al., 2016) and is a significant center of origin for many endemic plant species (Tadesse et al., 2017). Out of the country's 6,000 species of higher plants, 647 (10.74%) are endemic (Kelbessa and Demissew, 2014). Understanding the primary bee plant species and their flowering calendar in various agroecological zones is crucial for estimating the honey flow period, which is essential for effective beekeeping operations (Bareke and Addi, 2019). Identifying and understanding the distribution and flowering patterns of bee forage plants enables beekeepers to synchronize colony management practices with the peak availability of nectar and pollen. This synchronization can lead to increased honey yields and improved quality of honey (Bareke and Addi, 2019).

The flowering calendar and the seasonal cycles of honeybee colonies are interconnected, facilitating efficient seasonal colony management (Adi et al. 2014). Beekeeping operations should align with the phenological patterns of local honey plants to ensure that the peak population size of bees occurs before or during the nectar flow, even though bee populations naturally increase when resources are abundant (Bareke and Addi, 2018). Hence, having a beekeeping floral calendar helps the beekeepers plan and implement seasonal beekeeping activities, optimize honey production, and ensure the bees have access to the right resources at the right time.

Moreover, the concept of honeybee colony carrying capacity is not well understood or applied in these areas. Without this knowledge, beekeepers may either underutilize or overburden the available floral resources, leading to suboptimal honey production and potentially harming both the bee colonies and the environment.

Therefore, this study aims to identify bee forage plants and their flowering calendars while assessing the honeybee colony carrying capacity specific to the MaYEA operational areas. The purpose of this assessment is to equip beekeepers with the tools and knowledge needed to synchronize their management practices with the natural cycles of their environment. This strategic alignment will help optimize honey production and promote sustainable beekeeping practices.

1.1. Objectives of study

- Assess availability and distribution of honeybee floral resources and their flowering periods.
- Estimate the honey production capacity in selected potential areas of Ethiopia.
- Estimate the optimal density of honeybee colonies that can be sustained in MaYEA intervention areas.
- Estimate the employment potential of beekeeping in selected MaYEAs intervention areas.
- Identify key constraints that affect honey production.

1.2. Scope of the work

- The honey production potential of major and abundant honeybee plants as well as their flowering periods was reviewed from previous work.
- Comprehensive survey was conducted that includes seasonal beekeeping practices, land use patterns, diversity of bee flora resources, flora calendars, existing honeybee

colony densities, honey production potential, and the carrying capacity of honeybee colonies.

- Appropriate statistical tools were used to analyze collected data and estimate key parameters such as total bee colony carrying capacity and the production and employment potential of the apiculture sector.
- Focus group discussions on honey harvesting frequencies, honey yield per harvest in each harvesting season, land use type, honeybee colony density, and beekeeping practices were used to gather estimates of honey production and validate findings.
- The detailed report was compiled and validated to collect feedback and revise the report for final submission.

2. Study Methods and Approaches

2.1. Description of the study area

The study was conducted in the South Ethiopia region which includes South Omo (Hamar and Benatsemay Woredas), Ari (Baka Dawla Woreda), Konso (Kena Woreda), Gofa (Gazie Gofa and Ubba Debretehay Woredas), Gamo (Chencha, Garda Marta, Kemba and Kucha Alfa Woredas) and Wolaita (Sodo Zuria Woreda), Kafa (Bitu, Adiyo, Tello and Decha), Bench Sheko (Guraferda, Sheybench), Sidama (Darara, Malga and Wonsho) Zones (Figure 1). Data were not collected from Salamago and Melo Gada Woredas due to security problem, and inaccessibility of road, respectively. On the other hand, necessary data, particularly honeybee flora data, were not received from Mengeshi, Bona Zuria, Damot Pulasa, Boloso Sore Woreda and Jinka Town from the responsible government structure and hence, they were not included in the report.

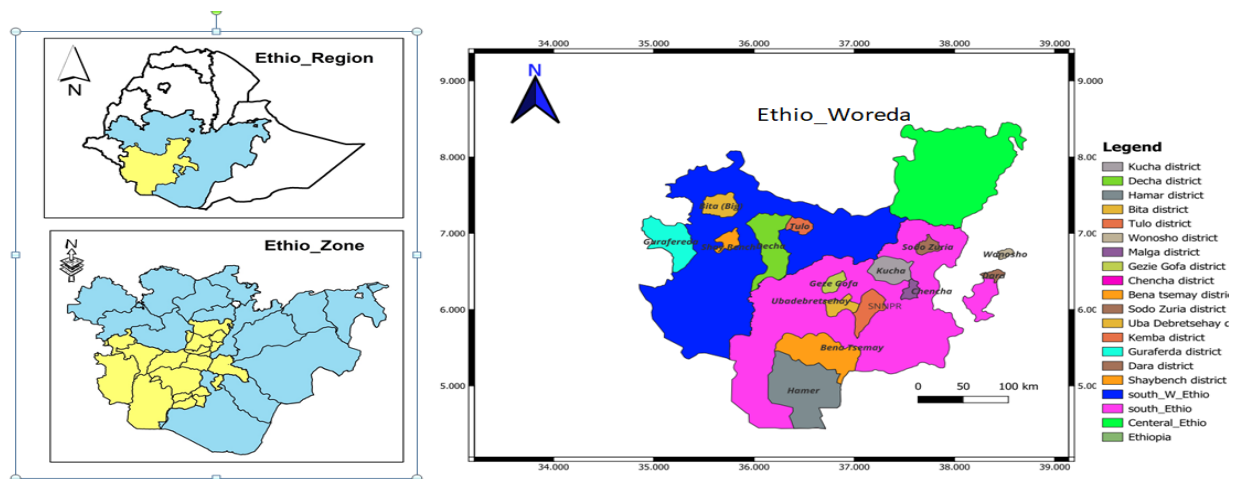


Figure 1. Map of the study area in the South Ethiopia region

The MaYEA intervention areas were first categorized by partners as having high, medium and low potentials for beekeeping, with the woredas mentioned below representing each category (Table 1).

Table 1. Selected woredas for the assessment in this study

Zone	Woreda	Potential level
Ari	Baka Dawla	High
South Omo	Hammar	High
	Bena tsemay	High
Konso	Kena	Medium
Gamo	Chencha	Low
	Garda Marta	High
	Kemba	Medium
	Kucha Alfa	High
Gofa	Gazie Gofa	Medium
	Ubba Debretsehay	Medium
Wolaita	Sodo Zuria	High
Kaffa	Adiyo	High
	Tello	Low
	Biti	High
	Decha	High
Bench Sheko	Guraferda	High
	Sheybench	Medium
Sidama	Darara	Medium
	Malga	Low
	Wonsho	High

2.2. Sampling Size and design of household survey

A stratified sampling approach was used, beginning at the zonal level and ending with the household as the ultimate sampling unit. Districts were served as the primary sampling units, followed by kebeles, enumeration areas and individual beekeepers. To ensure proper representation, three kebeles from each study woredas were purposefully picked, and respondents were chosen based on their beekeeping experience, ownership of bee colonies and knowledge on bee flora diversity and phenology to represent one-third of the total beekeepers. As a result, respondents from each study kebele ranged from 30 to 90.

2.3. Sampling design for honeybee flora inventory

Sampling design: Longitudinal transect survey was conducted from the edge of the kebele to the end (including all land use types and agroecology). Nested plotting system was applied. Number of plots varied from 45 to 80 plots/woreda and 18.9 to 33.6 km longitudinal transect walk per woreda. Main plot size was 400 m², with quadrats laid at 400 m intervals between plots for trees. Sub-plot sizes were 25 m² for shrubs and four (4) m² for herbs and laid at the fourth angle and at the center of the main plot for herbaceous species (Kent & Coker, 1992; Kent, 2011). Such a design crosses all land use types and agroecology of the area (Figure 2).

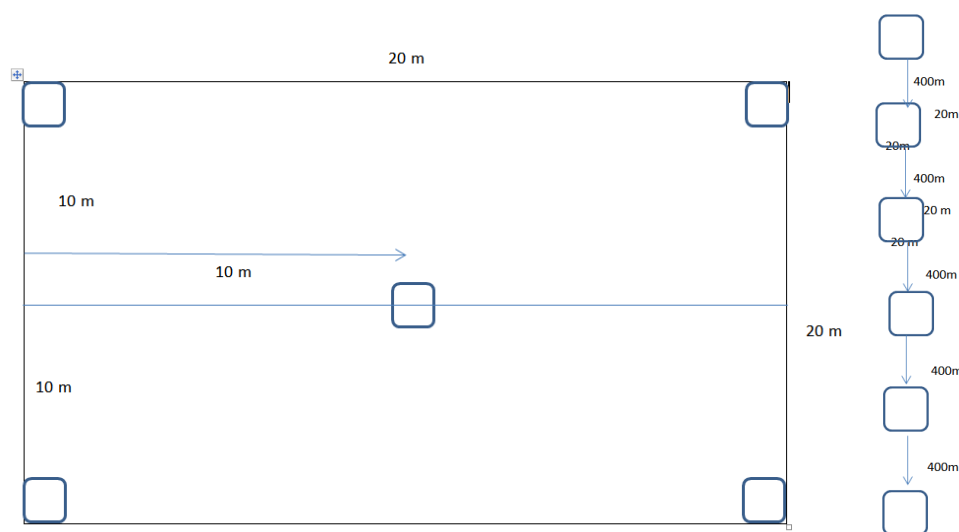


Figure 2. Layout of bee plant inventory with main plot and subplot location dimensions

2.4. Study Approach

The assessment follows a mixed approach in which both qualitative and quantitative data were collected and analyzed to assess bee flora resources, to estimate the colony carrying capacity, honey production and employment potential. The data was collected through literature reviews, surveys and ground bee plant inventory. The assessment also follows a participatory process in which key stakeholders participate and validate the results.

A. Assessing availability and distribution of honeybee floral resources and their flowering calendars

Primary data was collected through a ground inventory of honeybee flora and key informant interviews. Additionally, secondary data was gathered from reports by the woredas' livestock

offices, which provided information on dominant honeybee plants, harvesting seasons and frequencies, and active and dearth periods from a beekeeping perspective. Relevant published papers on beekeeping were also reviewed to complement the collected data.

B. Estimating honey production potential of selected woredas

To estimate the honey production potential of selected areas, a combination of primary data (ground honey plant inventory), secondary data (current honey production by hive types and literature review (Appendix 1) on honey production potential of dominant bee forage plants) were used. A longitudinal transact survey was conducted in selected study areas/kebeles to assess, identify and prepare an inventory of honeybee flora abundance and diversity. Subsequently, the honey production potential of the areas was estimated based on the honey production potential of these major and abundant honey plant species.

C. Estimating Honeybee colony carrying capacity of selected woredas

To estimate the honeybee colony carrying capacity of the selected areas, the current total number of honeybee colonies by hive type, as well as the study woreda's optimal honey production potential as a function of the amount of honey that can be collected from the dominant bee flora, were considered.

D. Employment potential of beekeeping in the study woredas

After determining the honeybee colony carrying capacity of the area, the employment potential of beekeeping was determined, as detailed in section 2.6.

E. Identifying major constraints of honey production

Both primary and secondary data were used to identify the major constraints of the honey production of the area. Primary data was collected using a questionnaire survey and focus group discussions (FGD). Secondary data was gathered by reviewing existing data and documentation, including project reports, government reports, and academic papers on beekeeping. The study focused on beekeeping potential, challenges hindering local communities from participating and succeeding in modern beekeeping, and opportunities for rural communities to engage in the beekeeping industry.

2.5. Data Collection methods and tools

2.5.1. Literature review

Literature review was conducted about honey production potential of major honeybee plants (Appendix 1).

2.5.2. Field surveys

A. Household interview: Semi-structured questionnaires were used for the field survey data collection (Appendix 2). It was conducted with respondents that were selected based on their beekeeping experience, ownership of bee colonies and knowledge on bee flora diversity and phenology.

B. key informant interviews: It was conducted with respondents that were selected based on their beekeeping experience, ownership of bee colonies and knowledge of bee flora diversity and phenology.

C. Focus group discussions: It included honeybee colony density, beekeeping practices, and honey production projections and challenges of beekeeping.

2.5.3. Inventory of bee forage plants

Data collection sheet was used for honeybee flora identification and inventory.

2.6. Data analysis methods

Current and expected honey yields: The expected honey yield is half the honey production potential of the study areas. The reason for dividing the honey production potential by two is that for every 1 kg of harvestable honey, bee colonies may consume 1 kg of honey to meet their nutrient requirements for maintenance and reproduction (Chaudhary, 2009).

The current honey yield in a given study area is determined as the sum of honey harvested from traditional, transitional and modern hives based on the existing honeybee colony density.

Total current honey yield in kg = Number of honeybee colonies in traditional hives * average productivity of traditional hives/year + number of honeybee colonies in transitional hives * average productivity of transitional hives/year + number of modern hives * average productivity of modern hives/year.

Then, the optimum expected honey yield (kg) = Expected honey yield - current honey yield (Al-Ghamdi *et al.*, 2016).

Honeybee colony carrying capacity: The current average optimum honey yield of well-managed honeybee colonies in South Ethiopia region was 8 kg per harvest for traditional hives, 15 kg for transitional hives and 20 kg for frame hives.

In order to determine the optimum honeybee colony carrying capacity of a given area, honey that can be consumed by colonies for their energy requirement and brood rearing and

current annual honey yield of well managed honeybee colonies in traditional, transitional and modern hives were considered. Assuming that all factors remain constant, to harvest 1 kg of surplus honey, honeybee colonies will have to consume a further 1 kg of honey for survival, brood rearing, as fuel energy to foragers. Based on this requirement, 2 kg of honey must be produced by honeybee colonies in order to harvest 1 kg of honey. As a result, the optimum number of traditional, transitional and modern hives per given area was calculated as follows:

Optimum number of traditional hives:

$$\frac{\text{Expected honey production potential of bee plants (kg)/ha}}{\text{Maximum honey yield of traditional hive} \times 2}$$

Optimum number of transitional hives:

$$\frac{\text{Expected honey production potential of bee plants (kg)/ha}}{\text{honey yield of well managed transitional hive} \times 2}$$

Optimum number of Modern hives:

$$\frac{\text{Expected honey production potential of bee plants (kg)/ha}}{\text{honey yield of well managed modern hive} \times 2}$$

(Chaudhary, 2009; Al-Ghamdi *et al.* (2016))

The estimated number of honeybee colonies to be established per area, based on different proportions of hive types, was as follows:

Optimum no. of honeybee colonies =

$$\frac{\text{EOHY} * \% \text{ of TDBC}}{(\text{Well managed honey yld of TDBC}) * 100} + \frac{\text{EOHY} * \% \text{ of TRBC}}{(\text{Well managed honey yld of TRBC}) * 100} + \frac{\text{EOHY} * \% \text{ of FBC to be established}}{(\text{Well managed honey yld of FBC}) * 100}$$

Where,

EOHY: Expected optimum honey yield

TDBC: Traditional honeybee colonies

TRBC: Transitional honeybee colonies

FBC: Frame honeybee colonies

Calculating the number of sites/Woreda

To estimate number of apiary site /Woreda, the economic flight range (2 km) of Worker honeybee was used (Hagler et al., 2011). Accordingly, workers honeybee at one site can economically forage and provide surplus honey from a total area of 12.56 km². It was calculated by the formula $A = \pi r^2$, and equivalent to 1256 ha.

$$\text{No. apiary site per Woreda} = \frac{\text{Area of the Woreda (ha or km}^2\text{)}}{1256 \text{ ha or } 12.56 \text{ km}^2}$$

Estimating Optimum number of honeybee colonies/site

Optimum no. of honeybee colonies per apiary site =

$$\frac{\text{Optimum no. of honeybee colonies by hive types}}{\text{No. of sites per woreda}}$$

Determining honeybee colony stocking/Woreda

Honeybee colony stocking per area = Optimum no. of honeybee colonies minus no. of currently introduced honeybee colonies.

- Overstock/under/Balanced with floral resource

Employment potential of beekeeping in selected MaYEAs intervention areas

MaYEA Program aims to increase national honey production by threefold in 2028. To achieve this, each youth is expected to manage five transitional hives and produce 20 kg of honey per hive annually. Based on the current average honey price in Ethiopia (ETB 500 per kg or ~USD8.9) the youths are expected to generate a total of USD1,426 million from honey sale (MaYEA program's joint MEL plan, 2024). It is equivalent to USD 757 per capita annual income, which is comparable to the national per capita income in 2024. The youth income in apiculture sites needs to be supplemented by complementary side business to fulfil the dignified and fulfilling job criteria.

No. of Youth to be involved in beekeeping =

$$\frac{\text{Optimum no. of transitional honeybee colonies to be established}}{5}$$

Calculating the diversity of bee plants:

The diversity of bee plants was assessed using the Shannon-Wiener Index.

S

$$\text{Shannon Index (H')} = - \sum_{i=1}^S p_i \ln p_i$$

Where:

H': Shannon-Wiener diversity index

S: the number of species

P_i: the proportion of individuals or the abundance of the ith species

ln: the natural logarithm, and Σ is the sum from species 1 to species S (Kent and Coker 1992; Ramírez-Arriaga et al. 2011).

The evenness of the species was calculated based on the following formula:

$$J = H' / H_{\max}$$

Where, H' : Shannon-Wiener diversity index and $H_{\max}$ is the maximum value of Shannon-Wiener diversity index, J evenness, the value of J ranges from 0 to 1. Higher values indicate higher levels of evenness. At maximum evenness, $J = 1$.

The relative abundance of bee flora was calculated as the following:

$$\text{Abundance (A)} = \frac{\text{Number of individual plant species}}{\text{Sampling area}}$$

$$\text{Relative abundance (RA): } \left(\frac{\text{Abundance of individual plant species}}{\text{Total abundance of all plant species}} \right) * 100$$

Data was analyzed using descriptive statistics (graph, table), Partitioning Around Medoids (PAM) was used to cluster Woredas based on their Expected optimum honey yield, Chi-square test, Fisher's exact test.

3. Results and Discussions

3.1. Availability and distribution of honeybee floral resources and their flowering periods

The diversity of bee flora resources varied across the study Woredas, as illustrated in Figure 3. The highest number of bee forage plant species was recorded in Sodo Zuria Woreda, where a total of 68 bee plant species were identified. This was followed by Gazie Gofa and Ubba Debretsehay Woredas, with 59 and 58 identified plant species, respectively (Appendix 2). In contrast, Wonsho Woreda exhibited the lowest number of bee flora species, with only 32 plant species documented (Figure 4).

The relatively high species richness identified in Sodo Zuria Woreda indicates that the area has well-preserved flora, most likely as a result of effective conservation efforts and sustainable land management practices. The presence of diverse bee flora in this Woreda implies a robust and resilient ecosystem that supports pollinators, particularly honeybees, by providing an abundance of nectar and pollen supplies.

On the other hand, the significantly lower number of bee flora species recorded in Wonsho Woreda may indicate ecological degradation. This reduced plant diversity could be attributed to factors such as habitat fragmentation, deforestation, agricultural expansion, and other anthropogenic disturbances. The decline in floral resources poses potential risks to local pollinator populations, which in turn can affect pollination services, biodiversity, and

agricultural productivity. Under these conditions, landscape rehabilitation and honeybee flora planting must be prioritized.

Food or the proportion of nectar to pollen sources

In the assessment of bee flora resources, it was found that the highest proportion of bee plant species providing only pollen was recorded in Kucha Alfa, accounting for 42.1% of the identified species (Figure 3). In contrast, Shay bench had the lowest proportion of bee plant species classified as pollen-only sources, making up just 14% of the total (Figure 4). Notably, the majority (86%) of bee plants identified in Shay bench Woreda were dual-purpose species, supplying both nectar and pollen resources to honeybees (Figure 4). In locations where a significant proportion of the flora plants are pollen sources, as noted in Kucha Alfa, indicate that there may be extensive agricultural practices, so planting bee flora nectar sources should be prioritized.

