SAMS
Smart Apiculture Management Services

International Partnership on Innovation

SAMS - Smart Apiculture Management Services

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N 5 - Api Management

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SAMS consortium partners

Logo	Partner name	Short	Country
	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (Coordinator)	GIZ	Germany
	University of Kassel	UNIKAS	Germany
	University of Graz (Institute for Biology)	UNIGRA	Austria
	Latvia University of Life Sciences and Technologies	UNILV	Latvia
	ICEADDIS – IT-Consultancy PLC	ICEADDIS	Ethiopia
	Oromia Agricultural Research Institute, Holeta Bee Research Center	HOLETA	Ethiopia
	University Padjadjaran	UNPAD	Indonesia
	Commanditaire Vennootschap (CV.) Primary Indonesia	CV.PI	Indonesia

Summary of the project

SAMS is a service offer for beekeepers that allows active monitoring and remote sensing of bee colonies by an appropriate and adapted ICT solution. This system supports the beekeeper in ensuring bee health and bee productivity, since bees play a key role in the preservation of our ecosystem, the global fight against hunger and in ensuring our existence. The high potentials to foster sustainable development in different sectors of the partner regions are often used inefficiently.

Three continents - three scenarios

(1) In Europe, consumption and trading of honey products are increasing whereas the production is stagnating. Besides honey production, pollination services are less developed. Nevertheless, within the EU 35% of human food consumption depend directly or indirectly on pollination activities.

(2) In Ethiopia, beekeepers have a limited access to modern beehive equipment and bee management systems. Due to these constraints, the apicultural sector is far behind his potential.

(3) The apiculture sector in Indonesia is developing slowly and beekeeping is not a priority in the governmental program. These aspects lead to a low beekeeper rate, a low rate of professional processing of bee products, support and marketing and a lack of professional interconnection with bee products processing companies.

Based on the User Centered Design, the core activities of SAMS include the development of marketable SAMS Business Services, the adaption of a hive monitoring system for local needs and usability as well as the adaption of a Decision Support System (DSS) based on an open source system. As a key factor of success, SAMS uses a multi stakeholder approach on an international and national level to foster the involvement and active participation of beekeepers and all relevant stakeholders along the whole value chain of bees.

The aim of SAMS is to:

- enhance international cooperation of ICT and sustainable agriculture between EU and developing countries in pursuit of the EU commitment to the UN Sustainable Development Goal (SDG 2) “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”,
- increase production of bee products,
- create jobs (particularly for youths/ women),
- trigger investments and establishe knowledge exchange through networks.

Project objectives

The overall objective of SAMS is to strengthen international cooperation of the EU with developing countries in ICT, concentrating on the field of sustainable agriculture as a vehicle for rural areas. The SAMS Project aims to develop and refine an open source remote sensing technology and user interaction interface to support small-hold beekeepers in managing and monitoring the health and productivity in their own bee colonies. Highlighted will be especially the production of bee products and the strengthening of resilience to environmental factors.

Specific objectives to achieve the aim:

- Addressing requirements of communities and stakeholder
- Adapted monitoring and support technology
- Bee related partnership and cooperation
- International and interregional knowledge and technology transfer
- Training and behavioral response
- Implementation of SAMS Business cooperation

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Executive summary

This final report on bee management and bee-health services of the SAMS project covers the objectives and main project creations of the last two years of work package 5 “Api management”. It fulfils the task 5.1 “contextualizing of local systems” including bee management and bee-health management. The beekeeping situation in Europe, Ethiopia and Indonesia strongly differs from each other. While there exists a plethora of books and journals dealing with European apiculture, by far less literature and public attention are available in Indonesia and Ethiopia. Ethiopia and Indonesia are rich in flora and fauna and have high potential in beekeeping and honey production. According to the data on honey import and export available from FAOSTAT, Ethiopia can be regarded a net exporter of honey (mostly to Europe), whereas Indonesia is a net importer (mostly from Asia). The major challenge for Ethiopian beekeeping is the transition of apiculture with autochthonous *Apis mellifera* bees from traditional hives to modern hives. In Indonesia on the other hand, more bee species exist, and developing sustainable beekeeping with different autochthonous bee species and the introduced Western honeybee is the main task.

We contextualized the situation of honeybees and beekeeping in the two target countries Ethiopia and Indonesia. The findings are based on scientific literature, complemented by expert opinions from the two target countries and elsewhere. Many scientific publications in English language exist on beekeeping, bee forage or honey bee health for Ethiopia, whereas for Indonesia by far fewer information was available. In summary, we were able to use content from 166 different literature sources for this final report. After the accessible literature was depleted, we mainly relied on expert opinions. The information of this deliverable can be used to facilitate dissemination especially in Indonesia by translation to local languages.

The information (including scientific references) was made publicly available by creating a glossary database – the SAMSwiki. The reviewed knowledge was structured by assigning it into a total of 12 main chapters and 58 subchapters. So far, the database includes 12 users, 76 articles and 95 uploaded files. The SAMSwiki serves as an online encyclopaedia that anyone can use and edit. It allows further extensions by consortium members, researchers or any interested people. The translation of the content to local languages to support the dissemination of knowledge gained within SAMS or already available from other research has already begun. The database therefore acts as a strong tool for beekeepers and researchers in all countries. An instruction on using the SAMSwiki is provided in this deliverable. Identified knowledge gaps are summarized and discussed to facilitate any further research or cooperation in the target countries.

The knowledge is translated to general recommendations for apiculture, where possible. This includes 20 strategic interventions to increase the quality of bee products. Those criteria are equally important for Ethiopia and Indonesia, as well as for every other country. Good beekeeping practice is strongly related to regional and environmental influences but in a global context, they include the ensuring of breeding through prolific young queens, an ample supply of food, effective and seasonally based management, the use of the right equipment, prevention of unwanted swarming and absconding behaviour, or protection from predators and threats affecting the health of honey bees. Within this document, ten important “rules” for honey bee colony management were formulated and they serve as a guideline for beekeepers to increase the quality of their honey bee products and to improve the health of their honey bee

colonies. Those rules were evaluated by highly experienced beekeepers from Ethiopia, Indonesia and Europe to guarantee their validity for these regions.

Due to the remote sensing approach of the SAMS project, colony behaviours and events that are suitable for smart bee management (precision beekeeping) have been defined and are discussed in contrast to the traditional detection methods. This includes also expert ratings of importance to beekeepers, technical feasibility, innovation and predictability. For a selection of the most important (highest ranked) defined events that can be detected by a remote sensing system, recommendations based on scientific evidence and good beekeeping practice are given. These recommendations are illustrated and can be implemented in decision support systems, including links to the SAMSwiki for further assistance.

Finally, research on ecological aspects of honey bee wellbeing has been made. Continuous availability of forage (nectar or honeydew and pollen) for bees is an important factor for honey bee health and productivity of a colony. The outcomes are systematic flowering calendars of important plants for honey bees in Ethiopia and Indonesia. Whereas we identified 590 plants for Ethiopia, only 43 plants are documented for Indonesia so far. Besides, latter are focused on the region West Java and we expect a much greater number of plants serving as forage for honey bees. We hope that with this first Indonesian flowering calendar, more attention on the floral resources for bees will be given and that more research projects will follow. The flowering calendars are included in the SAMSwiki and represented within this report in the Annex section and can be edited and extended, as well as being used for any smart application to support knowledge on bee forages.

I. Findings

1. SAMSwiki

The SAMSwiki is a publicly available database dealing with bees and beekeeping in Ethiopia and Indonesia and has the approach of a continuously growing knowledge database. Not only consortium members, but also researchers or any interested people are invited to contribute content to existing topics or to create new chapters. So far, the database includes 12 users, 76 articles and 95 uploaded files (status: 05.12.2019).

1.1. How to use the SAMSwiki

This chapter is the first article, visible at the SAMSwiki main page. With the following introduction, readers are able to create accounts and to add content to the SAMSwiki.

Visit the website (figure 1): https://wiki.sams-project.eu/index.php/Main_Page

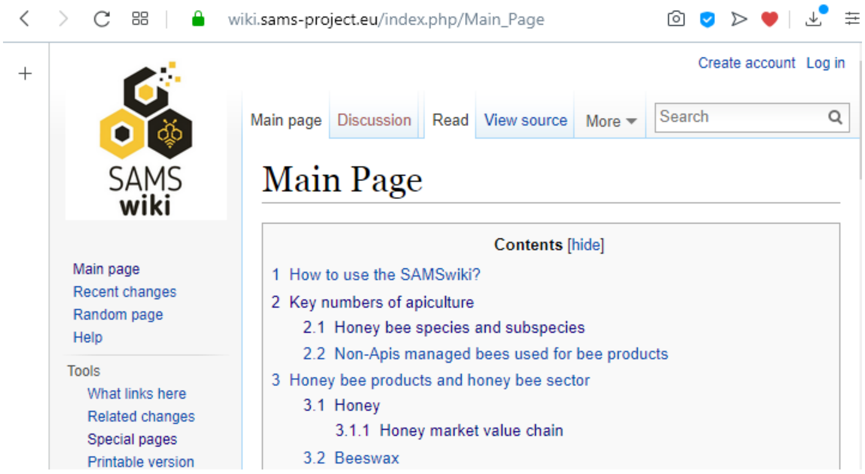

Figure 1: Main page of the SAMSwiki and its navigation bars on top and the left side.

Log in

- Click on the “log in” button on the right upper corner of the main page

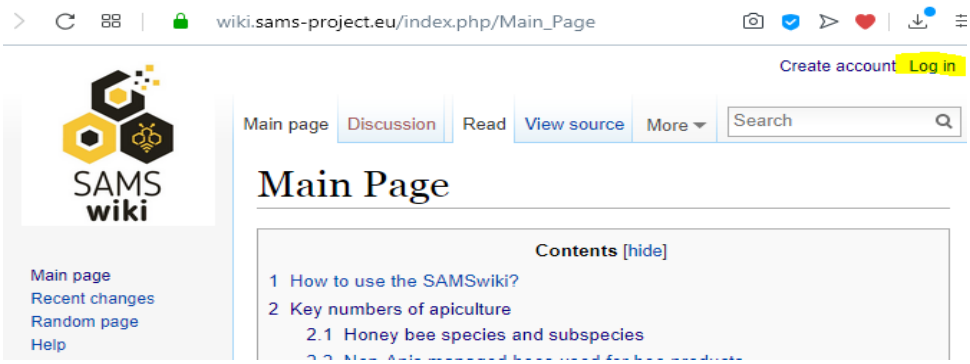

Figure 2: By clicking on the log in button you get access to the editing mode of the SAMSwiki.

Create an account and get access (figure 3):

- Click on the “create account” button on the right upper corner of the main page.
- Choose a username and a password and confirm your email address.
- Click on the “Create your account” button
- Change your password after receiving the invitation mail

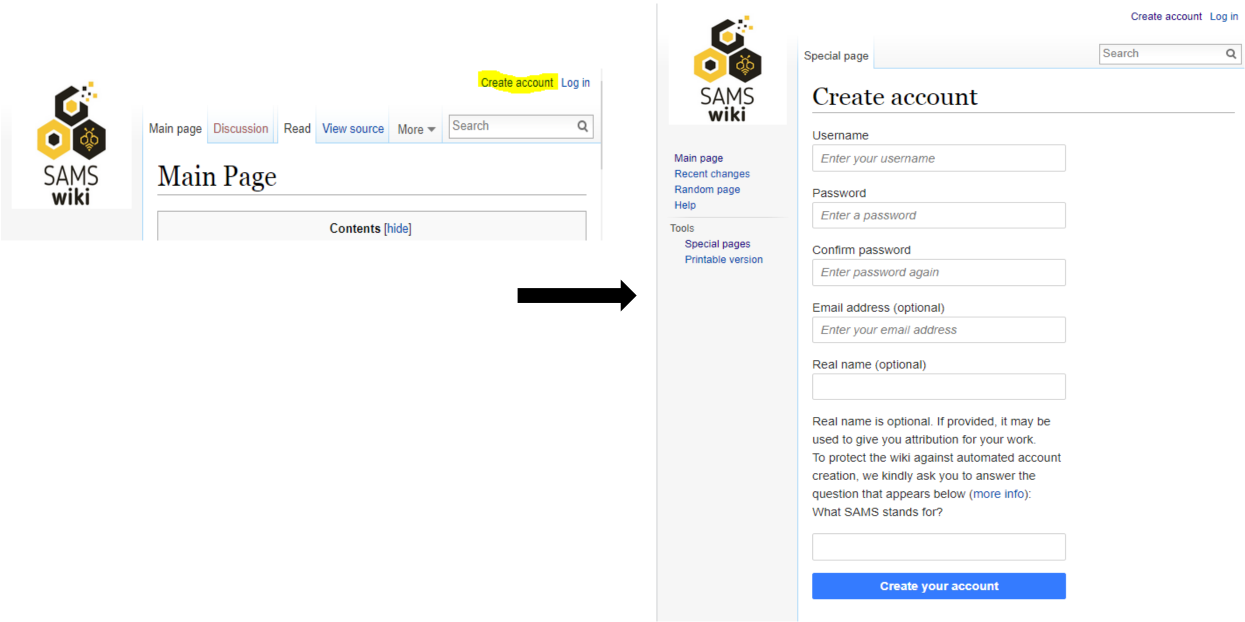

Figure 3: By choosing a username and a password it is possible to create an account.

Edit an existing page (figure 4):

- Click the "Edit" page tab at the top of the page.
- Make changes to the text.
- Click the "Save page" button.

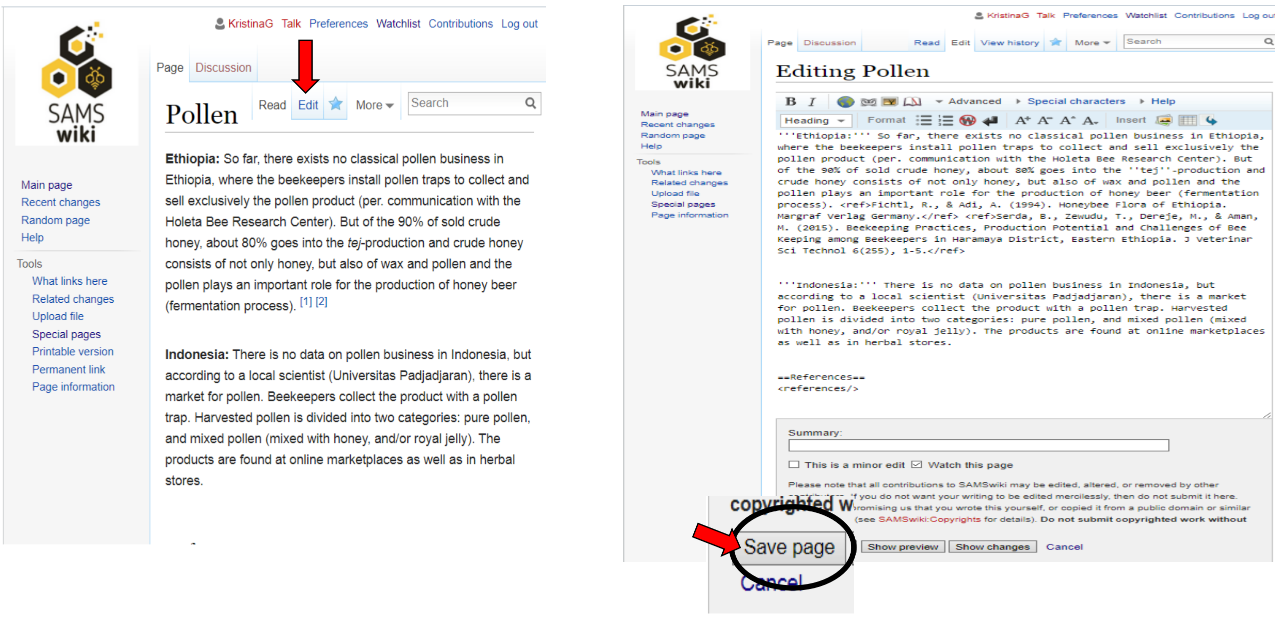

Figure 4: Use the “edit” tab and the “safe page” button to edit an existing page

Create a new page (figure 5):

- If you search for a page that does not exist (using the search box and "Go" button on the left of the page) then you will be provided with a link to create the new page.

- Click on the red coloured name of the new page (in the example given in the picture below: “Ethiopia”)
- Write your text
- Click on the “Safe page” button given on the end of the page (same as in “edit an existing page”)

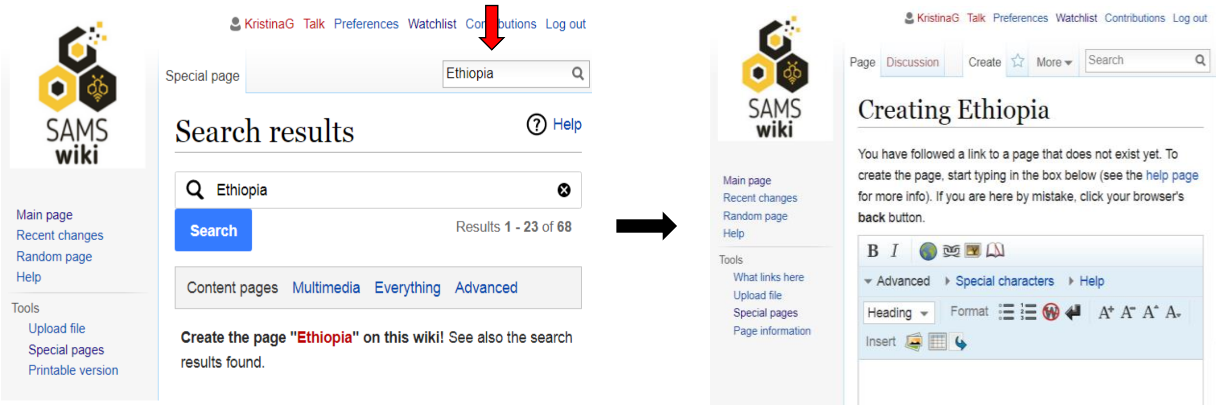

Figure 5: Use the search box to create a new page.

For further information (how to use html style, how to embed pictures, or tables, …) use the following link: https://www.mediawiki.org/wiki/Help:Contents

Citation style

The information provided in the SAMSwiki is based on scientific literature and on expert interviews. For this reason, always provide references to new content. To guarantee a uniform style of the SAMSwiki pages, use the following citation style: **APA TAYLOR AND FRANCIS**.

An instruction on the mentioned citation style is given under the URL (access date: 11.12.2018): https://www.tandf.co.uk/journals/authors/style/reference/tf_APA.pdf

2. Contextualizing of local systems

2.1. Flowering Calendar

Nectar and pollen are key resources for honeybees and bees must be able to find sufficient quantity and quality within their foraging radii. The foraging radius depends on the bee race (species), the local climate as well as on the environment, but a benchmark of 3 km can be expected for European *A. mellifera* colonies. Not every blooming plant produces nectar AND pollen and they differ in terms of nectar and pollen production (protein content, quantity, quality and flowering time). In a consequence, a high diversity of bee forage around the apiary is from high importance for honeybee health and in a broader sense for the income of the beekeeper. The tropical climate of Ethiopia and Indonesia enables a high diversity in flora and fauna. While important literature on honeybee forage for Ethiopia exists and needs to be published for Indonesia, floral calendars for both countries are missing. UNPAD is currently working on a floral calendar for West Java and we had the chance to take a look on it prior to publishing.

With the existing literature for Ethiopia and the one which is under construction for Indonesia, we created visually attractive floral calendars for both countries. Those calendars and a list of important crops are represented in the **Annex section** of this report.

2.1.1. Flowering calendar Ethiopia

All content was retrieved from: "Fichtl, R., & Adi, A. (1994). Honeybee Flora of Ethiopia. Margraf Verlag, Germany." and "Admasu, A., Kibebew, W., Ensermu, K., & Amssalu, B. (2014). Honeybee Forages of Ethiopia. Holeta Bee Research Center. Ethiopia." The calendar so far includes 590 plant species including if they are nectar and/or pollen forage and their flowering times.

2.1.2. Flowering calendar Indonesia

All content was retrieved from: “Bunyamin, A., Purnomo, D., Supriyadi, Y., Pratama, I., & Nawawi, M. (in prep.). Flowering Plants Time and Maps of West Java Area as Basic Data in Supporting Beekeeping Activities.” The calendar so far includes 43 plant species in the region of West Java including if they are nectar and/or pollen forage and their flowering times.

2.1.3. Important crops and insect pollination

Species and English names were retrieved from: “Klein, A.M. et al. (2007). Importance of pollinators in changing landscape for world crops. Proc. R. Soc. 274(1608): 303–313.” Klein et al. (2007) selected the leading global crops on the world market from the FAO crop production list of 2004 and assessed them into groups (crop species that are essentially, highly, moderately, slightly or not depending on insect pollination). The list may help beekeepers to better understand their bees and which crops are in dependence to or benefit from honeybees and their pollination ability. So far, the crops names were only translated into English and Bahasa, but it is also planned to include Amharic and Oromo sections in the SAMSwiki.

2.2. Key numbers of apiculture

Ethiopia: There is no official data on the total number of beekeepers in Ethiopia, but Gupta (2014) estimated it to be more than 1 million (Gupta, Reybroeck, van Veen, & Gupta, 2014).The number of bee hives in the country (2016) is 6,189,329 (FAO 2018), while the Ministry of Agriculture and Rural Development (2007) estimated the total number of honeybee colonies (hived and feral honey bee colonies) to be ~10 million (MoARD, 2007). The data has been put in context with the official numbers of the total population size and the total country area, resulting in 0.906 beekeepers/km^2, 6.189 colonies/beekeeper, 5.605 colonies/km^2 and 0.058 colonies/capita (Table 1).

Indonesia: There is no official data on the total number of beekeepers, nor the number of hives for Indonesia, but the Indonesian Central Bureau of Statistics (BPS) provided information on beekeeping with *A. mellifera* in West Java. Thus, the number of hives in West Java was 7,141 in 2016. The data has been put in context with the official numbers of the total population size (West Java) and the total country area (West Java) resulting in 0.202 colonies/km2 and 0.000153 colonies/capita (BPS, 2018) (Table 1).

Table 1: Available key numbers of apiculture (total population, total country area [km²], no. of beekeepers, no. of hives, beekeepers/km², colonies/beekeeper, colonies/km², colonies/capita, and the total amount of honey/year are shown.

	Ethiopia	**West Java (Indonesia)**
Total Population (2017)	104,957,438 [2]	46,709,600 [4] (263,991,379) [4]
Total country area [km²]	1,104,300 [2]	35,377 [4] (1,904,569) [5]
No. of beekeepers	>1 mio [1]	N/A (N/A)
No. of hives (*A. mellifera*)	6,189,329 [2]	7,141 [6] (N/A)
Beekeepers/km²	0.906	N/A (N/A)
Colonies/beekeeper	6.189	N/A (N/A)
Colonies/km²	5.605	0.202 (N/A)
Colonies/capita	0.058	0.000153 (N/A)
Total amount of honey/year [kg] (2016)	47,706,000 [2]	35,798.8 [6] (N/A)

References (Table 1):

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2.2.1. Honey bee species and subspecies

Table 2 represents native and introduced honeybee species and subspecies of Ethiopia and Indonesia. While in Ethiopia, five subspecies of *A. mellifera*, as well as different species of non-Apis species and the introduced *A. florea* are known, in Indonesia three subspecies of *A. cerana*, two of *A. dorsata*, 5 other *Apis* species and several non-*Apis* species are native.

*Table 2: Apis species and non-Apis species used for bee products in Ethiopia and Indonesia are shown. + stands for species, occurring in the particular country, *+ describes introduced species. ** The literature is not consistent in defining A. m. bandasii as an own subspecies: part of the scientific literature claims that A. m. bandasii belongs to A. m. jemenitica 1-5.*

		Ethiopia	**Indonesia**
Apis mellifera	*A. m. adansonii*	**+** [1] [2]	
	A. m. bandasii **	**+** [2] [3] [4] [5]	
	A. m. monticola	**+** [2] [3] [5] [6]	
	A. m. jemenitica	**+** [2] [3] [4] [5] [6]	
	A. m. scutellata	**+** [2] [3] [4] [5] [6]	

	A. m. woyi-gambella	+ [3] [5]	
	A. mellifera sp.		*+ [10]
Apis cerana	*A. c. himalayana*		+ [6] [11] [12]
	A. c. indica		+ [6] [11] [12]
	A. c. nuluensis		+ [6] [11] [12]
Apis dorsata	*A. d. binghami*		+ [6] [12] [13]
	A. d. dorsata		+ [14]
Other *Apis* species	*A. florea*	*+ [6] [7]	+ [6] [12] [13]
	A. andreniformis		+ [6] [13]
	A. koschevnikovi		+ [6] [12] [13]
	A. nigrocincta		+ [6] [13]
	A. nuluensis		+ [6] [12] [15]
Non-*Apis* species	*Trigona* spp.	+ [8] [9]	+ [6]

References (Table 2):

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2.2.2. Non-Apis managed bees used for bee products

In Ethiopia, as well as in Indonesia, it is traditional practice to use stingless bees (Meliponidae) from genus *Trigona* spp. for honey and propolis production. Their colonies are arranged in nests that are situated in cavities of walls or at the underside of branches and in hollow trees (Awraris et al., 2012; Gupta et al. 2014). In comparison to most *Apis* species, natural colonies of stingless bees can be very easily transferred into hives (mud pot, stone wall, bamboo hive).

They produce beeswax, honey, as well as high amounts of pollen and propolis. In Ethiopia, the honey yield of 200 ml/colony/year can be expected. In comparison, there is no data about the amount of harvested products of *Trigona* from Indonesia (Awraris et al., 2012; Gupta et al., 2014; Jensen, 2007). For a list of stingless bees, native to Indonesia, see Kahono et al. (2018).

2.3. Honey bee products and honey bee sector

Bees do not only produce honey, but also other very valuable products like beeswax, pollen, propolis, beebread or even bee brood can be considered as a "product". Within this chapter the following keywords are discussed: honey (production, honey market value chain), beeswax (statistics, use, …), pollen (statistics, use, …), propolis (statistics, use, …), import and export quotes of bee products, and the products' prizes. While there exists a cryptic market for pollen and propolis in Indonesia, Ethiopia's bee sector mainly focuses on honey and to some point on beeswax. Summarizing the data provided from FAO, Ethiopia can be regarded as a net exporter of honey (mostly to Europe), whereas Indonesia is a net importer (mostly from Asia). Prizes of bee products also differ greatly between target countries and even between regions.

2.3.1. Honey

Ethiopia: The country belongs to the largest honey producers in Africa and is among the top ten worldwide (**Import/Export of honey bee products**) and due to bimodal rains, honey can be harvested at least twice a year (Adeday, Shiferaw, & Abebe, 2012, MoA & ILRI, 2013). The annual honey production was estimated to be **43,000 t/year** with a potential honey production of about **550,000 t/year (**MoARD, 2007; Negash, & Greiling, 2017; Taye, Desta, Girma, & Mekonen, 2016). The potential annual honey production was estimated based on a nationwide modernization of the bee sector (modern hive, increased number of hives/beekeeper, ...) Approximately, **95%** of bee hives (**hive types**) in Ethiopia are **traditional** with low productivity (Negash, & Greiling, 2017). According to Gemechis (2016) and MoARD (2007) traditional beehives produce around **5-8 kg** honey, while the average honey yield in modern hives ranges from **15-20 kg** (Gidey, & Mekonen, 2010; Taye et al., 2015). According to FAO, the average amount of honey per hive over 24 years was 7.55 kg and therefore is in alignment with the prior mentioned observations (FAO, 2018). **70-80%** of produced honey is used to produce ***tej*** (traditional beverage) and the remaining percentage is sold as table honey (Gidey, & Mekonen, 2010; Legesse, 2014; SNV/Ethiopia, 2005). 10% of honey is consumed directly by the beekeeping households, while the rest is sold for gaining income (Gemechis, 2016). One major quality problem is the high **moisture level** of honey. Samples from all over the country revealed moisture content between **15.25%** and **30.45%**. The outcome varies with the type of used hives (traditional hives have 1.5-3.0% higher moisture content than modern hives) and the sample region (highly humid areas are more affected; Gemechis, 2016). Honey from traditional hives is sometimes a mixture of pollen, wax and honey, because it is not common among some Ethiopian beekeepers to separate the crude honey from other components (Fichtl, & Adi, 1994; SNV/Ethiopia, 2005). To the favoured storage materials for honey belong plastic bags, tins/barrels, plastic containers, clay/log pots and animal skin (Awraris et al., 2012). The leading honey and **beeswax** producing regions in Ethiopia include Oromia (41%), SNNPR (22%), Amara (21%) and Tigray (5%) (**honey market value chain**; SNV/Ethiopia, 2005).

According to FAO statistics (2018), the total volume of produced honey between the years of 1993 and 2004 increased constantly, but fluctuated afterwards: 24,000 t in 1993, 28,000 t in

1998, 40,900 t in 2004, and 42,000 t in 2008, 45,905 t in 2012, 0 t in 2013/2014 and 47,706 t in 2016 (FAO, 2018). As shown in figure 6, official data of FAO statistics (2018) also showed a honey production of 0 t in the years 2013 and 2014.

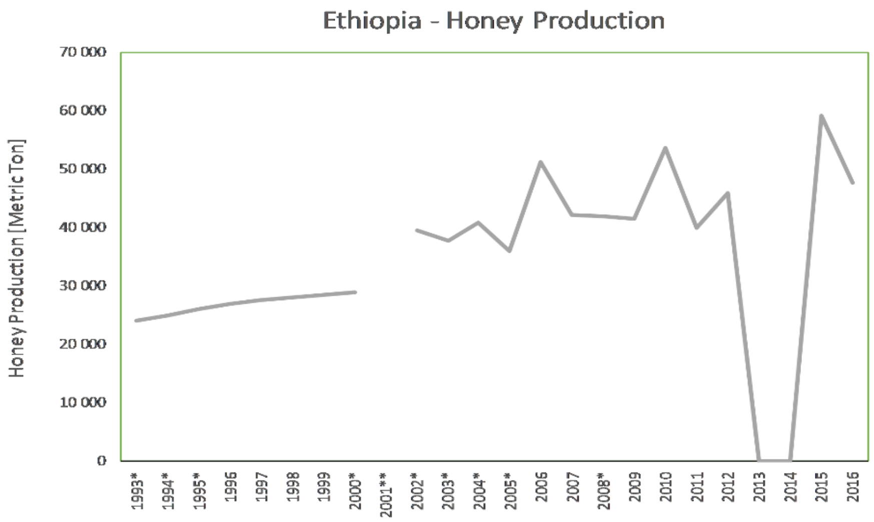

*Figure 6: Honey production in Ethiopia (1993-2016); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is not available.*

The amount of produced honey per hive ranged between 6.86 kg in 1993 and 10.49 kg in 2006 with an average production of 7.55 kg/hive in the years 1993-2016 (Figure 7) (FAO, 2018).

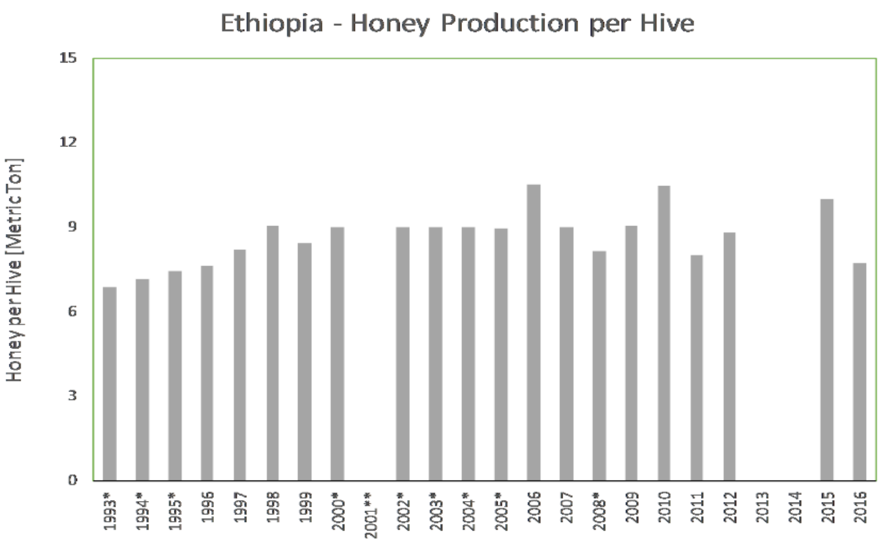

*Figure 7: Honey yield per hive in Ethiopia (1993-2016); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is not available.*

Indonesia: Unfortunately, neither FAO, nor another statistical provider give any data on the honey production of Indonesia. However, it is estimated, that Indonesia needs **3,750 t** of honey per year, while there is a supply of only **500-2,000 t** per year (Roman, 2006; Widiatmaka, Wiwin, Chandrasa, & Lailan, 2006). De Jong (2000) estimated the honey production in the region of Kalimantan (based on beekeeping with **"honey boards"**) between **53 kg** and **267 kg** per beekeeping operation (family) per year. Shouten et al. (2019) assessed the beekeeping situation on 4 islands of Indonesia and found, that the mean annual honey yield from *A. cerana* beehives ranges from 0.5 kg to 5 kg per hive and strongly depends on the **season**. One surveyed beekeeper mentioned a three times higher honey yield when harvesting in the wet season compared to a dry season's yield. The authors claim, that those results should be interpreted with caution, because questioned beekeepers rarely kept records (Shouten et al., 2019). It must be mentioned, that beekeeping in Indonesia is still considered to be a **"part time farming activity"** and therefore the beekeeping sector is still small. There are various forms of gaining honey, for example working with small colonies of stingless bees, or the practice of **honey hunting** of *A. dorsata*, where the forest honey is often consumed locally and therefore the data on the amount of harvested honey is not passed on for statistical assessments (de Jong, 2002). Further, the honey consumption per person per year is with **15 g** very low (Widiatmaka, 2006). There is less current information on the quality of Indonesian honey, but a study in 1988 revealed **high moisture** content between **20.7** and **36.3%** (22 samples from Sumatran village markets) and **adulteration** with sucrose (cane sugar, or sugar syrup) in most of the samplings. In addition, some of the investigated honey samples were boiled to evaporate the water for a higher viscosity of the product, which led to a **high hydroxymethylfurfural** (HMF) content (White, Platt, Allen-Wardell, & Allen-Wardell, 1988). In consistence is a study by Shouten et al. (2019) who described a mean moisture content of 24%. According to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), Indonesian beekeepers sell their honey in two different forms, **table honey** (common honey packed in a glass jar) and **nest honey or comb honey**, called "madu sarang" (honey sold including the whole comb). Selling nest honey is gaining more attractiveness, due to the widespread problem of honey adulteration.