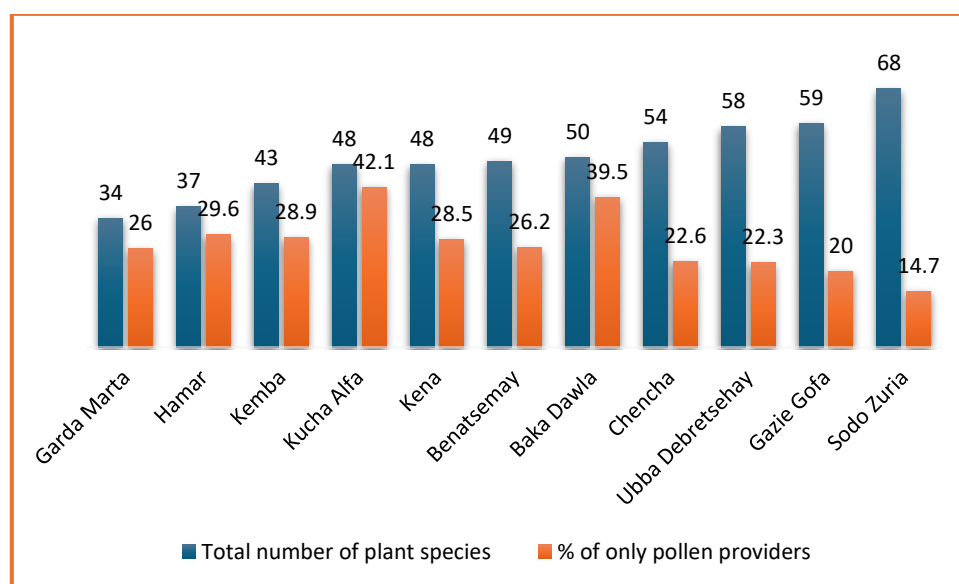


Figure 3. Number of bee flora identified and percentage of sole pollen sources in the study woredas in South Ethiopia region

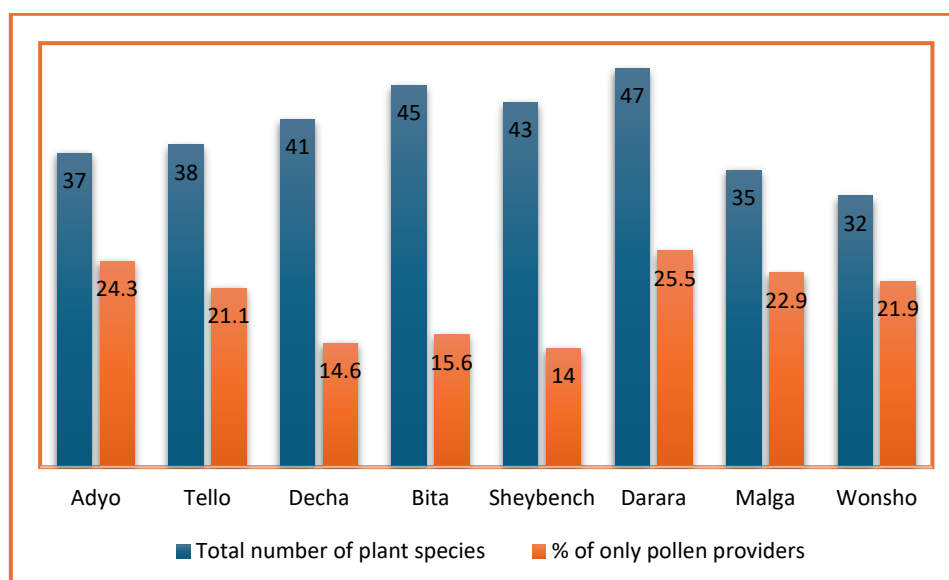


Figure 4. Number of bee flora identified and percentage of sole pollen sources in the study woredas in the Southwest and Sidama regions

3.1.1. Honey harvesting seasons, frequencies and dominant honeybee flora

The season and honey harvesting frequencies, which ranged from one to three, as well as the dominant honeybee flora contributing to honey production, varied across the study Woredas (Tables 2 and 3). In some areas, a single honey harvesting season was detected, whereas in others, two to three seasons were observed, as indicated below:

- **One honey harvesting season/frequency** was documented in Tello and Wonsho Woredas (Table 3).
- **Two honey harvesting seasons/frequencies** were recorded in Gardu Marta, Kemba, Ubba Debretehay, Kena, Baka Dawla, and Hamar Woredas of South region of Ethiopia (Table 2) and Adiyu, Guraferda, Decha, Darara and Malga Woredas of Southwest and Sidama Regions of Ethiopia (Table 3).
- **Three honey harvesting seasons/frequencies** were noted in Kucha Alfa, Chenchu, Gazie Gofa, Sodo Zuria, and Benatsemay Woredas in South region of Ethiopia (Table 2) and Bitu, and Sheybench Woredas (Table 3) of the Southwest region.

Those study woredas with three honey harvesting frequencies had their harvesting season between October to November, March to April, and May to June, aligning with the peak blooming periods of significant honeybee forage plants in each agroecological zone of south Region of Ethiopia (Table 2). The March to April harvesting period was a minor harvesting season, whereas it was absent in areas with only two harvests per year in the South Ethiopia

region. On the other hand, April to March was the major honey harvesting season in Southwest region of Ethiopia.

The diversity and abundance of honeybee plants that contribute to honey production varied between study woredas due to differences in climatic conditions, vegetation types, and floral cycles. These honeybee floras, which serve as primary nectar and pollen sources, played a crucial role in honey production. Their presence and abundance dictated the amount of annual honey harvests in each Woreda.

Understanding the seasonal availability of honey plants and their contributions to honey production is essential for optimizing beekeeping practices, improving colony management strategies and ensuring sustainable honey production.

Table 2. Major honeybee flora in the South Ethiopia region's study woredas that contribute to honey production

Woreda	Honey harvesting season	Major honeybee flora that contributes to honey production
Adiyo	November-December	<i>Guizotia scabra</i> , <i>Cordia africana</i>
	March to April	<i>Schefflera abyssinica</i>
Tello	October-Nov	<i>Trifolium spp</i> , <i>Guizotia scabra</i> , <i>Cordia africana</i>
Decha	January to February	<i>Vernonia auriculifera</i>
	March-April	<i>Schefflera abyssinica</i> , <i>Syzygium guineense</i>
Bit	November -December	<i>Guizotia scabra</i> , <i>Cordia africana</i>
	March-April	<i>Schefflera abyssinica</i> , <i>Coffea arabica</i> , <i>Syzygium guineense</i>
	May-June	<i>Croton macrostachyus</i> , <i>Eucalyptus globulus</i>
Sheybench	November-December	<i>Cordia africana</i> , <i>Guizotia scabra</i>
	January to April	<i>Vernonia auriculifera</i> , <i>Coffea arabica</i>
	March-April	<i>Syzygium guineense</i> , <i>Schefflera abyssinica</i>
Guraferda	November- December	<i>Cordia africana</i> , <i>Vernonia spp</i> , <i>Terminalia spp</i>
	April-May	<i>Schefflera abyssinica</i> , <i>Croton macrostachyus</i>
Darara	November-December	<i>Cordia africana</i> , <i>Guizotia scabra</i>
	April to May	<i>Croton macrostachyus</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia tortilis</i>
Malga	November -December	<i>Guizotia scabra</i> , <i>Cordia africana</i> , <i>Hypoestes forskalii</i>
	April -May	<i>Croton macrostachyus</i> , <i>Eucalyptus globulus</i>
Wonsho	March-April	<i>Coffea arabica</i> , <i>Vernonia auriculifera</i>

Table 3. Major honeybee flora in the Southwest and Sidama regions' study woredas that contribute to honey production

Woreda	Honey harvesting season	Major honeybee flora that contribute to honey production
Garda Marta	October to November	<i>Acacia senegal</i> , <i>Acacia sieberiana</i> , <i>Acacia seyal</i> , <i>Terminalia brownii</i> , <i>Prunus africana</i> , <i>Plectranthus</i> spp
	May to June	<i>Acacia tortilis</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia nilotica</i>
Kemba	October to November	<i>Acacia senegal</i> , <i>Terminalia brownii</i> , <i>Cordia africana</i> , <i>Plectranthus</i> spp, <i>Acacia seyal</i>
	May to June	<i>Acacia tortilis</i> , <i>Eucalyptus camaldulensis</i> , <i>Croton macrostachyus</i>
Kucha Alfa	October to November	<i>Acacia senegal</i> , <i>Terminalia brownii</i> , <i>Cordia africana</i> , <i>Acacia sieberiana</i> , <i>Acacia seyal</i>
	March to April	<i>Syzygium guineense</i> , <i>Coffea arabica</i>
	May to June	<i>Acacia tortilis</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia nilotica</i>
Chencha	October to November	<i>Acacia etbaica</i> , <i>Cordia africana</i> , <i>Acacia sieberiana</i> , <i>Plectranthus</i> spp, <i>Acanthus sennii</i> , <i>Aloe debrana</i>
	March to April	<i>Syzygium guineense</i> and other minor honey plant species
	May to June	<i>Eucalyptus globulus</i> , <i>Eucalyptus camaldulensis</i>
Gazie Gofa	October to November	<i>Cordia africana</i> , <i>Acacia sieberiana</i> , <i>Acacia seyal</i> , <i>Plectranthus</i> spp
	March to April	<i>Syzygium guineense</i> and other minor honey plant species
	May to June	<i>Eucalyptus camaldulensis</i> , <i>Croton macrostachyus</i> , <i>Acacia tortilis</i>
Ubba Debretehay	October to November	<i>Acacia senegal</i> , <i>Terminalia brownii</i> , <i>Acacia seyal</i> , <i>Acacia sieberiana</i> , <i>Cordia africana</i> , <i>Plectranthus</i> spp, <i>Prunus africana</i>
	May to June	<i>Acacia tortilis</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia nilotica</i>
Sodo Zuria	October to November	<i>Acacia sieberiana</i> , <i>Cordia africana</i> , <i>Acacia senegal</i> , <i>Acacia seyal</i>
	March to April	<i>Syzygium guineense</i> , <i>Coffea arabica</i>
	May to June	<i>Croton macrostachyus</i> , <i>Acacia nilotica</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia tortilis</i>
Kena	October to November	<i>Terminalia brownii</i> , <i>Cordia africana</i> , <i>Acacia seyal</i> , <i>Helianthus annuus</i>
	May to June	<i>Acacia tortilis</i> , <i>Eucalyptus camaldulensis</i> , <i>Croton macrostachyus</i>
Baka Dawla	October to November	<i>Acacia senegal</i> , <i>Cordia africana</i> , <i>Plectranthus ornatus</i> , <i>Acacia etbaica</i> , <i>Terminalia brownii</i>
	May to June	<i>Croton macrostachyus</i> , <i>Acacia nilotica</i> , <i>Eucalyptus camaldulensis</i>
Hammar	October to November	<i>Acacia senegal</i> , <i>Acacia etbaica</i> , <i>Terminalia brownii</i> , <i>Acacia seyal</i> , <i>Plectranthus ornatus</i>
	May to June	<i>Acacia tortilis</i> , <i>Acacia nilotica</i> , <i>Eucalyptus camaldulensis</i>
Benatsemay	October to November	<i>Terminalia brownii</i> , <i>Cordia africana</i> , <i>Acacia seyal</i> , <i>Acacia etbaica</i> , <i>Plectranthus ornatus</i>
	March to April	<i>Syzygium guineense</i> , <i>Coffea arabica</i>
	May to June	<i>Acacia tortilis</i> , <i>Croton macrostachyus</i> , <i>Acacia nilotica</i> , <i>Eucalyptus camaldulensis</i>

3.1.2. Bee flora diversity

Sodo Zuria Woreda has the highest bee flora species diversity ($H' = 3.6$, as shown in Table 4), with a relatively high number of bee forage species and a more evenly distributed population, indicating a well-balanced ecosystem that supports diverse plant-pollinator interactions. Gazie Gofa Woreda has the second-highest diversity ($H' = 3.12$).

In contrast, Garda Marta Woreda has the lowest diversity of bee plant species ($H' = 1.8$), probably due to habitat degradation, land-use changes, or climatic conditions that limit floral diversity.

Comparing these results with previous studies, research conducted by Bareke et al. (2024) in the Wonchi district reported an even higher diversity ($H' = 4.7$), followed by Waliso ($H' = 4.55$). These findings indicate that some regions, particularly those with heterogeneous landscapes, support a greater variety of bee forage plants, potentially enhancing biodiversity conservation.

The variations in bee plant diversity across different locations can be attributed to several ecological and environmental factors. Plant diversity is strongly influenced by topographic variables such as slope, aspect, and altitude (Addi et al., 2020). Areas with varied topography often create microhabitat that favors diverse plant communities, whereas flatter or homogeneously structured landscapes may limit species richness. Additionally, climatic conditions, soil fertility, and anthropogenic activities such as deforestation and agricultural expansion play crucial roles in shaping plant diversity and distribution patterns.

Evenness of bee flora resources

The highest evenness of bee plant species was recorded in Sheybench Woreda at 0.92, followed by Wonsho Woreda at 0.91 (Table 4). This relatively high evenness suggests a more balanced distribution of species within these areas, where no single species dominates significantly over the others. In contrast, the lowest evenness was observed in Hamar Woreda, indicating that the plant community in this area is less balanced, with certain species being highly dominant while others are relatively rare. Such variation in species evenness across different woredas may be influenced by environmental factors, land use patterns, and ecological interactions, all of which can impact the availability and distribution of bee forage plants.

Table 4. Diversity indices of the bee flora resources of study Woredas in the South, Southwest and Sidama regions

Woreda	Shannon's diversity index (H')	Evenness
Gazie Gofa	3.12	0.45
Ubba Debretsehay	3.07	0.38
Chencha	2.86	0.37
Garda Marta	1.8	0.35
Kemba	2.3	0.30
Kucha Alfa	2.5	0.35
Kena	2.54	0.33
Baka Dawla	2.65	0.34
Hamar	2.0	0.25
Benatsemay	2.6	0.34
Sodo Zuria	3.6	0.40
Tello	2.95	0.79
Adiyo	3.2	0.86
Decha	2.4	0.74
Bitu	2.6	0.72
Shey bench	2.72	0.92
Guraferda	2.74	0.81
Darara	3.12	0.82
Wonsho	2.8	0.91
Malga	2.9	0.79

Figure 5 illustrates that habitat loss and deforestation for agricultural expansion and charcoal production were widespread in the study Woredas. This has a significant impact on beekeeping, as it relies on natural floral resources and is inherently dependent on the environment.



Figure 5. Habitat loss and degradation in some of the study woredas

Figure 6 below illustrates variations in vegetation coverage across different landscapes. These differences may be influenced by factors such as topography, climatic conditions, and land use patterns. Variability in vegetation density and distribution across landscapes can provide insights into ecosystem health, biodiversity levels, and potential habitat suitability for various species. Additionally, these variations may reflect human activities such as agriculture, deforestation, or conservation efforts, which impact the structure and composition of plant communities in each area.

	
<i>Cordia africana</i> dominated landscape	<i>Acacia</i> species dominated landscape
	
Forest with diversity of bee flora	Agricultural land with remnant plant species

Figure 6. Variations in vegetation coverage across different landscapes

3.2. Honey production potential of the study areas in different seasons of the year

Major and minor honey harvesting seasons varied across the studied woredas, owing mostly to the honey production potential of the dominant and most abundant honeybee floras. In Ubba Debretsehay and Garda Marta Woredas, the peak honey harvesting period occurred between October and November. During this season, Ubba Debretsehay and Garda Marta recorded the expected optimum honey yield of 162.6 and 66.4 tons , respectively (Figure 7). Similarly, in Hamar and Benatsemay Woredas, the major honey harvesting season also fell within the October to November period, with significantly high optimum expected honey

production levels. Hamar Woreda achieved an optimum expected honey yield of 237.6 tons, whereas Benatsemay Woreda recorded the highest optimum expected honey production among these areas, reaching 297.1 tons (Figure 8). In addition to this, the major honey harvesting season was from November to December for Tello (36.1 tons) and Wonsho (178.9 tons, as indicated in Figure 9). On the other hand, March to April was the major honey harvesting seasons in all study woredas of the Southwest and Sidama regions, apart from Tello and Wonsho Woredas (Figure 9).

Conversely, in other Woredas, the major honey harvesting season was observed from May to June, highlighting differences in flowering cycles and environmental conditions. In Gazie Gofa Woreda, optimum expected honey production during this season reached 136.5 tons, while Chenchu Woreda recorded 40.4 tons. Similarly, Kemba Woreda produced 140.5 tons, whereas Kucha Alfa Woreda achieved an optimum expected honey yield of 55.5 tons (Figure 7). Additionally, Kena, Baka Dawla, and Sodo Zuria Woredas also experienced their primary honey harvesting season between May and June, with honey yields of 60.9, 98.5 and 50.6 tons, respectively (Figure 8).

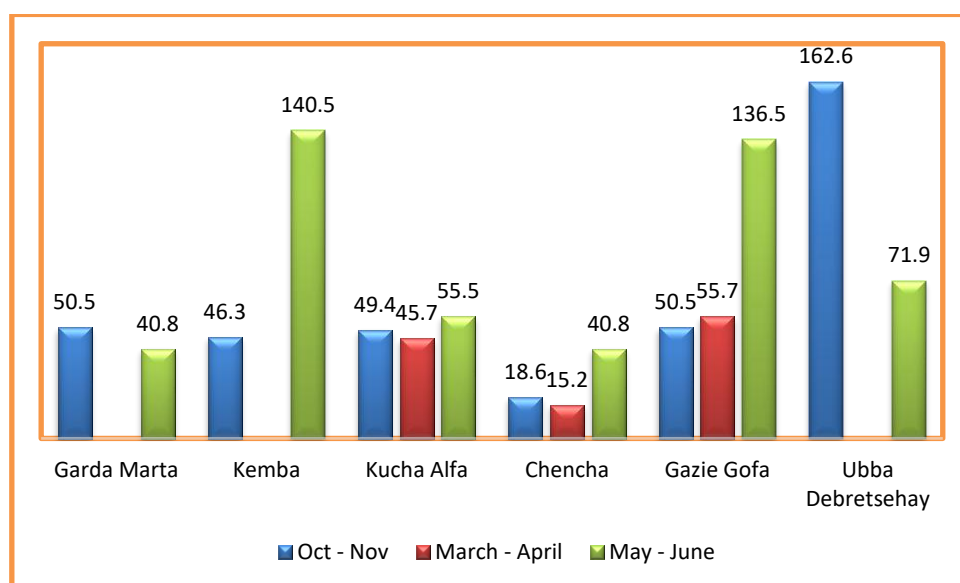


Figure 7. Expected Optimum Honey Yield in tons by Season in Garda Marta, Kemba, Kucha Alfa, Chenchu, Gazie Gofa and Ubba Debretehay Woredas.

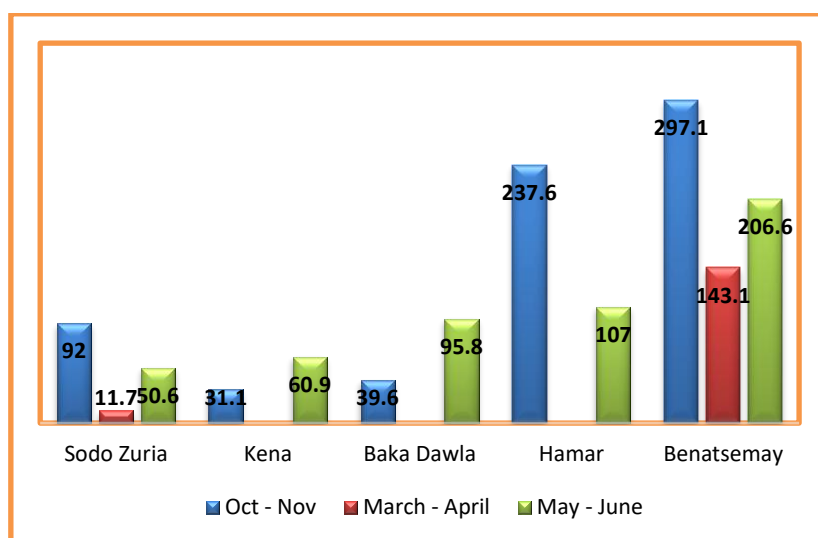


Figure 8. Expected Optimum Honey Yield in tons by Season in Sodo Zuria, Kena, Baka Dawla, Hammar, and Benatsemay Woredas.

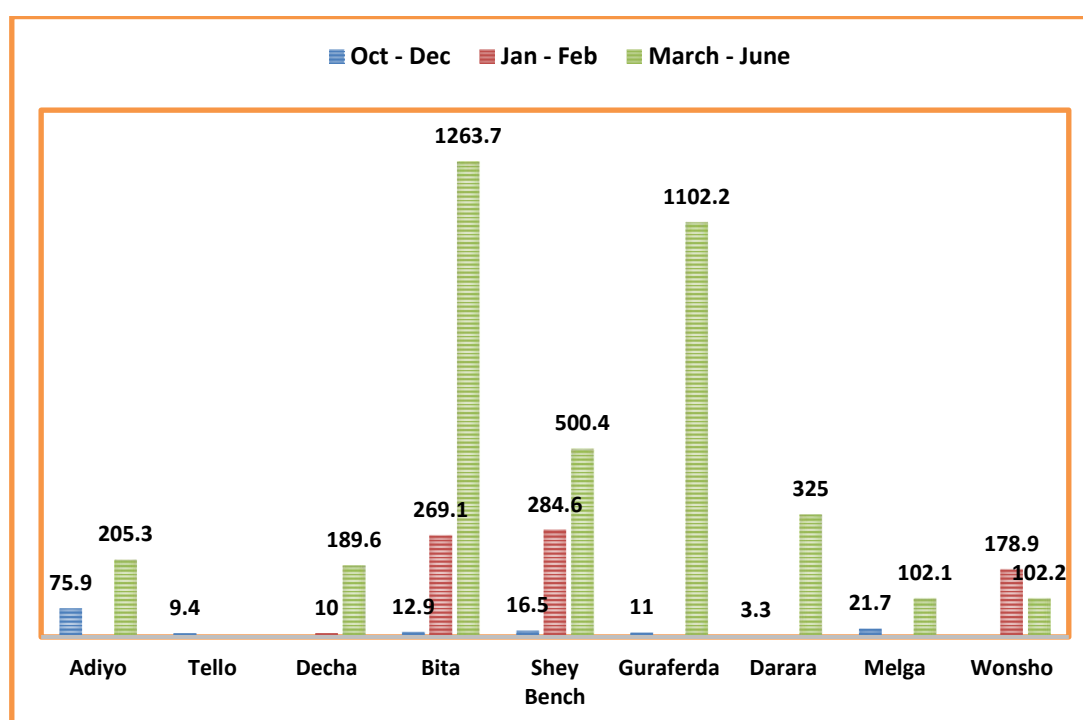


Figure 9. Expected Optimum Honey Yield in Tons in Adiyo, Tello, Adiyo, Decha, Bitu, Shey Bench, Guraferda, Darara, Malga and Wonsho Woredas.

3.2.1. Current and expected optimum honey production

The study revealed a notable variation between the expected optimum and current or actual honey yield throughout the surveyed woredas. The actual relative to estimated optimum honey yield varied significantly among the study woredas, highlighting variations in the

efficiency and effectiveness of honey production practices and utilization of the available honeybee flora.

Among the studied woredas, Baka Dawla had the highest percentage of honey production potential utilization, achieving 89.22% of its estimated optimum yield (Table 5). In contrast, Gazie Gofa had the lowest honey production efficiency, achieving only 13.04% of the anticipated optimum yield, indicating a major gap in honeybee colony management, sub-optimal harvesting efficiency or environmental constraints in the area. The widespread use of traditional beekeeping practice (98.13%) in Gazie Gofa woreda was a major contributor to this low production efficiency.

The total optimum honey yield from 20 Woredas in MaYEA intervention areas in the South, Southwest and Sidama Regions was 60,741.74 tons compared to 20,135.49 tons of actual honey production.

Across all studied woredas, the average proportion of actual honey production was 33% of the predicted optimum honey production (Table 5). This finding underscores that on the average, beekeepers in these regions use less than one-third of their honey production capacity. The underutilization could be due to a reliance on traditional beekeeping practices, limited access to modern beekeeping technologies, and inadequate colony management skills. The assessment found that 92.13% of beekeeping practices across all study woredas in the South Ethiopia, Southwest and Sidama regions were traditional. This heavy reliance on traditional beekeeping has a significant impact on honey yield compared to using transitional or frame hives. Transitioning to improved beekeeping practices may increase honey yield and contribute to the overall economic benefits in these areas.

Table 5. Current and expected optimum honey production in the study woredas of the South, Southwest and Sidama regions

Woreda	Current honey yield (tons)	Expected Optimum Honey yield (tons)	% of actual or current to expected optimum honey yield
Benatsemay	222.987	646.825	34.47
Hamar	69.299	344.64	20.11
Gazie Gofa	31.636	242.659	13.04
Ubba Debretsehay	95.642	234.564	40.77
Kemba	65.417	186.824	35.02
Kucha Alfa	46.12	150.64	30.62
Baka Dawla	64.465	135.446	47.59
Garda Marta	32.439	107.180	30.27
Kena	34.014	92.015	36.97
Chencha	13.540	74.276	18.23
Sodo Zuria	25.564	71.515	35.75
Adiyo	119.3	281.248	42.42
Tello	209.226	234.510	89.22
Decha	66.9	199.532	33.53
Bitu	625	1545.7	40.43
Shey Bench	159	785.1	20.25
Guraferda	259	1129.25	22.9
Darara	63	328.3	19.19
Malga	20	129.2	14.48
Wonsho	50	284.0	17.60
Total	2272.549	7203.424	32.14%
Percentage of current to expected optimum honey yield is 32.14%			

3.2.2. Clustering of the study woredas on their expected optimum honey yield

The clustering approach classified the study woredas into three, as indicated below:

Group I comprised six woredas: Sodo Zuria, Chencha, Kena, Garda Marta, Baka Dawla, Tello, and Malga which exhibited similar honey production potential (Figure 10). These Woredas share comparable environmental and ecological characteristics that support beekeeping, including a diverse array of honeybee forage plants, favorable climatic conditions, and ample land suitable for honey production.

Group II consisted of nine Woredas: Kucha Alfa, Kemba, Ubba Debretsehay, Gazie Gofa, Hammar, Decha, Darara, Adiyo, and Wonsho (Figure 10). The honey production potential

across these woredas was relatively uniform, likely due to similar vegetation types and nectar source plants, and common beekeeping practices.

Group III included three woredas: Benatsemay, Bita, and Sheybench (Figure 10), which demonstrated significantly higher honey production potential than the other groups. This elevated potential is attributed to several factors, including extensive natural forest cover, rich biodiversity, and an abundance of melliferous plant species that ensure a consistent nectar supply throughout the year. Additionally, these woredas experience relatively low levels of agricultural intensification, helping to maintain an optimal habitat for honeybee colonies. The clustering approach effectively classified woredas with similar honey production capabilities into the same group, providing valuable insights for targeted beekeeping development, resource allocation, and sustainable honey production strategies.

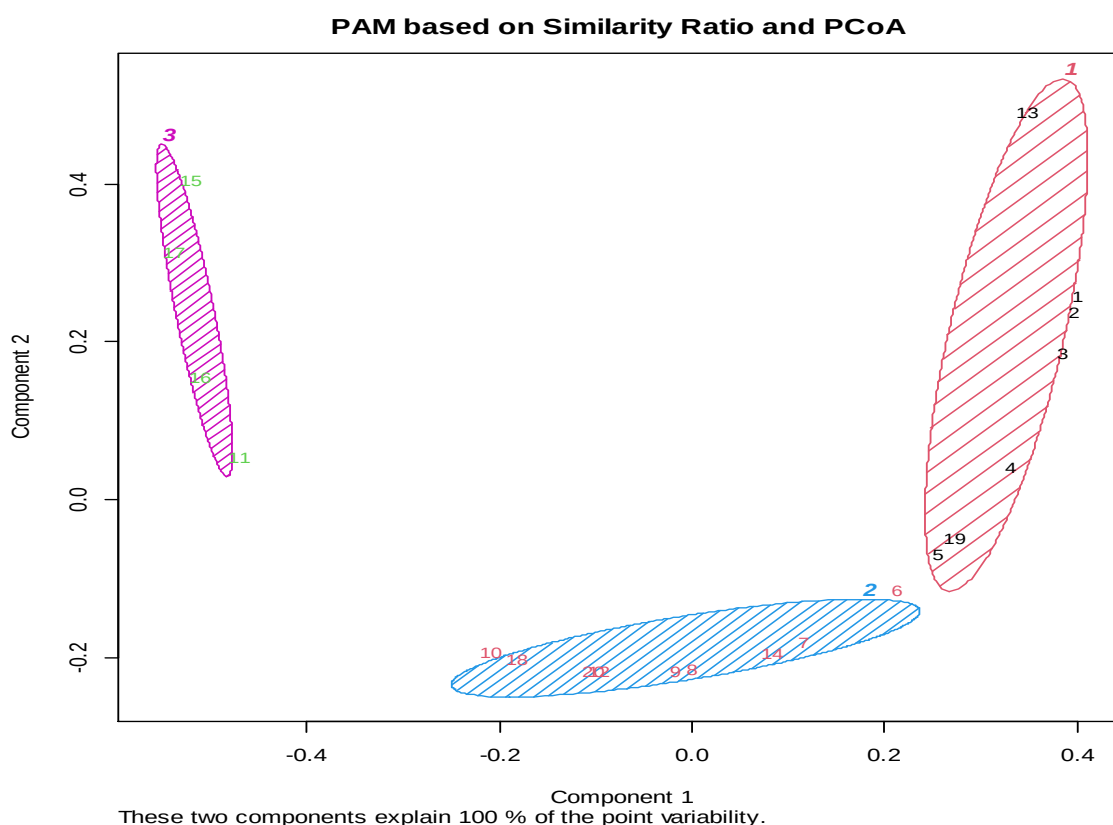


Figure 10. Clusters of the study Woredas based on their expected optimum honey production potential using Partitioning Around Medoids (PAM) analysis.

Note: Components 1 and 2 are PAM axis, a number in the clusters represents the sampling Woreda, letters represent number of clusters and the diagram in the figure showed a level of similarity among one another. PCoA: Principal Coordinates Analysis

3.3. Optimum honeybee colony carrying capacity

3.3.1. Current beekeeping practices by hive types

Traditional beekeeping practice remained the dominant practice in all of the sample woredas, with adoption rates ranging from 38.2% in Darara to 99.56% in Baka Dawla Woredas (Table 6). This indicates that the vast majority of beekeepers in these areas continue to use traditional beekeeping practices and hives made of local materials.

In contrast, adoption of transitional beekeeping, which includes certain modern techniques while retaining components of traditional practice is still quite low. The prevalence of transitional beekeeping ranged from 0.25% in Ubba Debretsehay to 59% in Darara woreda (Table 6). This suggests that, while there is some level of innovation in hive management, it is still in its early stage of adoption.

Similarly, the adoption of modern frame hives, which improve hive management, increase honey yields, and improve colony health, varied greatly among the study woredas. Notably, no frame hives with honeybee colonies were reported in Kucha Alfa and Baka Dawla Woredas, indicating a complete absence of modern beekeeping in these woredas. Sodo Zuria woreda had the highest adoption rate of frame hives, with 8.95% of beekeepers using modern beekeeping practices (Table 6).

These findings highlight the predominance of traditional beekeeping across the study Woredas while also indicating the slow but emerging transition toward modern and transitional beekeeping methods in certain woredas. Variation in beekeeping practices across study woredas may be influenced by factors such as access to training, availability of modern beekeeping equipment, and the level of support from extension services.

3.3.2. Current honeybee colony stocking

In all the study woredas, the number of honeybee colonies was generally below the optimal stocking level, ranging from 911 in Baka Dawla Woreda to 36,419 in Benatsemay Woreda. However, Tello Woreda exceeded the optimal level by 2,257 colonies (Table 6). High density of honeybee colonies in Tello woreda indicates strong competition for nectar and pollen, which in turn reduces the honey yield per colony. In such woredas, beekeepers must aggressively plant honeybee flora and sell surplus honeybee colonies to neighboring woredas.

In contrast, the low colony density recorded in other study woredas shows that available

floral resources are being underutilized. This underuse leads to substantial volumes of uncollected nectar and pollen, which could otherwise support a larger honeybee population and increase production. As a result, the full honey production potential of these landscapes remains untapped, limiting both beekeepers' economic gains and apiculture's contribution to local livelihoods. Addressing this mismatch through strategic colony management based on floral resource availability and colony carrying capacity assessments has the potential to increase honey yields and improve the sustainability of beekeeping practices in the study areas.

Table 6. Total honeybee colonies that are available currently, along with the percentage of each hive type, optimum number of colonies the area can sustain and the balance.

Woreda	Total honeybee colonies available currently (a)	% of honeybee colonies by hive types currently available			Optimum number of colonies the area can support (b)	Balance (a-b)
		Traditional	Transitional	Frame		
Gazie Gofa	4805	98.13	1.64	0.23	30058	25253
Ubba Debresehay	12013	99.5	0.25	0.25	29242	17229
Chencha	2862	93.12	3.7	3.18	8947	6085
Garda Marta	5310	98.27	1.56	0.17	13276	7966
Kemba	10500	97.73	1.74	0.52	23088	12588
Kucha Alpha	9015	97.68	2.32	0	18626	9611
Kena	5562	98.29	1.28	0.43	10179	4617
Baka Dawla	15985	99.56	0.44	0	16896	911
Hamar	13578	98.62	1.2	0.18	42792	29214
Benatsemay	44133	99.22	0.72	0.06	80552	36419
Sodo Zuria	4156	78.44	12.61	8.95	7933	3777
Adiyo	22006	97.9	1.7	0.4	52064	30058
Tello	33801	96	3.8	0.2	31544	-2257
Decha	28133	99	0.8	0.2	69864	41731
Bitu	45844	89	7	4	57917	12073
Shey bench	23698	99	0.5	0.5	44847	21149
Guraferda	100752	97	2.7	0.3	137170	36418
Darara	710	38.2	59	2.8	29600	28890
Malga	2972	89	8	3	10787	7815
Wonsho	2041	97	2.2	0.8	16045	14004

Note: The number of honeybee colonies that can be sustained is proportionate to the existing % of honeybee colonies by hive types.

3.3.3. Optimum number of honeybee colonies to be introduced

Table 7 shows the optimum number of new honeybee colonies that can be introduced in the study woredas, assuming beekeepers maintain 20%, 40% and 40% of their honeybee colonies in traditional, transitional and frame hives, respectively. Despite the projected

scenario, the current number of honeybee colonies established in most woredas is less than the planned targets. The only exceptions were Baka Dawla, Adiyio, Tello, Decha and Guraferda woredas, which had colony numbers that reached or exceeded predictions. In the previously indicated scenario, beekeepers should be able to sell honeybee colonies to neighboring woredas through a market linkage. The extent of understocking varied significantly across the study woreda, with the lowest honeybee colony deficit (969) recorded in Sodo Zuria woreda and the highest (64,931) in Bita Woreda (Table 7).

The optimal honeybee colony carrying capacity of a given area varies depending on the type of hive used and the overall beekeeping management plan. As the number of modern hive types, such as transitional and frame hives, increases, the total number of honeybee colonies that the area can support decreases. This is primarily because these hive types require larger foraging areas, better resource availability, and intensive management than traditional hives.

Frame and transitional hives produce more honey per colony due to improved colony management, and increased honeybee populations. However, they require more floral resources and space, limiting the overall number of colonies that can be supported in a given area. In contrast, traditional hives, allow for a higher density of honeybee colonies but produce lower honey yields per hive.

Table 7. The current number of honeybee colonies, optimum number of honeybee colonies that the area can support, with 20% traditional, 40% transitional & 40% frame hives, and the balance

Woreda	Current number of colonies	Optimum number of colonies (20% traditional, 40% transitional and 40% frame)	Balance
Gazie Gofa	4805	17390	12585
Ubba Debretsehay	12013	16810	4797
Chencha	2862	5324	2462
Garda Marta	5310	7682	2372
Kemba	10500	13389	2889
Kucha Alpha	9015	10796	1781
Kena	5562	5861	299
Baka Dawla	15985	9707	-6278
Hamar	13578	24699	11121
Benatsemay	44133	46357	2224
Sodo Zuria	4156	5125	969
Adiyo	22006	20156	-1850
Tello	33801	2588	-31213
Decha	28133	14300	-13833
Bitu	45844	110775	64931
Guraferda	100752	80930	-19822
Shey bench	23698.00	56266	32568
Darara	710.00	23528	22818
Malga	2972.00	9259.00	6287
Wonsho	2041.00	20353.00	18312

3.3.4. Optimum number of apiary sites that can be established

The ideal number of apiary sites per woreda varied significantly, reflecting variations in land sizes, ecological conditions, and suitability for beekeeping. Benatsemay had the highest (240) number of apiary sites, and Wonsho woreda with the lowest (11) number of apiary sites identified for honey production (Table 8). This is primarily due to variation in total land size, with Benatsemay having 301,198 hectares, providing adequate space for apiary site establishment, and allowing a wider spread of beekeeping operations. Wonsho woreda, on the other hand, has the smallest land area (14,314 hectares), which limits beekeeping space and results in fewer apiary sites.

3.3.5. Optimum number of colonies to be introduce per apiary site (1256 ha)

The optimum number of honeybee colonies that can be introduced per apiary site varies depending on the type of hive employed. This variation is governed by factors including forage availability, hive management efficiency, and local environmental conditions. When 20% traditional hives, 40% transitional hives, and 40% frame hives were distributed, Malga woreda has the highest (509) honeybee colonies per site, whereas Adiyo woreda had the lowest (104) (Table 8).

Malga woreda also had the highest (468), and Adiyo the lowest (97) honeybee colonies per apiary site for apiaries made up entirely of 100% transitional hives. Similarly, when apiaries were exclusively composed of 100% frame hives, the highest colony number (333) was in Malga woreda, and the lowest (72) for Adiyo woreda. These findings highlight the significant influence of hive type on the maximum number of colonies that can be maintained within an apiary. The differences observed across locations may be attributed to variations in forage plant availability, climate conditions, and colony management practices. Understanding these dynamics is essential for optimizing honey production, ensuring the sustainability of beekeeping operations, and promoting efficient utilization of flora resources.

Table 8. Optimum number of apiary sites per woreda and number of honeybee colonies per apiary site under various hive utilization scenarios

Woreda	Optimum no. of sites/Woreda	Optimum number of bee colonies to be introduced per apiary site		
		20% trad. + 40% trans. + 40% frame hives	100% Transitional hives	100% Frame hives
Gazie Gofa	63	276	257	193
Ubba Debretsehay	79	213	198	148
Chencha	17	313	291	218
Garda Marta	39	197	183	137
Kemba	54	248	231	173
Kucha Alpha	34	318	295	222
Kena	20	293	273	204
Baka Dawla	36	270	251	188
Hamar	96	257	239	180
Benatsemay	240	193	180	135
Sodo Zuria	15	342	318	238
Adiyo	82	104	97	72
Tello	37	212	197	137
Decha	90	159	148	103
Bitu	87	305	284	198
Shey Bench	41	278	259	194
Guraferda	188	430	400	300
Darara	12	376	350	262
Malga	17	509	468	333
Wonsho	11	326	303	227

3.3.6. Optimum number of honeybee colonies per apiary site (1256 ha) in different land use type

The optimal number of honeybee colonies per apiary site varies significantly across different land use types, primarily due to differences in floral resource availability and habitat quality. Among these, forested landscapes support the highest number of honeybee colonies per site, reflecting their rich diversity and abundance of nectar and pollen producing plants. Forest land demonstrated the highest capacity for honeybee colony accommodation across different land use types in the South region of Ethiopia, supporting up to 393 transitional honeybee colonies or 320 frame hive honeybee colonies per apiary site (Figure 11). This indicates the superior suitability of forest ecosystems for beekeeping, likely due to the

availability of diverse and continuous floral resources, favorable microclimatic conditions, and reduced exposure to agricultural pesticides.

Similarly, in the Southwest and Sidama regions of Ethiopia, forest land exhibited an even greater carrying capacity, accommodating up to 900 transitional honeybee colonies or 733 frame hive honeybee colonies per apiary site (Figure 12). This higher density of honeybee colonies may be attributed to the extensive forest cover, rich plant biodiversity, and relatively undisturbed natural habitats that provide ample forage resources throughout the year. The substantial difference in colony capacity between these regions suggests regional variations in floral abundance, land use intensity, and environmental conditions, which may influence honeybee colony productivity and sustainability.

Agroforestry systems demonstrated a strong capacity to sustain honeybee colonies, ranking second among land-use types in their ability to support apiculture. In the South region of Ethiopia, agroforestry-based apiary sites accommodated up to 148 transitional honeybee colonies or 121 frame hive colonies, highlighting their suitability for beekeeping (Figure 11).

Similarly, in the Southwest and Sidama regions, agroforestry systems supported even higher colony numbers, with apiary sites hosting up to 500 transitional honeybee colonies or 407 frame hive colonies (Figure 12). The substantial colony-holding potential of agroforestry systems underscores their ecological and economic significance in honey production, providing diverse floral resources, microclimate regulation, and habitat stability for honeybee populations. This reinforces the role of agroforestry as a sustainable land-use strategy that balances agricultural productivity with biodiversity conservation and pollinator health.

In contrast, wooded grasslands and pasturelands exhibited the lowest carrying capacity for honeybee colonies, with 131 transitional colonies or 73 frame hive colonies per site (Figure 11). This reduced colony density in grasslands was most likely due to a greater proportion of vegetation types that produce pollen but lack nectar supplies, which are required for honey production and colony survival. While pollen is essential for brood rearing and colony growth, the scarcity of nectar limits honey storage and overall colony expansion, making such landscapes less favorable for large-scale beekeeping operations.

Generally, these findings emphasize the importance of land use planning in sustainable apiculture. Forested ecosystems provide the most favorable conditions for maintaining high honeybee colony densities, followed by agroforestry systems, which offer a balance between agricultural productivity and pollinator habitat conservation. Conversely, open

grasslands and pasturelands, despite their pollen availability, require strategic floral enrichment such as the introduction of nectar-producing plant species to enhance their suitability for beekeeping. Understanding these variations in honeybee colony carrying capacity across different landscapes can help optimize apiary site selection, improve honey yields, and support long-term pollinator conservation efforts.

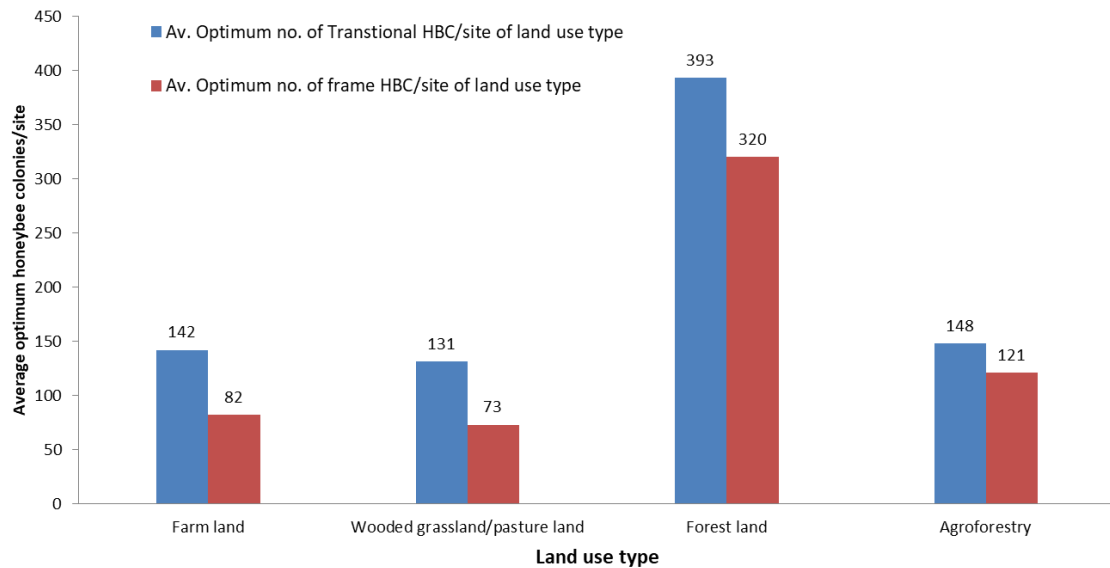


Figure 11. Average number of optimum honeybee colonies (HBC) per site (1256 ha) in different land use type in South Ethiopia.