2.3.1.1. Honey market value chain

A **well-differentiated honey market value chain** is equally important for **producers**, the **distributors**, as well as for the **consumers** to provide **uniform quality** and further to **increase the income**.

Ethiopia: Gemechis (2016) wrote about the domestic honey market value chain of Ethiopia: Crude honey is sold to **collectors** (nearest town/village markets) by small scale beekeepers. They pass on a great amount of the product to **whole sellers** in bigger cities and to local ***tej* breweries** (**honey**). The whole sellers act as **distributors** and sell the honey to **retailers**, ***tej* houses**, **processors** and **consumers** (Gemechis, 2016). Some beekeepers form **marketing and producing cooperatives**. They collect crude honey from members and sell the semi-processed product to processing companies or distributors. In 2013 there were nine registered honey processor companies in the country and some of them are also engaged in honey production (MoA & ILRI, 2013). In Ethiopia, there is a lack of "good beekeeping practice", thus, the cooperatives do not underly quality controlling bodies, nor have business concepts and therefore suffer from **quality loss** and cannot compete with **bigger companies** (lack of proper collection, storage and transportation facilities. In addition, the domestic honey market has several problems: the **smuggle** and **adulteration** of honey bee products, complaints of consumers about **increasing prices** of honey products, while the beekeepers have the feeling that the business is not rewarding (Gemechis, 2016). For local beekeepers, it is not common to separate table honey from beeswax and other ingredients, but during the *tej*-brewing process, beeswax is separated as a **byproduct** that is passed on to **beeswax** collectors and exporters. Hence, they serve as important stakeholders in the beeswax business (SNV/Ethiopia, 2005). About 10 percent of the produced honey in the country is not sold but consumed in the households. There are regions in Ethiopia, where not only 10%, but most of the honey is consumed by the beekeeping households. In a consequence, in those regions there are only fragments of, or no honey market chain at all (Serda, et al., 2015).

Indonesia: According to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), **fragments** of a honey market chain exist, but work needs to be done, to strengthen the value market chain. The honey market value chain is basically in the hands of the small-scale beekeepers. So far, beekeepers (producers) sell their products **online** in the form of bulk packaging by creating and marketing their **own brand**, or they offer it to **collectors** (i.e. distributors). In a next step, the collected products (honey, pollen, royal jelly, wax) will be further processed to adjust the quality of goods (flavour, water content, etc.). Table honey is sold in **bigger cities** situated around the particular farms. Beekeepers also sell their honey to customers, who ordered it by their own. The customers are mostly from the middle-and upper class and besides the honey's religious importance to the Islam, the upper class'es motives to buy honey are accompanied by believing in the healthy aspects of honey bee products. Most customers do not buy honey in the supermarket or at local markets, as the products that are offered there are mostly of poor quality (adulteration, etc..). So far, there are no widely known and understood certifications that guarantee the quality of the bee products (Masterpole et al., 2019). Some beekeepers hire agencies who promote and sell their honey. The agencies charge a fee on the actual honey price. Thus, but the customers must pay for the agencies' services, while beekeepers must not. There is no information on the beekeeper, product processing, nor the product's origin on the labels.

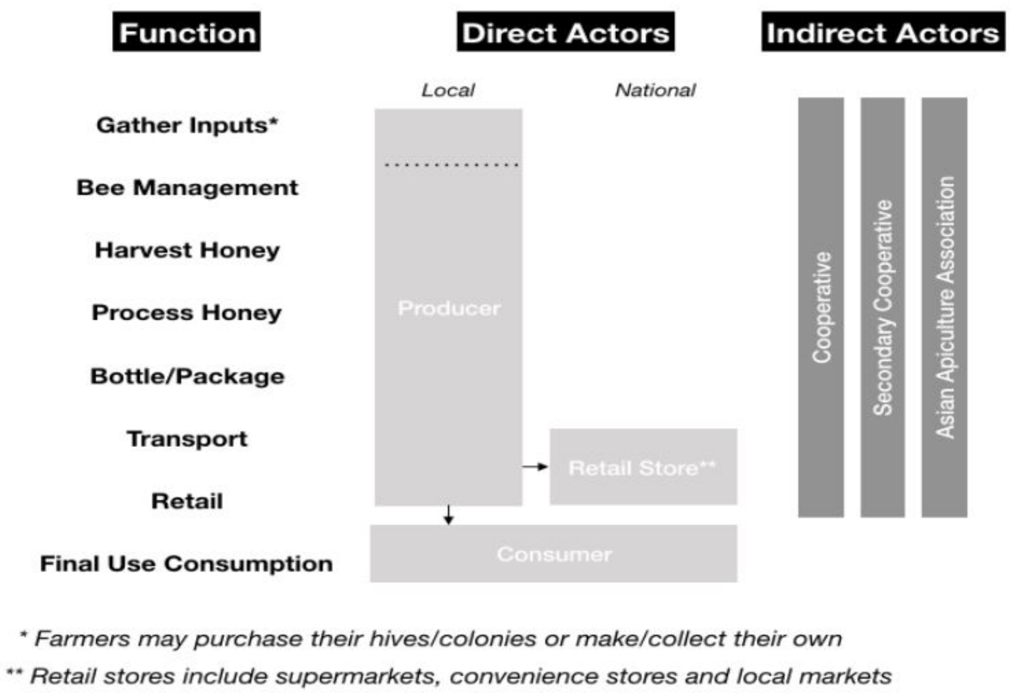

Figure 8: Example for a market value chain, rated as the one with the largest market potential in Lampung, Indonesia. Figure was retrieved from Masterpole et al. (2019).

2.3.2. Beeswax

Ethiopia: Not only the honey, but also the beeswax business has great potential in Ethiopia. Ethiopia is the **third biggest** beeswax producer in the world and number **one** in Africa with approximately **3,000 harvested t/year**, while the experts estimate the production potential at **50,000 t/year** (Gupta et al., 2014; Negash, & Greiling, 2017). The current production rate per **hive** is **0.95 kg/year**, with the major yield of beeswax out of the crude harvest of honey and other bee products from **traditional** (wax portion: 8.0-10.0%) rather than modern hives (0.5-2.0%; Gemechis, 2014; SNV/Ethiopia, 2005; Wilson, 2006). Despite the greater amount of beeswax yield in traditional hives, it is from **lower quality** due to the more difficult purification process (increased amount of foreign material). Ethiopian beeswax' quality from all over the country was evaluated, and in general, the quality is at a similar level as the rest of the world, but **adulteration** of the product constantly increases. The reasons are not only processing companies with unsuitable facilities for beeswax processing, but also the adulteration with cheaper fats (e.g. animal fat, plant oil and paraffins; (Gemechis, 2014). Another quality-lowering factor are ***tej*-breweries**. Many of the Ethiopian beekeepers do not know of the value of beeswax, and/or do not have the needed processing materials to sell the beeswax (Serda, et al., 2015). Thus, most of the harvested honey goes directly into *tej*-brewing and during the process, beeswax is separated as a **byproduct** (*sefef*) and gets sold to beeswax exporters and collectors, but the quality of this byproduct is low. Nuru and Edessa (2006) found, that the processing of crude beeswax with modern techniques is almost twice as efficient than using traditional methods to gain pure beeswax (Nuru & Edessa, 2006). In 2005, there were 16 registered companies who export beeswax, but only 4 of them are active, due to a lack of supply, or to a lack of international need (Gemechis, 2014). So far, there is no published data on the use of beeswax in Ethiopia, but it is believed, that a significant amount of beeswax is used to produce candles for orthodox churches (Gemechis, 2014).

Indonesia: Prior to 1996 and 1997 official data on the import and export quotes were provided to FAO. Ever since, the trading quotes of beeswax were based on estimations (see: "**Import/Export of honey bee products**"). In general, there is **no information** on the beeswax business in Indonesia: what are the production rates, is there a general use for beeswax, is it even harvested, is there a market chain, etc. According to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia) beeswax is widely used to produce cosmetics. He further claims, that to purchase beeswax, a direct order must be made to the particular beekeeper. In contrast to that, Shouten et al. (2019) assessed the beekeeping situation on 4 islands of Indonesia by conducting group discussions and interviews. They observed, that participating beekeepers did not know about the value of beeswax and therefore discard it (Shouten et al., 2019).

2.3.3. Pollen

Ethiopia: So far, there exists no classical pollen business in Ethiopia, where the beekeepers install pollen traps to collect and sell exclusively the pollen product (per. communication with the Holeta Bee Research Center). But of the 90% of sold crude honey, about 80% goes into the *tej*-production and crude honey consists of not only honey, but also of wax and pollen and the pollen plays an important role for the production of honey beer (fermentation process; Fichtl & Adi, 1994; Serda et al., 2015).

Indonesia: There is no data on pollen business in Indonesia, but according to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), there is a market for pollen. Beekeepers collect the product with a pollen trap. Harvested pollen is divided into two categories: pure pollen, and mixed pollen (mixed with honey, and/or royal jelly). The products are found at online marketplaces as well as in herbal stores.

2.3.4. Propolis

Ethiopia: It is known, that propolis can be harvested from every hive type and 95% of Ethiopian beekeepers use traditional **hives** (Gidey, & Mekonen, 2010; Nuru, Hepburn, & Radloff, 2002; Taye, Desta, Girma, & Mekonen, 2016). While the yield of propolis is **higher in traditional hives**, the **quality is lower** due to a contamination of pure propolis with beeswax, hive debris or body parts of bees (Nuru et al., 2002). Nuru et al. (2002) conducted a study, where propolis production was induced in traditional and in modern hive-systems. They exposed the hives to the external environmental conditions, by creating gaps within the hive. Bees show the behavior of filling those openings and, as prior expected, the propolis yield was **higher in manipulated hive-systems**. They found not only a correlation between the data of local weather stations and the propolis production, but also a significantly higher amount of harvested propolis in traditional, compared to modern bee hives. The authors claim, that **small, cost effective methods can help to increase the outcome significantly** (Nuru et al., 2002). Thus, this simple method may be used to increase the propolis yield of small scale beekeepers. Similar to **pollen**, the Holeta Bee Research Center and the Ministry of Agriculture and International Livestock Research Institute communicated, that there is no business for propolis, but beekeepers sometimes harvest it for home consumption (medical use; MoA & ILRI, 2013).

Indonesia: Stingless bees of the genus *Trigona* are known to collect higher amounts of propolis, compared to *Apis* species, therefore, Indonesian beekeepers use mainly colonies of ***Trigona spp.*** for propolis production ("meliponiculture"; see: **Non-Apis managed bees used for bee products**; Agussalim, Umami, & Erwan, 2015). In Indonesia, propolis is categorized as a **herbal product** and it is used for **medical purposes** (Hasan, Mangunwidjaja, Sunarti, Suparno, & Setiyono, 2013). The existing interest and the potential is reflected by studies, conducted to improve extraction methods of the product (Hasan et al., 2013; Wiwekiwati, & Walianto, 2017): According to local scientists (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), a propolis business **exists**. The product is sold mainly **online** and also can be found in local herbal drug stores (**prizes**). There is **missing information** on best harvesting time of propolis, how much propolis can be expected per colony, impact of propolis production on other bee products, factors that affect the propolis production, official numbers, etc.

2.3.5. Import/Export of honeybee products

2.3.5.1. Export of honey

Ethiopia: The total volume of exported honey between the years of 2000 and 2013 increased constantly: 1 t in 2000, 19 t in 2004, 196 t in 2008 and 904 t in 2013 (FAO, 2018). With increasing honey export quantity, the export volume of Ethiopia reached more than 3.25 million USD (Figure 9) (FAO, 2018).

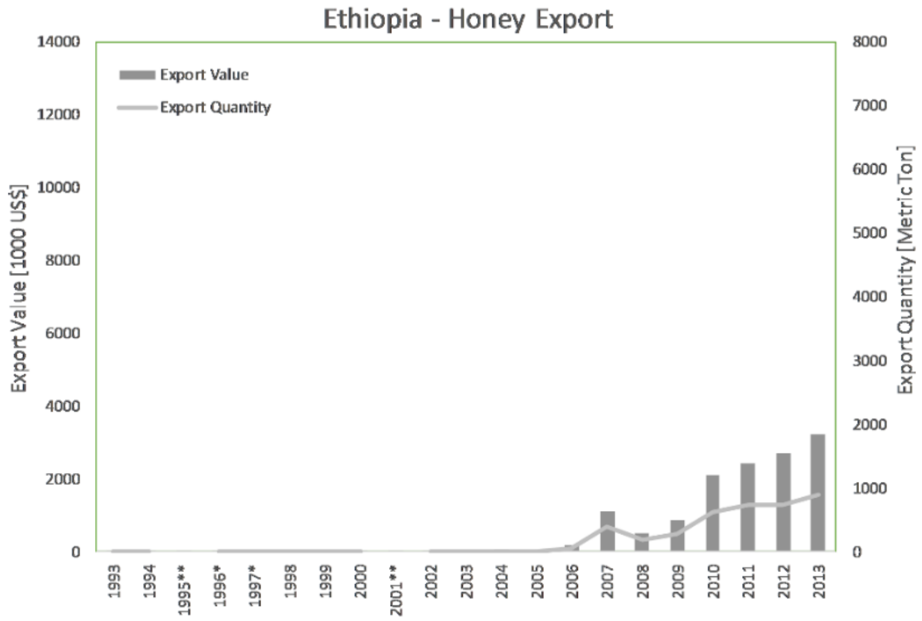

*Figure 9: Export data of honey-Ethiopia (1993-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is not available (FAO, 2018).*

Indonesia: On average, the total amount of exported honey between the years of 2000 and 2012 increased, but decreased again in 2013: 32 t in 2000, 1,270 t in 2004, 2,000 t in 2008, 765 t in 2012 and 207 t in 2013. There is a tremendous peak in 2009 with 7,355 t of exported honey. According to FAO, the data was officially provided, nevertheless there is a lack of information, how such a high increase can be explained (FAO, 2018). In 2013 the export volume of Indonesian honey reached 2.35 million USD (Figure 10) (FAO, 2018).

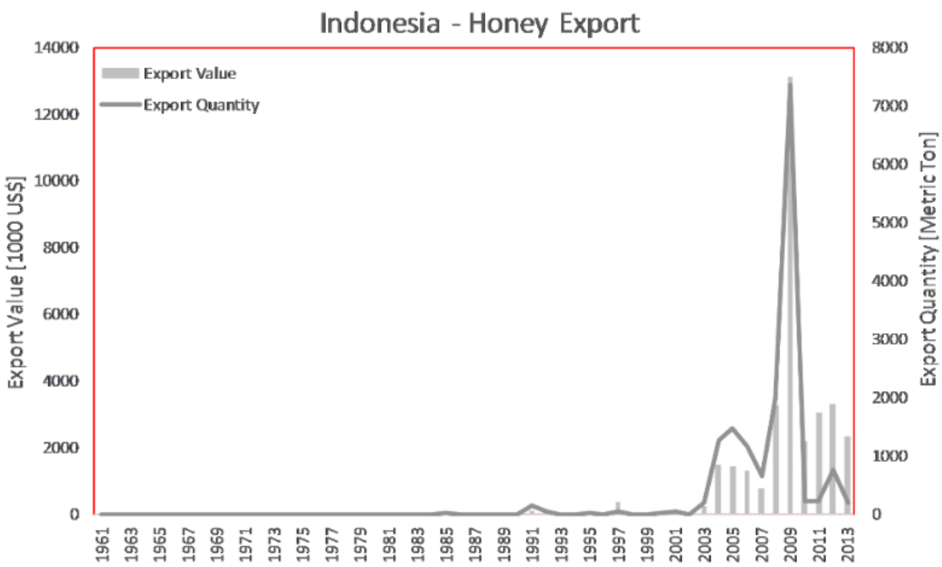

Figure 10: Export data of honey-Indonesia (1961-2013) (FAO, 2018).

2.3.5.2. Export of beeswax

Ethiopia: From 1993 until 1998 the total volume of exported beeswax increased constantly (247 t in 1993 and 956 t in 1998), while the year after, until 2001, the export quota declined (267 t in 1999 and 53 t in 2001). Ever since, the total amount of exported beeswax is fluctuating: 233 t in 2002, 402 t in 2003, 321 t in 2006, 372 t in 2007, 365 t in 2012 and 341 t in 2013 (FAO, 2018). In 2013 the export volume of Ethiopian beeswax reached more than 2.69 million USD. Thus, according to FAO, the export value has almost doubled within 7 years (1.42 million USD in 2006), although the export quantity has not increased significantly (Figure 11) (FAO, 2018).

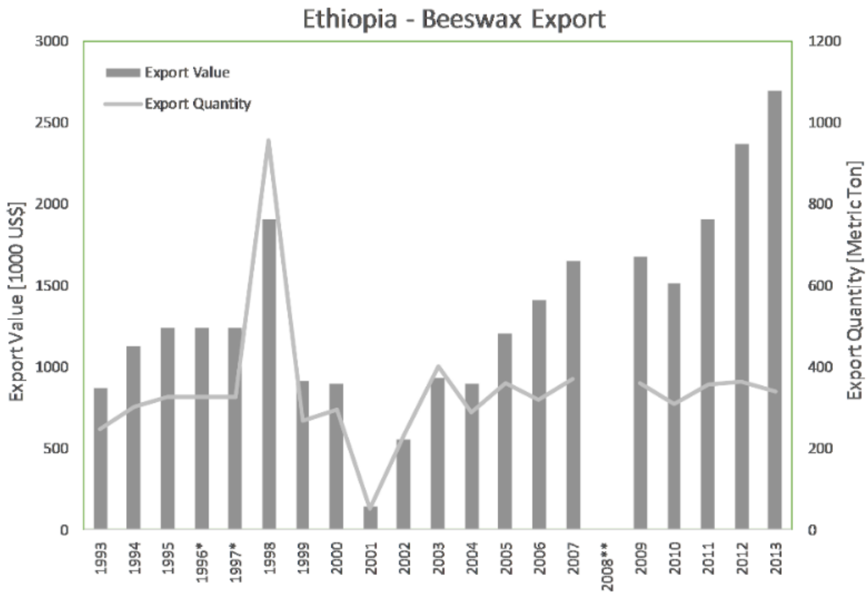

*Figure 11: Export data of beeswax-Ethiopia (1993-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO); **Data is not available (FAO, 2018).*

Indonesia: While the beeswax export quota of 1997 until 2013 are only based on estimations of the FAO, official data is available from 1961 to 1996. There are three major peaks in the years 1965 with 156 t, 1979 with 647 t and 1990 with a total amount of 1009 t. In the remaining years, the total volume of exported beeswax fluctuated (FAO, 2018). The export volume of Indonesian beeswax reached 401,000 USD in 1979, while the FAO estimated no export of beeswax at all between the years 1997 and 2013 (0 USD) (Figure 12) (FAO, 2018).

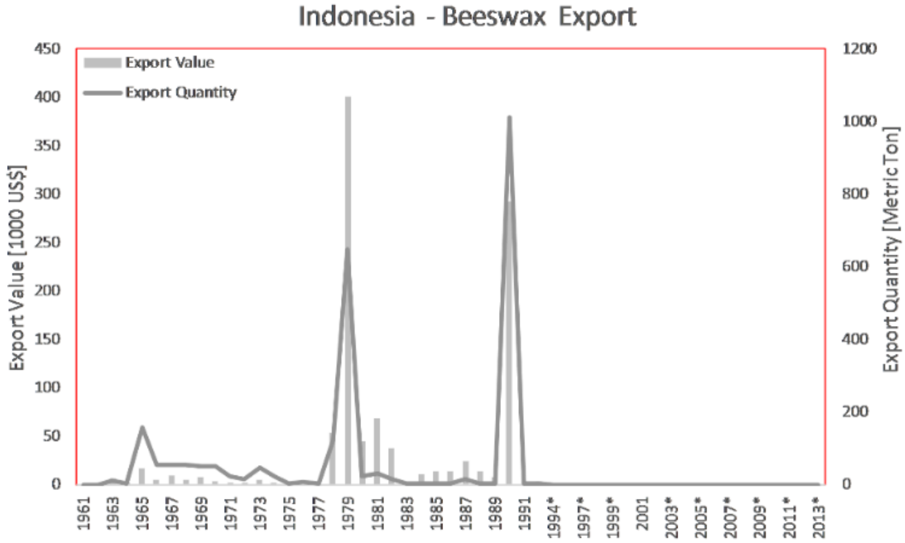

*Figure 12: Export data of beeswax-Indonesia (1961-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO, 2018).*

2.3.5.3. Import of honey

Ethiopia: There are several peaks regarding the import volume of honey: 10 t in 2006, 28 t in 2008, 49 t in 2013 (FAO, 2018). While the value of imported honey was about 23,000 USD in 2012, the import volume of honey reached more than 198,000 USD in 2013. Thus, according to FAO, the export value increased almost 8.5 times within a year, while the export quantity grew 12 times (Figure 13) (FAO, 2018).

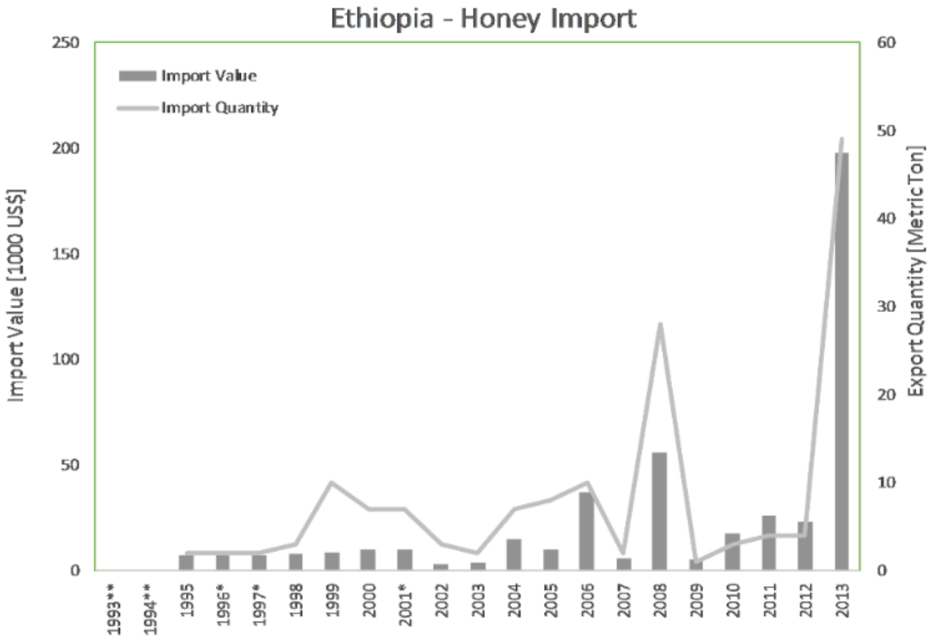

*Figure 13: Import data of honey-Ethiopia (1993-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO, 2018)*

Indonesia: The data of the years 1961 to 2013 show fluctuations in the import quota of honey: 8 t in 1965, 124 t in 1970, 37 t in 1975, 97 t in 1980, 56 t in 1985, 217 t in 1990, 577 t in 1995, 747 t in 2000, 776 t in 2005, 15,595 t in 2010 and 2,177 t in 2013 (FAO, 2018). However, among the mentioned years, there is an observable trend of an increasing amount of imported honey. The import volume of honey reached over 8.33 million USD in 2013 (Figure 14) (FAO, 2018).

*Figure 14: Import data of honey-Indonesia (1961-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO, 2018).*

2.3.5.4. Import of beeswax

Ethiopia: Regarding the import quota of beeswax in Ethiopia compared to those of honey, almost half of the years were not available at all. Focusing on the remaining data set, the import quantity fluctuates: 1 t in 2002, 2 t in 2004, 652 t in 2006, 0 t in 2008, 2 t in 2010 and 1,847 t in 2013 (FAO, 2018). Similar observations were made for the import value data of beeswax: 2,000 USD in 2002, 4,000 USD in 2004, 416,000 USD in 2006, 0 USD in 2008, 6,000 USD in 2010 and 3.43 million USD in 2013 (Figure 15) (FAO, 2018).

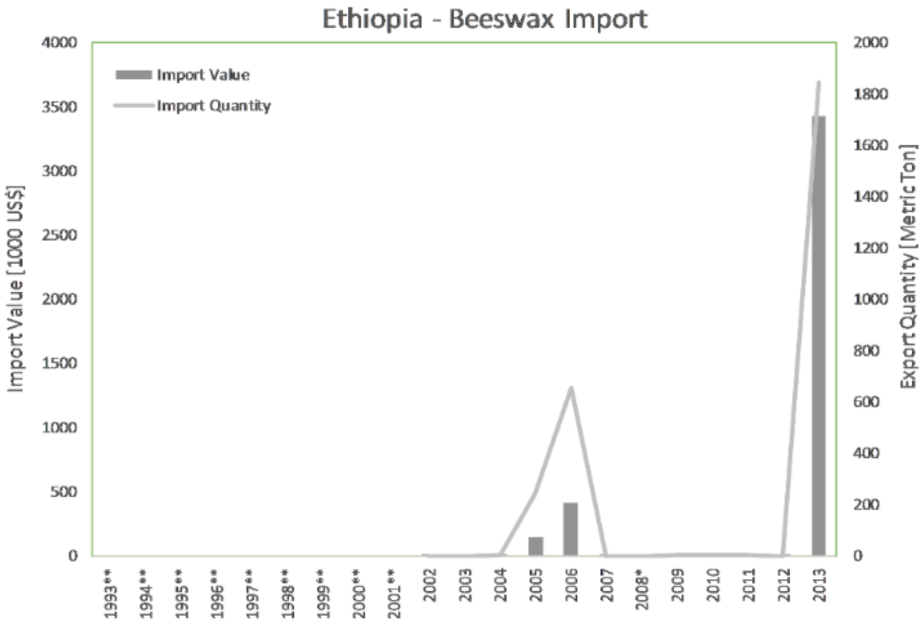

*Figure 15: Import data of beeswax-Ethiopia (1993-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO, 2018).*

Indonesia: While the beeswax import quota of 1996 until 2013 is only based on estimations of the FAO, official data was provided from 1961 to 1995. Indonesians' import of beeswax fluctuated between 1961 and 1995, but in general, there is an observable trend of increasing demand on beeswax: 0 t in 1965, 7 t in 1970, 62 t in 1975, 27 t in 1980, 28 t in 1985, 107 t in 1990 and 82 t in 1995, with peaks in 1978 (102 t) and 1990 (107 t) (FAO, 2018). Regarding the import value of beeswax, there is a high variance within years: in the year 1975 Indonesia payed 29,000 USD for a total amount of 62 t of beeswax, while the import value reached 490,000 USD for 82 t in 1995 (Figure 16) (FAO, 2018).

*Figure 16: Import data of beeswax-Indonesia (1961-2013); *Data is based on estimations of the Food and Agriculture Organization of the United Nations (FAO, 2018).*

2.3.6. Prizes

Ethiopia: In 2015, the average **honey** and colony prices were **131 Ethiopian Birr (ETB)/kg** (6.34 USD) and **667 ETB/colony** (32.28 USD), respectively (Yetimwork, Berhan, & Desalegn, 2015). According to a local scientist (personal communication with Kibebew Wakjira from Holeta Bee Research Center, Ethiopia), the prices increased (2018) to **260 ETB/kg** (9.45 USD) for honey and to **1,200** to **1,500 ETB** (43.64 USD to 54.55 USD) for new colonies. The price for 1 kg of purified **beeswax** was **250-300 ETB** (25-30 USD) in 2014 (Gemechis, 2014).

Indonesia: There is no official data regarding prices of honey bee products, but according to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), the price for 1 kg table honey is at around **200,000 Rupiahs (IDR)** (14.20 USD in 2018). Further, a study, were beekeepers of 4 islands of Indonesia were questioned, revealed high regional prize differences and high fluctuations of prizes at the same location. In Nusa Penida for example, the beekeeper gets up to **500,000** IDR (35 USD in 2015) for a 750 ml glass bottle of honey. This price can range from 400,000 to 1,2 million IDR. These fluctuations are based on the availability of honey. In remote areas throughout Java and Sumbawa, beekeepers have not only difficulties to sell their honey, they also get lower prizes, usually not more than **70,000** IDR/kg (4.80 USD in 2018; Shouten et al., 2019). Indonesian beekeepers often catch feral honey bee colonies to house them in hives. This may be the reason, while there is a lack of data on colony prices. The price for 100 ml liquid **propolis** ranges from IDR **45,000 to 300,000** (3.11 - 24.17 USD).

2.4. Bee forage

The following chapter covers topics like local climate, number of melliferous plants and important literature, and major honey flows (plants, seasons). The complete floral calendars are shown in the Annex.

2.4.1. Climate

Ethiopia: Depending on different classifications, there are three to five climate zones. The widely approved climate zones are: "Kolla" (hot zone; 1500-1800 m altitude) with an average temperature of 26 °C and an average rainfall of 300-700 mm, the flowering period is known to be short and therefore the honey bees are very productive as well as aggressive; "Woina-Dega" (cold-warm zone; 1,800-2,400 m altitude) with an average temperature of 22 °C and an average rainfall of 700-1,000 mm) and "Dega" (cold zone; 2,400-3,500 m altitude), where flowering occurs throughout the year, with an average temperature of 16 °C and an average rainfall of 1,000-1,200 mm (Bekele-Tesemma, & Tengnäs, 2007; Gupta et al., 2014; Gangwar, Gebremariam, Ebrahim, & Tajebe, 2010). The remaining climate zones are: "Bereha" (<1,500 m altitude) with an average temperature of >26 °C and an average rainfall of <300 mm and "Worech" (>3,500 m altitude) with an average temperature of 12 °C and an average rainfall of 1,200-1,500 mm). While the highlands of Ethiopia are widely populated, the colder lowland region is only sparsely populated by nomadic and semi-nomadic herdsmen (Le Houérou, & Corra, 1980). Winds, originating from over the Atlantic Ocean mark seasonal rainy periods resulting in most of its rainfall occurring in the highlands (mid-June to mid-September), as well as short periods of light rains. The second main rainy season occurs in April and May (Admasu, Kibebew, Ensermu, & Amssalu, 2014).

Indonesia: The prevailing tropical climate is characterized by its high temperatures throughout the year, the small day- to day changes (high standing sun), droughts, excessive rain and high humidity (Crane, 1990; Seidel, Fu, Randel, & Reichler, 2007). The average temperature is 26 °C and the average rainfall is at about 300 mm (CCKP, 2018). In addition, there are El Niño events in Indonesia, which lead to a later onset of the rainy season and drought events followed by unsecured food safety (Hamada et al., 2002; Hughen, Schrag, & Jacobsen, 1999; Naylor, Falcon, Rochberg, & Wada, 2001). By analysing the Indonesian rainfall data of the years 1961-1990, and by comparing the results with those before 1960, Hamada et al. (2002) concluded that there are four major climatic subregions in Indonesia. The main part of Indonesia is situated in the southern hemisphere and is characterized by an annual cycle with its rainfall maximum during September to February. The regions situated near the equator or in the northern hemisphere show a semi-annual cycle with its annual rainfall maximum in September-November in western parts of the Kalimantan central mountains and a different annual cycle with a maximum during March-August (relatively small rainfall). The other areas of Indonesia are known to not have clearly defined rainy and dry seasons (Hughen et al., 1999).