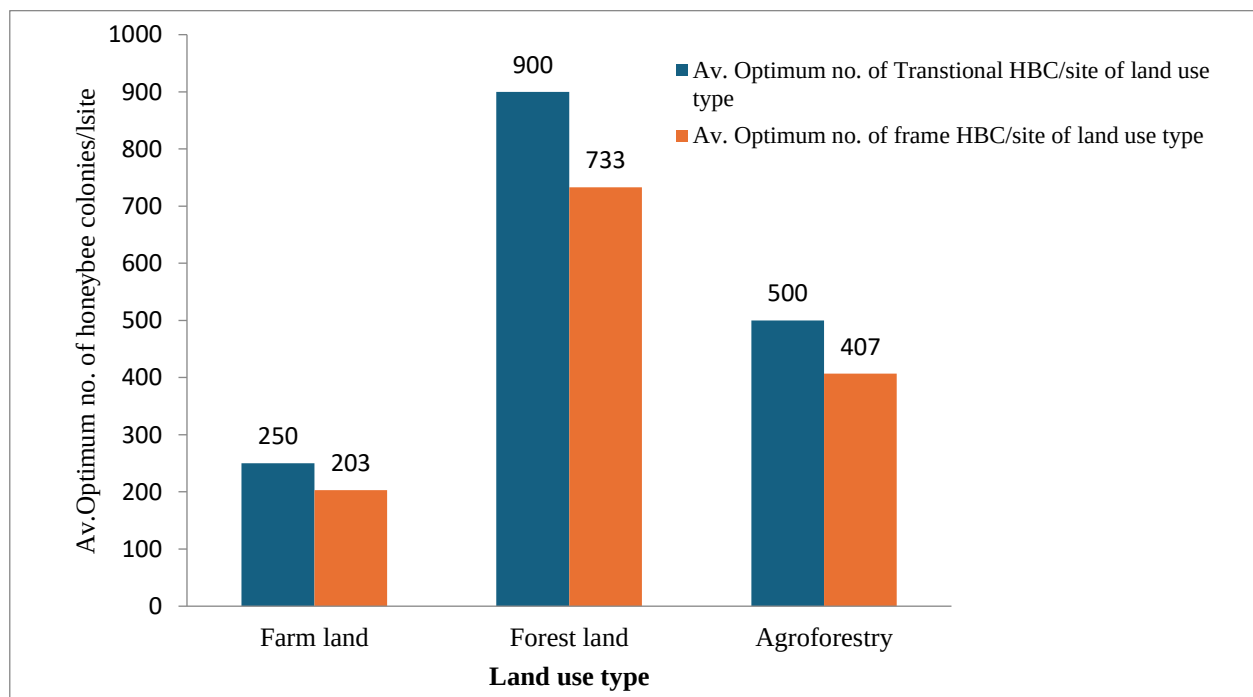


Figure 12. Average number of optimum honeybee colonies (HBC) per site (1256 ha) in different land use types in the Southwest and Sidama Regions.

3.4. Employment potential of beekeeping in selected MaYEAs intervention areas of South Ethiopia region

The potential for employment through beekeeping varies significantly across the study woredas due to differences in existing beekeeping infrastructure, available floral resources, and honeybee colony carrying capacity. To estimate the employment potential, the optimum number of honeybee colonies that can be supported using transitional hives was determined for each woreda. The existing number of transitional and frame hive honeybee colonies was then subtracted from this optimum colony estimate, revealing the number of additional colonies that could be established. This, in turn, allowed for an estimation of the number of youths who could potentially be employed through beekeeping expansion.

Based on the assessment, a total of 29,993 youths (Figure 13) were expected to be newly engaged in beekeeping across the 11 study woredas in the South region of Ethiopia. Likewise, in the Sidama and Southwest regions, approximately 46,213 youths (Figure 14) are projected to participate in beekeeping across the 9 studies woredas. In total, an estimated 76,206 youths from the South, Southwest, and Sidama regions of Ethiopia have the potential to be involved in beekeeping. The variation in employment potential across woredas is primarily due to differences in the current number of managed honeybee colonies (both transitional and frame hives), which influenced the additional capacity available for beekeeping expansion, as well as the total area of each woreda, which determined the scale of beekeeping operations.

Most importantly, the honeybee colony carrying capacity, which is determined by the amount and diversity of nectar and pollen supplies, had a significant impact on beekeeping expansion. Woredas with bigger amount of intact natural vegetation and high floral diversity exhibited a greater potential for supporting additional honeybee colonies, resulting in more job prospects in the beekeeping sector.

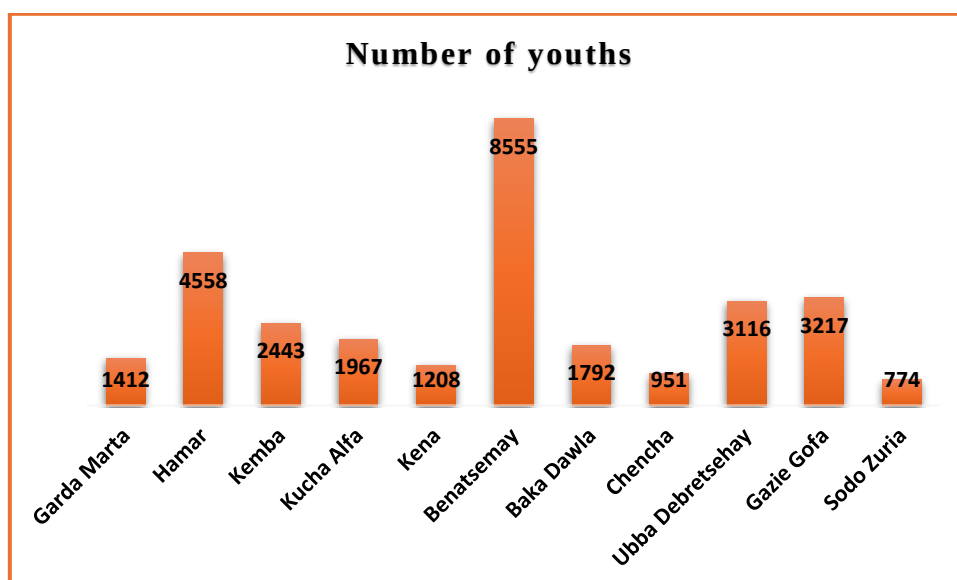


Figure 13. Number of youths that can newly be involved in beekeeping using transitional hives in the South region's study woredas

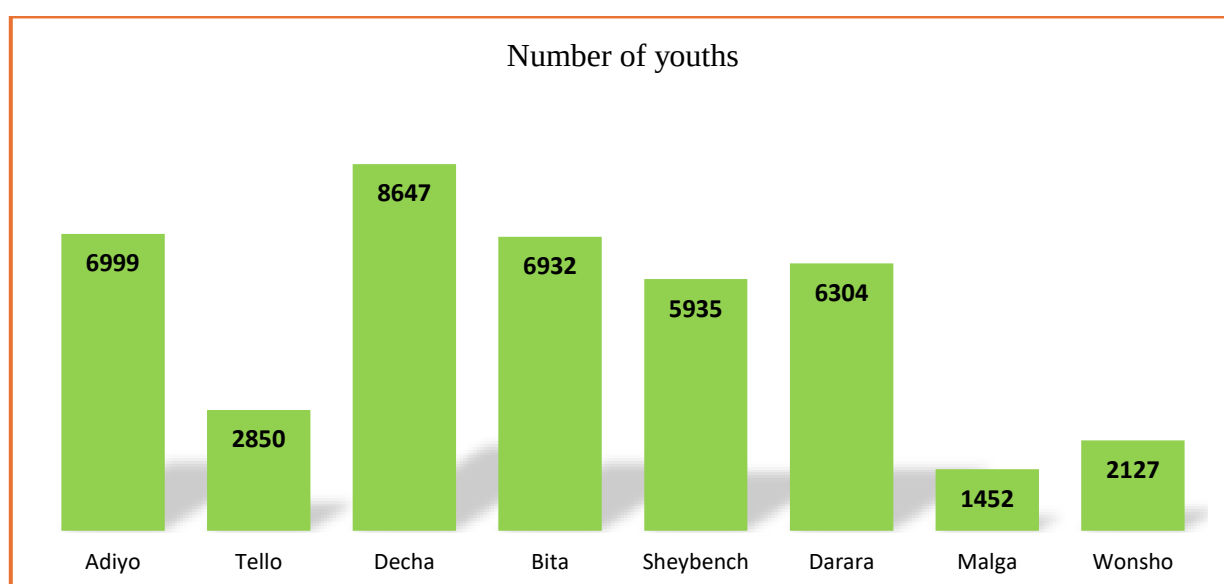


Figure 14. Number of young people that can newly be involved in beekeeping using transitional hives in the Southwest and Sidama's study woredas.

3.5. Key constraints that affect honey production

3.5.1. Source of honeybee colonies

The source of honeybee colonies exhibited significant variation ($p < 0.05$) across the study woredas, as shown in Tables 9 and 10. In all study areas, the primary method for acquiring bee colonies was through catching swarms, a traditional and widely practiced approach among local beekeepers. This method underscores the reliance on natural processes for

colony establishment in the region. Colony purchasing was not observed in any of the study woredas, highlighting potential economic, cultural, or logistical barriers to adopting this practice. This finding suggests that the beekeepers depend heavily on natural swarms to establish their beekeeping operations. The practice of buying and selling honeybee colonies is largely unknown, limiting the growth and commercialization of the beekeeping industry.

3.5.2. Honeybee colony placement

The location of apiaries also showed significant differences ($p < 0.05$) across the study woredas, reflecting diverse ecological and socio-cultural practices. In woredas such as Ubba Debretehay, Garda Marta, Kemba, Kena, Baka Dawla, Hamar, Benatsemay (Table 9), Adiyo, Tello, Bitu and Guraferda (Table 10) the majority of beekeepers hang their honeybee colonies on the big trees. Hanging honeybee colonies on trees presents significant challenges for hive management, particularly in terms of regular inspection, pest and disease control, and colony maintenance. Furthermore, feeding honeybee colonies during dearth periods becomes challenging when hives are hung in trees.

Conversely, in woredas such as Gazie Gofa, Chenchu, Kucha Alfa, Sodo Zuria (Table 9), Darara, Malga and Wonsho (Table 10), the majority of beekeepers chose to keep their colonies in backyard apiaries. Backyard beekeeping has several advantages, including ease of management, proximity for monitoring, and increased protection against predators and theft. This practice likely reflects differences in land use, accessibility to forested areas, and the intensity of agricultural activities in these regions.

Table 9. Response of beekeepers about source of bee colonies that used to start beekeeping, and location of site in study woredas

Category	Gazie Gofa	Ubb a Debrese hay	Gard a Mart a	Kem ba	Che ncha	Kuc ha Alfa	Ken a	Bak a Dawl a	Ham ar	Ben atse may	Sod o Zuri a	x ²	P-value
	%	%	%	%	%	%	%	%	%	%	%		
Source of bee colonies													
swarm Catc hing	100.00	100.00	100.00	100	100.00	100.00	100	93.30	100	100.00	98.30	46.4	0.03
Purc hasi ng	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.70		
Inhe rited from pare nt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.70	0.00	0.00	0.00		
Honeybee colony placement													
Bac kyar d	53.33	6.67	11.67	16.67	68.33	63.33	16.67	16.67	5.00	11.67	58.33	1416	0.001
Han ging on the tree	35.00	91.67	75.00	73.33	16.67	28.33	75.00	75.00	91.7	83.33	25.00		
Dedi cate d land	11.67	1.66	13.33	10.00	15.00	8.33	8.33	8.33	3.33	5.00	16.67		

Table 10. Response of beekeepers about source of bee colonies that used to start beekeeping, and location of site in study woredas of Southwest and Sidama Regions

	Adiyo	Tello	Decha	Bit a	Shey bench	Guraferda	Darara	Malga	Wonsho	X ²	P-value
Category	%	%	%	%	%	%	%	%	%		
Source of bee colonies										22.5	0.04
Swarm catching	100	98.3	100	100	100	100	100	100	100		
Gift from family	0.00	1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Honeybee colony placement											
Backyard	12.4	8	2	13	12	5	88	80	77	66	0.025
Kobo/dedicated land	12.5	25	53	25	7	13	4	3	13		
Hanging forest	75	67	45	62	81	82	8	17	10		

3.5.3. Honey harvesting frequency per year

Table 11 shows that the yearly frequency of honey harvesting varied significantly ($p < 0.05$) among the study woredas. In Gazie Gofa and Chenchu woredas, the majority of beekeepers reported harvesting honey once a year. In contrast, beekeepers in Ubba Debresehay, Gardu Marta, Kemba, Kucha Alfa, Kena, Baka Dawla, Benatsemay, and Sodo Zuria, harvest honey twice a year. This indicates the availability of two independent floral cycles or extended periods of nectar availability, supporting more frequent honey production.

In Hamar Woreda, a unique scenario was observed: half of the beekeepers harvested honey once a year, while the other half harvested twice. This variation could be related to differences in management practices, access to floral resources, or microclimatic conditions within the Woreda, which allows some beekeepers to capitalize an additional honey flow season.

In Bitu, Adiyo, Darara, Malga, and Wonsho, most beekeepers harvest honey twice a year, following a seasonal pattern influenced by local flowering calendars (Table 12). In contrast, in Tello and Decha woredas, most beekeepers harvest once a year, most likely due to variations in climatic conditions, floral resource availability, and colony strength. On the other hand, Guraferda woreda stands out as an exception, where the majority of beekeepers report harvesting honey three times a year. This increased harvesting frequency may be attributed to more favorable environmental conditions, a prolonged flowering period, or the presence of a diverse range of nectar-producing plant species that sustain honeybee colonies throughout the year.

Overall, the harvesting patterns observed across these woredas are consistent with the region's identified beekeeping calendar. The differences in harvest frequency highlight the impact of ecological factors, vegetation composition, and seasonal variations in nectar flow, all of which alter beekeeping operations in different localities.

3.5.4. Beekeeping Equipment Availability and Practices

Beekeepers in the studied woredas in the South region lacked essential modern beekeeping equipment, such as casting molds and honey extractors (Table 11). Only a few beekeepers in the Southwest and Sidama regions have access to these equipment (Table 12), highlighting a significant gap in modern beekeeping practices across these regions.

While some beekeepers possessed protective clothing such as bee veils, suits, and gauntlets, and some accessories such as smokers, chisels, and brushes, these tools were

not evenly distributed or readily available. Limited access to modern equipment and protective clothing reduces honey production efficiency while jeopardizing beekeeper's safety and productivity. In the absence of essential modern equipment, particularly honey extractors, beekeepers are forced to rely on traditional methods, which can result in a decreased honey yield, increased labor intensity, and potential contamination of honey.

Furthermore, the uneven distribution of protective clothes exposes many beekeepers to increased risks of bee stings and other occupational hazards. The absence of casting mold and honey extractors reflect the predominance of traditional beekeeping methods in these areas. Casting mold is crucial for producing uniform and durable wax foundation sheets, which are essential for modern hive management and productivity. Similarly, honey extractors, which facilitate the efficient and hygienic removal of honey from combs without damaging them, are vital for enhancing both the quality and quantity of honey harvested.

Traditional practices, while deeply rooted in cultural and local knowledge systems, often rely on improvised tools and methods that can limit productivity and efficiency. For instance, honey is commonly harvested by pressing the combs, a method that not only destroys the comb structure but also introduces impurities into the honey. Additionally, the lack of modern protective gear exposes beekeepers to risks such as bee stings, which can deter some individuals, particularly the elderly or inexperienced, from engaging fully in beekeeping activities.

Table 11. Perception of beekeepers about honey harvesting frequency per year and improved beekeeping equipment

Category	Gazie Gofa	Ubba Debretehay	Garda Marta	Kemba	Chencha	Kucha Alfa	Kena	Baka Dawla	Hamar	Benatsemay	Sodo Zuria	x ²	P-value
	%	%	%	%	%	%	%	%	%	%	%		
Honey harvesting frequency per year													
Once	58.33	45	41.67	48.33	53.33	31.67	18.33	23.33	50	31.67	15	22.77	0.02
Twice	41.67	55	58.33	51.67	45	50	81.67	76.67	50	68.33	73.33		
Three times	0	0	0	0	1.67	18.33	0	0	0	0	11.67		
Beekeeping equipment availability													
Protective cloth	16.67	20.00	16.67	20.00	3.30	20.00	16.67	3.30	6.67	20.00	33.33	23.44	0.03
Brush	16.67	20.00	16.67	20.00	3.30	20.00	16.67	3.30	6.67	20.00	33.33		
Chisel	3.33	6.67	3.33	6.67	3.30	3.30	6.67	3.30	3.30	3.30	6.67		
Smoker	6.67	16.67	6.67	16.67	3.30	6.67	13.33	3.30	3.33	16.67	23.30		
Casting mould	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Honey extractor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

Table 12. Perception of beekeepers about honey harvesting frequency per year and improved beekeeping equipment

Category	Adiyo (%)		Tello	Decha	Bitu	Sheybench	Guraferda	Darara	Malga	Wonsho	χ ²	P -value
Harvesting frequency per year												
one	15		98	100	27	55	15	22	25	42	54	0.256
Two	83		0	0	73	0	30	70	68	45		
Three	2		2	0	0	45	55	8	7	13		
Beekeeping equipment availability												
Honey extractor	2		0	3	5	5	4	3	6	5	63	0.06
Casting mould	5		5	3	5	5	3	5	7	5		
smoker	4		3	8	15	3	5	20	15	17		
protective cloth	5		4	9	14	7	16	17	17	15		
Brush		5	5	3	5	5	10	12	17	16		
Chisel		5	5	5	12	7	10	12	15	16		

3.6. Major beekeeping constraints

Eight major beekeeping constraints were identified in the study Woredas (Tables 13 &14). These include lack of beekeeping training, deforestation and habitat loss, absconding, pests and predators, agrochemical application, shortage of bee forage, lack of credit access and recurrent drought. The constraints faced by beekeepers showed variation across the study Woredas. However, a common and significant challenge across all study areas was the lack of access to improved beekeeping training, which was consistently ranked as the most critical issue in all the studied woredas (Tables 13 &14).

Another significant constraint identified was the lack of access to credit facilities, which was uniformly ranked as the third most pressing issue across all the study woredas (Tables 13 &14). Limited credit availability restricts beekeepers from investing in essential inputs, modern equipment, and other resources necessary for scaling up their operations and improving production efficiency. While these two issues were consistently prioritized, the remaining constraints varied significantly between the different woredas.

Lack of beekeeping training

A lack of proper beekeeping training severely limits the adoption of modern beekeeping technologies and weakens hive management. Untrained beekeepers struggle with fundamental practices, leading to poor colony health, inefficient pest control, and reduced honey production.

Without training, they may fail to adopt improved hive technology, proper hive placement, and advanced pest management techniques. This results in increased colony losses due to improper harvesting methods; lack of dearth period honeybee colony management and poor forage management further weaken colonies and lower honey production. Comprehensive training is essential to equip beekeepers with skills in modern hive management, pest prevention, and sustainable practices, ensuring higher productivity and colony sustainability.

Deforestation and habitat loss

Deforestation and habitat loss have profound negative effects on beekeeping practices by disrupting bee forage availability, altering floral diversity, and affecting climate conditions that are essential for healthy bee colonies. Deforestation destroys flowering plants, shrubs, and trees that provide nectar and pollen sources for honeybees. Reduced floral diversity causes poor nutrition for honeybees, weakening their immune systems and reducing honey

production. As a result of the loss in nectar-rich plant species, honey output decreases making commercial beekeeping less viable. Seasonal flowering patterns are disrupted, affecting honey flows and colony viability.

Habitat loss can also lead to overcrowding of honeybee colonies in fragmented landscapes, exacerbating the spread of pests and diseases. Furthermore, a lack of diverse pollen sources weakens honeybee colonies by making them more susceptible to pathogens.

Deforestation also alters local temperatures and humidity, disrupting the microclimate necessary for brood development and nectar secretion. Unstable climatic conditions affect flowering calendars, reducing the availability of forage. Consequently, the decline in bee populations negatively impacts pollination services for both wild and cultivated plants, leading to reduced crop yields for farmers.

Abscending

Beekeepers in the study area identified several critical factors contributing to honeybee colony absconding based on their knowledge and practical experience. According to the assessments, the most significant causes of colony absconding were related to poor hive management, environmental degradation, and external threats to the colonies.

One of the primary factors cited was poor management of beehives, which included improper hive maintenance, inadequate protection from pests and predators, and failure to provide necessary interventions during critical periods. Beekeepers highlighted that neglected or poorly maintained hives often become unsuitable for honeybee colonies, leading to increased stress and eventual absconding.

Another major cause was deforestation and the resulting shortage of bee forage during dearth periods. The destruction of natural habitats due to logging, agricultural expansion, and urbanization has significantly reduced the availability of nectar and pollen sources. This forage scarcity, especially during dry seasons or times of limited floral availability, forces colonies to abandon their hives in search of better feeding grounds.

The misuse of agrochemicals, particularly pesticides and herbicides, was also identified as a serious threat to honeybee survival. The indiscriminate use of chemical sprays on crops and surrounding vegetation not only contaminates the bees' food sources but also leads to direct poisoning of worker bees. As a result, colonies experience high mortality rates and, in extreme cases, total collapse, prompting surviving bees to leave the area.

Additionally, **pests and predators** were considered a persistent challenge to beekeeping in the study Woredas. Beekeepers reported attacks from hive-invading pests such as ants, wax moths, and small hive beetles, which weaken colonies and disrupt their normal activities. Larger predators, including honey badgers and birds that prey on bees, further exacerbate colony stress, often leading to abandonment.

Overall, the combination of **poor hive management, environmental degradation, agrochemical misuse, and pest pressure** creates an unfavorable environment for honeybee colonies, increasing the likelihood of absconding.

Pests and predators

The existence of honeybee pests and predators ultimately resulted in frequent absconding of colonies. Some pests such as ants, bee lice (*Braula coeca*), beetles (*Aethina tumida*), sugar ant, and wax moth (*Galleria mellonella*) attack honeybees and consume the hive products while predators such as the honey badger and bee-eater birds can cause serious damage to the hives leading to huge losses to the beekeepers (Tesfaye et al., 2017). During honey harvest, brood and larvae are damaged and killed, so that the reproduction rate gets diminished which might be the main cause of a currently declining of the bee population in the area. The beekeepers survey indicates that different honeybee pests and predators have been attacking their bee colonies in the area.