2.4.2. Number of melliferous plants and important literature

Ethiopia: The most important melliferous plants are well documented. Fichtl & Adi (1994) described over 500 species of melliferous plants in Ethiopia (400 herbs/shrubs and 100 trees). Another important book by Admasu et al. (2014) describes nearly 400 important species. Abera (2017) also describes important plants focussing on the south-eastern region of Ethiopia. Nevertheless, a floral calendar covering all regions in Ethiopia did not exist. Within this report, an overall floral calendar was created. It must be mentioned, that the flowering times strongly differ between regions. In addition, a book entitled "Atlas of honey plant pollen grain" was published by Nuru (2007), containing pictures and descriptions of pollen grains and their morphological structure (Amssalu, 2016). A floral calendar was developed based on the literature of Fichtl & Adi (1994) and Admasu et al. (2014) and is represented in the annex of this report and on the SAMSwiki.

Indonesia: So far, there is no literature available on important melliferous plants in Indonesia, but there is a study by Jasmi (2017) which describes important melliferous plants for *A. cerana* in polyculture plantation. Due to the similar biology and behaviour of *A. cerana* and *A. mellifera*, we assume that the described plants serve also as food sources for the introduced *A. mellifera* species. A floral calendar is also missing for Indonesia, but experts from the University of Padjadjaran are currently working on one for West Java. The flowering times of the assessed plants are shown in the Annex.

2.4.3. Major honey flows (plants, seasons)

The classification of a plant species as "important" **honey bee plant** often depends on different opinions of surveyed beekeepers, due to different criteria selecting and recognizing them (nectar flow, pollen amount, flowering period, quality, frequency of honey bee visits, ...).

Ethiopia: There are several important melliferous plant species within following botanical families: Acanthaceae (*Asystasia gangetica, Hypoestes forskaolii, Justicia bizuneshiae*), Agavaceae (*Agave sisalana*), Aloaceae (*Aloe* spp.), Anacaridaceae (*Ozoroa insignis*), Araliaceae (*Schefflera abyssinica*), Arecaceae (*Borassus aethiopum, Phoenix reclinata*), Asteraceae (*Bidens macroptera, B. pachyloma, Carduus camaecephalus, Carthamus* *tinctorius, Crassocephalum macropappum, Guizotia abyssinica, G. scabra, Helichrysum citrispinum, Mikaniopsis clematoides, Vernonia amygdalina*), Boraginaceae (*Cordia africana*), Cactaceae (*Opuntia ficus-indica*), Campanulaceae (*Lobelia rhynchopetalum*), Combretaceae (*Combretum molle, Terminalia brownii*), Ericaceae (*Erica arborea, E. trimera*), Euphorbiaceae (*Croton macrostachyus, Euphorbium candelabrum*), Fabaceae (*Acacia* spp.*, Acacia albia, A. brevispica, A. pentagona, A. senegal, A. seyal, A. sieberiana, A. tortilis, Albizia* spp.*, Dichtrostachys cinera, Piliostigma thonningii, Trifolium* spp.), Hypericaceae (*Hypericum revolutum*), Lamiaceae (*Becium grandiflorum, Satureja punctata*), Leguminosae (*Cassia arereh*), Malvaceae (*Grewia mollis, G. villosa*), Moraceae (*Ficus sur*), Myrtaceae (*Eucalyptus globulus*), Oleaceae (*Olea Africana*), Poaceae (*Andropogon abyssinicus*), Rhamnaceae (*Berchemia discolor, Ziziphus pubescens*), Rosaceae (*Hagenia abyssinica*), Rubiaceae (*Coffea arabica*), Sapotaceae (*Aningeria adolfi-friederici, Mimusops laurifolia*) and Ulmaceae (*Celtis africana, C. toka*) (Admasu et al., 2014; El Mahi, & Magid, 2014; Gupta et al., 2014; Haftom, Zelealem, Girmay, & Awet, 2013). It has to be mentioned, that there may be more plant families relevant for honey bees.

The literature is not consistent when it comes to major honey harvesting seasons. While Gemechis (2016) claims, that there are two seasons of honey harvesting: October-November and April-June (before and after rainy season), Gidey et al. (2012) distinguish between honey harvesting periods in the lowlands and midlands (November-December) and in the highlands (April-June). In general, it can be said that the best time for honey harvesting depends on the particular regions, due to the various climate zones in Ethiopia ("mini" harvesting seasons): e.g. in south western Ethiopia there is a major harvesting season from April-June, and a minor one from November-January (Awraris et al. 2012).

Indonesia: In general, almost no literature exists on important melliferous plants in Indonesia. Furthermore, there is no information on important floral species for *Apis mellifera*. However, due to the similar morphology and nutritional ecology of *A. mellifera* and *A. cerana*, it can be assumed, that floral species, important for *A. cerana*, also act as potential melliferous plant species for *A. mellifera*: Acanthaceae (*Asystasia coromandeliana*), Anacardiaceae (*Mangifera indica, Mangifera* spp.), Arecaceae (*Areca catechu, Arenga pinnata, Caryota mitis, Cocos nucifera*), Asteraceae (*Bidens pilosa, Clibadium surinamensis, Eupatorium inulifolium, E. odoratum, Galinsoga parviflora, Tithonia diversifolia, Mikania micrantha, Spilanthes iabadicensis, S. paniculata*), Bombacaceae (*Durio zibethinus*), Brassicaceae (*Brassica rapa, Brassica* sp.*, Rorippa indica*), Caricaceae (*Carica papaya*), Cucurbitaceae (*Momordica charantia, Cucumis sativus, Sechium edule*), Cyperaceae (*Cyperus kyllingia*), Euphorbiaceae (*Aleurites moluccana, Homalanthus pupulneus*), Fabaceae (*Acacia auriculiformis, A. mangium, A. crassicarpa, Calliandra spp. , Leucaena glauca, Mimosa invisa, M. pigra, M. pudica, Pithecellobium lobatum, Parkia speciosa*), Graminae (*Oryza sativa, Zea mays*), Lauraceae (*Cinnamomum burmanii, Persea americana*), Loranthaceae (*Loranthus europaeus*), Lythraceae (*Cuphea* spp.), Meliaceae (*Melia azedarach, Toona sureni*), Myrtaceae (*Psidium guajava*) and Verbenaceae (*Tectona grandis*) (Jasmi, 2017; Pribadi, 2016). Especially important seems to be *Calliandra calothyrsus* for both, pollen and nectar. It was introduced from South America in the 1930is (Fig below) and was distributed all over the Indonesian islands.

Figure 17: Calliandra calothyrsus is an important melliferous plant for Indonesian honey bees, flowering occurs throughout the whole year (Photo credit: Gratzer Kristina).

There is **cryptic information** on major harvesting seasons in Indonesia, but according to an informal survey, conducted by the Universitas Padjadjaran (2018), the most important harvesting season in **West Java** takes place from **January** to **May**, while it is also common to harvest minor amounts of honey during the whole year, if there is personal need. Shouten et al. (2019) observed that beekeepers within the study area (Nusa Penida, Bali and Java) harvested honey on average eight times a year. Hadisoesilo (2002) mentioned two honey seasons in Sulawesi: one from September to December and one from February to April. It must be mentioned, that from the article it was not clear, if those seasons are only related to honey obtaining from *A. dorsata*, or to *Apis* species in general.

2.5. Beekeeping

The chapter beekeeping deals with the following topics: honey bee species used for beekeeping, other types of gaining bee products including honey hunting and meliponiculture, hive types, bee hive manual of Deliverable 3.1 from Holeta Bee Research Center (Ethiopia), hive management (supplemental feeding, prevention of swarming, …), locally adapted hive management interventions (good beekeeping practice), biggest problems in beekeeping, status of migratory beekeeping, status of pollination business and beekeeping associations. Beekeeping or apiculture is the housing and maintaining of bees, mostly of the genus Apis, in hives. Not only the choice of the right honey bee race, but also the right hive-system and appropriate hive management contribute to successful and high profitable honeybee product yields. In this chapter honey bees that are used for beekeeping in the two target countries, as well as commonly used hive types and hive/colony management were assessed. In both target countries, the use of mostly traditional hive systems is common. In both countries the hive management plays a subordinate role, which means, that methods like supplementary feeding, requeening, swarm prevention or bee health management is not common in every region of the countries. Besides classical beekeeping, honey hunting and the use of stingless bees (meliponiculture) are widely practiced for gaining bee products. The research results also indicated, that there is no nation-wide good beekeeping practice and no pollination business at all. There are few beekeeping associations and their structure differ from those of Europe. Constraints and problems regarding the beekeeping sector were also assessed resulting in a variety of problems, from lack of knowledge about bee biology to a lack of market or finance facilities.

2.5.1. Honey bee species used for beekeeping

Ethiopia: ***A. mellifera*** is the most common used *Apis* species for beekeeping. According to a local scientist (personal communication with Kibebew Wakjira from Holeta Bee Research Institute, Ethiopia) beekeepers do not prefer a certain subspecies of *A. mellifera*. Instead they use the locally available subspecies for beekeeping (Fig. 18). In some regions of Ethiopia, colonies can be financially obtained (**prizes**) but the more common practice is to catch feral colonies and put them into hives. A study by Sebsib et al. (2018) reviewed that in the Kaffa, Sheka and Bench-Maji Zones, beekeepers use a specific method to attract the feral bee colonies. They clean the hives with *Clausena anisata* and *Capsicum frutescens* prior to fumigating them. For fumigation, depending on the region, either parts of the plant *Ekebergia capensis* together with wax, or plant parts of *C. Africana* are used (Sebsib & Yibrah, 2018).

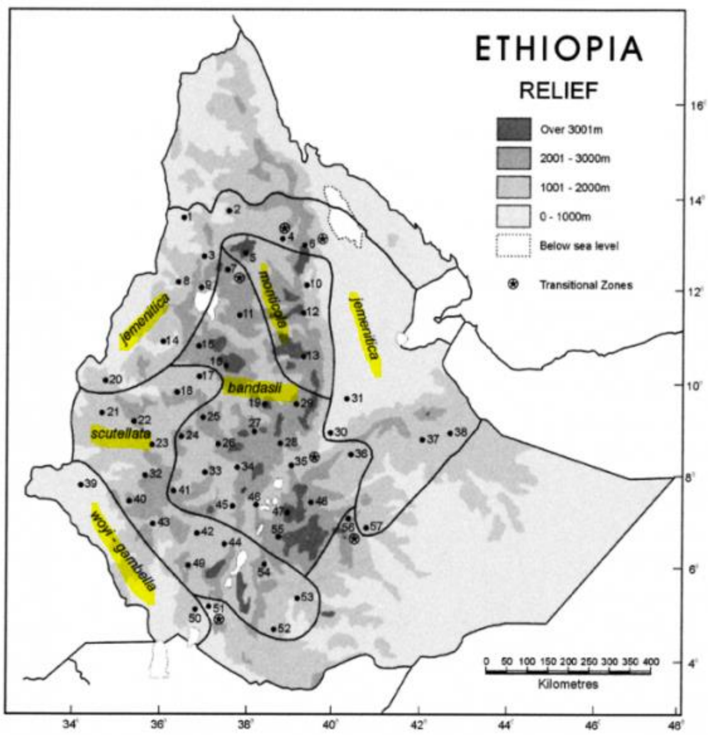

Figure 18: Distribution of the 5 subspecies of A. mellifera in Ethiopia. Picture was taken from Amssalu et al. (2004).

Indonesia: The most common used honeybee for beekeeping is ***A. cerana***. There is almost no information about beekeeping with *A. mellifera*, even though it is known, that in Java, beekeeping with *A. mellifera* is practiced mainly for migratory beekeeping (Gratzer et al., 2019). Beekeepers of stingless bees use local available feral bee colonies, by catching and housing them in hives (e.g. *Trigona spp.*) (pers. communication). For a list of the over 40 stingless bee species, observed in Indonesia, see Kahono et al. (2018).

2.5.2. Other types of gaining bee products, including honey hunting and meliponiculture

Besides the worldwide known beekeeping, there are also other ways of gaining bee products in Ethiopia and Indonesia.

Ethiopia: The country provides a rich flora and suitable ecological conditions for not only hived, but also for feral **bee colonies** (e. g. *A. mellifera*, Meliponinii). Thus, "**honey hunting**" from feral *A. mellifera* or stingless bee colonies is a common practice in Ethiopia. Honey hunters **trace and rob wild honeybee colonies** to make profit out of their products (Fichtl, & Adi, 1994; Gemechis, 2016). It must be mentioned, that traditional honey hunting is no sustainable way to obtain honeybee products, which led to the decrease of feral stingless bee species not only in Ethiopia but also in Africa (Anguilet, et al., 2015; Dietemann, Pirk & Crewe, 2009). Besides honey hunting and classical beekeeping, there is a third apicultural activity called "bee maintaining" which is defined as an intermediary stage of beekeeping, where humans guard wild living colonies and provide artificial nesting sites (Bradbear & FAO, 2009). In Ethiopia, there exists "forest beekeeping" which is the utilization of feral honeybee colonies (*A. mellifera*) as a resource without manipulating it. Honey collectors provide traditional nesting sites made of local available materials and harvest **honey** and **beeswax** one to two times per year. The provided nesting sites are placed in trees and the beekeeper has no influence on the quantity of the yield nor the harvest time. To increase the honey product yield, the number of nesting sites must be increased. Focusing on the absence of hive manipulation, forest beekeeping may belong to "bee maintaining" instead of classical beekeeping (Lowore, Meaton & Wood, 2018).

Indonesia: Almost every species of **honey bees** and **stingless bees** is used for **"honey hunting**", but in Indonesia the practice is mainly focussed on ***A. dorsata*** colonies (Bradbear & FAO, 2009; Kahono, Chantawannakul & Engel, 2018). *A. dorsata* is known to build single comb nests and so far, it was not possible to properly manage them. The honey yield of one *A. dorsata* colony is expected between **5 - 15 kg**, while a whole "honey tree" (*Sompuat*), housing numerous colonies, provides **50 - 300 kg** of honey (Lahjie & Seibert, 1990). In some regions of Indonesia, people practice "bee maintaining". There are efforts to attract wild living *A. dorsata* colonies by setting up tikung/tingku or also called sunggau (wooden planks or tree trunks) at which the migrating bee colonies build their nests. The tikung is usually made from a strong wood to improve its durability and it is often erected in areas of good bee forage availability. To increase the possibility of colonies occupying the tikung, some honey collectors smear beeswax or honey underneath it. Enough open space in front of the structure is highly recommended to offer the colonies a wide entrance/exit range (Hadisoesilo, 2002). This method is suggested to be a less dangerous technique to obtain honey than traditional honey hunting. *A. dorsata* prefers certain tree species over others for their nesting site. Those "honey trees" are usually not owned, but people mark it to signify their ownership of the nesting bee colonies. Harvesting takes place during the day and one to four people are involved. One person climbs the tree and uses a smoker made of bamboo to calm the bees. People harvest the bee products (mainly **wax** and **honey**) by cutting the whole nest off the *tikung* (Crane, Luyen, Mulder, & Ta, 1993; Hadisoesilo, 2002). To increase the attractiveness for feral honey bee colonies, some natural forests are managed and honey trees are preserved (De Jong, 2002). Honey from *A. dorsata* is an important product in parts of **western Kalimantan** (Lubis, Handayani, & Muazir, 2009). Another way to gain bee products is the **meliponiculture** with **stingless bees** from the genus ***Trigona***. Due to their low honey production, they are mainly used to gain **propolis** and **wax**. *Trigona* are easy to manage, do not require special beekeeping skills, and they can be housed in hollow logs, mud pots, bamboo pits, coconut shells, wooden boxes and pottery vessels (Lubis et al., 2009; Gupta et al., 2014).

2.5.3. Hive Types

A hive type is an enclosure structure in which honeybees are housed by apiarists. Every hive type has its own characteristics. On the one hand, **traditional hives** do not need **special skills** to build them, have **low starting costs** and are often made of simple, **locally available materials**. On the other hand, they have also disadvantages: the **bee management** is difficult (inspecting, harvesting, disease prophylaxis, adding supplementary food, …), hives are more **susceptible against external environmental stress** (climate conditions, pests and predators, …), the **yield** of honey bee products is often **lower** compared to modern types, and some hive types are even **destructive** to the surrounding forests (e.g. bark hives, log hives, …; Gupta et al., 2014).

Ethiopia: About 95% of Ethiopian beekeepers use traditional hive-systems made of cheap, locally available materials (clay, straw, bamboo, bark, logs, …). The remaining percentage of beekeepers use transitional (promoted since 1978) and modern hives (Gidey, & Mekonen, 2010; Taye, Desta, Girma, & Mekonen, 2015). The used hive system differs from region to region: while 56% of traditional hives were found in the Oromia region which produces 40% of national traditional hive honey, only 19% of people in the Amhara, Tigray and SNNP regions use traditional hives. Latter contribute 27% of national traditional hive honey production (MoA & ILRI, 2013). A survey by Tesfaye & Tesfaye (2007) revealed reasons, why most beekeepers do not possess modern hives-systems: the **starting costs are high**, **lack of managing skills**, **unavailability** of modern bee hives in the particular area, or a **combination** of the mentioned issues. The number of **movable frame hive-systems** was estimated to be **100,843** (2009; Gemechis, 2016). Modern beekeeping is mostly practiced in the **southwestern** and **central highlands** and since 1970, five movable frame hives were introduced to Ethiopia with **Zander**, **Langstroth** , and **Dadant** as the most common used hive systems, respectively (Gemechis, 2016; Hailemichael, 2018). Popular transitional beehives are either the **Kenyan top bar** hive, or the locally made "**Chefeka**" hive (Gemechis, 2016).

Figure 19: From left to right: traditional Ethiopian bee hive made of locally available materials. This hive type is installed in trees; clay pot hive for stingless bees used by the Holeta Bee Research Center in Ethiopia; transitional top-bar hive system; modern hive system with movable frames (Photo credit: Sascha Fiedler).

Based on the needs of local conditions, Kibebew Wakjira from the Holeta Bee Research Center in Ethiopia developed a possible standard hive system for future beekeeping in Ethiopia. This system is also suitable for the SAMS-hive-system established within the European Union's 2020 Horizon project SAMS - Smart Apiculture Management Services and can be adapted for Indonesian honeybees as well. For further details read the following chapter: **Bee Hive Manual**.

Indonesia: There is almost **no published data** available on hive types in Indonesia, but according to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), most beekeepers construct their own hives. Traditional hives consist, similarly to Ethiopia, of various, simple and locally available materials. For example, **stingless bees** (*Trigona*; see: **Other types of gaining bee products**) may be housed in **hollowed logs**, **mud pots**, **bamboo pits**, **coconut shells**, **wooden boxes**, or **pottery vessels** (Gupta et al., 2014). Modern models of housing Meliponini are wooden, vertical, terraced hives (Kahono et al., 2019). Further examples for commonly used traditional hives for *A. cerana* are **wall hives** (Theisen-Jones, & Bienefeld, 2016), or the “**glodok**” that consists of a horizontal bamboo hive. Honey is harvested by cutting the glodok into two halves (Crane, 1990). However, homemade hives that look **similar to modern hive-systems** are also defined as traditional. The habitus of the hives differ regionally by **dimension**, used **materials**, **entrance hole size**, and the **number of frames** inside. For example, while movable frame-hives with different sizes are used by beekeepers in the highlands of Bogor and Sukabumi, hives with double entrances are used in Halmahera, Ambon and Mollucas. Shouten et al. (2019) reported that the most often used hive type on the four islands Java, Bali, Nusa Penida and Sumbawa is the log hive, while in Southwest Java and western Bali, transition to beekeeping with frame hives was observed (Shouten et al., 2019). Despite there is no officially standardized size for bee hives or research on what hive types best fit the two different managed *Apis* species (*A. cerana, A. mellifera*) in Indonesia, the national **State Forest Own Company (PERHUTANI)** provides their own hive type for *Apis cerana* colonies and a large number of beekeepers try to copy the PERHUTANI bee hive-size for their own constructions (Perhutani, 1992).

Figure 20: From left to right: hives made for keeping stingless bee species; modern hive system with movable frames (Photo credit: Sascha Fiedler).

2.5.3.1. Bee hive manual

The Ethiopian and Indonesian apicultural sectors are underdeveloped. There is limited access and knowledge on modern beekeeping practices and beekeeping equipment, like modern **hive types**. To improve the beekeeping situation in the two target countries and to strengthen the international cooperation with the European Union, Kibebew Wakjira from the Holeta Bee

Research Center in Ethiopia developed a modern hive system, that is based on the existing and widely used Langstroth system, and has the potential to be used as a standard for Ethiopian *A. mellifera* bee colonies. The whole manual was developed as Deliverable 3.1. of the SAMS project and is publicly available via the project website or the SAMSwiki. Adaptions on the existing system also allow its use for *A. cerana*, the mostly managed ***Apis*** species in Indonesia.

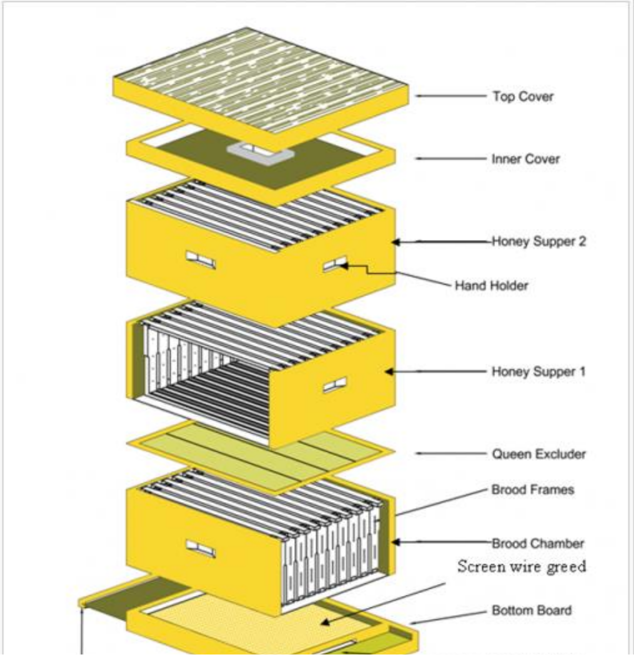

Figure 21: The beehive and its most important compartments. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

The aim of this chapter is not only to copy the detailed measurements of the hive which is suitable for *A. mellifera* colonies in Ethiopia, but to have access to a manual on how to build a modern beehive. The procedure of hive construction and operation by using an adapted Langstroth hive is given in this chapter. The detailed measurements for the bee space, cell depth, comb thickness and other parameters of the hive system were assessed through a study on local honeybee colonies in traditional hives and through workshops with local beekeeping institutions.

Tools and materials required for the hive construction:

Tools

- Thick Measure Feeler for adjusting thickness and surface smoothing
- Circular (buzz) saw for cutting wood
- Jointer machine for smoothing edges and creating side bar shoulders
- Measuring tape
- Digital caliper
- Framing square or drywall
- T-square
- Table saw
- Saber saw (sword with a slightly curved blade that is sharp on one edge)
- Putty knife or chisel,
- Hammer
- Clamps
- Power Drill - drill with bits
- Jigsaw
- Chop saw

- Sanding block
- Carpenter’s square (or a frame jig)
- Carbide - tip blade

Materials

- Waterproofed wood glue
- 19 mm thick waterproofed plywood
- 5 mm thick waterproofed plywood
- 5 and 8 cm galvanized nails
- 3 cm hardened trim nails (small nails)
- Cigar box nails (16 mm shoe nail)
- Timber for frames
- Timber for entrance block/reducer
- Lumber of thickness 20 mm after finished

Recommended wood for the beehive should not be soft woods. The boards must be dry and without cracks or rot

The most important parts of a Langstroth (and Dadant) beehive

- a loose bottom board
- a bottomless brood chamber (in front an entrance block, 10 frames per chamber)
- queen excluder (optional; placed horizontally on top of the brood chamber
- based on the population size of the colony, one or more honey supers (10 frames each; placed on top of the brood chamber)
- an inner cover (~ 5 mm thick; placed on top of chambers)
- the total hive system is covered by an outer cover made of wood which is covered with an aluminium or zinc sheet (cover should fit easily over the chambers)

Frames

A frame is a structure, which is used by the bees to build their storage combs to rear brood, store pollen, nectar and/or honey. Frames are constructed in such a way, that a series of them may be placed in a vertical position in the brood and/or honey chambers. The "bee space" in between is necessary for the bees to move freely. The top bar has to extend equally on both sides of the frame. A frame has a top bar, two sidebars and one bottom bar.

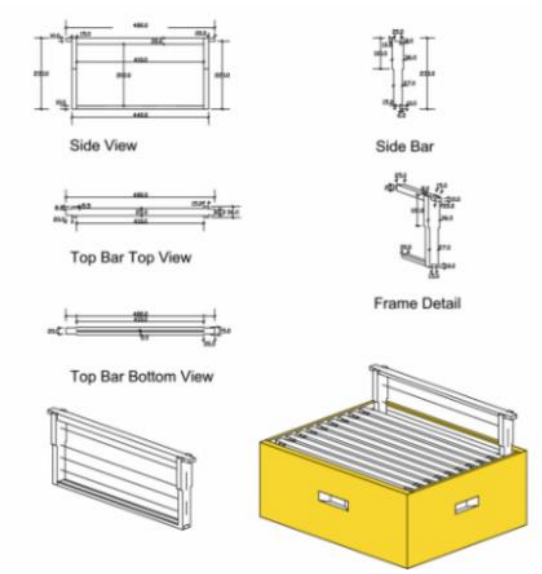

Figure 22: Standard frame with its dimensions. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1: Top bar

The **top bar** is 480 mm long, 20 mm thick and 25 mm wide. Well-dried wood should be used for the whole construction to prevent swelling and shrinking. Cut notches of 5 mm depth on the two sides and 10 mm depth on the bottom at 35 mm from the two ends to fit the top bars into the side bars. Then the ends of the top bar shall be joined into the side bars by these notches for facilitating the hanging for the frames. It is important to use grooved top bar frames to facilitate fixing of foundation, which otherwise warp if not inserted into the 5 mm deep groove.

Step 2: Bottom bar

The **bottom bar** is based on the top bar's size: 440 mm long, 20 mm wide and 10 mm thick. To fit perfectly to the side bars, cutting notch of 2.5 mm depth on the two sides at 15 mm from the two ends is important to fit the bottom bars into the side bars. Then the ends of the bottom bars shall be joined into the side bars by these notches.

Step 3: Side bars

The **side bars** are important parts of the frame to determine the bee space in the hive. The side bars should be of shoulder type. The side bar is 15 mm thick, 36 mm wide at the top and 27 mm wide at the bottom to provide the required bee space. The total length should be 230 mm having four holes for wire reinforcement every 57.5 mm. The hole is made at the center of the two side bars. This will give the holes at 37.5 mm away from the top bar and 47.5 mm away from the bottom bar while the remaining holes are made in a distance of 57.5 mm from each other. To facilitate the fitting of top and bottom bars with the side bars, cut two 10 mm deep grooves at 15 mm wide from the center and remove the cut from the center by leaving of two forks on the sides.

Step 4: Assembling and wiring the frames

Frame parts require precision to ensure proper services. It is important to make grooves of 55 mm depth centered on the bottom side of the top bar frames to facilitate fixing of the wax foundation. Use only specified frame nails (30 mm) to ensure that the frames remain square and hang properly in the chamber including the correct bee space. Wood glue shall be used prior nailing. Assemble the frame and drive 2 cigar box nails (16 mm) into the end bar at two corners of a side bar. When building a deeper frame, the builder should use a square (or a frame jig). It is important to use a carpenter's square to check the frames dimensions and angle. Assembling starts out by applying a dab of glue to each end of the top and bottom bars. After complete nailing and checking the frame, it becomes important to cross nail the side bars and top bar for durability.

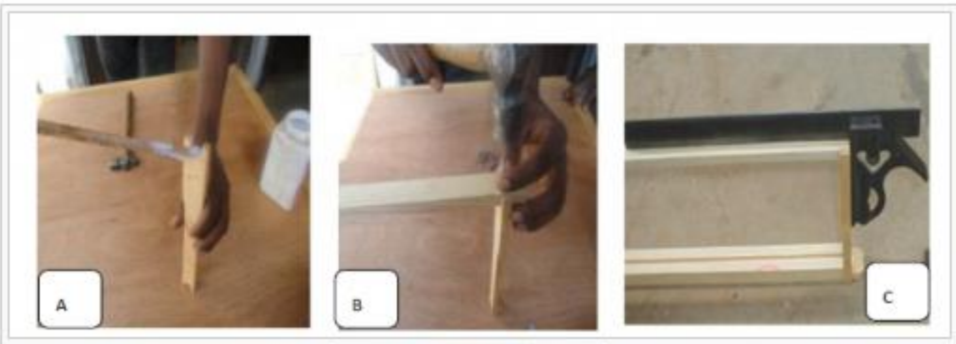

Figure 23: Assembling of frames: A) applying glue, B) nailing C) checking frame angle by using carpenter's square. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

The frames need to be wired. For maximum strength and longevity, use four horizontal standard food grade stainless steel frame wires. The wires should be drawn tight and secured with 16 mm cigar box nails.

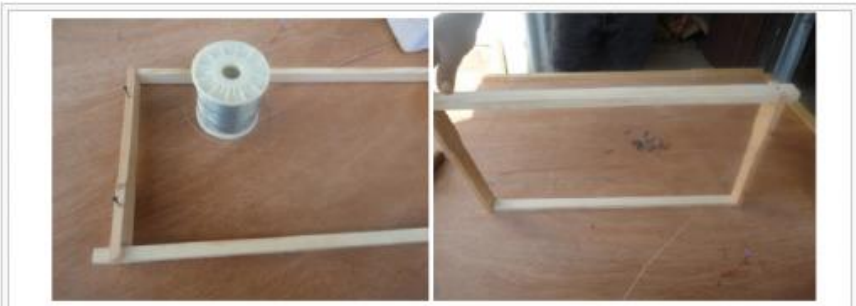

Figure 24: Wiring frames using food grade stainless steel frame wire. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Entrance block

The entrance block is a block placed in front of the hive on the bottom board to limit the entrance gate of the beehive. Usually, the entrance has a suitable size depending on the bee race. It fits between the bottom board and the first chamber and protects the bees from various pests and predators.

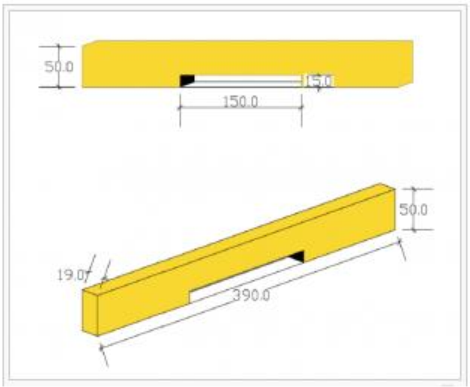

Figure 25: Entrance block and its dimensions. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1

The entrance block's dimensions: 390 mm long, 50 mm high, and 19 mm wide for the Langstroth. For the bees' entrance, a 15 mm wide and 150 mm long cut is made in the middle of the 390 mm length. The entrance block can be removed during the hot season for air circulation.

Bottom board

The bottom board is designed as a flat, four-sided rectangular wooden box on which the hive body is placed. It has ledges on three sides of the board and one slit in the front, which is usually covered by the entrance block. The mite floor is also a four-sided rectangular board to monitor pests within the colony. It is constructed from waterproofed plywood with sticky glue on it to trap small pests like varroa mites and larvae of the small hive beetle.

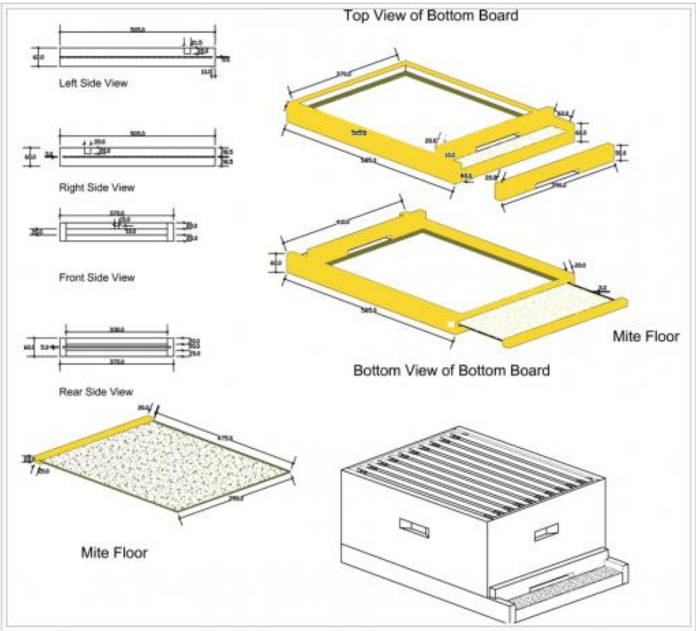

Figure 26: Dimensions and different views of the bottom board. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1

Cut two pieces of wood into a length of 585 mm and a height of 40 mm and one piece of wood 370 mm long and 40 mm high. Create a 5 mm wide and 5 mm deep groove 10 mm from the edge of the pieces slotting for placing the mite board. Also cut one piece of wood 370 mm long and 25 mm high but no do not put a groove here. This 25 mm wide wood piece is to create an open back silt at the bottom back of the bottom board designed primary to be covered by placing the mite board made of 5 mm thick plywood covered with a sticky glue for pest control (e.g. varroa mite and or larvae of the small hive beetle). This thin 5 mm plywood have to be fitted to a 370 mm long and 20 mm wide piece of wood with a 6 mm wide and 5 mm deep groove at its center to facilitate placing and removing the mite board.

Step 2

To start construction of the bottom board, align these four wood pieces to form a rectangle, sandwiching the shorter pieces inside the longer ones. Nail together the two sides using the 5 cm long, galvanized nails. Attach a piece of 19 mm waterproofed plywood to cover the bottom, using galvanized nails of appropriate size. To facilitate the stage for the entrance block and create a landing board for bees, form a small 80 mm x 370 mm rectangle on one side (front) and a bigger rectangle 505 mm x 370 mm on another side of the bottom board, by inserting a piece of wood with the following size: 370 mm long, 40 mm high and 20 mm wide between the 585 mm long sides.

Step 3

Cut a rectangular wire greed of 390 mm x 485 mm of mesh size between 3 x 3 mm to perfectly stretch over the bigger rectangle of 505 mm x 370 mm. This construction serves as screening method. Parasitic mites and other small pests that drop to the bottom of the hive fall through the wire mesh and are prevented from crawling back up. The smaller box created at the front serves as stage for the entrance block and landing board for bees have to be covered by a 370 mm long and 85 mm wide waterproofed plywood of 5 mm thickness.

Step 4

This assembled system shall be equipped with wooden rims on the two sides and back, the front left to be covered by the entrance block. The dimensions of the wood rims shall be of two pieces of 585 mm length, 20 mm height and 20 mm width and the other one of 370 mm length, 20 mm height and 20 mm width on top of the wire grid. Nail in place using trim nails. These wooden rims shall form a pivot on which the hive parts are placed. The rims also create a gap at the bottom of the brood chamber for the bees to freely move and allow air circulation.

Roof or top cover/lid

The key feature is that the cover is telescopic and extends down the sides of the hive body on which it is placed. This provides maximum protection and reduces the risk of rain seeping into the top chamber. The outside lid is a four-sided wooden plate, covered by a thin metal sheet of 0.5 mm and is always placed on the topmost chamber of the hive.

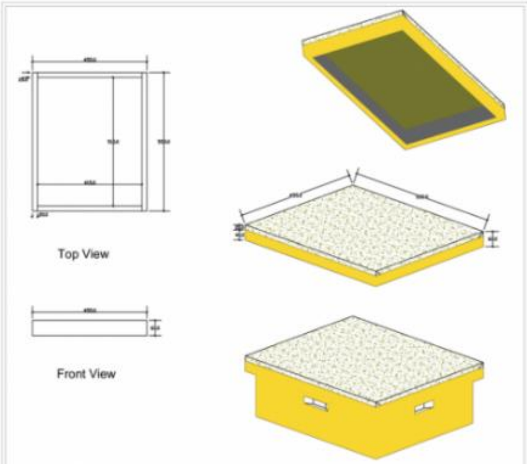

Figure 27: Different views of the top hive cover with its dimensions. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1

The top cover's side wall shall be from well-dried quality wood, with a wood thickness of 20 mm. The roof under the telescopic cover shall be of 19 mm thick waterproofed plywood or alternative from a well-dried wood but should not be more than two pieces joined together.

Step 2

Cut the lumber (550 mm X 400 mm X 65 mm; L X W X H) and form a rectangle, sandwiching the shorter pieces inside the longer ones. Nail together the two sides using 8 cm galvanized nails. Attach the telescoping top cover to plywood and use appropriate nails.

Step 3

The telescopic roof shall be suitably covered with a plain sheet of metal to protect the hive from rain. The sheet shall extend down below the edges of the top cover.

Inner cover/lid

The Inner cover is a four-sided, rectangular wooden box without a top and bottom. A waterproofed plywood separator screen with a passage hole is placed in the middle. Bees can visit the upper part of the inner cover through that hole. The inner cover serves as a "feeding station" for the provided **supplemental food** (e.g. sugar syrup or pollen patties) during dearth periods. The dimension of the inner cover consists of plywood to perfectly fit with wooden rims dimensions, similarly to the hive chambers.

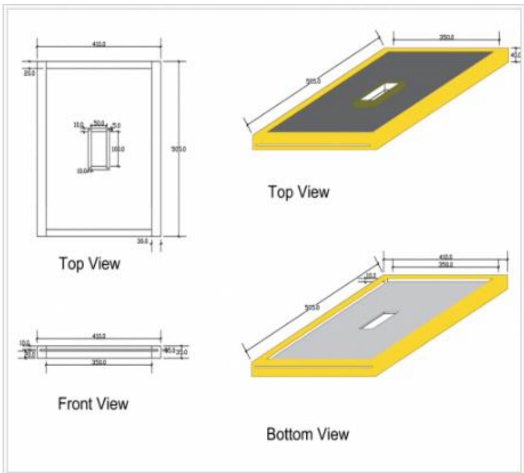

Figure 28: Dimensions and views of the inner cover equipped with wooden rims on the bottom and top parts. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1

The wooden rims consist of two pieces with dimensions of 505 mm length, 40 mm height and 20 mm width and two pieces with dimensions of 365 mm X 40 mm X 20 mm (L X H X W). By using a table saw, make a 10 mm deep by 5 mm wide groove at 10 mm distance from the edge of the 40 mm high wood pieces. Slide the 5 mm thick plywood into that groove.

Step 2

At the centre of the inner cover, a rectangular space of about 50 mm x 80 mm is cut and a tight ledge of 15 mm height and 30 mm width must be erected to facilitate provision of feeds.

Brood and honey chamber

The constructed hive bodies will protect the colony from external environmental factors (cold, wind, rain etc.) and must be long-living. The dimensions were chosen based on the four workshops. Brood and honey chambers are four-sided wooden boxes of rectangular cross-section without a top or a bottom, in which the (brood) frames are placed. The chamberers constructed in this manual hold 10 frames.

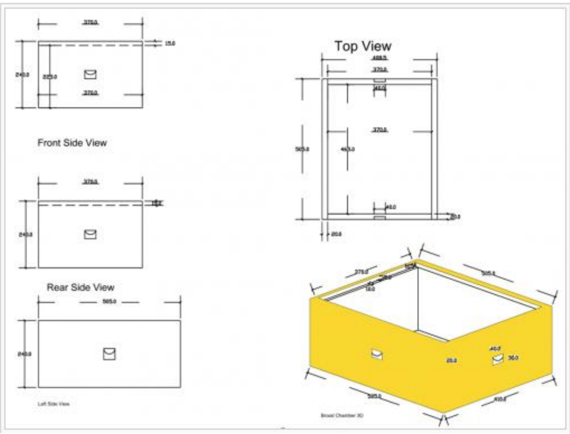

Figure 29: Dimensions and different views of a hive chamber. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 1

From a straight, well smoothed surface and edge lumber/timber, cut two pieces 505 mm long and two pieces 365 mm long for the sides of the hive chambers. Split them to match the height of the frames plus bee space.

Step 2

Rip each piece to a height of 240 mm. Use the table saw to cut a 15 mm deep by 10 mm wide notch out of the short side of each of the wood pieces. Complete the rabbet by making repeated cuts, moving the board away from the fence for each cut and crack away the slivers of wood. Then smooth the rabbet using a sander.

Step 3

Ten hive frames will rest on top of these notches inside each super when the hive is assembled. Use the power drill fitted with the 3 mm bit, drill holes along the edges of the specified longer pieces. Drilling pilot holes first helps to avoid splitting the wood. Fasten a clamp at the bottom of the vertical sides to support them as you work.

Step 4

Apply glue to the joints and then hammer a galvanized nail into each pre-drilled hole to fasten its sides to create a box by sandwiching the shorter pieces inside the longer pieces. Insert a frame to confirm that it slips easily into the super. It should hang from the rabbet and have a little play at each end. The super should accommodate 10 frames with 10 mm "bee space" in between. Make the handle pieces using the power drill fitted with the 4 mm bit, drill 3 holes along the length of each handle piece, and attach them to the supers using 40 mm long screws on each side. Repeat these steps with the remaining specified wood pieces to make more chambers/supers.

Figure 30: Building a hive chamber. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

Step 5

By using table saw, cut a notch, called rabbet, 15 mm deep and 10 mm wide into the shorter side to hold the frames so that the fence of 15 mm of 10 mm thick will remain to cover the hanging frames in each chamber. There shall be fixed hand holders with the following dimensions: 25 mm thick, 40 mm wide and 150 mm long on all the four sides of the outer faces of the chambers for lifting up the hive parts during hive operations.

Finishing the beehive

The different parts of the beehives should have a smooth finish by sanding and all edges should be trimmed square and smooth. All joints shall be sound and shall withstand normal use. For all types of beehive walls of chambers and roofs shall be joined by box corner joints, or tongue joints, properly nailed. When specified nails used for joints, there shall be one nail at each point. The distance between two consecutive nails shall be not more than 75 mm.

Painting the hive

Parts of the beehive exposed directly to weather should be painted with a suitable protective paint (leave the inside natural). The paint shall be nontoxic and shall not have any odour disagreeable to the bees and products of the hive. The colour of the paint is not important, but white or yellow can be preferred over dark colours. Before painting the hive, it is important to coat the hive in an exterior primer before putting on the final coat of paint. Oil based exterior primer for better weather protection is recommended, but any type of exterior primer will work.

Figure 31: Painting of the bottom board and inner cover. Figure retrieved from SAMS project D 3.1. (2018). Bee hive manual.

2.5.4. Hive management

Hive management, performed by beekeepers, is defined as active manipulation of a honey bee colony, to augment honey bee production and to ensure the survival of the colony. Common hive (see: hive types) management practices include: disease prophylaxis and treatment of infested colonies, swarm prevention/control, supplementary feeding, removing queen cells for swarm prevention, etc. (Carrol, 2006). Due to fragmentary published data, it must be mentioned, that none of the provided information is representative for the whole country, but for regions only.

Ethiopia: The beekeeping practice differs between regions. While a survey on beekeeping techniques in the Jijiga Zone revealed, that 13%, 14% and 23% of respondents inspect their hives internally every week, every fifteenth day, or once in a month, respectively (Fikru, 2015). A survey by Gebremedhin (2015) in the Amhara region and Kewet district revealed, that 33.3% of participants internally inspect their hives regularly. It has to be mentioned, that the results also depend on the type of beekeeping. Hive inspection in traditional in comparison to that of modern **hives** is unusual or not existing at all in many parts of Ethiopia (Kebede & Lemma, 2007;Kerealem, Tilahun, & Preston, 2009). Sebsib and Yibrah (2018) reviewed, that it is more common to externally inspect the hives and to clean the apiary to avoid **ant** attacks. They further found reasons for not internally inspect the bee hives: fear of bee stings, possible colony absconding, lack of time and lack of know how on the benefits of managing hives. There is no further description on the detailed process of "internal" and "external inspection" (manipulating the hive, or just observation of the colonies).

Indonesia: There is **no official information** available on hive inspection, but a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia) claims, that the number of hive inspections vary between **once in a week** and **once in a month**, depending on the forage availability, the urge of harvest, and on the beekeeping level of the beekeeper (main income, or additional income). Further, beekeepers who start the inspection, clean the area surrounding the hive, followed by opening the hive and assessing the status of the colony (**honey bee health** status, queen presence, ...). If necessary, experienced and high skilled beekeepers even expand their hives.

2.5.4.1. Feeding

Especially, during periods of forage unavailability, supplementary feeding is essential to avoid absconding and to ensure the survival of the colony. The suitable supplement must be chosen depending on the type of food shortage (pollen, nectar or water; Crane, 1990).

Ethiopia: An assessment on beekeeping practices in the Jigjiga Region (2015) revealed that interviewed beekeepers are aware of the importance of water availability for their honeybees. They **provide water** in form of **waterholes**, **ponds**, or **rivers/streams** near the apiaries (Fikru, 2015). Not all beekeepers offer supplementary feeding. While Assemu et al. (2013) revealed that over 60% of surveyed beekeepers in the western Amhara region provide supplementary bee forage, Serda et al. (2015) conducted a study in the Haramaya District, Eastern Ethiopia, and found that only 3.1% of participants supplementary fed their colonies during a lack of bee forage. To provide **carbohydrates**, Ethiopian beekeepers feed **sugar-, or honey solution**, or **flour of roasted grain** (barley and maize). Due to various **climate** conditions, there are regional differences on the time of additional feeding. Beekeepers of the Tigray region offer supplementary food mostly in the months **February to May**. In the western Amhara region, surveyed beekeepers revealed, that food shortage occurs over the year, while there is a peak in April, March and February, respectively (Assemu et al., 2013). According to Fichtl and Adi (1994), there are some regions, where it is common to offer “freshly slaughtered meat scraps” as a supplementary protein source. However, this method seems to be questionable regarding the possible human pathogens that may be enriched in the bee products. More common pollen substitutes are **chickpeas** and **peas** (Fichtl, & Adi, 1994; Solomon, 2009). In a study by Zaghlou et al. (2017) three different supplementary diets were compared (soy bean, chickpeas and yellow corn) resulting in an increase of honey yield, laid eggs/day and area of brood, while a supplementary diet on chickpeas led to the lowest increase.

Indonesia: Feeding of honeybee colonies is **not common in the country**. Flowering occurs throughout the year, and therefore it is often believed, that honeybees have enough forage (plants in flower may produce pollen but not nectar and vice versa; Crane, 1990). There is **no published data** available on supplementary feeding in Indonesia, but a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia) claims, that additional nourishment is practiced among beekeepers during the dry season. The most common supplementary **carbohydrate source** is **sugar solution** due to its easy availability and affordability. Beekeepers place the supplement inside the hive (small branch is placed inside the solution to provide protection). Widowati et al. (2013) compared local pollen substitutes with different composition. They found, that a mixture of **soy flour, skimmed milk, yeast, honey and sugar syrup** was preferred by *A. cerana* colonies and its consumption led to the highest productivity. The study showed, that locally available ingredients can be used to produce a high-quality protein source for honey bees.

2.5.4.2. Swarm prevention

Swarming may occur as either **reproductive swarming**, where the colony divides itself or as **absconding**, where the honeybee colony leaves its nest site if the environmental stress becomes high. While reproductive swarming is triggered by the size of the colony (Crane, 1999), absconding is related to various factors like drought, overgrazing, deforestation, honey bee diseases and pests, shortage of water, poor hive management, a lack of protection against bad weather, or a shortage of melliferous plants (pollen, nectar), etc.

Ethiopia: To prevent reproductive swarming, the beekeepers **cut parts of the brood combs**, **remove queen cells**, **enlargen the volume of the hives**, or provide instantly available new nesting sites in form of **empty hives** (Fikru, 2015; Solomon, 2009). Together with the mentioned methods, a study by Tessega (2009) revealed the important role of indigenous knowledge for beekeeping (Burie district and Amhara region). In the study area, 10.3% of respondents prevent swarming by smoking the beehives with bones of horses or mules, 5.1% used mule urine, fumigating with "white etan" (1.7%), or used "ambacho teketila" and "yejart eshoh" (2.6%). Sebsib and Yibrah (2018) reviewed, that the majority of beekeepers do not prevent swarming. One reason may be the wide distribution of traditional hives which are often installed in tall trees. Thus, an inspection is very difficult.

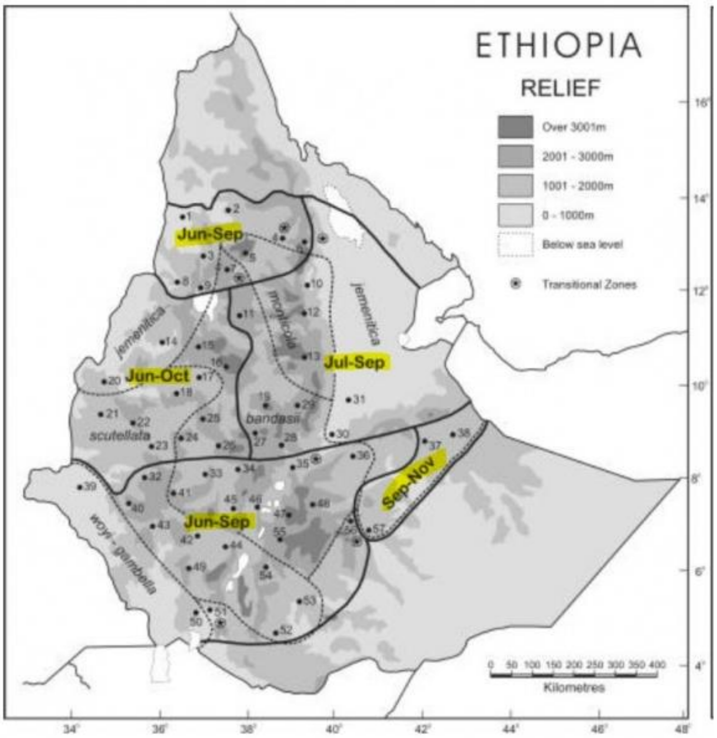

Figure 32: Distribution of the 5 subspecies of A. mellifera in Ethiopia and their main reproductive swarming periods. Picture was taken from Amssalu (2016).

Indonesia: There is no information available on management practices to prevent swarming, but in the regions of Pager Ageung, Tasikmalaya, Bawean Island and Gresik, beekeepers do not avoid swarming, instead, they let their colonies abscond during the drought season and recapture feral colonies during the flowering season (Kahono et al., 2018). According to a local scientist (Universitas Padjadjaran, Indonesia), beekeepers eliminate drone and queen cells, place "bee traps" nearby their hives, or produce offshoot colonies to prevent swarming events.

2.5.4.3. Bee health management

Ethiopia: According to a local scientist (personal communication with Kibebew Wakjira from Holeta Bee Research Center, Ethiopia), beekeepers, recognizing health issues within their bee colonies, must report to the district livestock offices (chapter: "Dealing with honey bee health issues"). If a beekeeper is not able to recognize the disease, the district livestock offices will help with the identification and offer advice on treatment methods.

Indonesia: According to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), the beekeepers of disease affected apiaries do not pass on the information to a governmental office, nor to a beekeeping association, but informally exchange their observations with other beekeepers who already gathered experience with the particular honey bee health issue.

2.5.4.4. Getting a new swarm

In Ethiopia and in Indonesia, numerous feral honeybee colonies exist. Therefore, many beekeepers rely on catching a swarm instead of buying one. To increase the chance of successfully catch a new colony, it is recommended to smear beeswax or propolis in the hive as it is believed that feral bee colonies find the new hive faster (pers. communication with UNPAD; Kigatiira, 2014).

2.5.5. Locally adapted hive management interventions (good beekeeping practice)

Ethiopia: In Ethiopia, there are decrees and proclamations by the government (pers. communication with HBRC): 1. Registration and control of pesticides, special Decree No. 20/1990 to lay a scheme of registration and control of hazardous chemicals to life and products of honeybees 2. Apiculture Resources Development and Protection Proclamation, No. 660/2009 for development and protection of apiculture resources.

Regarding scientific efforts, the Holeta Bee Research Center (HBRC) is the main institution for apicultural research, but since 2008, seven federal agricultural research centers and seventeen regional centers started to engage apicultural research activities (Amssalu, 2016; Hailemichael, 2018). As mentioned in the chapters **honey** and **hive types**, 95% of the beekeepers use traditional hives, but most of HBRC's research is based on modern technology and modern management systems aiming the development of the bee sector in the country (pers. communication with HBRC). Nevertheless, results may not be adapted to the actual situation in the country and therefore more than one research institution is needed to cover the widely used traditional system on the one hand and further promote modern techniques on the other hand.

Indonesia Nationally formulated good beekeeping practices are **unknown** but literature promoting good beekeeping practices exist. Nevertheless, local beekeepers rely mostly on their experiences. PERHUTANI employed "field officers", who teach local beekeepers good beekeeping practices. Examples for existing literature: “Petunjuk Praktis Budidaya Lebah Madu (*Apis cerana*)/Beekeeping Practical Guideline (*Apis cerana*) ” “Petunjuk Praktis Budidaya Lebah Madu (*Apis mellifera*)/Beekeeping Practical Guideline (*Apis mellifera*)” and “Petunjuk Praktis Peralatan Budidaya Lebah Madu (*Apis cerana* and *Apis mellifera*)/Practical Guideline for Beekeeping Tools (*Apis cerana* and *Apis mellifera*)”, all by PERHUTANI, “Rumah lebah" from Traditional to Modern Medicine”, by Hutagalung, and “Produk-produk Lebah Madu dan Hasil Olahannya/Honey bee products and their derivatives”, by Jaya (pers. communication with Universitas Padjadjaran, Indonesia).

To achieve the goal of exporting honeybee products into the EU, certain **quality standards** must be achieved. The **Strategic Intervention Plan**, written by SNV/Ethiopia in 2005 listed approaches to increase the quality of **honey bee products** (SNV/Ethiopia, 2005). It must be mentioned, that those criteria are equally important for Ethiopia and Indonesia, as well as for every other non-EU-country.

1. The use of antibiotics as a **preventive measure** is forbidden. If the use is necessary, you must follow the instructions exactly and remove all supers from the hive.
2. During **honey flow periods**, you should **not** feed supplementary sugar or sugar syrup.
3. Remove all frames, containing **fermented** honey, or **moldy** pollen.
4. To prevent tobacco taste and its tar residues, avoid the **excessive use** of a smoker while harvesting.
5. To avoid high moisture content, only harvest frames that are **at least 70%** sealed.
6. If necessary, use **chemical repellents** for harvesting carefully.
7. Supplement food should be positioned on an **upturned** hive cover instead of putting it on the ground.
8. The honey extraction should take place in a room that is **protected** from external moisture and honeybees.
9. To avoid the rotting of the hive, all component parts (floor, walls partitions) should have a **waterproofed surface**.
10. Do **not heat** honey **above** 40.6 °C to avoid the production of HMF (Hydroxymethylfurfural).
11. Machines and containers have to be **sealed** with **food-quality** paint or contain of **stainless steel** or food-quality plastic.
12. Do **not** smoke during the honey extraction.
13. To remove big pieces of wax, **filter** the honey after extracting process.
14. Do not store honey in rooms with **high** temperature, nor at places exposed to the **sun**.
15. To avoid the re-uptake of external moisture, be sure to properly **seal/shut** honey containers.
16. Do **not** collect pollen during honey harvesting season.
17. Working with food and non-food products requires **separate steps**.
18. If hives are placed in a "honey house", do not clean it, until all honey has been **stored** in airtight containers.
19. Chemical products (detergents, glue for labels, medicine, insecticides, herbicides, ...) have to be stored **separately** from the extraction room.
20. Do not use **used** oil barrels (even when waxed).

2.5.6. Biggest problems in beekeeping

The following assessment of constraints and problems may not be representative for the whole target country due to variability in local culture and conditions. In a consequence, regionally conducted scientific efforts may be contribute in the development of the whole country's beesector.

Ethiopia: Unsteady yield leads to unsteady income. Due to several factors like **poor management** of honeybee colonies and **traditional production systems**, the productivity and quality of bee products in Ethiopia is considered low (Beyene, Abi, Chalchissa, WoldaTsadik, 2016). The main problems are limited availability of **bee forage** (poisonous plants, seasonal availability, deforestation), **water shortage** (drought), the **swarming behavior and absconding** of honeybees, **colony mortality**, **reduction of honeybee colonies**, **pests and predators** (ants, honey badger, wax moths, *Varroa*...), **absence or poor quality of beekeeping equipment/materials**, indiscriminate use of **pesticides and herbicides**, the **lack of storage and marketing facilities** and, in general, a **lack of know how** (Gidey, Bethelhem, Dawit, & Alem, 2012; Gidey, & Mekonen, 2010; Legesse, 2014; Sisay, Gebremedhin, & Awoke, 2015; Yetimwork, et al. 2015). A study by Tesfaey & Tesfaye (2007) revealed that **98%** of respondents, living in the mid rift valley region, never participated on any **training** in terms of beekeeping. Furthermore, beekeeping seems to be uninteresting for some of the surveyed people due to above-mentioned **constraints** and due to a **combination** of those factors. Internal hive inspection seems to be totally unknown among many beekeepers, although they were visiting their hives for external inspection regularly. Most beekeepers do not know about the impact of **supplementary food** after honey harvesting season, nor about the importance of controlling swarming events (see: "**Hive Management**"-swarming prevention) of honeybees (Solomon, 2009). Conductors involved in the project ASPIRE, that assessed problems in business development, found out, that smallholder beekeepers especially suffer under a **lack of credit/finance**, a **loose linkage of producer-processor market**, **low quality** in honeybee products, **supply chain problems** for inputs, **international market linkages** and the **capacity border** of sector associations (Negash, & Greiling, 2017). Pots, skins and fertilizer bags are often used for honey packaging, but they are not suitable for it, which results in a decrease of honey quality. The **transport** from rural to urban regions often takes place with the use of labor animals, due to a lack of infrastructure (SNV/Ethiopia, 2005). Approximately **95%** of bee **hives** in Ethiopia are **traditional** beehives, that are **difficult to manage** and of **low productivity** (Negash, & Greiling, 2017). Traditional hives cannot be managed probably (no moveable frames) and this results in the damage of honey bee colonies during harvesting which causes severe population reduction. Traditional beekeeping with traditional hives (e.g. log hives) often contains the involvement of climbing high trees. Due to Ethiopian culture, climbing trees and therefore practicing forest beekeeping is not allowed for females (Awraris et al., 2012).

Indonesia: The **poor quality** of honey bee products is the major problem in Indonesia (>25% moisture, poor hygiene, diluting of honey with sugar syrup; Amir, & Pengembangan, 2002; Crane, 1990). In addition to a **lack of know how** on proper beekeeping, the honey bee product yield is low (Amir, & Pengembangan, 2002). Most of the Indonesian beekeepers use *A. cerana* for beekeeping, but this honey bee species is known to be less productive than *A. mellifera* and to show increased **absconding behavior** (Oldroyd, & Nanork, 2009). Unfortunately, there is not as much information on beekeeping in Indonesia compared to Ethiopia, but it is considered, that some problems are very similar in both countries (absconding of honey bees, lack of knowledge about beekeeping practices, bee forage problems, lack of storage facilities, lack of infrastructure, lack of market facilities, and the use of pesticides; (Amir, & Pengembangan, 2002; Akratanakul, 1987; Crane, 1990; Peluso, 1992).

2.5.7. Status of migratory beekeeping

Ethiopia: There is almost no information available on migratory beekeeping in Ethiopia, but it is considered as a rare practice (Tolera, Admasu & Tura, in press.). It is known, that in a region called Gijjam, simple migratory beekeeping is practiced. It is done for additional income, instead of increasing pollination. Farmers close the traditional baskets with fresh cow dung and carry the hives on the shoulders to the selected fields (Fichtl, & Adi, 1994).

Indonesia: There is a **lack of nationwide data** on migratory beekeeping in Indonesia, but in **Java**, migratory beekeeping is practiced with *A. mellifera* colonies, locally familiar as "mobile" beekeeping. Local habitants, stakeholders, landowners and official government representatives are owners of gardens, including their potential forage plants for honey bees. They often do not know about the benefits, and the role of the honey bee as a pollinator and therefore, the **rejection of honey bees** by the population is great. In addition to missing regulations on bee hive placement and extensive monocultures, mobile beekeeping evolved and today is still a common practice in Java (Kahono et al. 2018). One example of a **migration schedule** of *A. mellifera* in Java was given by a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia) who cooperated with the national State Forest Own Company (PERHUTANI): in May to July *A. mellifera* hives are placed in Central Java to forage on mostly kapok and randu, in August they are moved to Mt. Arca and Sukabumi to forage on *Calliandra spp.*, from September to October, beekeepers place their hives in Subang (rambutan forage), from November to April *A. mellifera* colonies are found in Cimangkok and Sukabumi to collect pollen of maize-plants. The detailed process of migrating, including the transport and handling of hives, is unknown.

2.5.8. Status of pollination business

While the knowledge on the importance of bees as pollinators exists in **Ethiopia**, there is **no pollination business** (pers. communication with Holeta Bee Research Center). In Indonesia also **no pollination business** exists. According to local scientists (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), many farmers do not believe in the importance of bees as pollinators and further think that bees harm their crops. In a consequence, scientific studies and the support of NGOs and GOs are from great interest to dam prejudices against honeybees.

2.5.9. Beekeeping associations

In Europe a beekeeping association is a kind of club, that educates, assists, informs, insures and brings together local and national beekeepers. They support the country's bees and beekeepers and have also certain responsibilities (regular meetings where they talk about changes in the beekeeping practice, inform about diseases, act as a contact for club members etc...). The beekeepers join those associations and usually pay a membership fee in exchange of using the provided services. Similar organized associations exist in **Ethiopia** but so far, there is no information about similar structures in **Indonesia**. Nevertheless, organizations exist which aim the education of the domiciled beekeepers. In addition, there are numerous projects aiming the improvement of the apicultural sector, but projects always have an expiring date.

Ethiopia: In Ethiopia there exist three beekeeping associations: **Ethiopian Apiculture Board (EAB)**, **Ethiopian Society of Apiculture Science (ESAS)** and **Ethiopian Honey and Beeswax Producers and Exporters Association (EHBPEA)**. **EAB** was established in 2009 and it aims to improve the honey production and productivity by ensuring quality production and safety issues. The Ministry of Agriculture is the patron of **EAB** (Negash & Greiling, 2017). About 10 years ago, SOS-Sahal was an important beekeeping project, providing beekeeping training (Gupta et al., 2014). With the support of SOS Sahel and other co-operatives (individual farmers and beekeepers), the **Zembaba Bee Products Development** & **Trade Promotion Cooperative Union** was established. This is no classical beekeeping association, but they offer training, good materials and market information, they assist members and improve methods of production and the main objective is to promote the market for honeybee products in the Amhara region. Zembaba Union also exports honey to foreign markets. Union members have to have 2 years of experience as beekeepers and they provide an agreed amount of honey to the co-operatives, which sell it to domestic markets. Afterwards, they distribute the annual profit to all the members (Mekonnen, 2008). Projects like **ASPIRE** (Apiculture Scaling up Program for Income and Rural Employment) and government initiatives like **ATA** (Agricultural Transformation Agency) aiming also the supporting of beekeeping interests. In addition, a lot of **organizations** (GOs and NGOs) and **initiatives** offer training on beekeeping every year. Despite all the efforts, the apisector still develops **very slowly** (ASPIRE, 2018; ATA, 2018). Other bee projects in Ethiopia: Improving the Productivity and Market Success of Ethiopian Farmers (IPMS) project, project funded by the Canadian International and implemented by ILRI, Facilitator for Change project implemented by Oxfam GB, Sustainable Land Management (SLM) Commissioned by: GIZ, German Federal Ministry for Economic Cooperation and Development, Young Entrepreneurs in Silk and Honey (YESH), by icipe etc...

Indonesia: PUSBAHNAS (National Apiary Center; PUSBAHNAS, 2018); **API Indonesia (Indonesian Apicultural Association;** Indonesian Apicultural Association, 2018) this organization is sub of **Asian Apicultural Association (AAA)**. AAA aims to "promote the exchange of scientific and general information relating to honeybee sciences and apiculture in Asia, and to encourage international co-operation in the study of problems of common interest" (AAA, 2018). The **Indonesian Forest Honey Network** or Jaringan Madu Hutan Indonesia (JMHI), was established in 2005 and is an umbrella organisation of 10 indigenous communities in Indonesia (Kalimantan, Sumatra, Sulawesi, Java, Flores and Timor Islands). The objective is to promote sustainable honey hunting by teaching a hygienic and environmentally safe harvesting system. The organisation works together with a social enterprise which is involved in marketing the harvested honey products throughout Indonesia and the profit is distributed between honey collectors (JMHI, 2018).

2.6. Bee pathology

There are numerous pests, pathogens and predators which affect the health of honeybee colonies and further may cause economic loss. Therefore, it is important for beekeepers to know about existing threats and how to treat a possible infestation. In the following chapter, an assessment on honeybee health status, major pests and predators and local treatment methods was conducted. Summarized, there is a wide variety of pests and pathogens that affect honeybee health in Ethiopia and Indonesia. They range from viruses, protozoa, bacteria, fungi and insecta to mites and mammals. In general, the research indicated that beekeepers in both countries underestimate the risk of honeybee diseases and that treatment methods, that are commonly used in the western world are unknown in Ethiopia and Indonesia. It is necessary to work on education dissemination to enlarge the understanding of honeybee biology and further increase the income.

2.6.1. Honey bee health

The table below represents a list of the most important pests and pathogens, affecting the health of honeybees in Ethiopia and Indonesia.

Table 3: Pests and pathogens present in Ethiopian and Indonesian honey bee colonies. N/A (not available) stands for a lack of data, +/- stands for a present/absent pest/pathogen.