Agrochemical application

The use of agrochemicals plays a crucial role in modern agriculture by controlling pests, weeds, and fungal infections, thereby enhancing crop yields. However, the improper application of hazardous pesticides poses a significant threat to beneficial insects, particularly honeybees. According to Kerealem et al. (2009), the misapplication of agrochemicals has led to widespread honeybee mortality, colony collapse, and even the abandonment of beekeeping activities. These negative effects not only endanger the livelihoods of beekeepers but also threaten agricultural productivity, as honeybees play an essential role in pollination.

In Ethiopia, farmers commonly apply a range of pesticides, many of which are highly toxic to honeybees. Among the most frequently used insecticides are Malathion 50%, Penetrate 50%, Ethiothoate 40%, Agrothoate 40%, Diazion 60% EC, Dimethoate 40% EC, and Ethiolathion 50%. Additionally, herbicides such as 2,4-D are extensively used across agricultural landscapes (Bareke & Addi, 2019). The indiscriminate and often improper

application of these chemicals leads to the contamination of floral resources, direct poisoning of foraging bees, and long-term sublethal effects on colony health.

A major consequence of agrochemical misapplication is mass honeybee mortality, resulting in declining colony populations. Weakened colonies not only produce less honey but also provide inadequate pollination services, which are vital for sustaining agricultural yields. Research has shown that pollinator-dependent crops suffer significant yield losses in the absence of effective pollination (Bezabeh, 2010).

Beyond direct chemical exposure, a lack of awareness among farmers about the importance of pollinators exacerbates the problem. Many smallholder farmers prioritize pest control without considering its broader impact on pollination and ecosystem stability. Limited extension services and inadequate training on pollinator-friendly pest management further contribute to this knowledge gap. To mitigate the negative effects of pesticide use, it is crucial to educate farmers on integrated pest management (IPM) strategies, encourage the adoption of bee-safe pesticides, and implement pollinator conservation initiatives.

Shortage of bee forage

The decline of diverse and abundant bee forage plants due to habitat degradation, deforestation, land-use changes, climate change, and monoculture farming poses a significant threat to honeybee colonies and the beekeeping industry. The reduction in floral resources limits nectar availability, leading to decreased honey production and lower economic returns for beekeepers. Seasonal fluctuations in forage further disrupt honey production cycles, while inadequate nutrition weakens honeybee immune systems, making colonies more susceptible to pests, diseases, and collapse. Beekeepers face rising costs for supplementary feeding and hive migration, while declining bee populations reduce pollination services, negatively impacting agricultural yields. To address these challenges, beekeepers implement strategies such as planting bee-friendly vegetation and practicing agroforestry. However, persistent forage shortages threaten economic stability, increase colony overstocking, intensify competition for resources, and ultimately reduce honey yields.

Lack of credit access

Limited access to credit severely hinders the adoption of modern beekeeping technologies and investment, restricting the sector's growth and profitability. Beekeeping requires an initial investment in modern hives, protective gear, honey extractors, and colony management tools. However, financial constraints force many beekeepers to rely on

traditional, less productive methods and prevent small-scale expansion, limiting economies of scale and commercial viability.

Without credit, beekeepers struggle to invest in honey processing and packaging equipment, reducing product quality and market competitiveness. The inability to obtain certifications, such as organic or fair trade, further restricts access to premium and export markets. Additionally, financial limitations make it difficult to manage colony health, monitor diseases, and mitigate climate risks, leading to increased colony losses and reduced sustainability.

Women and young people face even greater credit barriers, discouraging their participation in beekeeping despite its potential as a profitable, land-efficient agribusiness. This perpetuates subsistence-level production and slows the sector's contribution to national honey production, pollination services, and rural development.

Recurrent drought

Recurrent droughts significantly impact beekeeping by reducing bee forage availability, leading to poor nutrition, weaker colonies, and lower honey production. Water-stressed plants produce less nectar and pollen, affecting brood rearing and overall colony health. As food sources decline, honeybee colonies face starvation, increased mortality, and a higher risk of diseases and pests. Water scarcity further stresses bees, forcing them to travel long distances in search of hydration, which increases energy expenditure and predation risks.

Beekeepers must adapt by providing supplementary feeding, migrating colonies to better forage areas, and ensuring water availability near apiaries. However, these strategies increase management costs. Additionally, competition for limited forage resources leads to colony aggression and potential conflicts over water sources and land use.

Long-term ecological effects of recurrent droughts include shifts in floral composition and phenology, disrupting the natural relationships between bees and plants. Some drought-sensitive bee forage plants may disappear, reducing habitat quality for pollinators. To mitigate these effects, beekeepers can plant drought-resistant forage species, implement sustainable hive management practices, and advocate for conservation policies that protect pollinator habitats.

Table 13. Index and Rank values for major beekeeping constraints in Baka Dawla, Benatsemay, Hamar, Kena and Sodo Zuria Woredas

Beekeeping Constraints	Baka Dawla		Benatsemay		Hamar		Kena		Sodo Zuria	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Misuse of agrochemicals	0.11	6	0.09	8	0.09	8	0.12	5	0.09	8
Shortage of bee forage	0.12	5	0.12	5	0.12	5	0.11	6	0.12	5
Honeybee colony absconding	0.13	4	0.15	2	0.13	4	0.15	2	0.13	4
Pests and predators	0.15	2	0.13	4	0.11	6	0.13	4	0.10	7
Lack of credit access	0.14	3	0.14	3	0.14	3	0.14	3	0.17	1
Deforestation and habitat loss	0.10	7	0.10	7	0.10	7	0.10	7	0.15	2
Lack of beekeeping training	0.17	1	0.17	1	0.17	1	0.17	1	0.14	3
Recurrent drought	0.09	8	0.11	6	0.15	2	0.09	8	0.11	6

Index = sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for individual constraints divided by the sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for overall constraints

Table 14. Index and Rank values for major beekeeping constraints in Chencha, Garda Marta, Kemba, Kucha Alfa, Gazie Gofa and Ubba Debretehay Woredas

Beekeeping Constraints	Chencha		Garda Marta		Kemba		Kucha Alfa		Gazie Gofa		Ubba Debretehay	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Unwise agrochemicals application	0.11	5	0.09	8	0.12	5	0.12	5	0.09	6	0.08	8
Shortage of bee forage	0.14	4	0.12	5	0.13	4	0.10	6	0.13	4	0.17	2
Honeybee colony absconding	0.15	2	0.13	4	0.15	2	0.15	2	0.16	3	0.15	3
Pests and predators	0.09	6	0.15	2	0.10	6	0.13	4	0.10	5	0.10	5
Lack of credit access	0.15	3	0.14	3	0.14	3	0.14	3	0.17	2	0.14	4
Deforestation and habitat loss	0.08	8	0.10	7	0.10	7	0.10	7	0.08	7	0.08	7
Lack of beekeeping training	0.17	1	0.17	1	0.18	1	0.18	1	0.19	1	0.18	1
Recurrent drought	0.09	7	0.11	6	0.09	8	0.09	8	0.08	8	0.10	6

Index = sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for individual constraints divided by the sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for overall constraints

The severity of the constraints varied across the different study Woredas in the Southwest and Sidama regions of Ethiopia. The specific constraints identified in each woreda, as detailed in Tables 15 and 16, highlights variations in factors such as deforestation and habitat loss, unwise agrochemicals application, pests and predators, lack of beekeeping training, shortage of bee forage, and honeybee colony absconding. These differences underscore the need for developing location-specific interventions to address the unique challenges faced by beekeepers in each region.

Table 15. Index and Rank values for major beekeeping constraints in Southwest region's study woredas

Constraints	Adiyo		Tello		Decha		Bitu		Guraferda		Shey bench	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Unwise Agrochemicals application	0.122	7	0.138	1	0.13	2	0.128	3	0.138	1	0.147	2
Pests and predators	0.13	2	0.129	2	0.134	1	0.13	1	0.134	2	0.155	1
Deforestation and habitat loss	0.13	1	0.125	4	0.125	5	0.126	4	0.125	3	0.12	5
Honeybee colony absconding	0.122	5	0.116	8	0.127	3	0.121	7	0.119	8	0.121	4
Lack of beekeeping training	0.122	5	0.12	3	0.122	6	0.125	5	0.122	4	0.123	3
Recurrent Drought	0.121	8	0.123	6	0.119	7	0.12	8	0.12	7	0.115	6
Lack of credit access	0.129	3	0.124	5	0.125	4	0.129	2	0.12	6	0.111	7
Shortage of bee forage	0.124	4	0.117	7	0.118	8	0.121	6	0.121	5	0.107	8

Index = sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for individual constraints divided by the sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for overall constraints

Table 16. Index and Rank values for major beekeeping constraints in Sidama region's study woredas

Beekeeping constraints	Darara		Malga		Wonsho	
	Index	Rank	Index	Rank	Index	Rank
Unwise agrochemicals application	0.134	1	0.126	3	0.126	6
Pests and predators	0.129	2	0.126	2	0.126	5
Deforestation and habitat loss	0.117	8	0.126	2	0.126	7
Honeybee colony absconding	0.123	5	0.129	1	0.129	3
Lack of beekeeping training	0.122	6	0.125	4	0.125	2
Recurrent drought	0.121	7	0.123	5	0.123	1
Lack of credit access	0.128	3	0.123	5	0.123	6
Shortage of bee forage	0.127	4	0.123	5	0.123	4

Index = sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for individual constraints divided by the sum of (8*ranked 1st+ 7* ranked 2nd+6* ranked 3rd+5* ranked 4th+4* ranked 5th+3*ranked 6th+2* ranked 7th + 1*ranked 8th) for over all constraints

4. Conclusion

The study revealed a diverse range of bee forage species across 20 Woredas in the South, Southwest, and Sidama regions of Ethiopia, with significant variations in their abundance and honey production potential. While the optimum honey yield was estimated at 7,203.424 tons per year, only 32.14% of this potential is currently realized, highlighting opportunities for increased production. Honeybee colony numbers were generally below optimal levels, except in Tello Woreda, where excessive colonies led to resource competition. Forest lands and agroforestry systems were identified as very favorable habitats for high colony densities, particularly in the Southwest and Sidama regions. The study also projected that 76,206 youths could be engaged in beekeeping, supporting livelihoods and economic development. However, key constraints such as limited training, colony absconding, credit shortages, forage scarcity, and pest challenges must be addressed to optimize production and sustainability

5. Recommendation

A. Enhance improved beekeeping training and capacity building

Since traditional beekeeping practices are predominant in all study Woredas, it is essential to develop and implement targeted training programs for youth, emphasizing on modern beekeeping techniques such as:

- Ways to transfer traditional honeybee colonies to transitional and frame hive
- Efficient seasonal honeybee colony management based on flowering calendars of the area
- Honeybee colony feeding techniques and time of feeding
- Honeybee colony multiplication techniques
- Pests and predators controlling techniques
- Sustainable use of bee flora resources and their integration with different types of land use
- Pre and post honey handling methods
- Business development plans and market access to encourage youth engagement in apiculture as a viable livelihood

- Establishing Woreda-Level Beekeeping Training Centers
 - Setting up dedicated beekeeping training centers in each woreda to provide practical learning experiences
 - These centers should be equipped with modern apiary setups, demonstration hives, and relevant beekeeping equipment
 - They should also facilitate practical training sessions, and mentorship programs led by experienced beekeepers, honeybee experts and researchers.

B. Improve access to financial resources

- Governments and financial institutions should establish affordable credit schemes tailored for young beekeepers, including low-interest loans, cooperative financing, and microfinance, to support investment in modern hives and equipment
- Financial literacy programs and training should be expanded to equip young beekeepers with the knowledge to develop business plans and manage their budgets effectively
- Introducing mentorship programs to connect youths with experienced beekeepers to guide them in financial planning and enterprise growth
- Introducing digital banking and mobile payment solutions to streamline transactions, improve access to credit, and facilitate market participation
- Governments should also provide tax incentives and subsidies for beekeeping-related expenses to alleviate financial burdens and promote long-term investment in industry.

C. Enhance honeybee flora conservation by integrating with different land use types

- Establishing and maintaining nurseries operated by local communities through providing capacity building to produce seedlings of top-performing bee forage plants, ensuring a sustainable and regionally adapted supply
- Encouraging the planting and protection of diverse bee forage species, particularly in areas with seasonal shortages, to support colony survival during dearth periods
- Prioritizing the conservation of native and high-value nectar- and pollen-producing plants to sustain honeybee populations
- Engaging local communities, farmers, and beekeepers in establishing and maintaining bee forage reserves through conservation programs

- Developing integrated land-use plans to ensure the conservation of bee forage diversity
- Incorporating bee-friendly plants into agricultural landscapes, urban green spaces, and protected areas to ensure a continuous and diverse forage supply
- Collaborating with stakeholders, including policymakers, land planners, and farmers, to integrate honeybee-friendly vegetation into land-use strategies
- Facilitating research, training, and knowledge-sharing on best practices for integrating honeybee conservation with land management to foster collaboration among stakeholders
- Encouraging organic and regenerative farming practices that minimize chemical inputs and enhance floral resource availability.

D. Reduce the effect of agrochemical application

- Encouraging biological control, pest monitoring, crop rotation, and intercropping to reduce pesticide dependency
- Adopting less-toxic alternatives, updating lists of bee-friendly chemicals, and discourage highly toxic pesticides
- Applying pesticides when bees are less active, use targeted spraying methods, and calibrate equipment properly
- Training the farmers on bee conservation, responsible pesticide use, and sustainable farming through extension services
- Regulate pesticide use near pollinator habitats, enforce proper labeling, and promote certification for bee-friendly farms
- Plant bee-friendly flowers, restore natural habitats, and minimize excessive herbicide use
- Foster partnerships between researchers, policymakers, farmers, and beekeepers to develop sustainable agrochemical management strategies.

E. Shift honeybee colony placing from hanging on the tree to hive stand

- Placement of honeybee colonies should be shifted from hanging on trees to hive stands in forested areas or other suitable locations
- This practice enhances hive management by allowing easier monitoring, maintenance, and supplementary feeding during periods of forage scarcity, thereby improving colony well-being and productivity

- This approach encourages the participation of women and elderly individuals in the beekeeping business.

F. Promote practice of buying and selling honeybee colonies and establish formal markets

- The practice of buying and selling honeybee colonies is largely unknown in the South, Southwest and Sidama regions of Ethiopia, limiting the growth and commercialization of the beekeeping industry
- To transform this situation, it is essential to promote organized honeybee colony trading and multiplication
- Encouraging beekeepers to adopt colony multiplication techniques, such as splitting strong colonies and other queen rearing techniques to increase colony availability and sustainability
- Additionally, establishing formal markets for honeybee colony sales can create new economic opportunities, improve hive productivity, and contribute to the expansion of modern beekeeping practices in the regions.

G. Implement proper feeding management to cope with the dearth period for honeybees

- Proper feeding management should be implemented to ensure colony health, productivity, and survival during the dearth period for honeybees when natural forage is limited due to seasonal changes, drought, or habitat degradation.

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Appendix 1.

Table 1. Honey production potential of dominant bee forage plant species

Plant species	Life form	Honey potential (kg/ha)	Sources
<i>Acacia etbaica</i>	Tree	49.9	Tsegaye et al., 2024
<i>Acacia johnwoodii</i>	Tree	625	Adgaba et al., 2017
<i>Acacia seyal</i>	Tree	175	Crane, 1984
<i>Acacia tortilis</i>	Tree	163.4	Adgaba et al., 2016
<i>Acacia asaka</i>	Tree	128.9	Tsegaye et al., 2024
<i>Acacia nilotica</i>	Tree	31-100	Partap,1992
<i>Acacia Senegal</i>	Tree	275.7	Crane, 1984
<i>Acacia gerrardii</i>	Tree	511	Abdulaziz et al., 2015
<i>Acacia sieberiana</i>	Tree	325	Crane, 1984
<i>Acanthus sennii</i>	Shrub	41.1	Bareke et al., in press
Alfalfa (<i>Medicago sativa</i>)	Herb	15-1060	Ayers, 1992
<i>Aloe debrana</i>	Herb	36.6	Bareke et al., in press
<i>Asclepias syriaca</i> (Milk weed)	Herb	500 to 600	Zsidei, 1993
<i>Azadirachta indica</i>	Tree	100-200	Partap,1992
<i>Becium grandiflorum</i>	Shrub	5.5	Tsegaye et al., 2024
<i>Berberis species</i>	Shrub	100-300	Partap,1992
<i>Brassica campestris</i>	Herb	50-100	Partap,1992
<i>Brassica carinata</i>	Herb	8.9	Singh H, 2019
<i>Brassica juncea</i>	Herb	65.5	Masierowska, 2003
<i>Brassica napus</i>	Herb	300-500	Partap,1992
<i>Callistemon citrinus</i>	Tree	1264	Bareke et al., 2021
<i>Cedrela toona</i>	Tree	300-500	Partap,1992
<i>Coffea arabica</i>	Shrub	125	Bareke et al., 2021
<i>Cordia africana</i>	Tree	2.2	Tsegaye et al., 2024
<i>Croton macrostachyus</i>	Tree	780	Bareke et al., 2020
<i>Dahlia variabilis</i> (wild)	Herb	188	Bolesaw & Zbigniew, 2005
<i>Dalbergia sissoo</i>	Shrub	200-300	Partap,1992
<i>Dombeya torrida</i>	Tree	300	Bareke, 2024
<i>Echinops ritro</i>	Herb	471	Bolesaw & Zbigniew, 2005
<i>Echinops ruthenicus</i>	Herb	223	Bolesaw & Zbigniew, 2005
<i>Eucalyptus spp</i>	Tree	1000 to 1500	Partap,1992
<i>Gossypium spp</i>	Shrub	100-300	Partap,1992
<i>Helianthus annuus</i>	Herb	100-200	Partap,1992
<i>Hygrophila auriculata</i>	Herb	29.9	Bareke & Addi, 2022
<i>Lathyrus sylvester</i>	Herb	69	Bolesaw & Zbigniew, 2005
<i>Lavandula dentate</i>	Herb	51	Adgaba et al., 2017

<i>Lavandula pubescens</i>	Herb	24	Adgaba et al., 2017
<i>Leucas abyssinica</i>	Shrub	32.2	Bareke et al., in press
<i>Litchi chinensis</i>	Tree	500-1000	Partap,1992
<i>Malus domestica</i>	Shrub	15-20	Partap,1992
<i>Nepeta deflersiana</i>	Herb	18	Adgaba et al., 2017
<i>Otostegia fruticosa</i>	Shrub	14	Adgaba et al., 2017
<i>Pavonia urens</i>	Shrub	35	Bareke & Addi, 2024
<i>Phacelia tanacetifolia</i>	Herb	750	Vera et al., 2020
<i>Plectranthus species</i>	Herb	500-1000	Partap,1992
<i>Prunus armeniaca</i>	Shrub	100-300	Partap,1992
<i>Prunus cerasoides</i>	Shrub	100-300	Partap,1992
<i>Robinia pseudoacacia</i>	Tree	500-1000	Partap,1992
<i>Salvia leucantha</i>	Herb	60.2	Bareke & Addi, 2022
<i>Sapindus mukorossi</i>	Tree	300-500	Partap,1992
<i>Schefflera abyssinica</i>	Tree	1791	Bareke et al.,2020
<i>Sesamum indicum</i>	Herb	2.5	Singh H, 2019
<i>Sida hermaphroditis</i>	Herb	284	Bolesaw & Zbigniew, 2005
<i>Sinapis alba</i>	Herb	71.2	Masierowska, 2003
<i>Syzygium species</i>	Tree	200-300	Partap,1992
<i>Terminalia species</i>	Tree	100-300	Partap,1992
<i>Tilia (lime) species</i>	Shrub	90–1200	Crane et al., 1984
<i>Trifolium pratense (red clover)</i>	Herb	883	Szabo and Najda, 1985
<i>Trifolium alexandrinum</i>	Herb	300-500	Partap,1992
<i>Trifolium incarnatum</i>	Herb	140	Bolesaw & Zbigniew, 2005
<i>Trifolium repens</i>	Herb	200-500	Partap,1992
<i>Ziziphus nummularia</i>	Shrub	447	Adgaba et al., 2017
<i>Ziziphus spina-christi</i>	Shrub	900	Adgaba et al. 2012
<i>Ziziphus spina-christi</i>	Shrub	829	Adgaba et al., 2017

Appendix 2.

Table 2. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Gazie Gofa and Ubba Debretsehay Woredas,

Scientific name	Local name	Life form	Flowering period	Abundance in % by woreda		Food sources
				Gazie Gofa	Ubba Debrets ehay	
<i>Acacia nilotica</i>	Tsesse/Burkuk ke	Tree	April to May	0.9	2	N & P
<i>Acacia senegal</i>	Shara	Tree	Aug to Oct	9	15	N & P
<i>Acacia seyal</i>	Wachu	Tree	Aug to Oct	6	4	N & P
<i>Acacia sieberiana</i>	Chiche	Tree	Sept to Nov	3	4	N & P
<i>Acacia tortilis</i>	Tedech	Tree	April to May	11.1	15.1	N & P
<i>Acanthus sennii</i>	Kosheshlt/oha	Shrub	Sept to Nov	0.5	0.9	N & P
<i>Allium cepa</i>	Key Shinkurt	Herb	Oct to Nov	0.8	0.2	N & P
<i>Allium sativum</i>	Nech shinkurt	Herb	Oct to Nov	0.6	0.2	N & P
<i>Aloe debrana</i>	Ret/Godarrebu ssa	Herb	Oct to Dec	0.5	0.9	N & P
<i>Annona senegalensis</i>	Gishta	Shrub	April to June	0	0.2	N & P
<i>Arachis hypogaea</i>	Groundnut	Herb	Aug to Sept	0	0.2	N & P
<i>Balanites aegyptiaca</i>	Badena	Tree	Jan to Mar	0.9	0.9	N & P
<i>Bidens prestinaria</i>	Addile/Adeabe ba	Herb	Sept to Nov	0.9	0.8	N & P
<i>Brassica carinata</i>	Gommen	Herb	Sept to Nov	0.5	0.2	N & P
<i>Capparis sepiaria</i>	Ulumbo	Shrub	Sept to Nov	0.3	0.2	N & P
<i>Capsicum annuum</i>	Barbare	Herb	Sept to Oct	0.3	0.3	N & P
<i>Carica papaya</i>	Papaya	Tree	Sept to Oct	0.3	0.2	N & P
<i>Carissa edulis</i>	Lade/Agam	Shrub	Oct to Dec	0.9	0.8	N & P
<i>Chata edulis</i>	Chat	Shrub	Sept to Oct	0.9	0.2	N & P
<i>Cicer arietinum</i>	Shumbura	Herb	Oct to Dec	0.3	0	N & P
<i>Citrus aurantifolia</i>	Lomiya/Lome	Shrub	Sept to Oct	0.2	0.2	N & P
<i>Citrus sinensis</i>	Birtukan	Shrub	Sept to Oct	0.1	0.2	N & P
<i>Coffea arabica</i>	Tuke/Tukiyye/B una	Shrub	Feb to Mar	0.9	0.2	N & P
<i>Coleus abyssinica</i>	Shona	Shrub	Aug to Nov	0.6	0.4	N & P
<i>Combretum molle</i>	Soba	Tree	Dec to Jan	0.9	0.8	N & P
<i>Cordia africana</i>	Mokota/Galma/ Wanza	Tree	Aug to Oct	4	0.9	N & P
<i>Croton macrostachyus</i>	Anka/Bisana	Tree	May to June	4	1	N & P
<i>Erythrina brucei</i>	Korch	Shrub	Oct to Dec	0.5	0.5	N & P
<i>Eucalyptus camaldulensis</i>	Key barzaf	Tree	April to May	8	5	N & P
<i>Faba bean</i>	Bakela	Herb	Sept to Oct	0.2	0	N & P

<i>Glycine max</i>	Akuri ater/Soyabean	Herb	Sept to Oct	2.5	0.2	Pollen
<i>Grevillea robusta</i>	Gravelia	Tree	Sept to Nov	0.2	0.4	N & P
<i>Helianthus annuus</i>	Suf	Herb	Sept to Nov	0.2	0.2	N & P
<i>Hypoestes forskalii</i>	Busuno	Herb	Aug to Oct	0.9	0.9	N & P
<i>Ilex mitis</i>	Unso/Miessa	Shrub	Sept to Nov	0.5	0.4	N & P
<i>Justicia schimperiana</i>	Sansal/Dhumu ga	Shrub	Nov to Jan	0.2	0.2	N & P
<i>Linum usitatissimum</i>	Telba/Linseed	Herb	Sept to Oct	0.2	0	N & P
<i>Lippia adoensis</i>	Shasha/Kusay e	Shrub	Aug to Nov	0.6	0.5	N & P
<i>Lycopersicon esculentum</i>	Timatim	Herb	Sept to Oct	0.2	0.2	N & P
<i>Mangifera indica</i>	Mango	Tree	Sept to Oct	0.4	0.7	N & P
<i>Manihot esculenta</i>	Mitaboyye/Cas ava	Shrub	Sept to Oct	0.9	0.2	N & P
<i>Moringa stenopetala</i>	Aleko/Moringa	Tree	Sept to Nov	0.3	0.2	N & P
<i>Musa paradisiaca</i>	Muz/Banana	Herb	Sept to Oct	0.9	0.3	N & P
<i>Nicotiana tabacum</i>	Tambo	Herb	Sept to Nov	0.2	0.2	N & P
<i>Ocimum basilicum</i>	Basobila	Herb	Sept to Oct	0.6	0.4	N & P
<i>Persea americana</i>	Avocado	Tree	Sept to Oct	1	0.5	N & P
<i>Phaseolus vulgaris</i>	Badho/Boloke	Herb	Sept to Oct	0.4	0.5	N & P
<i>Pisum sativum</i>	Ater	Herb	Sept to Oct	1.2	0	Pollen
<i>Plectranthus ornatus</i>	Banjirile/Madda	Herb	Sept to Oct	0.8	0.8	N & P
<i>Plectranthus spp</i>	Mado/Haja'ile	Herb	Sept to Nov	3.50	2.10	N & P
<i>Prunus africana</i>	Okanse/tikur inchet	Tree	Oct to Dec	0.9	1.5	N & P
<i>Rhamnus prinoides</i>	Gesho	Shrub	Nov to Jan	0.5	0.15	Pollen
<i>Rhus natalensis</i>	Chalka	Shrub	Sept to Oct	2.50	2.4	Pollen
<i>Ruta chalepensis</i>	Tenaddam	Herb	Sept to Oct	0.2	0.5	N & P
<i>Solanecio gigas</i>	Oloma	Shrub	Sept to Oct	0.5	0.4	Pollen
<i>Solanum tubersum</i>	Dinich	Herb	Sept to Oct	0	0.2	Pollen
<i>Sorghum bicolor</i>	Gambo/Mashill a	Herb	Sept to Oct	4	7	Pollen
<i>Syzygium guineense</i>	Ocha/Dokma	Tree	Mar to April	7	0.9	N & P
<i>Terminalia brownii</i>	Galal'o/Galund a/Weybeta	Tree	Aug to Oct	0.9	8.00	N & P
<i>Vernonia amygdalina</i>	Gara/Grawa	Shrub	Jan to Feb	0.2	0.2	N & P
<i>Vernonia auriculata</i>	Buzo/Rejji	Shrub	Dec to Jan	0.9	0.4	N & P
<i>Zea mays</i>	Badala/Bokollo	Herb	Aug to Sept	9.1	13.3	Pollen
<i>unidentified bee plants</i>				0.3	1.00	

Note: Sept= September, Oct=October, Nov=November, Dec=December, Jan=January, Feb=February, Mar=March, Aug=August

Table 3. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Chench, Garda Marta, Kemb and Kucha Alfa Woredas.

Scientific name	Local name	Life form	Flowering period	Chench a (%)	Garda Marta (%)	Kemb a (%)	Kucha Alfa (%)	Food sources
<i>Acacia abyssinica</i>	Grar	Tree	Sept to Nov	0.9	0	0.2	0	N & P
<i>Acacia nilotica</i>	Tsesse	Tree	April to May	0.6	4.1	0.9	1	N & P
<i>Acacia senegal</i>	Grare	Tree	Aug to Oct	0.00	13	9	10	N & P
<i>Acacia etbaica</i>	Grare	Tree	Aug to Oct	10	0.00	0.00	0.00	N&P
<i>Acacia seyal</i>	Wachu	Tree	Aug to Oct	0.9	5	3	5	N & P
<i>Acacia sieberiana</i>	Chiche	Tree	Sept to Nov	2	10	0.9	1	N & P
<i>Acacia tortilis</i>	Shara	Tree	April to May	0.4	12	10	10	N & P
<i>Acanthus sennii</i>	Kosheshlt/oha	Shrub	Sept to Nov	2.50	0	0.5	0	N & P
<i>Allium cepa</i>	Key Shinkurt	Herb	Oct to Nov	0.4	0.2	0.3	0.2	N & P
<i>Allium sativum</i>	Nech shinkurt	Herb	Oct to Nov	0.4	0.2	0.3	0.2	N & P
<i>Aloe debrana</i>	Ret/Godarrebussa	Herb	Oct to Dec	1.6	0.4	0.3	0.4	N & P
<i>Annona senegalensis</i>	Gishta	Shrub	April to May	0.2	0	0	0	N & P
<i>Arachis hypogaea</i>	Groundnut	Herb	Aug to Sept	0	0	0	0.2	N & P
<i>Balanites aegyptiaca</i>	Badena	Tree	Jan to Mar	0.9	0.8	0.9	0.90	N & P
<i>Bidens prestinaria</i>	Addile/Adeabeba	Herb	Sept to Nov	0.9	0.9	0.9	0.9	N & P
<i>Brassica carinata</i>	Gommen	Herb	Sept to Nov	0	0	0	0.2	N & P
<i>Capparis sepiaria</i>	Ulumbo	Shrub	Sept to Nov	0.00	0.3	0.2	0	N & P
<i>Capsicum annuum</i>	Barbare	Herb	Sept to Oct	0.2	0.3	0	0.4	N & P
<i>Carica papaya</i>	Papaya	Tree	Sept to Oct	0.3	0.4	0	0.3	N & P
<i>Carissa edulis</i>	Lade/Agam	Shrub	Oct to Dec	0	0	0	0.2	N & P
<i>Chata edulis</i>	Chat	Shrub	Sept to Oct	0.3	0	0	0	N & P
<i>Cicer arietinum</i>	Shumbura	Herb	Oct to Dec	0.2	0	0	0.2	N & P
<i>Citrus aurantifolia</i>	Lomiya/Lome	Shrub	Sept to Oct	0.2	0	0	0.3	N & P
<i>Citrus sinensis</i>	Birtukan	Shrub	Sept to Oct	0.2	0	0	0.3	N & P
<i>Coffea arabica</i>	Tuke/Tukiyye/Buna	Shrub	Feb to Mar	0.9	0	0.9	1.9	N & P

Scientific name	Local name	Life form	Flowering period	Chench a (%)	Gard a Mart a (%)	Kemb a (%)	Kuch a Alfa (%)	Food sources
<i>Coleus abyssinica</i>	Shona	Shrub	Aug to Nov	0	0	0.5	0	N & P
<i>Combretum molle</i>	Soba	Tree	Dec to Jan	0	0	0.8	0.9	N & P
<i>Cordia africana</i>	Mokota/Galma/Wanza	Tree	Aug to Oct	6.00	0	5.3	1	N & P
<i>Coriandrum sativum</i>	Debo/Dimbilala	Herb	Sept to Oct	0.2	0.2	0.3	0.3	N & P
<i>Croton macrostachyus</i>	Anka/Bisana	Tree	May to June	9.00	0	7.10	0	N & P
<i>Erythrina brucei</i>	Korch	Shrub	Oct to Dec	0.5	0.4	0.7	0.2	N & P
<i>Eucalyptus camaldulensis</i>	Key barzaf	Tree	April to May	7.00	10	8	6	N & P
<i>Eucalyptus globulus</i>	Nech barzaf	Tree	April to May	15.00	0	0.9	0	N & P
<i>Faba bean</i>	Bakela	Herb	Sept to Oct	0.2	0	0	0	N & P
<i>Glycine max</i>	Akuri ater/Soybean	Herb	Sept to Oct	2.3	0	0	1.5	Pollen
<i>Grevillea robusta</i>	Gravelia	Tree	Sept to Nov	0.2	0.1	0.2	0.3	N & P
<i>Guizotia abyssinica</i>	Noug	Herb	Sept to Nov	0.2	0	0	0.3	N & P
<i>Helianthus annuus</i>	Suf	Herb	Sept to Nov	0.3	0	0.4	0	N & P
<i>Hypoestes forskalii</i>	Busino	Herb	Aug to Oct	0.2	0.8	0.90	0.9	N & P
<i>Ilex mitis</i>	Unso/Miessa	Shrub	Sept to Nov	0	0	0.3	0	N & P
<i>Justicia schimperiana</i>	Sansal/Dhumuga	Shrub	Nov to Jan	0	0	0	0.2	N & P
<i>Linum usitatissimum</i>	Telba/Linseed	Herb	Sept to Oct	0.2	0	0	0.3	N & P
<i>Lippia adoensis</i>	Shasha/Kusaye	Shrub	Aug to Nov	0.2	0	0	0	N & P
<i>Lycopersicon esculentum</i>	Timatim	Herb	Sept to Oct	0.2	0	0	0	N & P
<i>Malus sylvestris</i>	Apple	Shrub	Sept to Oct	0.2	0	0.3	0	N & P
<i>Mangifera indica</i>	Mango	Tree	Sept to Oct	0	0.9	0.6	0.6	N & P
<i>Manihot esculenta</i>	Mitaboyye/Cassava	Shrub	Sept to Oct	0.9	0.5	0.9	0.9	N & P
<i>Maytenus gracilipes</i>	Kartamme	Shrub	Sept to Nov	0	0	0.5	0	N & P
<i>Moringa stenopetala</i>	Aleko/Moringa	Tree	Sept to Nov	0	0	0.5	0.4	N & P
<i>Musa paradisiaca</i>	Muz/Banana	Herb	Sept to Oct	0.8	0.5	0.7	0.5	N & P
<i>Nicotiana tabacum</i>	Tambo	Herb	Sept to Nov	0.1	0.1	0.1	0.1	N & P

Scientific name	Local name	Life form	Flowering period	Chench a (%)	Gard a Mart a (%)	Kemb a (%)	Kuch a Alfa (%)	Food sources
<i>Ocimum basilicum</i>	Basobila	Herb	Sept to Oct	0.5	0	0	0.4	N & P
<i>Ocimum lamiifolium</i>	Kushura/Wancabbi	Shrub	Sept to Oct	0	0	0.7	0	N & P
<i>Persea americana</i>	Avocado	Tree	Sept to Oct	0.3	0.2	0.6	0.5	N & P
<i>Phaseolus vulgaris</i>	Badho/Boloke	Herb	Sept to Oct	0.4	0	0	0.5	N & P
<i>Pisum sativum</i>	Ater	Herb	Sept to Oct	0.6	0	0	0	Pollen
<i>Plectranthus ornatus</i>	Banjirile/Madda	Herb	Sept to Oct	0	0.8	0	0	N & P
<i>Plectranthus spp</i>	Mado/Haja'ile	Herb	Sept to Nov	4	2.5	4	0	N & P
<i>Prunus africana</i>	Okanse/tikur inchet	Tree	Oct to Dec	0.9	1.1	0.9	0.5	N & P
<i>Rhamnus prinoides</i>	Gesho	Shrub	Nov to Jan	1.2	0	0	0	Pollen
<i>Rhus natalensis</i>	Chalka	Shrub	Sept to Oct	0	3.2	0.9	4.6	Pollen
<i>Ruta chalepensis</i>	Tenaddam	Herb	Sept to Oct	0	0	0	0.6	N & P
<i>Solanecio gigas</i>	Oloma	Shrub	Sept to Oct	0.2	0	0	1.5	Pollen
<i>Solanum tubersum</i>	Dinich	Herb	Sept to Oct	0.3	0	0	1.5	Pollen
<i>Sorghum bicolor</i>	Gambo/Mashilla	Herb	Sept to Oct	9	9	9.5	17	Pollen
<i>Syzygium guineense</i>	Ocha/Dokma	Tree	Mar to April	0.90	0.9	0.9	1.9	N & P
<i>Terminalia brownii</i>	Galal'o/ Galunda/Weybeta	Tree	Aug to Oct	0.9	5	6	8	N & P
<i>Vernonia amygdalina</i>	Gara/Grawa	Shrub	Jan to Feb	0.1	0.2	0.3	0.1	N & P
<i>Vernonia auriculata</i>	Buzo/Rejji	Shrub	Dec to Jan	0.9	0	0	0	N & P
<i>Zea mays</i>	Badala/Bokollo	Herb	Aug to Sept	9.00	15	18.5	14	Pollen
<i>unidentified bee plants</i>				0.5	0.7	1	1.1	

Note: Sept= September, Oct=October, Nov=November, Dec=December, Jan=January, Feb=February, Mar=March, Aug=August

Table 4. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Kena Woreda

Scientific name	Local name	Life form	Flowering period	Kena (%)	Food sources
<i>Acacia brevispica</i>	Hamaressa	Tree	September to October	0.25	N&P
<i>Acacia nilotica</i>	Sabant/Burkuk ke	Tree	April to May	0.63	N&P
<i>Acacia seyal</i>	Wachu	Tree	August to October	4.05	N&P
<i>Acacia tortilis</i>	Tadacha/Kololta	Tree	April to May	7.03	N&P
<i>Achyranthes aspera</i>	Dergu Metenne	Herb	September to October	0.57	N&P
<i>Agave sisalana</i>	Niga/Alge	Shrub	September to October	0.63	N&P
<i>Allium cepa</i>	Key Shinkurt	Herb	October to November	0.32	N&P
<i>Allium sativum</i>	Nech shinkurt	Herb	October to November	0.72	N&P
<i>Aloe debrana</i>	Ret/Godarrebu ssa	Herb	October to December	0.62	N&P
<i>Balanites aegyptiaca</i>	Badanno/Hang alta	Tree	January to March	0.9	N&P
<i>Brassica carinata</i>	Gommen	Herb	September to November	0.32	N&P
<i>Cajanus cajan</i>	Erikib Ater (Kuredata)	Shrub	September to October	0.90	N&P
<i>Chata edulis</i>	Chat	Shrub	September and October	0.82	N&P
<i>Coffea arabica</i>	Buna	Shrub	February to March	0.90	N&P
<i>Cordia africana</i>	Otayta/Wanza	Tree	August to October	8.07	N&P
<i>Croton macrostachyus</i>	Maskanta/Bisana	Tree	May to June	4.48	N&P
<i>Cucurbita pepo</i>	Duba	Herb	September to November.	0.06	N&P
<i>Desmodium uncinatum</i>	Dismodium	Herb	September to October	0.44	N&P
<i>Dodonaea anugustifolia</i>	Ditata (Kitkita)	Tree	November to December	0.38	N&P
<i>Dovyalis caffra</i>	Koshommi	Shrub	October to January	0.06	N&P
<i>Eucalyptus camaldulensis</i>	Key barza	Tree	April to May	6.33	N&P
<i>Gossypium hirsutum</i>	Cotton (Fututa)	Shrub	September to November.	0.36	N&P
<i>Grevillea robusta</i>	Gravelia	Tree	September to November	0.13	N&P
<i>Grewia bicolor</i>	Dhayita/Harore ssa	Tree	September to October	0.3	N&P
<i>Helianthus annuus</i>	Suf	Herb	September to November	2.90	N&P
<i>Lycopersicon esculentum</i>	Timatim	Herb	September to October	0.57	N&P

<i>Mangifera indica</i>	Mango	Tree	September to October	0.9	N&P
<i>Manihot esculenta</i>	Moggo /Casava	Shrub	September to October	0.76	N&P
<i>Moringa stenopetala</i>	Halgo (Moringa)	Tree	September to November	0.82	N&P
<i>Morus alba</i> L.	Enjorri	Shrub	September to October	2.00	Pollen
<i>Ocimum basilicum</i>	Besobila	Herb	September to October	0.95	N&P
<i>Olea europaea</i>	Weira	Tree	October to November	0.32	N&P
<i>Persea americana</i>	Avocado	Tree	September to October	0.73	N&P
<i>Phaseolus vulgaris</i>	Adengore	Herb	September to October	0.55	N&P
<i>Psidium guajava</i>	Zeytuna	Shrub	September to October	0.62	N&P
<i>Rhamnus prinoides</i>	Gesho	Shrub	November to January	0.93	Pollen
<i>Ricinus communis</i>	Eyyeta/Kobbo	Shrub	September to October	0.90	N&P
<i>Sorghum bicolor</i>	Hunta/Mashilla	Herb	September to October	8.24	Pollen
<i>Syzygium guineense</i>	Dokma	Tree	March to April	0.06	N&P
<i>Terminalia brownii</i>	Waybeta	Tree	August to October	20.71	N&P
<i>Terminalia schimperiana</i>	Rukata	Tree	September to October	0.95	N&P
<i>Zea mays</i>	Bokolo	Herb	August to September	17.29	Pollen

Table 5. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Baka Dawla Woreda

Scientific name	Local name	Life form	Flowering period	Baka Dawla (%)	Food sources
<i>Acacia etbaica</i> Schweinf.	Dodota	Tree	Aug to Oct	3.00	N & P
<i>Acacia mellifera</i> (Vahl) Benth.	Dile/Qontir	Shrub	May to Aug	0.4	N&P
<i>Acacia nilotica</i>	Girare	Tree	April to May	1.37	N & P
<i>Acacia brevispica</i>	Hamarecha	Tree	Sept to Oct	0.20	N&P
<i>Acacia senegal</i>	Baraza/Saphansa	Tree	Aug to Oct	5.00	N&P
<i>Acacia seyal</i>	Wachu/Grare	Tree	Aug to Oct	0.87	N & P
<i>Acacia tortilis</i>	Girare	Tree	April to May	0.75	N & P
<i>Achyranthes aspera</i> Linn.	Busino/Matanne	Herb	Sept to Oct	0.37	N & P
<i>Aloe debrana</i>	Ret	Herb	Oct to Dec	0.42	N & P
<i>Balanites aegyptiaca</i>	Badena	Tree	Jan to Mar	0.90	N & P
<i>Brassica carinata</i>	Kale/Gommen	Herb	Sept to Nov	0.32	N&P
<i>Capsicum annuum</i>	Berbere	Herb	Sept to Oct	0.51	N & P
<i>Carica papaya</i> L.	Papaya	Tree	All year around	0.75	N & P
<i>Carthamus tinctorius</i> L.	Sufe	Herb	Oct to Dec	5.10	Pollen
<i>Chata edulis</i>	Chate	Shrub	Sept to Oct	0.90	N & P
<i>Citrus aurantifolia</i>	Lome	Shrub	Sept to Oct	0.12	N & P
<i>Clausena anisata</i>	Zuma/Limich/Ulumaya	Shrub	Oct to Dec	0.40	N & P
<i>Coffea arabica</i>	Buna	Shrub	Feb to Mar	0.9	N & P
<i>Combretum molle</i>	Soba	Tree	Dec to Jan	0.90	N & P
<i>Cordia africana</i>	Asha/Galma/Wanza	Tree	Aug to Oct	6.00	N & P
<i>Croton macrostachyus</i>	Beta/Bisana	Tree	May to June	5.11	N & P
<i>Dovyalis caffra</i>	Koshommi	Shrub	Oct to Jan	0.90	N & P
<i>Erythrina brucei</i>	Bera/Korch	Shrub	Oct to Dec	0.50	N & P
<i>Eucalyptus camaldulensis</i>	Key barzaf	Tree	April to May	3.37	N & P
<i>Euphorbia nubica</i> N. E. Br.	Ananno	Shrub	Sept to Oct	2.64	Pollen
<i>Glycine max</i>	Akuri Ater/Soyabean/Ringo	Herb	Sept to Oct	2.80	Pollen
<i>Grevillea robusta</i>	Gravelia	Tree	Sept to Nov	0.90	N & P