		Organisms	Ethiopia	Indonesia
Viruses		DWV, IAPV, SBV, VDV-1	**N/A**	**N/A**
Protozoa	**Amoeba**	*M. mellificae*	+ [1]	**N/A**
Bacteria	**Foulbrood**	AFB	**N/A**	**N/A**
		EFB	**N/A**	**N/A**
Fungi	**Nosema**	*N. Apis*	+ [1] [2] [3] [4]	**N/A**
		N. ceranae	**N/A**	+ [2] [12]
	Chalkbrood	*A. Apis*	+ [1] [4]	**N/A**
Insecta	**Lepidoptera**	G. mellonella	+ [4] [5]	**N/A**
		A. grisella	+ [4] [5]	**N/A**
	Diptera	*B. coeca*	+ [4] [6]	**N/A**
	Coleoptera	*A. tumida*	+ [1] [4]	**N/A**
		Cetoniinae	+ [1] [4]	**N/A**
	Hymenoptera	Ants	+ [4] [7] [8]	+ [13]
Mites	**Parasitic mites**	*Varroa destructor*	+ [4] [9]	+ [14] [15] [16] [17] [18]
		V. jacobsoni	**N/A**	+ [14] [15] [16] [17] [18]
		Tropilaelaps spp.	**N/A**	+ [14] [15] [16] [17] [18]
	Tracheal mites	*A. woodi*	+ [4]	- [2]
Birds		Meropidae	+ [4] [8] [10]	**N/A**
Mammals		*Mellivora capensis*	+ [10] [11]	- [19]

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2.6.1.1. Viruses

Pirk and colleagues reviewed, that in the year 2015, at least 23 "honey bee viruses" were known globally (Pirk, Strauss, Yusuf, Démares, & Human, 2015). Important viruses reported in Asia and/or Africa are: Black Queen Cell Virus (BQCV), Sacbrood Virus (SBV), Israeli Acute Paralysis Virus (IAPV), Deformed Wing Virus (DWV), Varroa destructor Virus 1 (VDV-1) and Acute/Chronic Bee Paralysis Virus (ABPV and CBPV) (Morse, & Nowogrodzki, 1990; Pirk et al., 2015). Despite there may be similar symptoms such as wing deformation in DWV and VDV-1, the pathogenesis of mentioned viruses differ from each other. The symptoms range from loss of hair to even paralysis of bees (Mumoki, Fombong, Muli, Muigai, & Masiga, 2014; Pirk et al., 2015).

Ethiopia: So far, 9 different viruses affecting honey bee health were detected in Africa (Pirk et al., 2015). While multiple viruses were observed in the neighbouring countries (**Threats for introduction of new pests**; Kajobe et al., 2010; Muli et al., 2014), there is a lack of information regarding the honey bee virus status in Ethiopia.

Indonesia: According to Ellis and Munn, 6 different honey bee viruses were observed in Asia (Ellis, & Munn, 2005). Unfortunately, there is a lack of data on the virus status in Indonesia.

2.6.1.2. Foulbrood

The European (EFB) and American (AFB) foulbrood disease are caused by *Paenibacillus larvae* and *Melissoccocus plutonius* two widespread bacteria, respectively. While both pests are highly contagious diseases, AFB is known to be more acute and wider distributed (Mumoki et al., 2014).

Ethiopia: The status of foulbrood is unknown, but AFB and EFB are present in the neighbouring country Eritrea, while it is absent, or suspected to be absent in Kenya, Sudan, South-Sudan and Uganda (Ellis, & Munn, 2005).

Indonesia: There is also a lack of knowledge regarding the foulbrood status in Indonesia!

2.6.1.3. Nosema

Nosema spp. (Dissociodihaplophasida; Nosematidae) is known to be a parasitic microsporidian and the causative agent of nosemosis (Morse, & Nowogrodzki, 1990). The infectious non-germinated spore of the pathogen is transmitted through the oral-faecal route of adult bees, or through mating. The most popular treatment in many countries is "fumagillin". While *N. apis* has a relatively wide distribution with a prevalence for colder climate, *N. ceranae* is mostly prevalent in the tropics and sub-tropics (Mumoki et al., 2014).

Ethiopia: *Nosema* existence in Ethiopia has been reported for the first time in 1989 by the Holeta Bee Research Centre (HBRC), Holeta. In a study by Desalegn and Amssalu (2015) over 200 honey bee colonies from all over Ethiopia were analysed and 37% were tested positive for *N. Apis*. They further investigated the severity of an infestation and concluded, that this disease is considered to be a negligible risk for Ethiopian honeybee colonies (Desalegn, 2015; Ellis, & Munn, 2005; Mumoki et al., 2014). Nothing is known about the presence of *N. ceranae* in Ethiopia.

Indonesia: *N. ceranae* is present but there is a lack of data regarding the dangerousness and treating methods of the pathogen, indicating that *Nosema* to our current knowledge represents a negligible risk in Indonesia (Botías et al., 2012; Ellis, & Munn, 2005; Wilson, & Nunamaker, 1983). Nothing is known about the presence of *N. apis* in Indonesia.

2.6.1.4. Chalkbrood

Ascosphaera apis (Onygenales; Ascosphaeraceae) is known to be a heterothallic fungus and the causative agent of the chalkbrood disease. Germinated spores in the intestinal tract of the brood lead to a mummification of the host. If untreated, the pathogen causes death of infected brood due to enzymatic toxicological and mechanical damage (Morse, & Nowogrodzki, 1990; Mumoki et al., 2014).

Ethiopia: *A. apis* is present and its geographical distribution and infestation rate is unequal within Ethiopia. Desalegn (2006) surveyed apiaries around Holeta and found that chalkbrood occurred in 17.4% of inspected honey bee colonies. Unfortunately, only cryptic information is available on chalkbrood disease in Ethiopia (e.g. treatment options, distribution pattern, severity, ...; Haylegebriel, 2014; Pirk et al., 2015). According to a local scientist, chalkbrood is nowadays common in Ethiopian honeybee colonies, but the disease seems to have minor effects on the colonies, and therefore no treatment is applied (pers. communication with Kibebew Wakjira from Holeta Bee Research Center, Ethiopia).

Indonesia: No information is available on chalkbrood disease in Indonesia.

2.6.1.5. Galleria mellonella

Galleria mellonella as well as *Achroia grisella* (Lepidoptera; Pyralidae) are also known as wax moths. Wax moth larvae consume remaining combs and stores. They are also known to not only infest living honeybee colonies, but also the wax comb storages of the beekeeper (i.e. field and store pest). They damage the honeybee colony by tunnelling through the hive with its honey combs, brood and even through the wood. By reducing the mass of the combs, an infestation with wax moths can lead to bald brood and galleriasis. The moths can also function as vector for pathogens. In general, it can be considered, that an infestation with wax moths get severe, if the honeybee colony was already weakened in the first place (Morse, & Nowogrodzki, 1990; Pirk et al., 2015; Pribadi, 2016).

Ethiopia: Wax moths are present all over Ethiopia (>20% infestation level) with the highest prevalence in the months December to March. A study revealed that among the infested colonies, 56-75% absconded or were affected by the parasite (Desalegn, 2015; Pirk et al., 2015). A study conducted by Tolera & Dejene (2014) reported, that wax moths are one of the most threatening pests in the Jimma Zone. Participant beekeepers reported, that 18% of their honeybee colonies were weak and affected by a numerous amount of wax moths. Cleaning the apiary, removing of old combs or hives and strengthening of the colony are considered methods to treat an infestation, or to avoid one with wax moths (*G. mellonella, Achroia grisella*) (Yetimwork, Berhan, & Desalegn, 2015).

Indonesia: According to Crane (1990) an infestation of *A. cerana* with *G. mellonella* can get severe, especially during the summer dearth. This kind of infestation is one of the main reasons of absconding (Crane, 1990). It is recommended to reduce the size of the hive entrance to avoid intrusion of adult wax moths (Pribadi, 2016). However, there is a lack of data on the dangerousness and presence of *Galleria mellonella* and *Achroia grisella* in Indonesia (Kwadha, Ong'amo, Ndegwa, Raina, & Fombong, 2017).

2.6.1.6. *Braula coeca*

Braula coeca (Diptera; Braulidae), also known as bee louse, feeds on nectar and rich in protein jelly directly from the honey bee, as well as on material secreted by the host. Their larvae tunnel through the hive, damaging it and nourish on the honey and pollen (Morse, & Nowogrodzki, 1990). There is evidence, that an infestation of *B. coeca* leads to a reduction of worker bees and further reduces honey production rate (Adeday, Shiferaw, & Abebe, 2012). A study showed, that a treatment with tobacco smoke reduces the amount of *Braula orientalis* and increases honey yield (compared to untreated hives) (Al Ghzawi, Zaitoun, & Shannag, 2009). This method may also be effective for hives, infested with *B. coeca*. At low presence, impact on honeybee populations is negligible, but *Braula* is known to play an important role as a vector of viruses and other diseases (Pirk et al., 2015).

Ethiopia: Adeday et al. (2012) reported an infestation level of 3-6% in Ethiopia, but *B. coeca* is considered to be a negligible risk (Pirk et al., 2015). A study by Haylegebriel (2014) revealed, that the hive type (transitional<modern<traditional) and the management type (apiary<backyard beekeeping) are significantly associated with the prevalence in infestation rate of *B. coeca*.

Indonesia: So far, there is no information on the presence and dangerousness of *B. coeca* in Indonesia.

2.6.1.7. Coleoptera

Aethina tumida (Coleoptera; Nitidulidae) and species from the family Cetoniinae (e.g. *Oplostomus fuligineus*, *Oplostomus haroldi*; Coleoptera; Scarabaeidae) are known as the small, and the adult large hive beetle, respectively (Neumann, Pettis, & Schäfer, 2015; Pirk et al., 2015). The large hive beetle consumes honey, pollen and honey bee brood. It invades the hive, instead of breeding in it (Crane, 1990; Ellis, Hepburn, Delaplane, Neumann, Elzen, 2003). The small hive beetle uses the honeybee hive as a protection from various environmental influences and as a food ressource. The larvae tunnel through the hive and comb store and cause damage to it (i.e. honey combs, brood and pollen) (Neumann, Pettis, & Schäfer, 2015). Based on an endemic distribution range in sub-Saharan Africa, the SHB was brought over sea and introduced to other continents (i.e. America, Australia, Europe) (Ellis, & Munn, 2005). Assuming the beetles are not present in numerous amounts and the honeybee colony is not already weakened, it can be considered, that an infestation with Cetoniinae does not significantly impact the colony (Pirk et al., 2015). Otherwise, the presence increases the rate of absconding in weakened honeybee colonies. In addition, they do play an important role as a vector of viruses and bacteria (Haylegebriel, 2014).

Ethiopia: Small (SHB) hive beetles, native to the sub-Saharan Africa (Neumann, Pettis, & Schäfer, 2015), and the large (LHB) hive beetle are present, but so far it is considered as a negligible pest. However, a study by Alemayehu et al. (in press) revealed, that the small hive beetle may have a negative effect on honey bee colonies, especially in poor managed apiaries and/or hives. They described, that the presence of SHB led to severe reduction in honeybee products (honey, pollen, and also brood). The amount of SHB was higher in months following the dearth periods. Unfortunately, there is no further information on the impact and infestation rate of Cetoniinae on Ethiopian honeybee colonies (Ellis, & Munn, 2005; Pirk et al., 2015).

Indonesia: So far, there is no information on hive beetles in Indonesia (e.g. presence, infestation severity, ...; Neumann, Pettis, & Schäfer, 2015), but assuming a successful host swap, Oldroyd and colleagues believe, that *A. tumida* may become a threat to *A. cerana* due to infested shipments from Australia to Asia (Oldroyd, & Nanork).

2.6.1.8. Ants

Many types of ants are known to affect honeybee colonies, by entering the hive and removing food and brood (Pirk et al., 2015). In general, the bees are able to defend their hive entrance against ant attacks, but if the colony is weakened, or the particular ant species is known to act aggressive, ants can severely impact the colony (Morse, & Nowogrodzki, 1990). To avoid an infestation with ants, Crane (1990) suggests to clean vegetation near the bee hives, use ant-proofed hive stands (long legs, that stand in shallow containers filled with oil, or diesel) and the use of pesticides (Crane, 1990).

Ethiopia: Ants are present and have a severe impact on weakened colonies (especially in honey beehives with poor hive management) (Awraris et al., 2012; Gidey, & Mekonen, 2010; Teklu, 2016). A study conducted by Tolera & Dejene (2014) revealed that ants are one of the most threatening pests in the Jimma Zone (Tolera, & Dejene, 2014). In southeast Ethiopia, ants belong to the most severe pests in beekeeping (Gidey et al., 2012). The assessment of an infestation with ants (western and southern Shoa zone) revealed that 44.2% of honeybee colonies were yearly attacked by ants. 24% of invaded honeybee colonies abscond, while

4.2% are too weak to survive the ant attack. An overall economic loss of 3,839,810 Ethiopian Birr (ETB)/year is estimated due to infestations with ants (Desalegn, 2015).

Indonesia: There is a lack of data regarding the severity of ant-attacks on honeybee colonies in Indonesia, but Crane (1990) mentioned, that ants and their impact on honeybee colonies are one of the most widespread problems for beekeepers in tropical regions. According to her, migrating ant colonies can contain up to 700,000 individuals that raid and kill along its path. Army ants, that are also present in Indonesia, for example forage in groups and are able to invade and destroy a beehive within a few hours (Morse, & Nowogrodzki, 1990; Terrence, & MCGlynn, 1999).

2.6.1.9. *Varroa*

Varroa spp. **(Acari; Varroidae) -** ***V. destructor, V. jacobsoni, V. underwoodi, V. rindereri***

Varroa belongs to the parasitic mites and is known to be one of the most dangerous pests in honeybees worldwide. *Varroa* weakens the colony by feeding on their haemolymph and by acting as a vector for viruses and other pathogens. They enter brood prior capping and reproduce in the sealed brood cells (Crane, 1990; Morse, & Nowogrodzki, 1990; Mengistu, Kebede, & Begna, 2016). The natural host of *V. destructor* was the Asian honeybee *A. cerana*, but due to a host-switch, when the Western honeybee was introduced to Asia, *V. destructor* spread worldwide (Botías et al., 2012).

Ethiopia: There are no reports of high colony losses that are directly linked to the parasitic, introduced *V. destructor* mite, thus in Ethiopia it is not common to treat infested honeybee colonies chemically. Surveys revealed that most Ethiopian beekeepers do not know about the possible impact of *V. destructor* on their colonies (Ebisa et al., 2016). Researcher also do not rule out that honeybee populations in Africa may be more resistant against *V. destructor* due to several factors like climate conditions (i.e. almost no overwintering) (Muli et al., 2014; Pirk et al., 2015).

Indonesia: Several species of *Varroa* exist in Indonesia (*V. destructor, V. jacobsoni, V. underwoodi, V. rindereri*), known to infest different honeybee species and subspecies. Regarding the beekeeping with *A. cerana*, studies revealed, that *V. destructor* seems to be not economically important, not only due to the increased hygiene behaviour of *A. cerana*. Though, increased grooming behavior of *A. cerana* in cleaning and removing *Varroa* mites is not only triggered by exogenous stimuli through visual and olfactory detection, but also on genetics. Unfortunately, there is no data on the impact of *V. destructor* on Indonesian *A. mellifera* (i.e. infestation rate, severity, ...) (Diao et al., 2018; Gupta et al., 2014; Oldroyd, & Nanork, 2009; Rosenkranz, Aumeier, & Ziegelmann, 2010).

2.6.1.10. *Tropilaelaps* spp.

Tropilaelaps spp. (Mesostigmata; Laelapidae) - *T. clareae* belongs to the tracheal mites and naturally infests *A. dorsata* colonies. *T. clareae* is not able to life longer than a few days on adult honeybees, but they are able to infest up to 90% of the brood (Crane, 1990). The infestation of *T. clareae* on *A. mellifera* colonies leads to severe damage that are similar to those of *Varroa destructor* (Oldroyd, & Nanork, 2009). Besides *T. clarae*, other Tropilaelaps species, namely *T. mercedesae* and *T. koenigerum'* are native to Asia (Denis, Anderson, & Morgan, 2007).

Ethiopia: There is no information about a possible presence of *Tropilaelaps spp.* in Ethiopia.

Indonesia: *Tropilaelaps spp.* is present in Indonesia, but there is no data about dangerousness, nor treatment, indicating that *Tropilaelaps* represents a negligible risk in Indonesia (Oldroyd, & Nanork, 2009; Ellis, & Munn, 2005).

2.6.1.11. *Acrapis woodi*

Acaris woodi (Acari; Tarsonemidae) belongs to the tracheal mites and is known to infest young adult honeybees and nourish on their haemolymph. It has been shown, that the presence of *A. woodi* negatively affects the life span of bees. Crane (1990) claimed that the infestation rate of *A. woodi* is correlated with the quality of the beekeeping and the richness of melliferous plants in the environment (Crane, 1990).

Ethiopia: There is information on the presence of *A. woodi*, but none on the dangerousness of the parasite on African (i.e. Ethiopian) honeybee colonies (Pirk et al., 2015).

Indonesia: According to Ellis and Munn (2005) *A. woodi* is expected to be absent in Indonesia, due to limited investigations made with negative results (Ellis, & Munn, 2005).

2.6.1.12. Others

There are several other pests, pathogens and predators affecting the health of honeybees:

Malpighamoeba mellificae (Amoebozoa; Malpighamoebidae) is known to be the causative agent of amoeba disease. *M. mellificae* is a single celled parasite affecting the malpighian tubules of honeybees. As a result, the life cycle of bees is shortened (Haylegebriel, 2014).

Ethiopia: Within Ethiopia, the existence of *M. mellificae* has first been reported in 1998 by Amssalu and Desalegn, but the risk of an infestation is considered negligible (Desalegn, 2015; Haylegebriel, 2014).

Indonesia: There is a lack of data regarding the status of *M. mellificae* in Indonesia!

Birds of the family Meropidae (Coraciiformes). A single bee eater is able to consume up to 600 honey bees per day (Pirk et al., 2015).

Ethiopia: Bee eaters are present within Ethiopia, but their occurrence does not have a severe impact on local apiaries. They attack honeybee colonies especially during rainy seasons and beekeepers may decrease bird pressure by setting up scarecrows in their apiary (Awraris et al., 2012; Pirk et al., 2015; Teklu, 2016).

Indonesia: So far, there is no information on the impact of birds on honeybee health in Indonesia.

Mellivora capensis (Carnivora; Mustelidae). The honey badger breaks up the hive to rob the combs and feed on it (Crane, 1990).

Ethiopia: The honey badger damages honey bee colonies in the months November to April due to increased brood and honey in the hives (Awraris et al., 2012; Gidey et al., 2012).

Indonesia: *M. capensis* is not present in Indonesia (Jana, Vanderhaar, & Hwang, 2003).

2.6.2. Dealing with honey bee health issues

Ethiopia: According to a local scientist (personal communication with Kibebew Wakjira from Holeta Bee Research Center, Ethiopia), beekeepers, who recognise honeybee health problems within their bee colonies, have to report to the district livestock offices. Most of the beekeepers have a lack of knowledge when it comes to identify pests like *Varroa*, or microscopic pathogens like fungi or bacteria. Thus, they report the observed symptoms and/or pass on samples of the hive to the district livestock offices. The office responds to the report and if they cannot help properly, they collect the information or even samples from the particular apiary to send it to the Holeta Bee Research Center for further identification and to provide required solutions. Based on the outcome, they give feedback and offer suggestions for handling the health issue. If there is no outcome, the honeybee health team will travel to the localities to further study the case. Unfortunately, there is a lack of published information on that topic.

Indonesia: According to a local scientist (personal communication with Marlis Nawawi from Universitas Padjadjaran, Indonesia), the beekeepers of disease affected apiaries do not pass on the information to a governmental office, nor to a beekeeping association, but informally exchange their observations with other beekeepers who already gathered experience with the particular honey bee health issue. There is no regularly conducted assessment on honey bee health of Indonesian government, because beekeeping is still considered to be a "second class farm activity". Unfortunately, there is a lack of published information on that topic.

2.6.3. Treatments (if any) commonly applied to different pests

Ritter and Akratanakul (2006) published a guide that summarizes the most common honeybee pests and diseases as well as its most favorable treatment methods. The publication is available as open access via the website of FAO (Ritter, & Akratanakul, 2006).

Ethiopia: To treat an infestation with **ants**, Ethiopian beekeepers use several methods such as placing the hive on small cans and fill them with ash and dirty engine oil, bring out ash around the **hive**, frequent smoking or using local eucalyptus leaves for fumigation (Gidey, & Mekonen, 2010; Teklu, 2016). Several studies revealed that ants are one of the most threatening pests in Ethiopia (Teklu, 2016; Tolera, & Dejene, 2014). Modern methods include the use of benzene, malathion and smooth iron sheets (Teklu, 2016). People use dogs or cats, fence their apiaries or hang their hives into trees to protect them from predators like **honey badgers or mice**. One traditional method to "treat" an infestation with **bee lice** is smoking or fumigating the hive with e.g. tobacco, dung, grass, or offer supplemental food (Bekele, Genet & Temaro, 2017). So far, no information on regular treatment against ***varroa*** mites was published, it therefore can be considered, that in most regions of Ethiopia, no treatment at all is applied. Reasons may be a lack of knowledge on the severe impact of ***Varroa* spp.** on honeybees or simply a higher resistance of African honeybee populations may be possible. Studies suggested that **propolis** acts as a natural acaricide and therefore may be a possible treatment method against ***Varroa*** (Ebisa et al., 2016; Shimelis, Yared, & Desalegn, 2016). In a study conducted by Teklu (2016), beekeepers from southern Ethiopia practiced following traditional methods to destroy mites in the hives: burning, killing, and removing the whole hive (Teklu, 2016). To treat an infestation with the **Small Hive Beetle** (SHB), Alemayehu et al.

(2018) recommend to combine seasonal colony management (removing unoccupied frames, regular hive cleaning, additional feeding in the dearth period, …) with the trapping of **SHB**s' larvae by dead brood trap to increase the treatment success (Alemmayehu, Amssalu, & Taye, 2018). Other treatment methods include the use of DDT, or roach killer but those methods have a negative effect on the environment (Teklu, 2016). Cleaning the apiary, removing of old combs or hives and strengthening of the colony are considered methods to treat an infestation, or to avoid one with **wax moths** (***G. mellonella***, ***Achroia grisella,*** Yetimwork, Berhan, & Desalegn, 2015). Summarized, traditional control methods against ants, wax moths, beetles mammals or birds are practiced (Teklu, 2016), but the treatment of "invisible" organisms like fungi, or bacteria is not common at all (Bekele et al., 2017).

Indonesia: So far, there is almost **no information** on treatment methods against pests affecting honeybees in Indonesia except that local beekeepers reported about killing wasps and hornets in the apiary.

2.6.4. Threats for introduction of new pests

Throughout history, with all the exploration trips and globalization, diseases affecting **honeybee health** have been spread worldwide. That led to host-shifts of pests/pathogens between introduced and native honeybee species and subspecies. ***Varroa destructor*** and ***Nosema ceranae*** are known to have swapped over from ***A. cerana*** to ***A. mellifera***, when the Western honeybee was introduced to Asia. On the opposite, **Thai Sac Brood Virus**, **Israeli Acute Paralysis Virus** and several **tracheal mites** were originally observed in *A. mellifera* before spreading to *A. cerana* (Botías et al., 2012; Theisen-Jones, & Bienefeld, 2016).

Ethiopia: The exchange of diseases or parasites is always possible through neighbouring countries (i.e. Eritrea, Uganda, Somalia, Kenya, Sudan, South-Sudan, or Djibouti). For example, foulbrood is so far no officially observed disease in Ethiopia, but was detected in Eritrea and therefore may spread through the international border to Ethiopia and other neighbouring countries (Ellis, & Munn, 2005). Another notable factor is the international trade and transport of honeybee colonies.

Indonesia: The country consists mainly of islands but also shares borders with Malaysia and Australia. Despite Australia is known to have strict border regulations, the rate of disease exchange is high at over-land boundaries (Thompson et al., 2003). There is almost no information on honeybee disease distribution in Indonesia, but it is considered, that the transport of goods over sea is also a major risk for the distribution of pests and pathogens. One example for a possible future threat for Indonesians' *Api*sector is the small hive beetle (SHB). While there is no data on the presence/absence in Indonesia, SHB occurs in the neighbouring Australia (Theisen-Jones, & Bienefeld, 2016). As mentioned above, international trade and transport of honeybee colonies are also considered to be a risk regarding the introduction of new pest

2.7. Education and dissemination

Ethiopia: In general, most of the Ethiopian beekeepers are not properly trained and have not visited beekeeping training centers, but gained their knowledge from further generations within the family/village (Fichtl & Adi, 1994). There is not much information on beekeeping training sites, but one example is: “Honeys of Ethiopia”, a network that brings together producers and consumers. They offer technical support, knowledge exchange and beekeeping training, and they also promote the products nationally and internationally (Honey of Ethiopia, 2018). The Ethiopian Society of Apiculture Science (ESAS) provides training manuals that can be purchased from the office of ESAS. They were written in English and in three different local languages and they contain guidelines/manuals for quality production, honeybee product harvesting and postharvest management (Negash & Greiling, 2017). Holeta Bee Research Center also provides hard copies of simplified training manuals for beekeepers, including a production manual for different beekeeping equipment. There are also several **Beekeeping associations** and projects formed by NGOs and GOs, aiming the training of Ethiopian beekeepers.

Indonesia: There is no information about the state of beekeeping knowledge of local Indonesian beekeepers (bee biology, hive management, threats, ...). Do they gain their knowledge from further generations, or is there another source (e.g. beekeeping training center). “Perum Perhutani” is a govermental organisation that introduced a beekeeping program in 1974 and is located in central Java. The responsibilities reach from research and development (forage, breeding, honey bee health, hive management, feed supplement, ...) and training of rural beekeepers, to reengineering equipment for hive management, quality control, processing honey bee products and promoting bees to improve their reputation.

3. Possibilities for smart bee management (Precision Beekeeping)

To assess the status of a honeybee colony, the beekeeper needs to visually inspect the inside of the **hive**. This procedure is time consuming and may stress the colony. The active monitoring and remote sensing by appropriate ICT solutions (Precision Beekeeping) may be a useful tool to support the **management** of **honeybee health**, colony development and even the bee productivity. One practice for Precision Beekeeping is the use of **Decision Support Systems**. Without sufficient data analysis it is not possible to get added value from different bee colony measurement systems. Decision Support System (DSS) can be adapted for the Precision Beekeeping for automatic data analysis and is considered as one of the sub-systems of the Precision Beekeeping. Using different algorithms and models, DSS can help the beekeepers to identify different bee colony states and warn about abnormal situations of the colony. Different bee colony states may have different levels of importance and can be identified with different levels of reliability. DSS can process and combine data related to the bee colony weight, temperature, sound etc. DSS decisions can be split into two groups: individual rules, which are based on single colony monitoring and differential rules, which are based on comparison of different colonies within one apiary.

Table 4: Smart management possibilities for bee colony state detection. Bold events/states were identified to be the most relevant for the SAMS project. Asterisks (*) rank the importance, technical feasibility, grade of innovation and predictability of each event or colony state.

Event or state of the colony	**Importance to the beekeeper** (from less* to more important***)	**Traditional detection method**	**Parameter to measure**	**Technical Feasibility** (from easy* to complicated***)	**Innovation** (from already existing* to new***)	**Predictability** (from not-, easy* to complicated***)
Start of the mass nectar flow	***	Observation of the flight activity outside the hive	Weight	*	*	Flowering calendar
End of the nectar flow	**	Evaluation of the colony	Weight	**	*	**
Swarming	**	Observation of the swarmed colony	Temperature, sound, weight	***	**	***
Pre-Swarming	**	Visual observation of the colony	Sound	***	***	-
Queenless	**(*)	Detailed visual observation of the colony	Temp., sound	***	**	-
Broodless	**(*)	Detailed visual observation of the colony	Temp., sound	**	**	-
Absconding	***	Detection afterwards	Temp., weight	*	***	-
Colony Collapse Disorder (CCD)	**	Detection afterwards	Temp., weight	*	***	-
Death	***	Visual observation of the colony	Temp., sound, weight	*	*	-
Colonisation	?	Visual observation	Temp., sound, weight	*	***	-

3.1. Identify threshold values for honey harvest

There is almost **no information** on threshold values for the honey harvest, but placing the hive on a **scale** allows to gather information about possible **honey harvest times**, or to estimate the **amount of food reserves**. Collecting continuous data provides information on not only colony growth or food consumption, but also on variations in **nectar or pollen availability**, and absconding of colonies. It has to be mentioned, that weather conditions and the hive types (various moisture levels) have influence on the weighting-data (e.g. strong winds, snow, rain, …; Meikle & Holst, 2014)

3.2. Identify swarming events

Bees produce specific sound patterns (Zaecepins et al., 2016). During a study conducted by Ferrari and colleagues (2008), an **in-hive sound recording** (microphone) of 270 h revealed, that the sound characteristics and temperature change at swarming events. While the **sound frequency increased** from a range of 100-300 Hz to 500-600 Hz, the **temperature drops** from 35 °C to 33 °C. In comparison, Seeley and Tautz (2001) observed that certain workers start to emit short whistling tones with a rising frequency of 100-200 Hz to about 200-250 Hz about 1 hour prior reproductive **swarming occurs**. They further indicated that this tone causes other bees to prepare for departure by warming up their flight muscles. Bencsik and colleagues (2011) used **accelerometers** and its vibrational amplitudes to explore the swarming behaviour of *A. mellifera* resulting in a **correlation of data with occurred swarming events**. For further improvement of the study setup, they suggest to combine the used methods with a **weather monitoring logging device** and to use a pattern recognition algorithm that is more complex than the cross-correlation function used for their study (Bencsik et al., 2011). Another useful information to predict swarming events and to assess **honeybee health** problems is gaining knowledge about the particular **brood cycle**. In a further study by Bencsik et al. in 2015, a **correlation between vibrational amplitude data and the brood cycle** in a close range of the sensor was found. They further suggest, that the process of brood cycle monitoring could be conducted with only one-hour measurements during the night.

3.3. Technical feasibility/SAMS definitions

- **Start mass nectar flow:** increase in weight by a certain percentage (e.g. 10%) compared to the average weight data of the last few days. The percentage value may be country- or operation depending.
- **Active foraging:** bees bring in slightly more nectar than they consume overnight (beehive's weight steadily increases over several days or stays more or less the same). Theoretically, during active foraging, a distinctive pattern in weight data should be noticeable.
- **Consumption during dearth periods** (winter in temperate zones, dry/rainy season in tropical zones): bees consume stored honey (beehive's weight decreases).
- **Swarming:** Detection of such a state is possible by temperature, sound or weight data. Since bees prepare their flight muscles (by heating them) before leaving the hive, the temperature inside the hive also increases, thus this can be observed in measured hive temperature data. Several researches have been dedicated to audio data analysis regarding bee colony state detection, including swarming. During these studies it was found that there is a distinguishable shift in frequencies during swarming event.

- **Queenless/Queenright:** Some authors were able to determine potentials for the detection of the queenless state with analysis of audio data by applying artificial intelligence methods (Nolasco et al., 2019; Robles-Guerrero et al., 2019).
- **Broodless:** Detection of this state could be possible by temperature data. During brood rearing bees try to maintain stable temperature (34-36°C), but during broodless state temperature inside the hive tends to depend on ambient temperature (Stalidzans & Berzonis, 2013).
- **Absconding:** Absconding is still not investigated enough. Theoretically, by the assumptions of the SAMS project, it should be determined by temperature and weight data. After absconding there are no "living beings" that could perform thermoregulation inside the hive, therefore a noticeable weight reduction should also be observed.
- **Death:** Death of the colony can be detected by the temperature measurement or/and by sound. Death detection could involve a comparison between real-time colony temperature with the environmental temperature and if the difference is not significant, then it can be concluded that the colony is dead.

3.4. Biological definitions

Nectar flow: The nectar flow is the period when forage (pollen, nectar) is available to bees. During this period, the nectar production is higher than the nectar consumption resulting in a surplus beyond the colony's needs - the bees are able to convert nectar into honey and store it in honey combs (GOV, 2015). It is important that the beekeeper is familiar with the major nectar flow periods (vegetation, quality of nectar sources) in the apiary surroundings, including their starts to optimize colony management and honey production (Bayir & Albayrak, 2016).

- **Start of the nectar flow:** The beginning of the active foraging state of a colony. This event is set by the time melliferous plants in the surrounding area start blooming and provide nectar to the bees.
- **End of nectar flow:** The event when major and minor forage sources ceased blooming and the bees must feed on their stored honey in the hive.
- **Mass nectar flow:** If a major nectar flow is in bloom, bees are able to collect the nectar in high abundances. This event rarely occurs in nature but rather occurs in "man-made" gardens or agricultural lands with lower diversity.