<i>Hypoestes forskalii</i>	Busino	Herb	Sept to Nov	3.00	N &P
<i>Ilex mitis</i>	Kunsil/Miessa/	Shrub	Sept to Nov	0.00	N&P
<i>Lantana camara</i>	Enaro	Shrub	Sept to Oct	0.80	N &P
<i>Mangifera indica</i>	Mango	Tree	Sept to Oct	0.90	N &P
<i>Moringa stenopetala</i>	Konki/Moringa	Tree	Sept to Nov	0.00	N&P
<i>Musa X paradisiaca</i>	Muze	Herb	All year round	0.92	N &P
<i>Ocimum lamiifolium</i>	Kushura/Wanc abbi	Shrub	Sept to Oct	0.90	N &P
<i>Ormocarpum trichocarpum</i>	Moshito	Shrub	Sept to Dec	0.32	N &P
<i>Carica papaya</i>	Papaya	Tree	Sept to Oct	0.50	N &P
<i>Persea americana</i>	Avocado	Tree	Sept to Oct	0.2	N&P
<i>Phytolacca dodecandra L'Her</i>	Endode	Shrub	Oct to Dec	0.62	N &P
<i>Plectranthus ornatus</i>	Banjirile/Madda	Herb	Sept to Oct	5.10	N &P
<i>Rhamnus prinoides</i>	Gesho	Shrub	Nov to Jan	0.50	Pollen
<i>Ricinus communis L.</i>	Kobbo/Gulo	Shrub	Sept to Oct	0.90	N &P
<i>Ruta chalepensis</i>	Tenaddam	Herb	Sept to Oct	0.80	N &P
<i>Solanum incanum L.</i>	Kotse Garenti/Bulabul o	Herb	Sept to Oct	3.96	Pollen
<i>Sorghum bicolor</i>	Hunta/Mashilla	Herb	Sept to Oct	12.70	Pollen
<i>Syzygium guineense</i>	Dokma	Tree	Mar to April	0.90	N &P
<i>Terminalia brownii</i>	Sugar/Arra/Aba lo	Tree	Aug to Oct	5.10	N &P
<i>Terminalia schimperiana</i>	Debden/Dekila	Tree	Sept to Oct	0.90	N &P
<i>Vernonia amygdalina</i>	Gara/Grawa	Shrub	Jan to Feb	0.92	N &P
<i>Vernonia auriculata</i>	Buzi/Rejji	Shrub	Dec to Jan	0.87	N &P
<i>Zea mays</i>	Bokolo	Herb	Aug to Sept	14.00	Pollen

Note: Sept= September, Oct=October, Nov=November, Dec=December, Jan=January, Feb=February, Mar=March, Aug=August

Table 6. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Hamar and Benatsemay Woredas

Scientific name	Local name	Life form	Flowering period	Hamar (%)	Benatsemay (%)	Food sources
<i>Acacia etbaica</i> Schweinf.	Dodota	Tree	Aug to Oct	10.00	4.00	N & P
<i>Acacia mellifera</i>	Dile/Qo ntir	Shrub	May to Aug	0.50	0.90	N&P
<i>Acacia nilotica</i>	Girare	Tree	April to May	5.00	4.10	N & P
<i>Acacia brevispica</i>	Hamare cha	Tree	Sept to Oct	0.30	0.90	N&P
<i>Acacia senegal</i>	Baraza/ Saphansa	Tree	Aug to Oct	13.00	5.00	N&P
<i>Acacia seyal</i>	Wachu/ Grare	Tree	Aug to Oct	4.00	3.00	N & P
<i>Acacia tortilis</i>	Girare	Tree	April to May	10.00	8.00	N & P
<i>Achyranthes aspera</i> Linn.	Busino/ Matanne	Herb	Sept to Oct	0.60	0.90	N & P
<i>Aloe debrana</i>	Ret	Herb	Oct to Dec	0.50	0.80	N & P
<i>Balanites aegyptiaca</i>	Badena	Tree	Jan to Mar	0.90	0.90	N & P
<i>Brassica carinata</i>	Kale/Go mmen	Herb	Sept to Nov	0.2	0.90	N&P
<i>Capsicum annuum</i>	Berberere	Herb	Sept and Oct	0.00	0.40	N & P
<i>Carica papaya</i> L.	Papaya	Tree	Year around	0.70	0.80	N & P
<i>Carthamus tinctorius</i> L.	Sufe	Herb	Oct to Dec	0.00	3.10	Pollen
<i>Chata edulis</i>	Chate	Shrub	Sept and October	0.00	0.80	N & P
<i>Citrus aurantifolia</i>	Lome	Shrub	Sept to Oct	0.50	0.80	N & P
<i>Clausena anisata</i>	Zuma/Limich/Ul umaya	Shrub	Oct to Dec	0.00	0.00	N & P
<i>Coffea arabica</i>	Buna	Shrub	Feb to Mar	0.00	5.00	N & P
<i>Combretum molle</i>	Soba	Tree	Oct to Jan	0.90	0.90	N & P
<i>Cordia africana</i>	Asha/G alma/ Wanza	Tree	Aug to Oct	0.50	6.00	N & P
<i>Croton macrostachyus</i>	Beta/Bi sana	Tree	May to June	0.30	7.00	N & P
<i>Dovyalis caffra</i>	Koshom mi	Shrub	Oct to Jan	0.50	0.70	N & P
<i>Erythrina brucei</i>	Bera/Ko rch	Shrub	Oct to Dec	0.60	0.40	N & P
<i>Eucalyptus camaldulensis</i>	Key barzaf	Tree	April to May	1.00	3.00	N & P
<i>Euphorbia nubica</i> N. E. Br.	Ananno	Shrub	Sept to Oct	7.10	1.20	P
<i>Glycine max</i>	Akuri ater/So	Herb	Sept to Oct	0.00	2.20	P

	yabean/ Ringo					
<i>Grevillea robusta</i>	Graveli a	Tree	Sept to Nov	0.50	0.40	N &P
<i>Hypoestes forsaolii (Vahl) R. Br.</i>	Busino	Herb	Sept to Nov	0.90	2.00	N &P
<i>Ilex mitis</i>	Kunsil/ Miessa/	Shrub	Sept to Nov	0.55	0.60	N&P
<i>Lantana camara</i>	Enaro	Shrub	Sept to Oct	0.90	0.50	N &P
<i>Mangifera indica</i>	Mango	Tree	Sept to Oct	0.80	0.60	N &P
<i>Moringa stenopetala</i>	Konki/M oringa	Tree	Sept to Nov	0.50	0.40	N&P
<i>Musa X paradisiaca</i>	Muze	Herb	Year around	0.00	0.60	N &P
<i>Ocimum lamiifolium</i>	Kushur a/Wanc abbi	Shrub	Sept to Oct	0.80	0.50	N &P
<i>Ormocarpum trichocarpum</i>	Moshito	Shrub	Sept to Dec	0.90	0.40	N &P
<i>Carica papaya</i>	Papaya	Tree	Sept to Oct	0.50	0.40	N &P
<i>Persea americana</i>	Avocad o	Tree	Sept to Oct	0.00	0.20	N&P
<i>Phytolacca dodecandra</i>	Endode	Shrub	Oct to Dec	0.00	0.20	N &P
<i>Plectranthus ornatus</i>	Banjirile /Madda	Herb	Sept to Oct	2.00	1.00	N &P
<i>Rhamnus prinoidea</i>	Gesho	Shrub	Nov to Jan	0.00	0.50	P
<i>Ricinus communis L.</i>	Kobbo/ Gulo	Shrub	Sept to Oct	0.80	0.40	N &P
<i>Ruta chalepensis</i>	Tenadd am	Herb	Sept to Oct	0.50	0.50	N &P
<i>Solanum incanum L.</i>	Kotse Garenti/ Bulabul o	Herb	Sept to Oct	2.50	0.20	P
<i>Sorghum bicolor</i>	Hunta/ Mashilla	Herb	Sept to Oct	10.00	9.00	P
<i>Syzygium guineense</i>	Dokma	Tree	Mar to April	0.00	1.00	N &P
<i>Terminalia brownii</i>	Sugar/A rra/Abal o	Tree	Aug to Oct	9.10	7.00	N &P
<i>Terminalia schimperiana</i>	Debden /Dekila	Tree	Sept to Oct	0.90	0.90	N &P
<i>Vernonia amygdalina</i>	Gara/Gr awa	Shrub	Jan to Feb	0.00	0.50	N &P
<i>Vernonia auriculata</i>	Buzi/Re jji	Shrub	Dec to Jan	0.00	0.60	N &P
<i>Zea mays</i>	Bokolo	Herb	Aug to Sept	10.00	10.00	P
Total				99.25	99.4	

Note: Sept=September, Oct=October, Nov=November, Dec=December, Jan=January, Feb=February, Mar=March, Aug=August

Table 7. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Sodo Zuria Woreda

Scientific name	Local name	Life form	Flowering period	Sodo Zuria (%)	Food sources
<i>Acacia abyssinica</i>	Grar	Tree	Sept to Nov	0.90	N&P
<i>Acacia nilotica</i>	Tsesse/Burkukke	Tree	April to May	3.00	N&P
<i>Acacia senegal</i>	Shara	Tree	Aug to Oct	2.50	N&P
<i>Acacia seyal</i>	Wachu	Tree	Aug to Oct	2.00	N&P
<i>Acacia sieberiana</i>	Chiche	Tree	Sept to Nov	2.00	N&P
<i>Acacia tortilis</i>	Tedech	Tree	April to May	4.00	N&P
<i>Acanthus sennii</i>	Hamakka/Sokorru	Shrub	Sept to Nov	0.50	N&P
<i>Acranthus aspera</i>	Dergu	Herb	Sept to Oct	0.80	N&P
<i>Albizia schimperiana</i> Oliv.	Mukarba/Zagiya	Tree	Feb to Mar	0.50	N&P
<i>Aloe debrana</i>	Godareta	Herb	Oct to Dec	0.60	N&P
<i>Annona squamosa</i> L.	Gishta	Shrub	Sept to Nov	1.10	P
<i>Asparagus africanus</i> Lam.	Timbala/Hidda sariti	Herb	Oct to Dec	0.30	N&P
<i>Bersama abyssinica</i>	Walasenu/Lolchisa	Shrub	Dec to Jan	0.40	N&P
<i>Bidens pilosa</i> L.	Antaqalo/chogogit	Herb	Sept to Oct	0.80	N&P
<i>Cajanus cajan</i>	Pigeon pea	Herb	Oct to Dec	0.90	N&P
<i>Calpurnia aurea</i> (Aiton) Benth.	Mahilluwa/Cheka	Shrub	Sept to Nov	0.40	N&P
<i>Carissa edulis</i>	Ladiya/Agamsa	Shrub	Oct to Dec	0.90	N&P
<i>Casimiroa edulis</i> LaLava	Kasmir	Tree	Sept to Oct	0.20	N&P
<i>Citrus aurantifolia</i>	Lomiya/Lome	Shrub	Sept to Oct	0.20	N&P
<i>Clausena anisate</i>	Dashalomiya/Ulum aya	Shrub	Aug to Oct	0.20	N&P
<i>Coffea arabica</i>	Tukeya/Buna	Shrub	Feb to Mar	4.00	N&P
<i>Cordia africana</i>	Wanza/Moqonse/Mokota	Tree	Aug to Oct	11.00	N&P
<i>Croton macrostachyus</i>	Bisanna/Anka	Tree	May to June	13.00	N&P
<i>Cucurbita pepo</i>	Duba	Herb	Sept to Nov.	0.40	N&P
<i>Datura arborea</i>	Turuma abeba	Shrub	Sept to Nov	0.20	N&P
<i>Dovyalis caffra</i>	Koshommi	Shrub	Oct to Jan	0.20	N&P
<i>Erythrina brucei</i>	Korch	Shrub	Oct to Dec	0.20	N&P
<i>Eucalyptus camaldulensis</i>	Key barzaf	Tree	April to May	12.00	N&P
<i>Euphorbia nubica</i> N. E. Br.	Annanno/Maxxuwa	Shrub	Sept to Oct	0.50	P
<i>Euphorbia nubica</i> N. E. Br.	Ananno	Shrub	Sept to Oct	0.80	P
<i>Grevillea robusta</i>	Gravelia	Tree	Sept to Nov	0.30	N&P
<i>Grewia ferruginea</i> Hochst.	Xawayya/Dokonu	Tree	Sept to Oct	0.20	N&P
<i>Guizotia abyssinica</i>	Mech/ Adille	Herb	Oct to Dec	0.90	N&P

<i>Hypoestes forskalii</i>	Dergu	Herb	Sept to Nov	0.90	N&P
<i>Jacaranda mimosifolia</i> D.Don	Jakaranda	Tree	Nov to Jan	0.40	N&P
<i>Justicia schimperiana</i>	Dhumuga/Sensel	Shrub	Nov to Jan	0.30	N&P
<i>Lantana camara</i>	Tundugiya	Shrub	Sept to Oct	0.60	N&P
<i>Leucas martinicensis</i>	Bokolu/herb	Herb	Sept to Nov	0.40	N&P
<i>Lycopersicon esculentum</i>	Timatim	Herb	Sept to Oct	0.40	N&P
<i>Maesa lanceolata</i> Forssk	Abayyi/Imbis/Galga cho	Shrub	Sept to Oct	0.70	N&P
<i>Mangifera indica</i>	Mango	Tree	Sept to Oct	0.90	N&P
<i>Manihot esculenta</i>	Mittaboyye/Kasava	Shrub	Sept to Oct	0.90	N&P
<i>Maytenus arbutifolia</i> (Hochst. ex A.Rich.) R.Wilczek	Tutuwa/Kartamme	Shrub	Sept to Dec	0.80	N&P
<i>Maytenus obscura</i>	Aliga/Kombolcha	Tree	Oct to Dec	0.50	N&P
<i>Moringa stenopetala</i>	Halgo (Moringa)	Tree	Sept to Nov	0.30	N&P
<i>Morus alba</i> L.	Enjorri/Enjera	Shrub	Sept to Oct	0.40	P
<i>Ocimum lamiifolium</i>	Wancabbi	Shrub	Sept to Oct	0.80	N&P
<i>Ocotea kenyensis</i>	Waratuke/Buniti	Shrub	Dec to Jan	0.90	N&P
<i>Olea europaea</i>	Weira	Tree	Oct to Nov	0.80	N&P
<i>Persea americana</i>	Avocado	Tree	Sept to Oct	0.90	N&P
<i>Phaseolus vulgaris</i>	Bolokke/Logoma	Herb	Sept to Oct	0.90	N&P
<i>Pisum sativum</i> L.	Ater	Herb	Sept to Oct	0.20	P
<i>Plectranthus punctatus</i>	Adilaliha/Bala dullacha	Herb	Sept to Oct	0.90	N&P
<i>Premna schimperi</i> Engl.	Urgessa	Shrub	Aug to Sept	0.30	N&P
<i>Rhamnus prinoides</i>	Gesho	Shrub	Nov to Jan	0.40	P
<i>Rhus glutinosa</i>	Tatessa	Tree	Oct to Dec	0.80	N&P
<i>Ricinus communis</i> L.	Kobbo	Shrub	Sept to Oct	0.80	N&P
<i>Sesbania sesban</i> (L.) Merr.	Sesbania sesban	Shrub	Aug to Sept	0.40	N&P
<i>Sida rhombifolia</i> L.	Karava	Shrub	Sept to Nov	0.30	P
<i>Sida schimperiana</i>	Dandireta/chifrigi	Shrub	Sept to Dec	0.50	N&P
<i>Solanum incanum</i> L.	Bulo/Hiddi Ioni	Shrub	Sept to Dec	0.40	N&P
<i>Syzygium guineense</i>	Ocha/Dokma	Tree	Mar to April	1.60	N&P
<i>Terminalia brownii</i>	Weyibeta/Wagera	Tree	Aug to Oct	0.70	N&P
<i>Vernonia amygdalina</i>	Gara/Grawa	Shrub	Jan to Feb	0.80	N&P
<i>Vernonia auriculata</i>	Buzo/Rejji	Shrub	Dec to Jan	0.92	N&P
<i>Vernonia hochstetteri</i>	Kanamakka/Damot gurra	Shrub	Sept to Nov	0.90	N&P
<i>Vernonia thomsoniana</i>	Soyama/Amakka	Shrub	Jan to Feb	0.80	N&P
<i>Zea mays</i>	Bokolo/Bedela	Herb	Aug to Sept	10.50	P
				98.92	

Note: Sept= September, Oct=October, Nov=November, Dec=December, Jan=January, Feb=February, Mar=March, Aug=August

Table 8. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Adiyo and Tello woredas

No	Scientific name	Local name	Life form	Flowering Period	Adiyo	Tello	Food source
1	<i>Albizia schimperiana</i>	Catto	Tree	Sept	3.7		N&P
2	<i>Allophylus abyssinicus</i>	Sheo	Tree	Sept	3.8	0.56	P
3	<i>Apodytes dimidiata</i>	Wondefo	Tree	Oct	0.9	1.06	N&P
4	<i>Bersama abyssinica</i>	Boqqo	Tree	Dec	11	0	N&P
5	<i>Bothriocline schimperi</i>	Yemesho	Shrub	Sept	4.9	0	P
6	<i>Galinosoga parviflora</i>		Herb	Sept	3	0	P
7	<i>Bidens prestinaria</i>	Kello	Herb	Sept	0.6	3.4	P
8	<i>Coffea arabica</i>	Buno	Herb	Feb	18	2.82	N&P
9	<i>Bidens pilosa</i>	Kello	Herb	Oct	0	4	P
10	<i>Carica papaya</i>	Papyo	Shrub	Oct	2.3	0	N&P
11	<i>Rhus vulgaris</i>		Shrub	Oct	1	0	P
12	<i>Pisum sativum</i>	Ataro	Herb	Sept	2	0	P
13	<i>Carissa edulis</i>	Agamo	Shrub	Oct	0.96	0	N&P
14	<i>Calpurnia aurea</i>	Ceeke	Shrub	Oct	0.44	0	N&P
15	<i>Cordia africana</i>	Dio	Tree	Aug	0.82	2	N&P
16	<i>Croton macrostachyus</i>	Wago	Tree	May	1.74	2.7	N&P
17	<i>Datura arborea</i>	Ababo	Shrub	Oct	1.88	1.8	N&P
18	<i>Dombeya torrida</i>	Shaweko	Tree	Oct	1.34	2.8	N&P
19	<i>Ekebergia capensis</i>	Ororo	Tree	Jan	0.99	1.34	N&P
20	<i>Eucalyptus, globulus</i>	Barzafo	Tree	Mar	9	2.12	N&P
21	<i>Galiniera saxifraga</i>	Dido	Shrub	Oct	2.10	0.62	N&P
22	<i>Olea welwitschii</i>	Yahoo	Tree	N&P	0	0.35	May
23	<i>Polyscias fulva</i>	Karasho	Tree	N&P	0	0.59	Oct
24	<i>Millitia ferrugnea</i>	Bebero	Tree	N&P	0	0.86	Sept
25	<i>Guizotia scabra</i>	Tuffo	H	Nov	3.9	10	N&P
26	<i>Grevillea robusta</i>	Gravillo	Tree	Sept	4.4	0	N&P
27	<i>Hagenia abyssinica</i>	Habessho	Tree	Sept	2.8	0.2	P
28	<i>Persea americana</i>	Avocado	Shrub	Nov	7.40	0.70	N&P
29	<i>Plectrantus punctatus</i>		Herb	Sept	0.2	0	N&P
30	<i>Pouteria adrofedrici</i>	Shaoo	Tree	Feb	2.23	0.02	N&P
31	<i>Ricinus communis</i>	Kobo	Shrub	Sept	0.2	0	N&P
32	<i>Schefflera abyssinica</i>	Buto	Tree	Mar	0.3	1.12	N&P

33	<i>Syzygium guineense</i>	Yino	Tree	Feb	0.4	0.02	N&P
34	<i>Trifolium spp</i>	Hogeyo	Herb	Aug	3	0.8	N&P
35	<i>Terminalia schimperi</i>	Abalo	Tree	Dec	0.04	0	N&P
36	<i>Issoglosa somalensis</i>	Qoro	Herb	Oct	4	5	N&P
37	<i>Sericostachys scandens</i>	Shudo	Shrub	P	0	2.2	Nov
38	<i>Vicia faba</i>	Ato	Herb	Aug	2	4	N&P
39	<i>Saturja paradoxa</i>	Naddo	Herb	Sept	3	5	N&P
40	<i>Vernonia auriculifera</i>	Dangrato	Shrub	Dec	2.1	1.57	N&P
41	<i>Vernonia amygdalina</i>	Gerawoo	Shrub	Dec	0.93	0	N&P
42	<i>Zea mays</i>	Baroo	Herb	Aug	0.4	20	P
43	<i>Impatiens hochtteri</i>	Egeqo	Herb	Sept	5	3	N&P
44	<i>Pyschnostachyus emini</i>	Yeroo	Herb	Dec	0.45	0.04	N&P
45	<i>Acanthus eminii</i>	Phecco	Shrub	Sept	0.2	2.2	N&P

Table 9. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Decha and Bitu woredas

No	Scientific name	Local name	Life form	Food source	F.Period	Decha (%)	Bitu(%)
1	<i>Aframomum corrorima</i>	Afiyo	Herb	N&P	Sept	0.05	0.22
2	<i>Albizia schimperiana</i>	Catto	Tree	N&P	Sept	0.2	0.32
3	<i>Allophylus abyssinicus</i>	Sheo	Tree	P	Sept	0.13	3.1
4	<i>Bothriocline schimperi</i>	Yemeshe	Shrub	P	Sept	0.4	2.72
5	<i>Bidens prestinaria</i>	Kello	Herb	N&P	Sept	2.6	1.05
6	<i>Coffea arabica</i>	Buno	Herb	N&P	Feb	1.74	0.9
7	<i>Cordia africana</i>	Dio	Tree	N&P	Aug	0.19	0.64
8	<i>Croton macrostachyus</i>	Wago	Tree	N&P	May	0.15	0.19
9	<i>Combretum molle</i>	Dabaqa	Tree	N&P	Dec	2.1	0.14
10	<i>Datura arborea</i>	Ababo	Shrub	N&P	Oct	0.67	2.2
11	<i>Dombeya torrida</i>	Shaweko	Tree	N&P	Oct	0.05	1.2
12	<i>Ehretia cymosa</i>	Wagimo	Tree	N&P	Oct	1.6	0.28
13	<i>Ekebergia capensis</i>	Ororo	Tree	N&P	Jan	0.02	0.16
14	<i>Eucalyptus, globulus</i>	Barzafo	Tree	N&P	Mar	0.83	0.16
15	<i>Euphorbia candelabrum</i>	Gachoo	Tree	N&P	Oct	0.4	0.38
16	<i>Galiniera saxifraga</i>	Dido	Shrub	N&P	Oct	0.08	1.73

17	<i>Guizotia scabra</i>	Tuffo	Herb	N&P	Nov	7	0.38
18	<i>Maesa lanceolata</i>	Caggo	Tree	P	Aug	2	0.69
19	<i>Maytenus spp</i>	Shiko	Tree	N&P	Oct	0.38	0.38
20	<i>Millitia ferrugnea</i>	Bebero	Tree	N&P	Sept	0.48	1.5
21	<i>Olea welwitschii</i>	Yahoo	Tree	N&P	May	0.02	0.3
22	<i>Olea capensis</i>	Yahoo	Tree	N&P	May	0.22	0.14
23	<i>Pavonia urens</i>	Sheyo	Herb	N&P	Oct	3	1.5
24	<i>Persea americana</i>	Avocado	Shrub	N&P	Nov	0.65	0.99
25	<i>Pterolobium stellatum</i>	Garo	Shrub	P	Sept	13	0.21
26	<i>Phoenix reclinata</i>	Yebbo	Tree	N&P	Oct	0.43	2
27	<i>Plectrantus punctatus</i>		Herb	N&P	Sept	0.4	0
28	<i>Polyscias fulva</i>	Karasho	Tree	N&P	Oct	0.02	9.4
29	<i>Pouteria adrofedrici</i>	Shao	Tree	N&P	Feb	0.33	1
30	<i>Schefflera abyssinica</i>	Buto	Tree	N&P	Mar	0.4	0.7
31	<i>Syzygium guineense</i>	Yino	Tree	N&P	Feb	0.63	3
32	<i>Issoglossa somalensis</i>	Qoro	Herb	N&P	Oct	0.92	0.25
33	<i>Vicia faba</i>	Ato	Herb	N&P	Aug	1	0.35
34	<i>Vernonia amygdalina</i>	Gerawoo	Shrub	N&P	Dec	0.17	0.09
35	<i>Zea mays</i>	Baroo	Herb	P	Aug	10	3
36	<i>Impatiens hochtteri</i>	Egeqo	Herb	N&P	Sept	4	0.43
37	<i>Pyschnostachys emini</i>	Yeroo	Herb	N&P	Dec	0.6	0.02
38	<i>Acanthus eminii</i>	Phecco	Shrub	N&P	Sept	0.3	3
39	<i>Ilex mitis</i>	Qeto	Tree	P	Sept	0.03	0.02
40	<i>Pyschnostachys emnis</i>	Yearo	Shrub	N&P	Sept	1	0.01
41	<i>Laggera pterdonata</i>	Hupicho	Shrub	P	Sept	0.44	0.06

Table 10. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Sheybench woreda

No	Plant species	Local name	Life form	Flowering period	Sheybench (%)	Food source
1	<i>Acacia spp</i>	Girar	Tree	Sept-Nov	3.8	N&P
2	<i>Acmella caulirhiza</i>	Gutich	Herb	Sept-Nov	9	P
3	<i>Albizia gumifera</i>	Sissa	Tree	Sept-Nov	8	N & P
4	<i>Andropogon abyssinica</i>	Muja	Herb	Sept-Nov	7.8	P
5	<i>Bidens pilosa</i>	Bondok	Herb	Sept-Nov	8	P
6	<i>Bidens prestiniaria</i>	Adey ababa	Herb	Sept-Nov	17	P
7	<i>Achyranthes aspera</i>	chogogit	Herb	Sept-Nov	12	P
8	<i>Citrus spp</i>	Burtukan	Shrub	Sept-Nov	8	N&P
9	<i>Clausena anista</i>	Limich	Shrub	Sept-Nov	5.2	N&P
10	<i>Coffea arabica</i>	Buna	Shrub	Feb-Mar	17	N&P

11	<i>Cordia africana</i>	Wanza	Tree	Sept-Nov	2.9	N&P
12	<i>Croton macrosatchyus</i>	Bisana	Tree	May-June	7.3	N&P
13	<i>Datura arobrea</i>	Yemogn ababa	Shrub	Dec-Jan	16	N&P
14	<i>Diysprous abyssinica</i>	Gayo	Shrub	Sept-Nov	2	N&P
15	<i>Ekebrgia capensis</i>	Oro	Tree	Dec-Jan	2.6	N&P
16	<i>Etrinia brucei</i>	Korch	Tree	Sept-Nov	11	N&P
17	<i>Eucalptus globlus</i>	Nech barzaf	Tree	March- April	22	N&P
18	<i>Eucalyptus camaludensis</i>	Key barzaf	Tree	March- April	31	N&P
19	<i>Euphorbia abyssinica</i>	Kulkual	Tree	Sept-Nov	15	N&P
20	<i>Euphorbia tricuali</i>	kichib	Shrub	Sept-Nov	12	P
21	<i>Guizotia scbara</i>	Mech	Herb	Sept-Nov	21	N&P
22	<i>Gravillea robusta</i>	Gravillea	Tree	Sept-Nov	10	N&P
23	<i>Lippia adonesis</i>	Kosert	Shrub	Sept-Nov	6	P
24	<i>Glycine max</i>		Herb	Sept-Nov	0	P
25	<i>Mangifera indica</i>	Mango	Shrub	Sept-Nov	25	P
26	<i>Mayenus spp</i>	Atat	Shrub	Sept-Nov	1.2	N&P
27	<i>Millitia ferruginea</i>	Birbira	Tree	Sept-Nov	1.7	N&P
28	<i>Musa paradisca</i>	Muz	Herb	Sept-Nov	12	P
29	<i>Hypheneria spp</i>	Muja	Herb	Sept-Nov	11	P
30	<i>Persea americana</i>	Avocado	Shrub	Sept-Nov	6	N&P
31	<i>Piper capensis</i>	Timiz	Shrub	Sept-Nov	29	P
32	<i>Pisum sativium</i>	Ater	Herb	Aug	30	P
33	<i>Eluesine folicofloia</i>	Akirma	Herb	Aug	35	P
34	<i>Pouteria altissimai</i>	Gommo	Tree	May-June	6.4	N&P
35	<i>Prunus africana</i>	Tiku inchet	Tree	Sept-Nov	18	N&P
36	<i>Psidium ginneense</i>	Ziythun	Shrub	Sept-Nov	1.2	N&P
37	<i>Ruta chalopensis</i>	Tena adam	Herb	Sept-Nov	3.1	P
38	<i>Schefflera abyssinica</i>	Getem	Tree	Sept-Nov	2.1	N&P
39	<i>Sesbania sesban</i>	Sesbania	Shrub	Sept-Nov	1.2	N&P
40	<i>Syzygium guniinese</i>	Dokima	Tree	Feb-Mar	2.1	N&P
41	<i>Vennia auriculifera</i>	Buz	Shrub	Dec-Jan	11.2	N&P
42	<i>vernonia amygadliana</i>	Girawa	Shrub	Dec-Jan	4.2	N&P
43	<i>Vicia faba</i>	Bakela	Herb	Sept-Nov	11	p
44	<i>Zea mays</i>	Boqolo	Herb	Sept-Nov	0	P
45	<i>Solanum capiscum</i>	Berbera	Herb	Sept-Nov	0	P

Table 11. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Darara and Malga Woredas

No.	Scientific name	Local name	Life form	Flowering g period	Darara (%)	Malga(%)	food source
1	<i>Bidens prestinaria</i>	Adalcho	Herb	Sept-Oct	6.2	14.5	P
	<i>Bidens pilosa</i>		Herb	Sept-Oct	0	12	P
2	<i>Discopodium penninervium</i>	Amararicho	Shrub	Sept-Oct	0.2	0	N&P
3	<i>Persea americana</i>	Avicado	Tree	Oct	4.7	14.9	N&P
4	<i>Eucalyptus camaludensis</i>	Baherzaf	Tree	March	0.07	20	N&P
5	<i>Millettia ferruginea</i>	hegedicho	Tree	Sept-Oct	0.02	0.02	N&P
6	<i>Eucalyptus globulus</i>	Birzaff	Tree	March-May	1.37	12	N&P
7	<i>Croton macrostachyus</i>	Masincho	Tree	May	1.3	15	N&P
8	<i>Guizotia scabra</i>	Bole	Herb	Oct-Dec	7.9	10	N&P
9	<i>Coffea arabica</i>	Buna	Herb	Feb-Mar	6.7	43.6	N&P
10	<i>Pterolobium stellatum</i>	Garo	Herb	Sept	4	0	p
12	<i>Sorghum bicolor</i>	Yango	Herb	Oct	3	0	p
13	<i>Casimiroa edulis</i>	Casimera	Tree	Sept -Oct	1.29	1.7	P
14	<i>Euphorbia candelabrum</i>	Charecho	Tree	Sept -Oct	0.04	0	N&P
15	<i>Calpurnia aurea</i>	Chekata	Tree	Sept -Oct	0.34	25	N&P
16	<i>Terminalia schimperiana</i>	Dabaka	Tree	Nov-Dec	0	0	N&P
18	<i>Olea africana</i>	Ejersa	Tree	May	0.22	0	N&P
19	<i>Schefflera abyssinica</i>	Gatancho	Tree	April	0.04	0	N&P
20	<i>Vernonia auriculifera</i>	hegedicho	Shrub	Dec-Jan	1	6	N&P
21	<i>Acacia tortolis</i>	Tadacha	Tree	March-May	2.7	17	N&P
22	<i>Grevillea robusta</i>	Giravilia	Tree	Sept -Oct	14	19	N&P
23	<i>Galinosoga parviflora</i>	Abbadabo	Herb	Sept -Oct	2.01	0	Pollen
24	<i>Zea mays</i>	Maize	Herb	Aug	1.29	0	Pollen
25	<i>Brugmansia arborea</i>	Nech abeba	Shrub	Nov-Dec	1.7	0	N&P
27	<i>Carica papaya</i>	Papya	Shrub	Nov-Dec	0.03	0.02	N&P
28	<i>Ekebergia capensis</i>	Garibecho	Tree	Dec-Jan	0.03	0	N&P
29	<i>Ehretia cymosa</i>	Gidincho	Shrub	Nov-Dec	0.42	0	N&P
30	<i>Cordia africana</i>	Wodicho	Tree	Jun-Aug	1.3	30	N&P
31	<i>Vicia faba</i>	Bakela	Herb	Sept	7.7	20	P
32	<i>Balanite aegyptica</i>	Bedena	Tree	Sept-Oct	0.02	0	P
33	<i>Achyranthes aspera</i>	Gerbabo	Herb	Sept-Oct	3.09	15	P
34	<i>Maytenus arbutifolia</i>	Cuco	Shrub	Sept-Oct	1.7	0	N&P

35	<i>Ocimum lamifolium</i>	Damakesie	Herb	Sept-Oct	4.7	0.7	N&P
36	<i>Hypoestes forskalii</i>	Dergu	Herb	Sept-Oct	10	28	N&P
37	<i>Solanum tubersum</i>	Dincha	Herb	Sept-Oct	1.3	3	P
38	<i>Dodonaea angustifolia</i>	Itancha	Tree	Sept-Oct	2.9	0	N&P
39	<i>Celtis africana</i>	Shisha	Tree	Sept-Oct	2.4	9	N&P
40	<i>Acacia seyal</i>	Wacco	Tree	Sept-Oct	1.2	0.02	P
41	<i>Acacia tortoils</i>	Xadecha	Tree	April-May	2.7	1.2	N&P
42	<i>Berasama abyssinica</i>	xewarko	Tree	Dec-Jan	0.02	0.12	N&P
43	<i>Malus domestica</i>	Apple	Shrub	Sept	0.02	0.42	N&P
44	<i>Ocimum basilikum</i>	Besobila	Herb	Oct	0.44	0.9	N&P
45	<i>Trifolium spp</i>	Maget	Herb	Sept	0.4	0.9	N&P
46	<i>Ricinus communis</i>	Kobbo	Shrub	Sept	0.33	0.22	N&P

Table 12. Abundance in % and the type of food sources they provide to honeybees (nectar and/or pollen) of bee flora in Wonsho woreda

No	Plant name	Local name	Life form	Flowering period	Wonsho (%)	Food source
1	<i>Persea americana</i>	Avocado	Tree	Oct-Nov	6.169	N
2	<i>Bidens spp</i>	Adalecho	Herb	Sept	1.851	P
3	<i>Malus syvelstris</i>	Apple	Shrub	Sept	0.185	N&P
4	<i>Eucalyptus globulus</i>	Barzafii	Tree	March	3.856	N&P
5	<i>Zea mays</i>	Boqolo	Herb	Aug	4.935	P
6	<i>Millitia ferruginea</i>	Hedigencho	Tree	Sept	2.221	N&P
7	<i>Croton macrostachyus</i>	Manchiso	Tree	May	2.807	N&P
8	<i>Guizotia scabra</i>	Bole	Herb	Oct	16.965	N&P
9	<i>Euphorbia candlabura</i>	Gacho	Tree	Sept	0.154	N&P
10	<i>Grevillea robusta</i>	Garvillo	Tree	Sept	0.278	N&P
11	<i>Hypoestes forskalii</i>		Herb	Sept-Nov	6.169	N&P
12	<i>Caulpurea aurea</i>	ceekata	Shrub	Sept-Nov	0.740	N&P
13	<i>Justicia schimperina</i>	Sensel	Herb	Oct-Dec	4.935	N&P
14	<i>Szygium guineense</i>	Dubancho	Tree	Feb-Mar	0.864	N&P
15	<i>Olea africana</i>	Ejersa	Tree	May	0.093	N&P
16	<i>Achyrantes aspera</i>	Gerbicho	Herb	Oct-Nov	0.154	P
17	<i>Vernonia amgdalina</i>	Hecho	Shrub	Dec-Jan	1.172	N&P
18	<i>Vernonia auriculifera</i>	Rejicho	Shrub	Dec-Jan	3.516	N&P

19	<i>Casimira edulis</i>	Casimira	Shrub	Sept-Nov	0.617	P
20	<i>Carica papaya</i>	Papaya	Tree	Oct-Nov	0.463	N&P
21	<i>Coffea arabica</i>	Buna	Shrub	Feb-Mar	2.468	N&P
22	<i>Mangifera indica</i>	Mango	Shrub	Sept-Nov	2.313	N&P
23	<i>Discopodium . peninervium</i>	Hamararo	Shrub	Sept-Nov	3.023	P
24	<i>Cordia africana</i>	Wodicho	Tree	Sept-Nov	8.174	N&P
25	<i>Salvia spp</i>		Herb	Sept-Nov	3.701	N&P
26	<i>Ensete ventricosum</i>	Ensete	Herb	Sept-Nov	3.763	N&P
27	<i>Brucea antidysentrica</i>	Yemogn Ababa	Shrub	Sept-Nov	0.370	N&P
28	<i>Sesbania sesbana</i>	Sesbania	Shrub	Sept-Nov	0.308	N&P
29	<i>Bersama abyssinica</i>	Teberco	Shrub	Sept-Nov	1.357	N&P
30	<i>Borago officinalis</i>		Herb	Sept-Nov	1.234	P
31	<i>Psidium gaurvae</i>	Zeyiyuna	Shrub	Sept-Nov	0.617	N&P
32	<i>Celosia aregentea</i>	Chogogit	Herb	Sept-Nov	0.817	P

Appendix 3: Household Survey

International Center of Insect Physiology and Ecology (icipe) Mass Youth Employment in Apiculture (MaYEA) Program

Household ID: _____

Name of supervisor: code _____

Name of the enumerator: (code): _____

General information

Region _____

Zone _____

Woreda _____

Date of interview-----

Time started _____ Time

completed _____

GPS location _____

1. Household characteristics

1.1. Name of the Respondent _____

1.2. Sex of the household head: 1=Male, 0=Female,

1.3. Age of the household head _____ years

1.4. Marital status of the household head: 1. Married, 2. Single, 3. Widowed, 4. Divorced

1.5. Education level of household head: 0. Illiterate, 1= Grade 1 2=Grade 2, etc. up to grade 12, 13=TVETs, 14=Informal education, 15. Religious education, 16= College/university

2. Land Holding of the family and major crops grown in hectare

2.1 Backyard area _____ ha

2.2 Farm Land _____ ha

2.3 Grazing Land _____ ha

2.4 Plantation Area _____ ha

2.5 Total land holding (auto sum) _____ ha

3. Beekeeping information

3.1 Do you currently have honeybee colonies? 1. Yes 2. No

3.1.1 If yes, how many honeybee colonies do you own currently in traditional beehives? _____

3.1.2 How many honeybee colonies do you have in transitional beehives?

3.1.3 How many honeybee colonies do you have in movable frame hives?

3.2 When did you start beekeeping? _____ Year (s)

3.3 How did you start beekeeping? 1. by training 2. Learning from family 3. Learning from neighbors, 4. Other specify _____

3.4 What is the source of honeybee colonies when you start beekeeping? By catching the swarm 2. By purchasing the honeybee colony 3. Gift (inherited) from parents 4. Other specify _____

3.5 If the answer for question 3.4 is by purchasing, what is the price of one honeybee colony? _____ ETB

- 3.6 When (month) do you normally transfer honeybee colonies to transitional or frame hives?
- 3.7 Why did you choose the season (month)? _____
- 3.8 Where do you keep bees? 1=backyard, 2=trees (forest), 3=dedicated land
- 3.9 Are there flowering crops where the bees are kept (fruit trees or other crops)? 1=Yes, 0=No
- 3.10 Is there a forest or other vegetation within 3 km where the bees are kept? 1=Yes 0=No
- 3.11 What has happened to your honey production system over the years? 1) Remain traditional, 2) improved from traditional to modern 3) started honey production only recently, 4=Others
- 3.12 What is the trend of honey production/productivity over years? 1=Increasing, 2=Decreasing, 3=Remain the same
- 3.13 What are the reasons for the change/lack of change?
- 3.14 Have you ever used multiplication of bee colonies? 1=YES 0=NO

4. Honey Production

Please fill the following table with total honey production in 2016 E.C months

Hive type	Honey harvesting period 1. Sep 2. Oct, 3. Nov, 4. Dec, 5. Janu, 6. Feb, 7. Mar 8. Apr 9. May. 10. June	Number of [hive type] with bee colonies in the season	Number of honeybee colonies in [hive type] from which honey is harvested in the season	Amount of honey produced in the season in kg	Amount of honey sold in the season (kg)	Total income from honey sale in the season (ETB)
Traditional hives						
Transitional hives						
Frame bee hives						

5. Skill and knowledge

5.1. Did you get practical training on beekeeping from government and/or NGO during the past 5 years?

1. Yes 2. No

5.2. If your answer for question 5.1 is yes, what kind of technical training did you receive? 1= Seasonal bee managements 2=Beeswax processing 3= Pre and post honey harvesting and handling 4=packing and marketing 5=Production of other bee products (Propolis, Roya jelly and pollen), 6=Others (Please specify):

5.3. What kinds of beekeeping tools do you have? 1=Protective cloth, 2=Smoker, 3=Casting mold, 4=Honey extractor, 5=Others (please specify): _____

5.4. Fill the following table with major honeybee floras in your area?

No	Local name	Flowering time from to months	Rank from high to low

5.5. How many times do you harvest honey in a year in your area? 1=Once, 2=Twice, 3= Three times, 4= more than three times

5.6. What is the major honey harvesting time of honey in the area? Months of the year:

5.7. What is the minor honey harvesting time of honey in the area? Months of the year:

6. Agrochemical applications

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

5.1 If yes, why do you apply chemicals? 1=Crop pest control, 2=Weeds control, 3=Malaria control, 4=Others (specify) _____

5.2 At what stage of crop growth do you apply the chemicals? 1=Early growth stage 2= mid growth stage 3= At the beginning of flowering 4= As disease/pest signs are observed, 5= Other (specify) _____

5.3 When do you apply agrochemicals/ pesticides (time of application)? 1= In the morning, 2= Afternoon, 3= in the evening

5.4 Do you think that the shortage of bee forage occurs in your local area? A) Yes B) No

5.5 If yes in which month/season is the most critical shortage of bee forage happen? Months of the year

5.6 Do you feed your bees supplementary food other than local bee forages? Yes/ No

5.7 What kind of feed do you offer to your honeybees? 1= Besso 2= Shiro 3= Sugar syrup 4= Honey, 5= Others (specify).

6 What are the major constraints of beekeeping practices in your area?

Constraints	Rank (high to low)
Agrochemicals application	
recurrent drought	
short of bee forage	
Lack of trained manpower	
Absconding colony	
Pests and predators	
Lack of credit access	
Shortage of improved beekeeping equipment supply and cost of the equipment	
Deforestation and habitat loss	
If others (specify)	