Swarming: Colony reproduction in honeybees is called swarming. A certain pheromone concentration triggers this behaviour which is mostly correlated to a strong colony growth - the workers start rearing new queens. The first (prime) swarm is headed by the colony's own queen and leaves the nest a few days before the new queens emerge from the cells. The prime swarm settles in a new area and, if successful, establishes a new bee colony. In cases where the original swarm is still large, a newly emerged queen leaves the nest with an afterswarm (cast). The original, or parent colony that remains in the nest, or any cast is led by a queen who has genes inherited from the previous queen and from a different father-drone (Crane, 1990). Often swarming activity is undesirable for beekeepers, as the reduced population size has a negative impact on the productivity of the colony.

Queenless/Queenright: A queenright bee colony comprises of bee brood, adult bees (female worker bees and in the brood rearing season male drones) and one reproductive honeybee queen. Queenless colonies do not have a queen. Reasons for the absence are the death of the queen in the hive or during her mating flights, or by removal of the queen by the beekeeper. If fertilized eggs and young larvae are present, or are provided by the beekeeper, the colony is able to rear a new queen. If the colony has no open brood available, or if the beekeeper does not provide a new queen ("requeen"), the colony will die (Crane, 1990).

Broodless: A honeybee colony is broodless, if there is no brood (eggs, larvae, or pupae) in the colony. Natural broodless states occur in healthy bee colonies, are country depending and emerge during dearth periods (winter, dry season, rainy season…) or concern colonies who have recently swarmed and have no mated queen yet. Besides, broodless states can also occur unnaturally during the active brood rearing cycles of honeybees. Most of the time unnatural broodless states or nearly broodless states are related to the manipulation of the beekeeper, for example by using substances for *varroa* mite control (formic acid). Cases that are not related to the mentioned scenarios most often have a pathological origin. Either way, broodless states should be investigated (Crane, 1990).

Absconding: „Absconding comprises the departure of all adult bees of a colony from their nest, leaving behind whatever brood and stores are in it. Absconding may be due to a shortage of food, to disturbance, or to other adverse circumstances (Crane, 1990). Absconding occurs more often in tropical honeybee species.

Colony Collapse Disorder (CCD): CCD is a phenomenon that occurs if a bee colony breaks down for unknown reasons and was originally observed in America, where beekeepers complained about a large-scale loss of their managed honeybees. Within the last few years, the phenomenon spread over to other continents and today, is seen as a global risk for honey bees (Dainat, van Engelsdorp & Neumann, 2012; van der Zee et al. 2012; 2014; Brodschneider et al., 2016; 2018; Gray et al., 2019). CCD has several specific symptoms: the rapid loss of adult worker bees (brood and immature honey bees are still found in the nest), the absence of bodies in or around the affected hives, the delayed infestation of hive pests (e.g. kleptoparasites such as small hive beetles, wax moths, …).

Death: Colony death has a variety of reasons and reach from diseases or pests affecting the colony, over starvation to high exposure of pesticides. Depending on the cause of death, the appearance of a dead colony also differs. For example, in CCD, there are almost no dead bees around the hive, while it is the case if the colony was affected by a pest or pathogen. In the latter case, the sister bees clean their hive from sick bees to counteract the threatening organisms. In comparison, poisoned bees, for example through pesticides, are abundantly found in the hive.

Colonisation: Empty hives got occupied by a (feral) bee swarm. Beekeepers in many parts of the world, especially in tropical regions depend on the natural colonization of bees in provided hives. Those "bait beehives" are positioned on routes known for bees using them during swarming or migration activities (Nuru et al., 2002).

3.5. SAMS-system based recommendations/management options

For a selection of the most important (highest ranked) defined events that can be detected by a remote sensing system (table 4), illustrations and recommendations based on scientific evidence and good beekeeping practice are given within this chapter.

3.5.1. Mass nectar flow

Explanation: during **nectar flow** bees collect nectar and pollen to sustain their colony. If a major nectar flow is in bloom, bees are able to collect the nectar in high abundances. The surplus of nectar is converted into honey and stored in the hive.

Output SAMS-system: increase in weight by a certain percentage (e.g. 10%) compared to the average weight data of the last few days. The percentage value may be country- or operation depending.

Recommendations:

- Have a look into the hive.
- Check if the honey is ripe (when >70% of the frame is sealed; no brood on the frame): use a refractometer or do a shake test (turn the honey frame horizontally and shake it jerkily - if splashes are observable, the honey needs more time).
- extract the honey and leave enough forage to the bees.
- protect your product from direct sunlight and store it in a dry surrounding.
- If the honey is not ready yet, do nothing and close the hive.

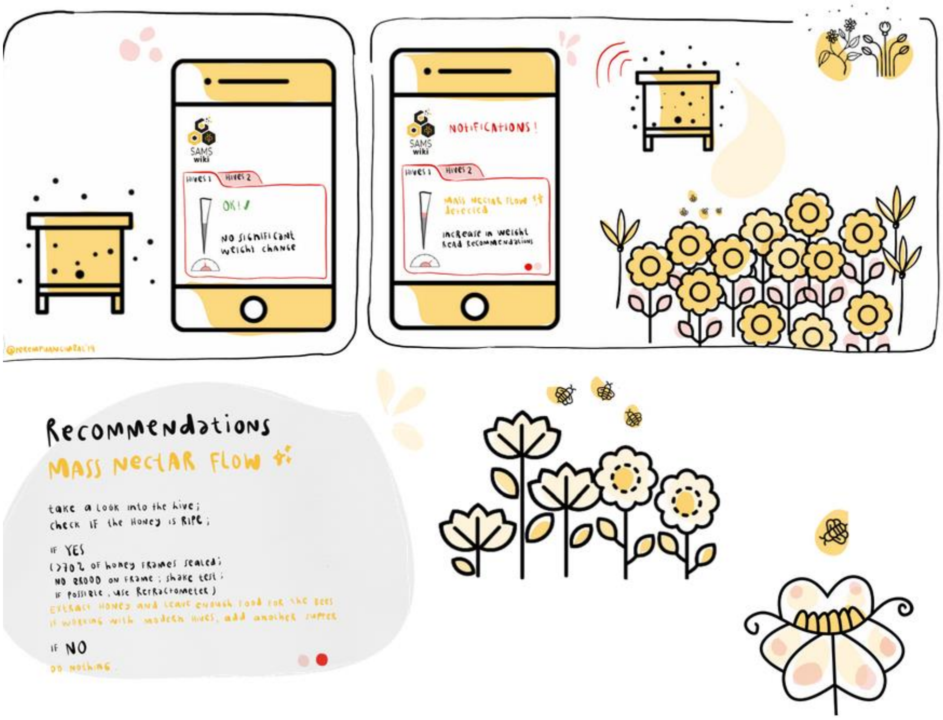


Figure 33: SAMS-system based recommendations for a mass nectar flow (illustration: Perempuangimbal/LabtekIndie/SAMS project).

3.5.2. Absconding

Explanation: **Absconding** behaviour occurs when the environmental conditions for bees are unfavourable (food shortage, disease/pesticide pressure). As a result, the honeybees leave their nest/hive and leave food and brood behind. The behaviour is mainly observed in tropical regions.

Output SAMS-system: Theoretically, absconding should be determined by temperature and weight data. After absconding happened, there are no “living beings” that could perform thermoregulation inside the hive, therefore a noticeable weight and temperature reduction should be observed.

Recommendations:

- Have a look into the hive.
- If absconding has not taken place yet, revitalize with two frames containing adult bees, brood and pollen.
- Alternatively, requeen the colony.
- If the colony already absconded think of sanitation decisions. A sanitation decision includes the cleaning and disinfection of the affected hive to avoid disease-transfer. Possible methods are to flame-scarf the inside of the hive (frames and equipment), or to use chemicals (bleach, caustic soda, similar substances...). Please adhere to the instructions and work carefully.

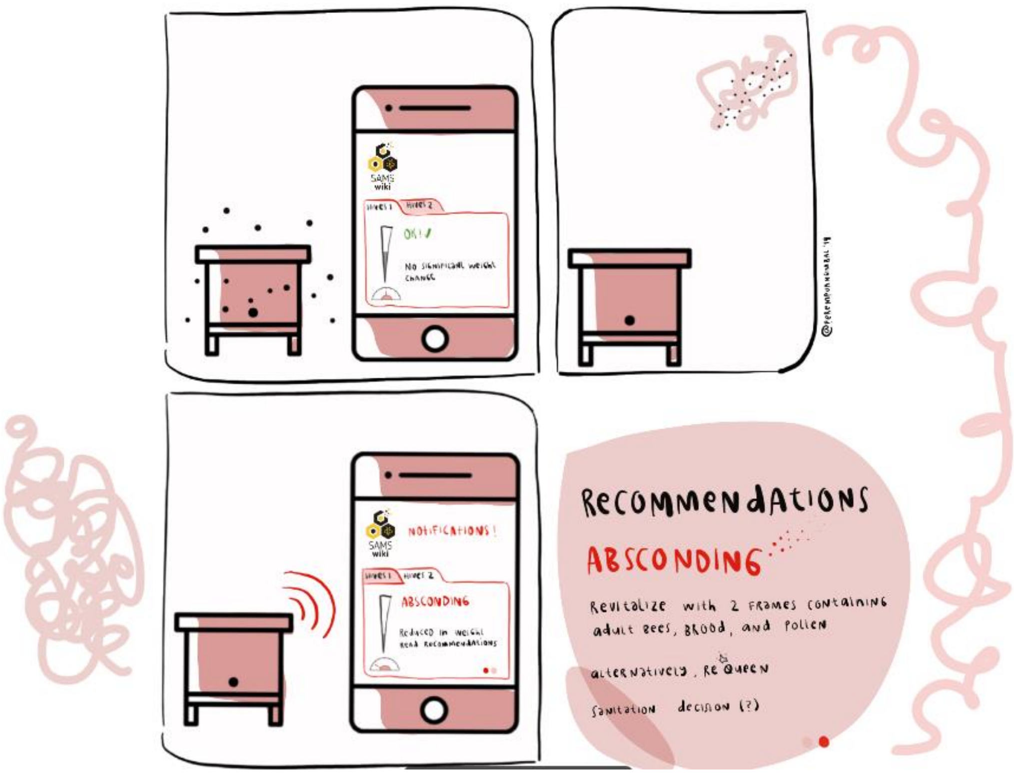


Figure 34: SAMS-system based recommendations for absconding (illustration: Perempuangimbal/LabtekIndie/SAMS project).

3.5.3. Broodless state

Explanation: A **broodless state** is defined as a bee colony without brood (eggs, larvae or pupae). Natural broodless states occur in healthy bee colonies, are country depending and emerge during dearth periods (winter, dry season, rainy season…) or concern colonies who have recently swarmed and have no mated queen yet. Besides, broodless states can also occur unnaturally during the active brood rearing cycles of honeybees. Most of the time unnatural broodless states or nearly broodless states are related to the manipulation of the beekeeper, for example by using substances for varroa mite control (formic acid). Cases that are not related to the mentioned scenarios most often have a pathological origin Either way, broodless states should be investigated.

Output SAMS-system: This state could be detected by monitoring the temperature. During brood rearing bees try to maintain stable temperatures (34-36°C), but in broodless states the temperature inside the hive tends to depend on the ambient temperature.

Recommendations:

- Note: depending on the season and climate zone, broodless states are desired (e.g. winter in temperate zones).
- Unexpected broodless state: have a look into the hive.
- Add frames containing adult bees, open brood (eggs and larvae) to the broodless colony.

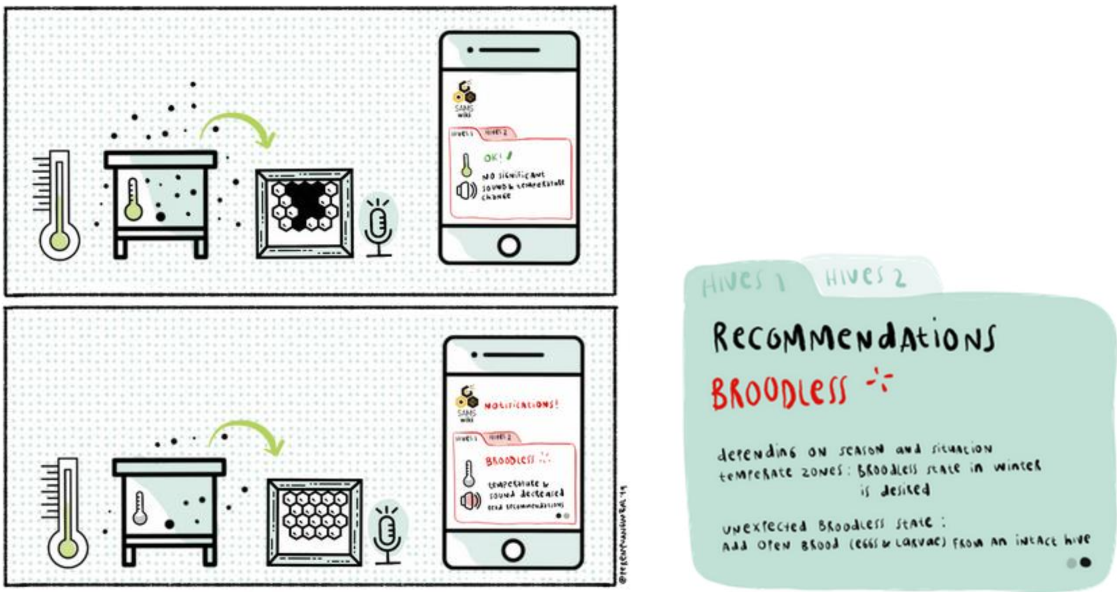


Figure 35: SAMS-system based recommendations for broodless states in the colony (illustration: Perempuangimbal/LabtekIndie/SAMS project).

3.5.4. Death

Explanation: Colony death has a variety of reasons and reach from diseases or pests affecting the colony, over starvation to high exposure of pesticides. Depending on the cause of death, the appearance of a dead colony also differs. For example, in CCD, there are almost no dead bees around the hive, while it is the case if the colony was affected by a pest or pathogen. In the latter case, the sister bees clean their hive from sick bees to counteract the threatening organisms. In comparison, poisoned bees, for example through pesticides, are abundantly found in the hive.

Output SAMS-system: Death of the colony can be detected by the temperature measurement or/ and by sound. Death detection could involve a comparison between real-time colony temperature with the environmental temperature and if the difference is not significant, then it can be concluded that the colony is dead.

Recommendations:

- Have a look into the hive.
- If the colony died: close the hive entrance; hives without bees attract robbing bees from neighbouring colonies (risk of disease-transfer or transfer of toxic substances).
- Sanitation of the hive (frames and equipment) by cleaning (flame-scarf) and disinfection (bleach, costic soda, similar substances...).

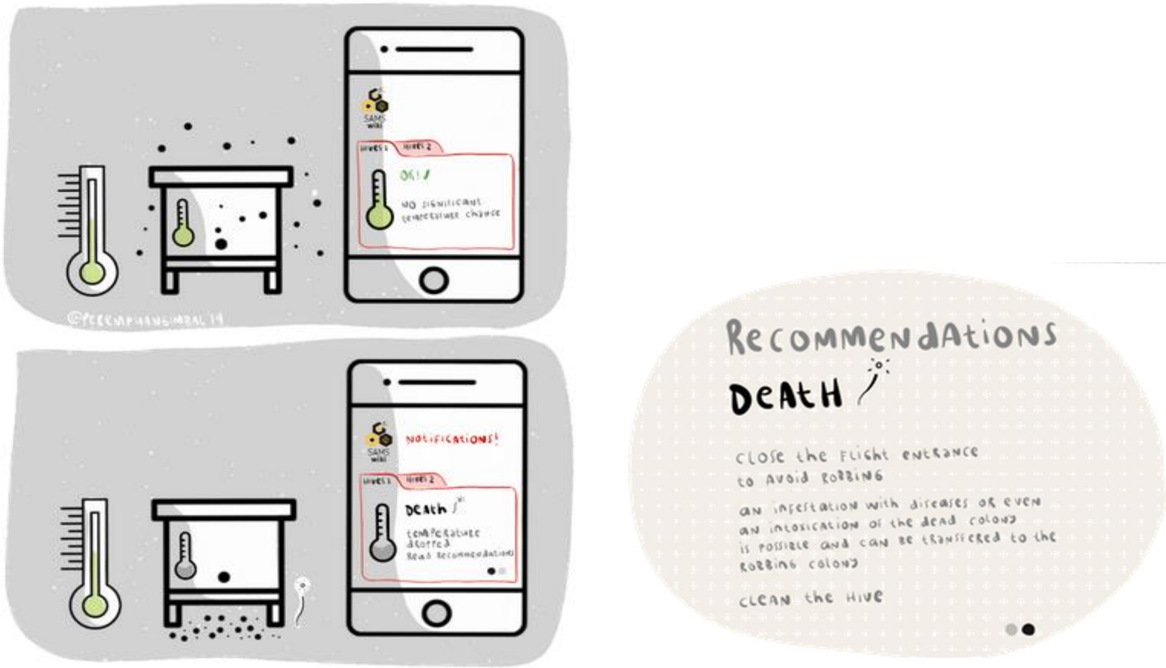


Figure 36: SAMS-system based recommendations for a dead colony (illustration: Perempuangimbal/LabtekIndie/SAMS project).

4. Bee management and bee health guide

Good beekeeping practice (GBP) affects the health and productivity of a bee colony. As GBP strongly depends on its regional and environmental surroundings, it is not possible to formulate global rules of GBP. Within chapter 4 “Bee management and bee health guide” a very basic guideline is given on the most important beekeeping activities. To guarantee methods that are practiced in tropical climate, most of the content within the following chapter was retrieved from the books "Beekeeping Manual for beginners" by Holeta Bee Research Center and the APIRE project and from "Advanced Beekeeping Manual by Ethiopian Beekeepers Association and Netherlands Development Organization (SNV-Ethiopia). In addition, 10 “rules” of honeybee management were developed together with experts from Europe, Ethiopia and Indonesia. They are represented in chapter 5 “10 rules of honey bee management”.

4.1. Apiary site selection

An apiary is defined as the place where bees are kept in the hive to forage nectar and pollen grains in order to produce honey and other hive products. The size of apiary could be mainly limited by: types and abundance of bee forage, location, capital investment and skilled manpower.

Natural vegetation: The presence of natural plant habitat and cultivated crops near and around the apiary is the basic requirement for the establishment of apiary. The natural vegetation composed of forest trees, shrubs, herbs and climbers provide adequate nectar and pollen for the foraging bees. Besides the natural vegetation, the availability of cultivated crops such as oil crops (rape seed, linseed, sunflower, sesame), cereals (maize, sorghum), vegetables (pea, chick pea, grass pea), horticultural plants (citrus, mango, avocado, banana, coffee), and forage crops (vetch, alfalfa, clover species) has also paramount importance. Be aware that most of the agricultural plants are treated with pesticides and herbicides and therefore may harm the bees foraging on them. Generally, melliferous plants should be available for bees within a 2 to 3 km distance from the apiary.

Fresh water: Honeybees need water not only for individual consumption but also for brood rearing and hive ventilation. Water is searched by the bees all the seasons but more during the prolonged dry months. A water source (e.g. river, or lake) near the apiary is obligate. It is also possible to bring fresh water to the apiary site using an earth canal or a water bucket.

Presence of native honeybees: Use bees that are native to the area you are living in. Prior to site selection it is better to observe foraging bees or ask the local people for the presence of bees in the area.

Suitable altitude: The altitude effects plant availability and population distribution of honeybees. According to survey result of MoA altitude ranging from 1000 - 2400 m.a.s.l is the most suitable for commercial beekeeping.

Avoid chemical substances and pollution: Chemicals such as pesticides sprayed on crops poison honeybees while foraging on flowers. This may lead to mass death or weakening of bee colonies. Therefore, the apiary site should not be exposed to chemical substances. If nearby agricultural lands need to use such substances, the beekeepers should take some measures or should negotiate with crop growers. If a negotiation does not work, think of transferring your apiary to a new place with lower exposure to pesticides and herbicides.

Presence of diseases and pests: There are many enemies of honeybees such as ants, wax moth, beetles, bee-eater birds, honey badgers but also almost or completely invisible pests such as mites, bacteria or fungi can become a serious problem causing great losses to both honeybees and their products. Therefore, in site selection, the area should be free from various pests, predators and diseases incidence.

Consideration for neighbours or the general: Establishing good relations with neighbours, local farmers, land owners and the general public is a major factor in finding and maintaining a successful apiary site. Talk to them about the value of bees as pollinators; educate them about swarms, flight paths etc. The general public is often ignorant and frightened of bees. If they become alarmed about the presence of bee hives, their complaints can result in loss of the apiary site of a beekeeper. In general, it is not advisable to establish an apiary near schools, hospitals, dairy and poultry farm sites, and market places.

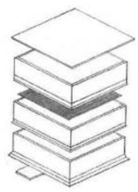
Accessibility: Accessibility to the apiary is essential; perhaps the most important factor in apiary site selection, because the beekeeper must visit it throughout the year at all kinds of weather. Avoid locations with great distances, as carrying equipment and heavy supers is part of the beekeeping business. Easy movement of equipment in and out of the apiary ensures that a beekeeper's routine activities will be productive.

Hive placement and orientation: It is important to keep hives away from fertile spots or farmland: they should be placed on rocks or on the poorest portions of the land, for which the beekeeper has little or no other use. Shade from trees retards the flight of workers. Direct sun exposure of hives all day also forces bees to gather a lot of water in order to cool the hive. So, the apiary is best situated near natural wind protection such as hills, buildings, or evergreen. Providing shade may be important, depending on the climate. Other requirements are a dry ground and good air drainage. Hives should be arranged in such a way that the distance between two colonies is at least 1.5 m if they have to be oriented in straight rows, as this leads to drifting of bees between colonies and also the possibilities of robbing. If not, colonized beehives must be arranged in zigzag or in "S" shape fashion.

4.2. Beekeeping equipment

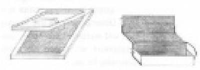
Beekeeping equipment is material used for beekeeping and beekeeping related activities. Some of the most important materials needed for modern beekeeping are:

Beehive (frame hive): use and reuse of frames/combs is possible; handling (inspection, supering, reducing supers, pest/predator control …) is easier and honey extracting without damaging the combs is possible. In some parts of Ethiopia, using this hive leads to an annual honey yield of about 25 to 45 kg. With experience and good beekeeping practice even a better honey yield is possible.

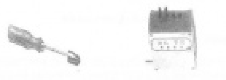


Frame wire: the wax foundations get attached to the wires.

Casting mold: to produce wax foundation sheets.

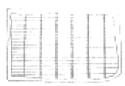


Transformer and Embedder: through heat, the transformer or embedder are used to attach the foundation sheets to the wire.



Embedded knifes: hot iron sheets or knifes help to fix the wax foundation sheets to the frame wire.

Queen excluder: a device to separate worker bees from the queen, drones and brood. This guarantees honeycombs without brood in it. The queen excluder can be produced from plastic, flat iron sheets, wires, aluminium or stainless-steel metals.

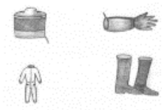


Chisel (bee keeper's or hive tool): is made of iron metal and has a sharp surface on the end. Mostly, it is considered as a hand tool of a beekeeper used to open the hive, cleaning purposes and other unnecessary materials seen in the hive. It can be made locally or its purpose can be replaced by a knife.

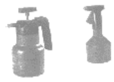
Bee brush: a soft brush used to remove bees from frames or to clean the bottom board of the hive.

Smoker: during the inspection of the hive, smoke (herbals, plant based and natural materials) can be used to calm the bees.

Protective Clothes for the beekeeper: this includes gloves, a bee veil, an overall, or jacket (bee suits) and boots.



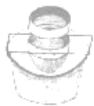
Water Sprayer: is sometimes used to calm down the bees during bee colony transferring and swarm catching.



Uncapping – fork or knife: the fork is used to manually decap the combs prior to putting them in the honey extractor.

Honey extractor (centrifuge): hand or electrical driven. Honey combs are inserted in the honey extractor and the honey gets out of the combs through centrifugal force.

Honey strainer: is a double course screen used to remove the bits of wax and other debris during the normal extractions of honey from the comb.



Honey storage tank: extracted honey is best stored in a tank made of stainless steel or food grade plastic and a very tight lid. The tank should be storage in a dark and cool place.

Honey weighing scales: to weigh honey prior to selling it.

Honey jars (glass or plastic): for selling the harvested honey.

Pollen Trap: The pollen trap is mounted in front of the hive entrance. If closed, the bees walk through a tight mesh and lose their collected pollen. The pollen falls in a drawer, which easily can be collected by the beekeeper.

Propolis grid: the propolis grid, made of wood, metal or plastic, can be placed under the lid of the hive, or between the frames in the hives. Bees are driven by their instinct and close the holes in the grid with propolis. The propolis can be harvested by placing it in a cold room, or a refrigerator.

4.3. Bee colony transfer

Preparations

To transfer bee colonies from a traditional or a nucleus hive to a transitional, or a modern frame hives several arrangements have to be made:

- Bring the bees and the hive to the new site to acclimate them to the new surroundings.
- Fence the area if predators live nearby.
- Only use pure beeswax (no chemicals) for the wax foundations.
- Prepare wax foundations for the new hive (frame wire, embedded knife or transformator, casting mould).
- Clean the new hive and frames prior to any operation.
- Prepare the new site by clean the ground from plants and based on your region or topographies (e.g. backyard beekeeping) do the transfer process in the evening. Avoid sites near frequently used roads or agricultural fields.

Equipment

- New hive
- Activated smoker
- Bee brush
- Water sprayer (optional)
- Bee hive chisel
- Knife
- Collection pan for old combs and another one for smooth honey combs
- A flat sheet to place the hive on during transfer
- Wagon for transporting unused materials
- Wire or rope
- Queen cage
- Feeder frame, or box for supering
- Needle and rope
- Protective clothes

Transfer of the bee colony from a traditional (Ethiopia) hive into a modern frame hive

1. Put the prepared sheet on the ground.
2. Place the smoker, the bee brush and the optional water sprayer nearby.
3. Place the traditional hive on the sheet/mat and keep its position (do not roll it!).
4. Bring the new hive near the sheet and open the lid/cover of the frame hive; the entrance of the frame hive should be towards the mat.
5. From now on work carefully to avoid damaging the bees or the queen bee.
6. Open the lid of the traditional hive and immediately smoke around the edges.
7. Remove the combs one by one and always watch out for the queen. The brood and honey combs need to be placed separately.
8. Use the bee brush to clear the combs from remaining bees.
9. If already discovered the queen, catch her. Otherwise look out for her on the mat/sheet.
10. Place the queen in the new hive to attract the other bees of the colony.

11. Safe the brood combs and tie them to empty frames with a needle and rope.
12. When the old hive is empty, hold it with both hands and forcefully push down on the mat to remove all bees from the inside. Make sure that no bees are left in the hive.
13. Is the process done, place the new hive in position of the old hive.
14. Clean the working area and the materials.

Follow up and support the colony

On the next day, go back to the site and inspect the beehive and the surroundings. Did the bees already adapt to the new conditions? Bees going in and out the hive and bring back pollen is a good sign.

4.4. External hive inspection

Every time a beehive gets opened, the colony gets disrupted. To understand what goes on in the bee colony, a complete inspection is un-avoidable, but an external hive inspection, especially observing the activity of bees at the hive entrance gives a first impression on the hive status and tells the beekeepers, if internal inspection is necessary at all. In general, it is said that the more active your bees are, the better. Strong colonies are more active than weak ones. Bees carrying plant pollen is an indicator of brood rearing in the colony and the colour of the pollen loads indicates the plants that are in bloom at the time. When observing the bees at the hive entrance, the manner the bees land at the entrance gives information on the amount of nectar being collected by the foragers. Bees landing heavy or lose their grip when landing on the landing board are often heavy loaded with water or pollen. Heavy loaded forager bees indicate a nectar flow. Another indicator of nectar flow is the strong smell of nectar at the hive (Conrad, 2019). Accumulation of bees at the hive entrance could have several reasons: starvation, poisoning, swarm preparations, attacking predators, or simply when it is a hot day. Inspecting the surrounding where the beehives are placed helps to find out if there are ants and other predators. If so, necessary corrective measures should be taken. Also monitor dead bees around the entrance of the hive. A few dead bees are totally normal, but if an extraordinary number of dead bees was observed, there could be something wrong with the colony.

4.5. Internal hive inspection

Internal hive inspections work for movable frame hives but not for traditional hives with fixed combs. Regular inspection is an important management practice to assess the status of the bee colony. Based on the findings during the process, corrective measures and further management steps are planned. Among others, the following checks are the most common ones:

- Check if the hive needs more or less room.
- Check the food supply of the colony.
- Check for swarming signs.
- Check the colony's health status.
- Check if the time is right for a queen excluder.
- Check if the honey is ripe and check if it is time to harvest the honey.

Depending on the used bee species, their strength or the season, bees are more or less aggressive. Therefore, necessary preparations should be made to take care and to prevent injuries.

1. **Protective gear** is recommended and should be cleaned regularly. Bees scent bee venom from the distance and this may irritate them. The colour of gear may also play a role. Prefer light colours.

2. If working with **aggressive bees**, is necessary to wear clothes under the protective gear. Make sure, that the zippers run all the way through. Wearing clothes that are too light or thin may lead to stings. Also make sure, that the bee veil is not too close to the face, otherwise stings get through. The smoke for the internal inspection has to last through the whole operation time.

3. Choose good weather conditions on your target day. When inspecting beehives, the weather should not be windy, cold or rainy. Do not wear perfume or other strong-smelling cosmetics. Sweat and body odour may also affect the bees.

4. If a human gets **stung** by a bee, gently remove the sting from the body and wash the affected body part with water. Otherwise the other bees get alarmed and become more aggressive. People with minor allergies to bee venom show symptoms of itching, body swelling, breathing problems and vomiting. People who have a serious allergy are affected very quickly by the venom. In addition to the mentioned symptoms, they will have a higher heart beat and more intense body sweating and breathing problems. Those people should be transferred into a hospital quickly.

5. **Avoid loud noises, disturbances and fast movements**.

6. **Standard beehive opening procedures:** The top lid should always be removed. Stand on the side or behind the beehive and blow smoke into the colony. Use a chisel or a knife to liod the cover and blow smoke on the sides and into the beehive. Completely remove the lid and blow smoke into the hive to led the bees move away, If the inspection takes place in the lowest chamber, place the other chambers on the upturned lid cover; do not place them on the pure ground.

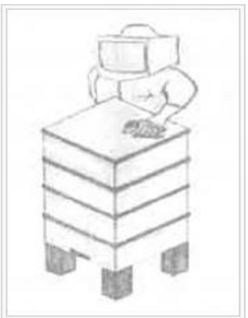


Figure 37: The beekeeper should not stand in front of the beehive. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

7. **Avoid the exposure of larvae or brood to sunlight, avoid robberies by other bees.** If the inspection takes place during the day, the inside of the hive should not be exposed to the

sun longer than necessary. Weaker colonies should be inspected prior to strong colonies to avoid robbing.

Management procedures

Supering: During flowering season, the bee colony size increases rapidly. The bees need more space in the hive, otherwise they split and swarm. Providing more space to the colony leads to more space for brood rearing and in the end to increased honey foraging. If the colony in the bottom box is overcrowded, supering at the right time is necessary. External observations indicate a great number of bees passing the hive entrance; in the evening, many bees cluster at the hive entrance; internal inspection results in frames and bee lines covered with bees or half of the frames are full of eggs. If observed, adding a new chamber is important. Do not add another box, if the apicultural season is already over and most of the plants ceased blooming, because this will have no or a negative effect on the colony. If the bottom box and the first additional box are crowded, a second box can be added to the hive.

Process: Open the cover of the beehive which needs an additional chamber. On top of it, place the new chamber which contains frames with wax foundation and align it properly. To make sure that the bees do not avoid the new chamber, take 3-4 frames containing brood from the existing box and bring it up in the centre of the new box. If the colony is too weak, bees will eventually not go up and the eggs/larvae die.

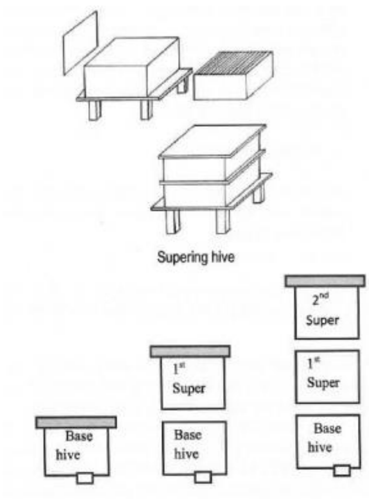


Figure 38: The supering setup. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

Installing of queen excluders: if the beekeeper decides to use queen excluders to guarantee a brood-free honey chamber, the right timing is essential for installation. Queen excluders should be mounted in a strong colony during flowering season. Some beekeepers install them during they add a super.

Process: Open the top cover and use smoke to let the bees move down. Replace the frames: frames containing honey and sealed brood (pupae) are transferred to the upper box. The brood needs to be placed in the centre of the box. Those frames containing open brood and pollen can be placed in the lower chamber. Place the queen excluder on top of the lower box and align it correctly. Add the upper box and also align it carefully. After honey harvest, the excluder should be removed.

Reproductive swarming: During flowering season, the bee colony size increases rapidly. The bees need for space in the hive, otherwise they split and swarm. This can result in decreased honey harvest. Improved beekeeping practice emphasizes the control of bee reproduction and colony splitting.

- Offer enough space in the hive.
- If a colony is crowded, 2-3 frames containing eggs and open brood should be replaced by wax foundations. The frames containing brood can be used for weaker colonies.
- Inspect the overcrowded colony every 10 days and check for queen cells. All queen cells must be destroyed.

Honey harvest

- sweet nectar smell in the apiary's surrounding.
- the number of bees passing the hive entrance decreases as they have enough food
- in the evening, bees tend to cluster at the hive entrance
- to assess the ripeness of honey, an internal inspection must be conducted.

Supplemental feeding: during drought seasons, weaker colonies need supplemental feeding. This will prevent absconding and starvation of colonies. The provided food should be of good quality. A shortage of honey is replaced by carbohydrates such as sugar and a shortage of pollen will be bridged by protein sources like corn-, soy-, or chickpea flour.

Sugar: The most common way to feed sugar is in form of a sugar solution (a mixture of water and sugar). The relation between sugar and water should be either 1:1 or 2:3 (for example during winter in temperate climate). In case of the 1:1 solution, 1 kg of sugar is added to 1 l of hot water. The cooled down solution is fed to the colony. Outdoor feeding should be avoided due to robbing organisms and disease transfer. The internal feeding requires specific containers that are placed in the hive. For details, the beekeeper can watch YouTube videos by using the keywords "bee feeder" "feeding bees".

Pollen substitute: Substitutes may be prepared of pulse and cereal flours (beans, peas, soy, chick peas, barly, ...). Pulses and cereals are first roasted and grounded to flour. The flour may be put in a weather protected container near the hive. Do not provide too much flour. The bees would not use it in time and this may affect the aroma of it. Moisture may affect the flour and lead to mould which bees bring in the hive.

4.6. Honey harvest

Honey types:

- Natural honey: natural honey includes pollen and nectar from one or several plant species.
- Crystallized honey: crystallized honey is still as nutritious and sweet as liquid honey. Crystallization depends on the water-sugar content of honey and on the flowers the nectar was retrieved from. Basically, due to high sugar and low water content, the sugar is over-represented and therefore cannot get dissolved in the water. The honey crystallizes.

- Crushed honey: Crude honey is not filtered or extracted from the honey comb.
- Cream honey: through continuous stirring of regular liquid honey, the product gets creamy.
- Comb honey: this type of honey is not extracted and sold in the honey comb. Comb honey is getting more and more popular around the globe and is sold at higher prices than regular table honey.
- Pressed honey: honey combs that are free from brood and pollen are pressed and filtered. If already crystalized, the comb gets jacketed with water to indirectly heated.

Harvesting Honey

To avoid high water content, it is strongly recommended to harvest the honey when its mature. Bess seal ripe honey with a light and thin wax layer. If more than 70% of the honeycomb is sealed, the honey is considered to be ripe (enough). Honey consisting of one pollen type (monofloral) has a higher demand and can be sold at higher prices than multifloral honey. Another indicator of harvesting time is the smell of sweet nectar in the hive's surrounding. The number of bees passing the hive entrance decreases when they do have enough food and they tend to cluster at the hive entrance in the evening.

Keeping the natural flavour and aroma of honey is essential. Therefore, avoid the excessive use of the smoker. Honey harvested from one apiary contributes of the same floral composition, no matter of which hive type was used (traditional, transitional, modern). Nevertheless, quality differences may occur due to a messy way of working (handling, harvesting, storing, harvesting of unripe honey, excessive use of smoke, mixing of pollen with honey, using unclean and or coverless containers). During honey harvest, the beekeeper can get rid of the old (dark) combs in the hive and recycle the wax.

Harvesting honey from transitional or traditional hives

Honey harvesting of traditional hives should take place from both sides, otherwise, the comb of the unharnessed side becomes old and the bees stop using the comb. Old combs and or /dark combs containing ripe, or unripe honey and/or dry pollen should also be collected-this can be sold to honey wine producers.

Honey extraction

Prepare a container and sieves in different sizes. Break the honey comb into pieces and put it on a coarse sieve to remove big particles. Let the liquid honey flow through the sieve into the container by gravitational force. Repeat the process with a fine sieve.

Figure 39: Setup for honey harvesting from transitional or traditional hives. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

Harvesting honey from modern frame hives

Take out honey combs with ripe honey and without brood or pollen and gently brush away the bees with a bee brush. Optional bee escapes can also be installed 24 hours prior to the harvest to free the honey chambers from bees. One frame at a time is taken out of the hive with the help of a chisel. Honey combs are collected in an empty transport box. Optional, the frames can be numbered to identify their origin.

Honey extraction

After the harvesting process, honey is still liquid and warm. Therefore, honey extraction should take place as soon as possible to avoid extra working steps. To extract honey, the required equipment and materials should be prepared, cleaned, washed and dried. Ideally, every beekeeper should have a processing room that is free of dust, or odour. The room should have a cement floor and it should be covered with a plastic sheet. The wall should be painted with food grade paint and there should be mesh wires mounted in front of the windows. If the beekeeper has no such option, the extraction can take place at home, but it is recommended to cover the floor with a plastic sheet, or a mat. Nevertheless, a water line for hygienic reasons should always be accessible. The honey extraction depends on the desired end-product. Uncapping forks or knifes are used to uncap the honey combs. Honey extractor: After the uncapping process, the combs are placed in the chambers of the honey extractor. The cover of the device should be closed to prevent honey from spilling out of it. Manually, or automatically cranking of the device leads to the extraction of the honey from the combs. The honey flows into a prior positioned container. Now, the crude honey needs to be filtrated to separate the solid compound from the product. To ease the filtering process, the container can be placed in a warm water bath to slightly heat up the honey and make it more liquid. The honey is filtered with specific filters and left for at least a day to let the foam float at the top. Scoop off the foam and other particles with a spoon. For more details, the beekeeper can watch YouTube videos by using for example the keywords "honey extraction", "honey harvesting" or "honey extractor".

Figure 40: Scheme of the honey extraction process from moveable frame hives. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

Honey extraction with a honey press

An alternative to extract honey with a honey extractor is pressing the honey with a professional, or a self-build honey press. Insert the freshly harvested honey combs in a mesh, or in nylons and place the bag between two discs of the honey press. Prepare a container at the outlet of the honey press to collect the squeezed honey. Use the handle to press the honey. Separate the leftover beeswax from the honey and repeat the steps as often as necessary. Finally, scoop off any foam floating at the top.

Figure 41: Illustration of the honey extraction process with a honey press. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

Storage of honey

The moisture content of honey which is going to be stored for a long time period should not be more than 19%. The honey container should be clean and have a tight cover. Containers used for other things like cooking, oil or gas should not be used for storing honey. The storage room should be dark, dry and cool. Honey adsorbs foreign odours. Therefore, it is not recommended to store honey with products that have a strong odour like honey wine (*tej*), or beer. Stored honey should not be exposed to direct sunlight. Containers made of aluminium or stainless steel are preferred for honey storage.

4.7. Beeswax harvest

One method to recycle old beeswax is to melt it down. Further methods of rendering wax include the processing in solar wax melters, by boiling in water then filtering, or by using steam or boiling it in soft water or rain water and press. YouTube offers numerous instruction videos (suggested keywords: “melting beeswax”, “cleaning beeswax”, “processing beeswax”, …).

4.8. Pollen harvest

Besides carbohydrates, minerals, lipids, vitamins and water, honey bees need proteins for a balanced diet. The only protein source for bees is plant pollen. Young bees consume pollen and worker bees feed it to the brood. Pollen grains are small, male reproduction units (gametophytes) formed in the anthers of the higher flowering plants. Pollen is also valuable for human consumption and therefore it is a valuable honey bee product too and can be marketed by the beekeeper. Pollen collection from the incoming forager bees can be done by removing pollen pellets from the bees before they enter the hive using a specially designed device called pollen trap. There are many designs of pollen traps (figure 42) with the efficiency rarely exceeds 50%, i.e. less than 50% of the returning foragers lose their pollen pellets. In this way, it is possible to collect marketable size of pollen without affecting or interfering the normal honey production processes. The pollen trap should not be activated longer than necessary to avoid affecting the normal bee colony development.

Figure 42: Pollen collection with pollen traps that are mounted at the hive entrance. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.9. Propolis harvest

Propolis is a sticky, aromatic, dark-coloured and resinous material that honey bees collect from living plants. They mix it with wax and use it as construction material. They repair cracks in the beehive, mummify larger organisms entering the beehive and that cannot be transported outside and cover the inside of cells. Propolis has a strong anti-fungal and anti-bacterial effect and is a valuable bee product for the pharmaceutical and cosmetic industries that contributes to the beekeeper’s income.

Propolis can be harvested from all types of hives. It is often found around the hive entrances, between bottom and super chamber, between frames, in holes and cracks.

Intentionally making holes and cracks in the hive increases propolis production (figure 43). For modern beehives special propolis collection grids exist. The bees seal the holes of the grid and by cooling it down, the propolis gets easy to remove.

In traditional hives, special openings that cover the entrances of the hives are mounted. The harvested product should be free of impurities like wood, dust, wax or dung.

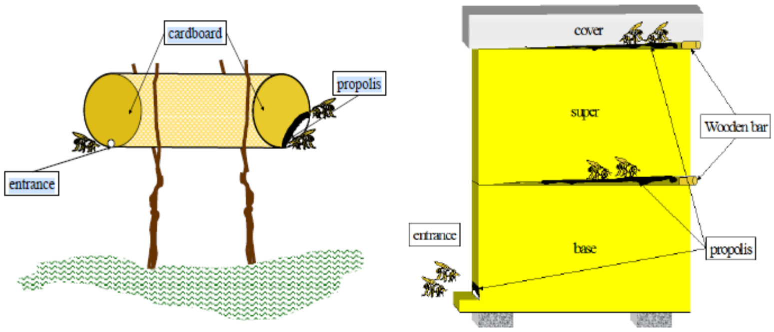


Figure 43: Propolis production methods in traditional (left) and modern (right) hive systems. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.10. Swarming prevention

Colony reproduction in honey bees is called swarming. Reproductive swarming occurs during the flowering season. In those seasons, the worker bees collect numerous amounts of pollen and nectar and the queen lays thousands of eggs resulting in space constraints- a large colony splits and swarms. If the honey bee colony swarmed, the honey harvest decreases. To control unwanted swarming, the bees need enough space. Through internal inspection, the beekeeper destroys every occurring queen cell in the hive. Swarming cells are often located at the periphery of the frames.

- offer enough space in the hive by adding supers.
- if a colony is crowded 2-3 frames containing eggs and open brood should be replaced by wax foundations. The frames containing brood can be used for weaker colonies.
- optionally split the colony.
- inspect the overcrowded colony every 10 days and check for queen cells. All queen cells must be destroyed.

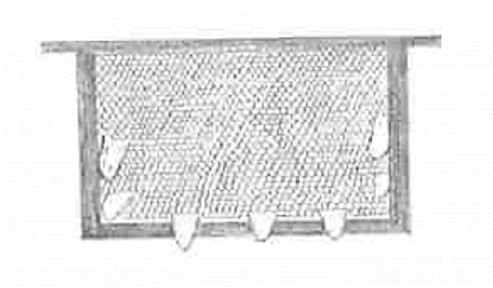


Figure 44: Queen cells constructed for swarming. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.11. Absconding

Absconding occurs mainly in tropical areas and is triggered by a shortage of food, excessive disturbances or other environmental circumstances. Management options were formulated during the SAMS project:

- Take a look into the hive.
- If absconding has not taken place yet, revitalize with two frames containing adult bees, brood and pollen.
- Alternatively, requeen the colony.
- If the colony already absconded think of sanitation decisions. A sanitation decision includes the cleaning and disinfection of the affected hive to avoid disease-transfer. Possible methods are to flame-scarf the inside of the hive (frames and equipment), or to use chemicals (bleach, caustic soda, similar substances...). Please adhere to the instructions and work carefully.

4.12. Bee health management

Two main groups of diseases were described: the ones affecting the bee brood and the ones that affect the adult bees. If a beekeeper inspects a colony and observes a disease, the disease transfer from the sick to the healthy bee colony must be avoided

To avoid disease transfer between colonies:

- do not use the same equipment used for the sick colony.
- do not transfer frames from a sick to a healthy colony.
- avoid feeding honey or pollen from a sick colony to a healthy colony.

Further reasons of transfer:

- purchasing used equipment or colonies.
- splitting colonies that carry diseases.
- amalgamate sick with healthy colonies.

4.12.1. Chalkbrood

A. apis is transmitted to the bee colony by food and water, or through contaminated equipment or infected queens or worker bees. Cold or humid conditions also increases the risk of getting infected with *A. apis*. If a colony which is affected by chalkbrood does not have enough food, disease control is difficult. If a colony is already infected, cleaning the hive can help to control the disease. Further, the equipment should be disinfected (e.g. with fire) prior to and after manipulating the affected colony. Do not use frames of that colony for other colonies. Strengthen the colony by supplemental food and change the position of the hive into an area with more sunlight. Requeening the colony is also an option. Heavily affected frames should be removed and exchanged by frames with wax foundation.

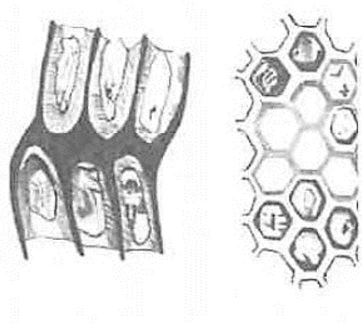


Figure 45: Chalkbrood affected bee brood. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.12.2. Nosema

N. apis affects adult honey bees. Infected bees crawl on the floor, the entrance of the hives and on the frames and some fall down, unable to move. Affected bees decrease their nursing activities. The brood and the queen get undersupplied. If the queen is also infected, the egg laying activity also decreases. Sick bees are often observable by a swollen abdomen and an odd movement pattern. To control the disease and prevent it, the colonies should get enough food by either transferring them to an area with more available forage or by bridging dearth periods with supplemental food. Place with too much shadow or high humidity are also sub-optimal. Optional, the queen should be replaced by a new one. In severe cases only, chemical fumigants (e.g. Fumagillin) can be used as a treatment for the disease.

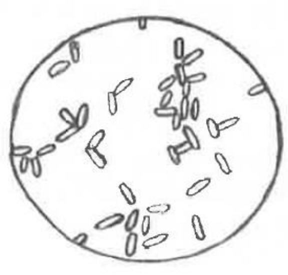


Figure 46: Nosema apis spores trigger the nosemose disease. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.12.3. Varroa

The *varroa* mite sucks the haemolymphs and on the fat bodies of bees. Affected bees lose weight, and in a consequence of the infestation, their legs, wings or both can become paralyzed through another disease (viruses)-they become unable to crawl or fly. In Europe, special acaricides are used to kill most of the mites, but so far no method exists that frees the affected colony 100% from the mite. Besides, the transfer rate between colonies is also high and therefore the re-infestation. If using a chemical substance, always follow the instructions! Another, method to stop the spread of the disease is to disrupt the brood cycle by preventing queens from laying eggs, or removing brood frames.

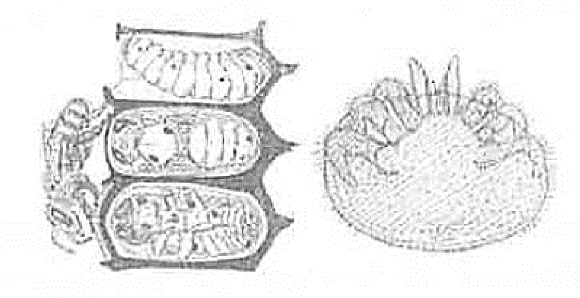


Figure 47: Varroa mites inside the brood cell (left) and adult mite (right). Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.12.4. Ants

Beekeepers in area prone to ant attacks need to protect their bees:

- hang the beehive with ropes or with other materials on trees or on poles (traditional hives).
- attach a smooth metal sheet to the stem of the tree or pole (traditional hives).
- place the hive stands with cone shaped smooth iron sheets or used inner tubes of a tyre.
- sprinkle hot ash around the hive.
- look for the ants' nest and kill the queen and eggs (in case of a severe infestation)
- clean the hive area and keep the grass short.
- do not dispose any honey or wax near the apiary-this attracts ants and other organisms.

Figure 48: Ant protection method. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.12.5. Wax moths

Adult wax moths enter the colony and lay their eggs into the hive. Empty hives or wax storage facilities without bees are a great opportunity for the reproduction of wax moths. The freshly hatched wax moth larvae start to destroy the wax structures in the hive. If a bee colony is not strong enough, such a wax moth infestation may lead to severe problems. In tropical regions, colonies that are too weak to counteract often abscond. Besides observing the adult moths, its pupae or larvae, an infestation can also be recognized through moth waste or their silken webs (funnels).

Management tips:

- remove old and dark honey combs.
- clean the hives of infested and in a consequence absconded bees; melt the wax.
- do not discard pieces of wax around the apiary.
- remove combs, severely infected by wax moths.
- the colony should be as strong as possible to defend itself. Offer supplemental food in the post-harvest seasons.
- remove super during food shortage seasons.
- Remove any cracks in the hives.
- To reuse hives that are contaminated by wax moths, dip them in boiling water and wash them thoroughly.

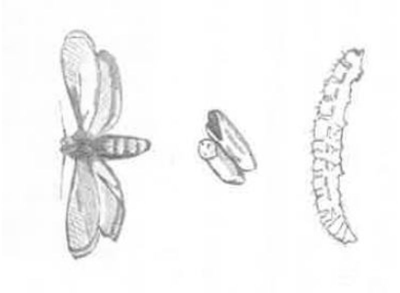


Figure 49: Adult wax moth, its pupae and larvae. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

4.12.6. Honey badger

Honey badgers eat bees and bee products. Its tail is covered with fine long hair making bee stings ineffective. Repeated attacks result in colony absconding.

Management options to control the honey badger:

- fence the apiary
- use of guard dogs to scare the honey badgers away
- tie hives onto firm objects
- hang hives (traditional) on a tree or on poles.

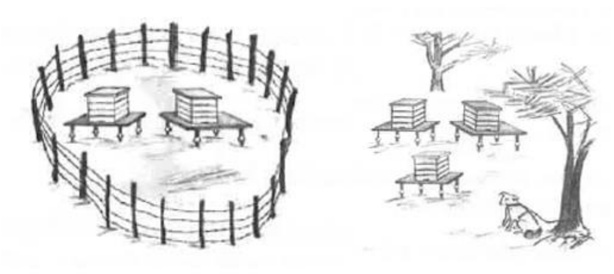


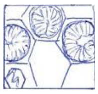
Figure 50: Preventation methods for the honey badger from left to right: fencing of the apiary, using of a guard dog to scare away the honey badger. Fig. retreived from Ethiopian Beekeepers Association & SNV (2011).

5. 10 Rules of honey bee management

Good quality of honey bee products, high productivity and the excellent health status of honey bees are the ultimate goals of beekeeping. To achieve those goals, good beekeeping practice (GBP) is crucial. GBP is strongly related to regional and environmental influences but in a global context, GBP includes the ensuring of breeding through prolific young queens, an ample supply of food, effective and seasonally based management, the use of the right equipment, prevention of unwanted swarming and absconding behaviour, or protection from predators and threats affecting the health of honey bees. Within this document, ten important “rules” for honeybee colony management were formulated and they serve as a guideline for beekeepers to increase the quality of their honeybee products (e.g. honey) and to improve the health of their honeybee colonies. Those rules were evaluated by highly experienced beekeepers from Ethiopia, Indonesia and Europe to guarantee their validity for these regions.

Rule 1: The quality of your bee product needs to be secured

Honey is made of floral nectar, collected by honeybees, and needs some time to mature - the main reason is the water content. Honey with high water content is still very similar to nectar and is exposed to the risk of fast fermentation, resulting in sour tasting honey. This risk is correlated with the humidity in tropical countries. For honey wine this fermentation is wanted, but not for table honey. Therefore, harvest honey only from honey frames (no brood) that are at least 70% sealed. You can also do a shake test to identify if the honey is mature. Therefore, turn the honey frame horizontally and shake it jerkily. If you recognize any splashes, the honey is not ripe yet. If available, a honey “refractometer” also can be used to test the product for its water content. Further, protect your honey from direct sunlight and avoid moist conditions. If you observe fermented honey, or moldy pollen, remove those frames from the hives.



Rule 2: Breeding activity is an indicator for a strong and

The relative performance of a honeybee colony depends on its numerical strength. To check, if reproduction takes place, open the hive and look at the brood area. Do you see the queen, eggs, and/or bee larvae? If yes, chances are high that the colony is queenright (queen is present) and therefore develops normally. Another indicator is the brood pattern of the brood area- it should look solid and compact.

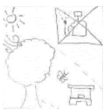
Rule 3: A honeybee colony has to have enough food

To be sure that your honey bee colony has enough food, every beekeeper should be aware of the colony surroundings. What plants are in flower and when? Is there a phenology calendar (= flowering calendar) for your region which may help you? It is important, that your bees have enough melliferous plants (=plants which produce bee forage in the form of nectar and/or pollen and can be collected by bees) in their environment (should be checked, before the hive is set up at the particular location). If there is a lack of forage opportunities, think of growing your own melliferous plants. It has to be mentioned though, that not every plant is a nectar AND pollen producer.

It is also important to check not only the surroundings, but also the colony itself. When observing the flight entrance, are there returning pollen foragers? When opening the hive, are there combs filled with honey or beebread (=processed pollen)? If not, consider to offer supplemental food (carbohydrates and/or protein). Sugar syrup should only be provided outside of the honey harvesting season to avoid the falsification (adulteration) of honey (quality loss, fermentation, …). Make sure to place the supplemental food on the upper side of the brood chamber in a closed environment like an empty honey chamber instead of putting it on the bottom board to avoid robbery by other bees and predators. Another important point in times of harvest is to leave sufficient reserves of honey and pollen for dearth periods.

Rule 4: Keep your colony healthy – aim for a low predator-, pest-, and pathogen- pressure

There are numerous amounts of organisms affecting the honeybee. As the organisms and the control methods strongly vary between regions, it is important to get in contact with experienced local beekeepers, (if existing) development agents, research centres, beekeeping associations and training centres that may provide that information for you. Maybe there are even authoritative services when you need help? It is not possible to free your colonies of every bee-health affecting organism, but it is very important to keep the pest/pathogen/parasite/predator-pressure as low as possible. Be aware, that the use of certain substances as antibiotics as a preventive measure is not allowed in every country. This has to be checked before its use is considered. Further, if the use of antibiotics or other chemical substances are necessary, you have to follow the instructions exactly. As an example: Clean the bottom board (if existing) of the hive regularly from detritus and other dirt during your other beekeeping activites.



Rule 5: Provide a safe environment for your beehives

Choose a location, which is suitable and safe for your bees' needs. The preferred area/location protects the hives from excessive weather conditions (rain, high temperatures, wind, etc…), has a low exposure to agricultural pesticides (avoid areas with high pesticide exposure), and is rich in foraging opportunities throughout the season (nectar, pollen and water). Common examples for agricultural fields with high pesticide exposure are wine, maize, tea, coffee or cocoa.

Rule 6: Provide a safe environment for yourself

To provide a safe environment for yourself, do not open your colonies on days of unfavorable weather conditions, overthink your steps prior to conduct them, work slowly and be calm and use equipment in good condition. Those steps are important to avoid injuries and unnecessary working steps. Be sure to have the opportunity to call someone for advice or in case of injuries/emergencies.

Rule 7: Dark beeswax needs to be exchanged but wax is valuable - reuse or process it

Depending on the bee species used for beekeeping and their specific behavior (e.g. brood rearing activity), beeswax gets darker sooner or later. Therefore, check the color of your frames at least once a year and if necessary, replace them with empty frames or frames containing light wax to keep your colonies strong and healthy. As wax belongs to the most valuable raw materials for a beekeeper, be sure to not throw it away. Instead recycle it by melting it down. You can use the pure wax to either produce wax foundations for your bee hives, sell it, or process it. For this purpose, special wax melters exist, but it is also possible to use solar power by putting the old wax in a bucket and leave it in the sun for several hours. To get to the valuable purified wax, simply skim off the waste. If you are not sure how to do it, YouTube is a great tutorial tool (suggested keywords: “melting beeswax”, “cleaning beeswax”, “processing beeswax”, …).

Rule 8: Control UNWANTED swarming and absconding behavior

In general, it is a good thing if bee colonies are strong enough to show reproductive swarming behavior but if you do not want half of your bees leaving the hives, you may be interested in controlling it. For this purpose, you should requeen a colony every 2 years and offer enough room within the hives. Absconding greatly differs from reproductive swarming. Absconding greatly differs from reproductive swarming. Bees in tropical regions show absconding behavior by leaving the nest and brood and storage in it behind. The behavior is triggered by unfavorable environmental conditions (droughts, low forage opportunities) or disease/pest pressure. To avoid absconding, good beekeeping practice is very important: keep the disease pressure low (rule 4), offer enough natural food and water and offer supplemental food in times of need (rule 3), manipulate the hives with methods that cause as little stress as possible (e.g. open the hive only if it is necessary).

Rule 9: Avoid robbery through other honeybees or other organisms

Robbery through other honeybees or organisms like wasps, hornets, ants, or even mammals cause significant stress to your bees and even can lead to the death of your colonies. Additionally, by robbing the nest of weak bee colonies, there is a risk of disease-transfer to the robbing colony. Strong bees defend their nesting sites more successfully, therefore it is very important to keep your colonies as strong as possible to avoid robbery. For this purpose, keep the disease pressure low (rule 4), place supplemental food on the upper side of the brood chamber in a closed environment like an empty honey chamber (rule 3), narrow down the size of the hive entrance, work in a hygienic way and do not leave your equipment or brood/honey containing frames accessible to bees and other organisms. Another method to reduce robbery, especially in dry seasons or times of low forage opportunities, is to add more distance between your bee hives.

Rule 10: Educate yourself

There are no rigid beekeeping rules that fit perfectly for every beekeeper and there is also no perfect system fitting all honey bees of the world. For this reason, it is essential to constantly educate yourself and to find out what's happening in your region. Get in contact with other beekeepers and learn from each other or maybe you can even share tools and logistics. Find out if there is a local beekeeper network and if not, you may be interested in developing one by yourself. Are there possibilities to visit beekeeping trainings? Also visit the internet and watch for example YouTube videos on beekeeping but be critical and use only methods that fit to your region and bee race. It is also very helpful to document your hive management and phenology (flowering) of forage by taking notes and compare them between years.

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6. Knowledge Gaps

Based on the evaluated literature and expert interviews, the following knowledge gaps were identified and need further research attention. Especially beehive management and bee health issues are not well investigated or documented and an assessment of statistically important key numbers is missing in both target countries and therefore are in need of further research. All the following mentioned knowledge gaps are also available on the SAMSwiki database.

6.1. Ethiopia

In general, with the Holeta Bee Research Center and other institutions, the scientific efforts on local honeybees and the Ethiopian beesector are rising, but there are still many knowledge gaps:

- General key numbers and statistical data on the number of hives in the country, or the annual honey production rate, as well as import and export quotes are well described, but there is still a lack of basic information, for example the number of beekeepers in the country is based on estimations.
- Based on the literature, there seems to be a beeswax business, and beeswax import and export quotes are published, but information on the use of beeswax or statistical data on the production rate within the Ethiopian population is not described.
- There are scientific studies dealing with increasing propolis yield, but information on a propolis business, how it is used, or if local beekeepers collect the product was not available.

- There is important literature available describing melliferous plants, but regional floral calendars are missing.
- A big issue is missing information on hive management practices in Ethiopia. There is fragmentary published data available, but firstly none of them describes nationwide practices and secondly, about 95% are traditional beekeepers and therefore hive management, as we know it in Europe may not be possible in traditional hives. Nevertheless, to verify that, scientific research is necessary. Furthermore, in the existing literature sometimes there seems to be a misunderstanding when it comes to the difference of "reproductive swarming" and "absconding" of honey bees. Similarly, the evaluated bee health management knowledge is based on personal communication with local experts, but no records were available.
- According to a local expert, good beekeeping practice, similar to European standards exist within the country, but it is considered to be underdeveloped and needs further research.
- It was not possible to assess the migratory beekeeping status due to missing literature (is it practiced at all, how, …).
- Based on personal communication, there seems to be no pollination business at all. Published data is missing.
- In general, basic information on the presence of honey bee pests/pathogens and predators affecting the honey bee health is described, but especially when it comes to possible treatment methods, almost no literature based knowledge is available.
- No studies on honey bee viruses were available (presence, distribution, severity, ...).
- No studies on foulbrood were available (presence, distribution, severity, ...), but the disease exists in neighbouring countries and therefore it is a question of time until *Paenibacillus larvae* and/or *Melissoccocus plutonius* cross the boarders.
- *Nosema apis* is present in Ethiopia, but no studies on *N. ceranae* were available (presence, distribution, severity, ...).
- Parasitic mites like *Varroa destructor* are present, but no studies on *Tropilaelaps* spp. were available (presence, distribution, severity, ...).
- The methods of local beekeepers on how to deal with honey bee health issues are only based on personal communication with local experts and published literature is missing.

6.2. Indonesia

Compared to the other target country Ethiopia, in general fewer (English) literature is available for Indonesia. In Indonesia, the relationship between local people and bees is not based on strong traditionalism as in Ethiopia. Expert interviews revealed that many Indonesian people have certain prejudices against bees. Those range from fear of bee stings, to a lack of know how on the importance of bees as pollinators. This might be the reason, why study programs on national honey bees and the national beesector barely exist.

- Basic statistical information on beekeeping is missing (number of beekeepers, no. of hives, amount of produced honey, etc...).
- *A. mellifera* was introduced to Indonesia, but morphological and genetic studies are needed to identify the origin(s) of the introduced *A. mellifera* subspecies.
- Honey production statistics are missing or are only based on estimations. Studies on the assessment of honey quality exist, but they are not up to date anymore (prior 2000).

- The described structure of Indonesia's honey market value chain is only based on personal communication with local experts. No publications were available.
- It was not possible to find information on a possible beeswax business (statistics, use, ...).
- A pollen business in the country exists, but related information is only based on personal communication with local experts. No publications were available
- Based on personal communication, a propolis business exists, but no statistics or further details were available.
- Almost no literature deals with important melliferous plants and a floral calendar will only be developed for West Java, but so far no calendar for the rest of Indonesia exists.
- Information on honey harvesting season(s) is/are not well described and only based on personal communication with local scientists. No studies were available.
- Based on the evaluated literature, it was not clear which hive types are commonly used or what was the difference between modern and traditional hive-systems. Based on personal communication with local scientists, self-constructed hives are also considered as traditional, even though they were movable frame hives.
- A big issue is missing information on hive management practices in Indonesia. There is fragmentary published data available, but the information is not representative for the whole country. Furthermore, and as already mentioned for Ethiopia, in the existing literature sometimes there seems to be a misunderstanding when it comes to the difference of "reproductive swarming" and "absconding" of honey bees. Described knowledge on bee health management practices is only based on personal communication.
- Good beekeeping practice rules in Indonesia are non-existing.
- Migratory beekeeping with *A. mellifera* exists, but the information is only based on personal communication with local experts and detailed information is missing. No studies were available.
- Studies dealing with beekeeping problems and constraints are missing, but it is assumed, that Indonesia has similar problems as Ethiopia.
- Many Indonesian people do not know about the importance of bees as pollinators resulting in a lack of pollination business and a lack of regimentation of hive placement. Many local farmers do not permit bee hives next to their fields. Further research and education are necessary.
- Beekeeping associations exist, but their structure is not comparable to European associations. Literature is missing.
- When it comes to pests/pathogens and predators affecting the health of honey bees, there is only few literature available. This not only concerns possible treatment methods through beekeepers, but also basic information like the presence of a certain disease in Indonesia.
- No studies on honey bee viruses were available (presence, distribution, severity, ...).
- No studies on *Malpighamoeba mellificae* were available (presence, distribution, severity, ...).
- No studies on birds affecting the honey bee colony's size were available (species, distribution, severity, ...).
- No studies on foulbrood were available (presence, distribution, severity, ...).
- *Nosema ceranae* is present in Indonesia, but no studies on *N. apis* were available (presence, distribution, severity, ...).
- No studies on chalkbrood disease were available (presence, distribution, severity, ...).
- No studies on wax moths were available (presence, distribution, severity, ...).

- No studies on bee lice were available (presence, distribution, severity, ...).
- No studies on small, or adult large hive beetles were available (presence, distribution, severity, ...).
- Information on the methods of local beekeepers on how to deal with honey bee health issues are only based on personal communication and very cryptic.
- We do not know, how and if local beekeepers treat their honey bee colonies in case of an infection. No publications were available.
- No information on institutions, who offer nationwide education and dissemination of beekeeping related topics were available

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III. Annex

Flowering calendar of important melliferous plant species in Ethiopia

All content was retrieved from: "Fichtl, R., & Adi, A. (1994). Honeybee Flora of Ethiopia. Margraf Verlag, Germany." and "Admasu, A., Kibebew, W., Ensermu, K., & Amssalu, B. (2014). Honeybee Forages of Ethiopia. Holeta Bee Research Center. Ethiopia."

Table 5: Flowering calendar of important melliferous plant species in Ethiopia. "o" means flowering, "+" peak flowering, "o" nectar or pollen source, "+" high quantities of nectar or polen, "~" low quantities of nectar or pollen. Content was retrieved from Fichtl & Adi, 1994 and Admasu, et al., 2014.

Species	Plant family	Growth form	Amharic	Afar	Oromo	Nectar source	Pollen source	J 01	F 02	M 03	A 0	M 05	J 06	J 07	A 08	S 09	O 10	N 11	D 12	Reference
Acanthus eminens	Acanthaceae	herb/shrub	-			~	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Acanthus sennii	Acanthaceae	herb/shrub	KOSHESHLA		KOSORU, SOKORU	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Asystasia gangetica	Acanthaceae	herb/shrub	KOSHESHLA			o	o	o	o	o				o	o	o	o	o	o	Fichtl & Adi, 1994
Barleria grandis	Acanthaceae	herb/shrub	-			o	o										o	o		Fichtl & Adi, 1994
Barleria ventricosa	Acanthaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Brillantaisia madagascariensis	Acanthaceae	herb/shrub	-		DARGU	o	o	o								o	o	o	o	Fichtl & Adi, 1994
Dicliptera maculata	Acanthaceae	herb/shrub	-			o	o	o								o	o	o	o	Fichtl & Adi, 1994
Hygrophila auriculata	Acanthaceae	herb/shrub	YESIET-MLAS, AMEKIELA		KORATTI-SARE	o	o	o	o						o	o	o	o	o	Fichtl & Adi, 1994
Hypoestes forskaolii	Acanthaceae	herb/shrub	DARGU		DARGU	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Hypoestes triflora	Acanthaceae	herb/shrub	TQUR-TIELENG		DARGU	o	o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Isoglossa laxa	Acanthaceae	herb/shrub	-		DARGU	o	o									o	o	o	o	Fichtl & Adi, 1994

Isoglossa somalensis	Acanthaceae	herb/shrub	-		DARGU	o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Justicia heterocarpa	Acanthaceae	herb/shrub	-			o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Justitia ladanoides	Acanthaceae	herb/shrub	TELENGE, CHINGERCH			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Justitia schimperiana	Acanthaceae	herb/shrub	SENSEL		T/DUMUGA	o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Phaulopsis imbricata	Acanthaceae	herb/shrub	-		DARGU	o	o	+	o	o	o	o	o	o	o	o	+	+	+	Fichtl & Adi, 1994
Ruttya speciosa	Acanthaceae	herb/shrub	-			o	o										o	o	o	Fichtl & Adi, 1994
Barleria eranthemoides	Acanthaceae	herb/shrub	YESETAF		SHISHI	o	o									o	o			Admasu et al. 2014
Baleria submollis	Acanthaceae	herb/shrub				o										o	o			Admasu et al. 2014
Blephbaris edulis	Acanthaceae	herb/shrub	YAYIT ESHOH			o	o									o	o	o		Admasu et al. 2014
Hygrophila schulli	Acanthaceae	herb/shrub	AMEKELA, KORJEJOT, KURMBA, KURUMBEYE		QORRATI-SAREE	o	o	o	o	o					o	o	o	o	o	Admasu et al. 2014
Justicia bizuneshiae	Acanthaceae	herb/shrub				o	o									o	o			Admasu et al. 2014
Peristrophe paniculata	Acanthaceae	herb/shrub		ANDOLIVA		o	o									o	o	o		Admasu et al. 2014
Agave americana	Agavaceae	herb/shrub	QAICHA			+	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Agave sisalana	Agavaceae	herb/shrub	KACHA	YA-A		+	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Dracaena steudneri	Agavaceae	tree	CHOWYEH, TABATOS		LANKUSO, MERKO, SHOWYE	o	o	o	o											Fichtl & Adi, 1994
Allium cepa	Alliaceae	herb/shrub	QEYSHINKURT	ASA BESEL	QULLUBBII DIIMAA	o		o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014

Aloe berhana	Aloaceae	herb/shrub	IRET		Argisa	o	o	o	o	o								o	o	Fichtl & Adi, 1994
Achyranthes aspera	Amaranthaceae	herb/shrub	TIELENJ, ATTUCH		DARGU, MATANNE	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Celosia argentea	Amaranthaceae	herb/shrub	BEIBEITO		ABABO	o	o	o	o	o	o	o				o	o	o	o	Fichtl & Adi, 1994
Amaranthus hybridus	Amaranthaceae	herb/shrub			AJOFTU		o									o	o	o	o	Admasu et al. 2014
Celosia polystachya	Amaranthaceae	herb/shrub					o								o	o				Admasu et al. 2014
Chionothrix latifolia	Amaranthaceae	herb/shrub	SHELEL		GARRI		o	o											o	Admasu et al. 2014
Cyathula uncinula	Amaranthaceae	herb/shrub	BEGD ZEMEDIE, CHOGOGIT, YEKALM QIM, YEMOGNFKR		DARGUU, KADERA DHALTU		o									o	o			Admasu et al. 2014
Crinum abyssinicum	Amaryllidaceae	herb/shrub	-			+	o						o	o						Fichtl & Adi, 1994
Scadoxus multiflorus	Amaryllidaceae	herb/shrub	YEDJIB AGEDA		ABRASA		+		o	o	o	o								Fichtl & Adi, 1994
Mangifera indica	Anacardiaceae	tree	MANGO		MANGO	o	o	o	o	o									o	Fichtl & Adi, 1995
Rhus glutinosa	Anacardiaceae	tree	MBS, QMMO		ADESSA, MUGAN, TATESSA	o	o	o									o	o	o	Fichtl & Adi, 1996
Schinus molle	Anacardiaceae	tree	TQUR-BERBERIE			o	+	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1997
Ozoroa insignis	Anacardiaceae	tree	SHELEL		GARRI	o	o	o											o	Admasu et al. 2014
Alepedia longifolia	Apiaceae	herb/shrub	-			o	o							o	o	o	o	o		Fichtl & Adi, 1994
Anethum foeniculum	Apiaceae	herb/shrub	KAMUN, INSLAL		KAMUNI	o	o									o	o	o		Fichtl & Adi, 1994
Anethum graveolens	Apiaceae	herb/shrub	NSLAL, SELAN		KAMUNI	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Coriandrum sativum	Apiaceae	herb/shrub	DMBLAL		DEBO, SHUCAR	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994

Ferula communis	Apiaceae	herb/shrub	NSLAL, DOG			o	o	o	o						o	o	o	o	o	Fichtl & Adi, 1994
Steganotaenia araliacea	Apiaceae	herb/shrub	SHUNKWORI		JIRMA-JALESA	o	o	o	o						o	o	o	o	o	Fichtl & Adi, 1994
Trachyspermum ammi	Apiaceae	herb/shrub	NECHI-AZMUD		AZMUD-ADDI, KAMON, KAMUNI	o	o										o	o	o	Fichtl & Adi, 1994
Peucedanum mattirolii	Apiaceae	herb/shrub	SRE-BIZU				o									o	o			Admasu et al. 2014
Carissa edulis	Apocynaceae	herb/shrub	AGAM		AGAMSA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Cryptostegia grandiflora	Apocynaceae	herb/shrub				o		o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Nerium oleander	Apocynaceae	herb/shrub			MACHALLOW	~	~	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Adenium obesum	Apocynaceae	tree	-			o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1998
Ilex mitis	Aquifoliaceae	herb/shrub	MISIR GEMFO		KETTO (Kaf); HAMSIKA, KETTO, MIESA, TILTO, WOLKITE GAADHII	o	o	o											o	Admasu et al. 2014
Arisaema enneaphyllos	Araceae	herb/shrub	YELREGNOCH TILA		ABUTAYE	o	+				o	o	o							Fichtl & Adi, 1994
Zantedeschia aethiopica	Araceae	herb/shrub	YETIRUMBA-ABEBA			o	o									o	o	o	o	Fichtl & Adi, 1994
Cussonia holstii	Araliaceae	tree	GEDETAMO, CAQMOSH, YEZNJERO-GOMMEN, GOMBOGERIE, DUDUNA		HARFATU, GETEMI, ANDEROCCI, ARFATTU	o	o									o	o	o		Fichtl & Adi, 1999
Polyscias fulva	Araliaceae	tree	YEZNJERO-WENBER		ABERRA, ANDALO, ANDOJE, ANKISSA, ANTALLO, GUDUBA, HUDA, KARASHO KORIBA, TALAÖ	o	o	o	o	o	o							o	o	Fichtl & Adi, 2000
Schefflera abyssinica	Araliaceae	tree	GETEMA, QUSTYA		ARFATTU, GATAMA, HARFATU, MARFATU	o	o			o	o	o								Fichtl & Adi, 2001

Phoenix reclinata	Arecaceae	tree	HOSA'NA, SELLEN HOSANA, ZEMBABA		MEEXII	o	o										o	o	o	Fichtl & Adi, 2002
Calotropis procera	Asclepiadaceae	herb/shrub	TOBBIYA		KIMBO	o		o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Gymnema sylvestre	Asclepiadaceae	herb/shrub	-			o		o	o	o	o	o	o	o	o			o	o	Fichtl & Adi, 1994
Periploca linearifolia	Asclepiadaceae	herb/shrub	MOYDER		ANANNOO, BORIINOO	o	o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Sarcostemma viminale	Asclepiadaceae	herb/shrub	YEMEDER-QENCHIB	MAIDU		o	o	o											o	Admasu et al. 2014
Asparagus africanus	Asparagaceae	herb/shrub	KESTEENICHA, YESET QEST		HIDDII SAAREE, SARITI	o	o										o	o	o	Fichtl & Adi, 1994
Acmella caulirhiza	Asteraceae	herb/shrub	YEMDR-BERBERIE, DAME			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Ageratum conyzoides	Asteraceae	herb/shrub	AREMA		ADDA, ITUFO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Anthemis tigreensis	Asteraceae	herb/shrub	-			o	o	o	+	+	+	+	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Aspilia africana	Asteraceae	herb/shrub	-			o	o									o	o	o		Fichtl & Adi, 1994
Aspilia mossambicensis	Asteraceae	herb/shrub	-			o	o							o	o	o	o	o	o	Fichtl & Adi, 1994
Berkheya spekeana	Asteraceae	herb/shrub	-			o	o									o	o	o		Fichtl & Adi, 1994
Bidens ghedoensis	Asteraceae	herb/shrub	-		KELLO	o	o								o	o	o	o	o	Fichtl & Adi, 1994
Bidens macroptera	Asteraceae	herb/shrub	ADEY ABEBA, MESKEL ABEBA		KELLO	o	o									o	o	o	o	Fichtl & Adi, 1994
Bidens pachyloma	Asteraceae	herb/shrub	ADEY ABEBA, MESKEL ABEBA		KELLO	o	o									o	o			Fichtl & Adi, 1994
Bidens pilosa	Asteraceae	herb/shrub	CHEGOGIT, YSATAN-MERFY		MAXXANE		o									o	o			Fichtl & Adi, 1994
Bidens prestinaria	Asteraceae	herb/shrub	ADEY ABEBA, MESKEL ABEBA		KELLO	o	o									o	o			Fichtl & Adi, 1994
Bothriocline schimperi	Asteraceae	herb/shrub	-			o	o	o	o								o	o	o	Fichtl & Adi, 1994
Carduus camaecephalus	Asteraceae	herb/shrub	KOSHESHLA			o	o	o										o	o	Fichtl & Adi, 1994

Carduus nyassanus	Asteraceae	herb/shrub	KOSHESHLA			o	o	o	o									o	o	Fichtl & Adi, 1994
Carthamus lanatus	Asteraceae	herb/shrub	YE-AHIYA-SUF			o	+	o									o	o	o	Fichtl & Adi, 1994
Carthamus tinctorius	Asteraceae	herb/shrub	SUFF		BORDA, SUFII, SUUFI, SUUFIBORDA	o	o	o	o									o	o	Fichtl & Adi, 1994
Centaurea melitensis	Asteraceae	herb/shrub	-			o	o	o										o	o	Fichtl & Adi, 1994
Cichorium intybus	Asteraceae	herb/shrub	-			o	o	o	o									o	o	Fichtl & Adi, 1994
Cirsium dender	Asteraceae	herb/shrub	DANDER			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Cirsium englerianum	Asteraceae	herb/shrub	KOSHESHLA			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Cirsium schimperi	Asteraceae	herb/shrub	KOSHESHLA			o	o	o	o	o	o	o							o	Fichtl & Adi, 1994
Conyza steudelli	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Cosmos bipinnatus	Asteraceae	herb/shrub	-			o	o	o									o	o	o	Fichtl & Adi, 1994
Crassocephalum sarcobasis	Asteraceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Crassocephalum vitellinum	Asteraceae	herb/shrub	JEGALLATIIT, LTI-MAREFYA			o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Crepis rueppellii	Asteraceae	herb/shrub	YEFYEL-WETET			o	o	+	+	+	o	o	o	o	o	o	o	o	+	Fichtl & Adi, 1994
Cynara scolymus	Asteraceae	herb/shrub	-			+	o	o								o	o	o	o	Fichtl & Adi, 1994
Dahlia pinnata	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Echinops ellenbeckii	Asteraceae	herb/shrub	KOILO, KOSHESHLA			o	o	o	o	o	o	o						o	o	Fichtl & Adi, 1994
Echinops giganteus	Asteraceae	herb/shrub	KOSHESHLA, SHOKI			o	o	o	o								o	o	o	Fichtl & Adi, 1994
Echinops hispidus	Asteraceae	herb/shrub	KOSHESHLA			o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Echinops longisetus	Asteraceae	herb/shrub	-		KOSORU	o	o	o								o	o	o	o	Fichtl & Adi, 1994
Eclipta prostrata	Asteraceae	herb/shrub	-			o	o		o	o	o	o	o	o	o					Fichtl & Adi, 1994

Echinops macrochaetus	Asteraceae	herb/shrub	KOSHESHLA			o	o	o	o	o							o	o	o	Fichtl & Adi, 1994
Emilia discifolia	Asteraceae	herb/shrub	-			o	o	o	o	o						o	o	o	o	Fichtl & Adi, 1994
Ethulia gracilis	Asteraceae	herb/shrub	-			o	o	o	o								o	o	o	Fichtl & Adi, 1994
Flaveria trinervia	Asteraceae	herb/shrub	-		GOROSEZA	o	o	o									o	o	o	Fichtl & Adi, 1994
Galinsoga parviflora	Asteraceae	herb/shrub	BALCHA, GOROSITU, DHA-NEQAY, NEKELKEGNE, YEMDR-BERHERU, ABADABO, YESHEWA-AREM		ABATABO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Haplocarpha schimperi	Asteraceae	herb/shrub	GETIN			o	o	o	o	o	o	o	o					o	o	Fichtl & Adi, 1994
Helianthus annuus	Asteraceae	herb/shrub	JABAR-SUF, YEFERENG-SUF, SUF		DUBI, ISUFI-FERENJI, NUGI ADI	o	o	?	?	?	?	?	?	?	?	?	?	?	?	Fichtl & Adi, 1994
Helichrysum formosissimus	Asteraceae	herb/shrub	-				o	+	o	o	o	o	o	o	o	o	+	+	+	Fichtl & Adi, 1994
Helichrysum splendidum	Asteraceae	herb/shrub	-				o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Helminthotheca echioides	Asteraceae	herb/shrub	-			o	o	o	o								o	o	o	Fichtl & Adi, 1994
Inula confertiflora	Asteraceae	herb/shrub	WONAGIFT		BULAANCHOO, HAXAWWII	o	o	o	o	o					o	o	o	o	o	Fichtl & Adi, 1994
Lactuca inermis	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Laggera pterodonata	Asteraceae	herb/shrub	KES-KESA			o	o	o	o									o	o	Fichtl & Adi, 1994
Launaea cornuta	Asteraceae	herb/shrub	-			o	o										o	o	o	Fichtl & Adi, 1994
Microglossum pyrifolia	Asteraceae	herb/shrub	HAREG			o	o	o	o	o	o						o	o	o	Fichtl & Adi, 1994
Mikaniopsis clematoides	Asteraceae	herb/shrub	HAREG			o	o	o	o	o								o	o	Fichtl & Adi, 1994
Peltocephalus varians	Asteraceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Senecio fresenius	Asteraceae	herb/shrub	-		ANGAASUU	o	o	o	o	o	o	o	o						o	Fichtl & Adi, 1994

Senecio hadiensis	Asteraceae	herb/shrub	-			o	o	o	o	o							o	o	o	Fichtl & Adi, 1994
Senecio lyratus	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Senecio myriocephalum	Asteraceae	herb/shrub	-		GAWEH, GAWE, INGESHU	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Senecio ochrocarpus	Asteraceae	herb/shrub	QEBQEBO		DIFU	o	o								o	o	o	o		Fichtl & Adi, 1994
Senecio steudelii	Asteraceae	herb/shrub	-			o	o				o	o	o							Fichtl & Adi, 1994
Silybum marianum	Asteraceae	herb/shrub	-			o	o								o	o	o	o	o	Fichtl & Adi, 1994
Solanecio angelatus	Asteraceae	herb/shrub	HAREG			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Solanecio mannii	Asteraceae	herb/shrub	-			o	o	o	o									o	o	Fichtl & Adi, 1994
Sonchus asper	Asteraceae	herb/shrub	-			?	?	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Sonchus bipontini	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o			o	o	o	o	o	Fichtl & Adi, 1994
Sphaeranthus suaveolens	Asteraceae	herb/shrub	-		HOLAGABIS	o	o	o	o	o	o	o	o			o	o	o	o	Fichtl & Adi, 1994
Tagetes minuta	Asteraceae	herb/shrub	ELLCHIBO, GEMIE, GEMMA-HASHISH, YAHIYA ARITI, YAHIYA SHITO		AJOFTU, HADDA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Tagetes patula	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Tridax procumbens	Asteraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Vernonia adoensis	Asteraceae	herb/shrub	FERES ZENG, TIKWA		SUKE	o	o	o	o	o	o	o	o	o			o	o	o	Fichtl & Adi, 1994
Vernonia auriculifera	Asteraceae	herb/shrub	GUJO, REGI		REJJI	o	o	o	o	o	o	o						o	o	Fichtl & Adi, 1994
Vernonia biafra	Asteraceae	herb/shrub	-			o	o	o	o	o										Fichtl & Adi, 1994
Vernonia leopoldii	Asteraceae	herb/shrub	CHIBO			+	o	o									o	o	o	Fichtl & Adi, 1994
Vernonia rueppellii	Asteraceae	herb/shrub	GUJO		REDJII, REJJI	+	o	o	o	o						o	o	o	o	Fichtl & Adi, 1994

Vernonia schimperi	Asteraceae	herb/shrub	-			o	o	o	o	o						o	o	o	o	Fichtl & Adi, 1994
Vernonia theophrastifolia	Asteraceae	herb/shrub	-			o	o										o	o	o	Fichtl & Adi, 1994
Vernonia thomsoniana	Asteraceae	herb/shrub	-		SOYAMA	o	o	o	o	o										Fichtl & Adi, 1994
Vernonia urticaria	Asteraceae	herb/shrub	-			o	o	o	o	o							o	o	o	Fichtl & Adi, 1994
Xanthium spinosum	Asteraceae	herb/shrub	YESET MILAS		KORE-BUSE	o	o	o	o	o	o	o						o	o	Fichtl & Adi, 1994
Guizotia scabra	Asteraceae	herb/shrub	ADEY ABEBA, GAGIE, MECH		ADELA, AWAAYYYEE, HADAA, TUUFOO	o	o										o	o	o	Admasu et al. 2014
Bartlettina sordida	Asteraceae	herb/shrub					+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Carduus pycnocephalus	Asteraceae	herb/shrub	KOSHOSHILA		QOREE-HARREE		+								o	o				Admasu et al. 2014
Chrysanthemum coronarium	Asteraceae	herb/shrub					o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Cineraria abyssinica	Asteraceae	herb/shrub					o									o	o			Admasu et al. 2014
Cirsium vulgare	Asteraceae	herb/shrub			QOREE HARREE		o									o	o			Admasu et al. 2014
Crassocephalum macropappum	Asteraceae	herb/shrub	LET'I-MAREFIYA			o	o	+	o	o	o	o	o	o	o	o	o	+	+	Admasu et al. 2014
Dicrocephala chrysanthemifolia	Asteraceae	herb/shrub			HADAA, NUUGA, TABBAGIDII		o									o	o			Admasu et al. 2014
Galinsoga quadriradiata	Asteraceae	herb/shrub	ABA-DABO, AREMAMO NEGELEGN		ABBADEEBO, ABBAGUYYA RUFKEDDIE	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Helichrysum citrispinum	Asteraceae	herb/shrub	NECHILO, SETEGARDA		NACHILO, NATCHILO, TUKA		o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014

Helichrysum stenopterum	Asteraceae	herb/shrub				o	o									o	o			Admasu et al. 2014
Kleinia grantii	Asteraceae	herb/shrub			RAAFU-QAMALE, RAAFU, GAMALEE		+									o	o			Admasu et al. 2014
Kleinia squarrosa	Asteraceae	herb/shrub					+	o											o	Admasu et al. 2014
Laggera crispata	Asteraceae	herb/shrub	GEMIE, QES BEDEJA, KESKESSIE		AJAYA, ASHKASHO	o	o						o	o	o	o	o			Admasu et al. 2014
Launaea intybacea	Asteraceae	herb/shrub	ECH MESKEL, MECHMESKEL		HOOLA -GABBISA, OLA-GABBIS		o										o	o	o	Admasu et al. 2014
Parthenium hysterophorus	Asteraceae	herb/shrub			FARAMISISSA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Senecio schultzii	Asteraceae	herb/shrub	GEDEET, QUEDEET			o	o	o	o	o	o	o	o					o	o	Admasu et al. 2014
Solanecio gigas	Asteraceae	herb/shrub	YESHKOKO-GOMEN		JILMMA JALDESSA, NOOBE	o	o									o	o	o	o	Admasu et al. 2014
Verbesina encelioides	Asteraceae	herb/shrub					o									o	o			Admasu et al. 2014
Vernonia amygdalina	Asteraceae	herb/shrub	GRAWA		EBICHA, GEEBICHA	+	o	+	+	o	o	o							o	Admasu et al. 2014
Vernonia galamensis	Asteraceae	herb/shrub					o									o	o			Admasu et al. 2014
Vernonia hochstetteri	Asteraceae	herb/shrub	NEKHIELU		DAMOT GURRA	o	o						o	o	o	o	o			Admasu et al. 2014
Xanthium strumarium	Asteraceae	herb/shrub	DEHA NIKEL		BANDOO		o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014

Zinnia elegans	Asteraceae	herb/shrub					o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Balanites aegyptiaca	Balanitaceae	tree	BEDDENNO, KUDKUDDA, JEMO, GUZA, QACONA		BADDANNO, DOMOHO	o		o	o	o								o	o	Fichtl & Adi, 2004
Impatiens glandulifera	Balsaminaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Impatiens hochstetteri	Balsaminaceae	herb/shrub	-			o		o	o	o	o	o					o	o	o	Fichtl & Adi, 1994
Impatiens rothii	Balsaminaceae	herb/shrub	GURSHT			o	o	o	o	o	o	o			o	o	o	o	o	Fichtl & Adi, 1994
Basella alba	Basellaceae	herb/shrub			LEEBOO	o	o									o	o			Admasu et al. 2014
Begonia wollastonii	Begoniaceae	herb/shrub	-				o								o	o	o	o	o	Fichtl & Adi, 1994
Berberis holstii	Berberidaceae	herb/shrub	ZENQILA			o	o						o	o	o	o	o	o	o	Fichtl & Adi, 1994
Tecoma stans	Bignoniaceae	herb/shrub	-			o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Borago officinalis	Bignoniaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Jacaranda mimosifolia	Bignoniaceae	tree	YETEBMENJA-ZAF			o	o	o	o	o										Fichtl & Adi, 2005
Stereospermum kunthiana	Bignoniaceae	tree	WASHNT, ZANA		UTORO, BODORO	o	o	o	o	o	+	+				o	o	o	o	Fichtl & Adi, 2006
Tecomaria capensis	Bigoniaceae	herb/shrub				o	o	+	o	o	o	o	o	o	o	o	o	+	+	Admasu et al. 2014
Adansonia digitata	Bombacaceae	tree	BAMBA			o						o	o	o						Fichtl & Adi, 2007
Ceiba pentandra	Bombacaceae	tree	YETIT-ZAF, YEKBRITT-NCHET			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2008
Chorisia speciosa	Bombacaceae	tree				o		?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Cynoglossum coeruleum	Boraginaceae	herb/shrub	CHIGOGOT, FERISH-TENU, SHINGUG		MATANE-CHATI	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994

Echium plantagineum	Boraginaceae	herb/shrub	-			o	o	o	o									o	o	Fichtl & Adi, 1994
Heliotropium cinerascens	Boraginaceae	herb/shrub	SHEKO		BAGANAPSI, DARRASA, SEBEKONE, SOKENE	o	o	o	o	o	o	o			o	o	o	o	o	Fichtl & Adi, 1994
Trichodesma zeylanicum	Boraginaceae	herb/shrub	KOSKUS		AREMU LAEZAB	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Cordia africana	Boraginaceae	tree	WANZA		WADESSA	o	o	o	o	o							o	o	o	Fichtl & Adi, 2009
Ehretia cymosa	Boraginaceae	tree	GAME, HULAGA, MUKERBA, GARMI		WAGI, WURUGU, URAGA	+	o	o	+	+	+	+	o	o	o	o	o	o	o	Fichtl & Adi, 2010
Brassica carinata	Brassicaceae	herb/shrub	GOMEN ZER, SENAFC, YEGURAGIE GOMEN		RAAFUU, GOMANA, MIDAN-RAFU, SIANO, RAAFUU SIMBIRO	o	o	o	o	o	o							o	o	Fichtl & Adi, 1994
Brassica napus	Brassicaceae	herb/shrub	-			o	o									o	o	o		Fichtl & Adi, 1994
Brassica nigra	Brassicaceae	herb/shrub	SENAFCHI		SANAVI, ISENAFICCIA	o	o	o	o	o	o					o	o	o	o	Fichtl & Adi, 1994
Crambe hispanica	Brassicaceae	herb/shrub	-		FUJUL	o	o					o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Erucastrum abyssinicum	Brassicaceae	herb/shrub	YEWOF GOMEN		GOMANZA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Lepidium sativum	Brassicaceae	herb/shrub	FETO		FETO, CIRCUFA, FECIO, SHIMFI	o	o										o	o		Fichtl & Adi, 1994
Raphanus raphanistrum	Brassicaceae	herb/shrub	-			o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Rorippa nasturtium-aquaticum	Brassicaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Sinapis alba	Brassicaceae	herb/shrub	SENAFCH			o	o										o			Fichtl & Adi, 1994
Alysum alyssoides	Brassicaceae	herb/shrub					o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Buddleja davidii	Buddlejaceae	herb/shrub				+	o	o											o	Admasu et al. 2014
Buddleja polystachya	Buddlejaceae	tree	AMFAR, ANFAR, ATKUAR		ADADO, CHIAI	o	o	+	+	+	+	+	o	o	o	o	o	+	+	Admasu et al. 2014

Nuxia congesta	Buddlejaceae	tree	ASKWAR, CHECH' IHO, SEGED, TIKUR-ASQUAL	ATARO	ANFARE, IRBA	o	o	o	o	o	o	o					o	o	o	Admasu et al. 2014
Boswellia papyrifera	Burseraceae	tree	QERERRIE, YETAN-ZAF		LIBANAT, GALGALAM, KAFAL	o	o	o	o								o	o	o	Fichtl & Adi, 2013
Commiphora erythraea	Burseraceae	tree			HAGAR-AD, HAGAR-RNEDOW, HAGARSO, HAGARSU		+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Opuntia cylindrica	Cactaceae	herb/shrub	-			o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Opuntia ficus-indica	Cactaceae	tree	QULQWAL		TINI, GURA	o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2014
Campanula edulis	Campanulaceae	herb/shrub	YEREGNA-MSA			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Canarina abyssinica	Campanulaceae	herb/shrub	TUTU			o	o						o	o	o	o				Fichtl & Adi, 1994
Canarina eminii	Campanulaceae	herb/shrub	TUTU		SHASHETAY, TUTO ROBBA		o									o	o			Admasu et al. 2014
Gynandropsis gynandra	Capparidaceae	herb/shrub	ABETEYO			o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Maerua angolensis	Capparidaceae	herb/shrub	AGATCHLAL, FRTETA, TEMENIE	ASTAN	QENQELCHA	o	o	o	o	o	o						o	o	o	Fichtl & Adi, 1994
Ritchie albersii	Capparidaceae	herb/shrub	DNGAY-SEBER			o	o	o	o	o	o	o	o				o	o	o	Fichtl & Adi, 1994
Boscia salicifolia	Capparidaceae	herb/shrub			ALUTTOO, LALATOO, QEYISA	o		o											o	Admasu et al. 2014
Cadaba farinosa	Capparidaceae	herb/shrub	DNGAY SEBER		DAMBII		o									o	o	o		Admasu et al. 2014
Cleome gynandra	Capparidaceae	herb/shrub	AWQO BEQE			o	o									o	o			Admasu et al. 2014
Maerua crassifolia	Capparidaceae	herb/shrub			KALKALCHA, QANQALCHA, DHUMISHO		o	o											o	Admasu et al. 2014
Maerua oblongifolia	Capparidaceae	herb/shrub	WAWATIE				o	o											o	Admasu et al. 2014

Crateva adansonii	Capparidaceae	tree	DINKIA-SEBBER			o	o	o	o	o								o	o	Fichtl & Adi, 2015
Sambucus canadensis	Caprifoliaceae	tree				+		?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Carica papaya	Caricaceae	tree	PAPAYA		PAPAYA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2016
Catha edulis	Celastraceae	herb/shrub	CHAT		CATI, GOFA JIMAI	o	o	o								o	o	o	o	Fichtl & Adi, 1994
Maytenus arbutifolia	Celastraceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Maytenus obscura	Celastraceae	tree	ATAT		KOMBOLCHA	o	o										o	o	o	Fichtl & Adi, 2017
Maytenus senegalensis	Celastraceae	tree	NEC-ATAT, GULO-KOKKOBA, QOQQOBA		JIMA -HARRE, KOMBOLCHA	o	o	o	o	o	o	o					o	o	o	Fichtl & Adi, 2018
Maytenus gracilipes	Celastraceae	tree	ATAT		HACHACHA; KARXAMME		o								o	o	o			Admasu et al. 2014
Maytenus putterlickioides	Celastraceae	tree			FOLKOLCHA, FONKONCHA		o	o											o	Admasu et al. 2014
Gloriosa simplex	Colchicaceae	herb/shrub	-		ARAMANDAWA		~					o	o	o	o					Fichtl & Adi, 1994
Combretum paniculatum	Combretaceae	herb/shrub	-		GABAI, SHAGA, BEGE	o	?	o	o							o	o	o	o	Fichtl & Adi, 1994
Combretum molle	Combretaceae	tree	AVALO, BAGUR, FUTUKA		BIK'AA, BIIQAA, DAANNISA, DADARNSAA, DANDAMSA, DIDDIQSSAA, DUGHEESSA, RUUKEESAA	o	o	o	o	o	o									Fichtl & Adi, 2019
Anogeissus leiocarpa	Combretaceae	tree	MOK		SILEK	o	o									o	o			Admasu et al. 2014
Terminalia brownii	Combretaceae	tree			ABAALOO, ALULOO, BALANGAA, BARESAA, GALALDO, GLELIO, REESSAA	o	o				o	o	o	o						Admasu et al. 2014

Terminalia schimperiana	Combretaceae	tree	ABALO, TAGYIE		AMBE, BAGURE, KOLISA, QAXALEE	+	o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Commelina benghalensis	Commelinaceae	herb/shrub	YEWHA-ANQUR, WOFANQUR		DILISHA, HOLEGEBIS, LABUNCHE		o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Cyanotis barbata	Commelinaceae	herb/shrub	YEWOF QOLO, YEJIB DINICH			~	o								o	o	o	o		Fichtl & Adi, 1994
Ipomoea purpurea	Convolvulaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Ipomoea tenuirostris	Convolvulaceae	herb/shrub	AYIT- HAREGE			o	o	o	o	o								o	o	Fichtl & Adi, 1994
Kalanchoe densiflora	Crassulaceae	herb/shrub	INDAHULA		ANCORURA	o	o										o	o	o	Fichtl & Adi, 1994
Kalanchoe lanceolata	Crassulaceae	herb/shrub	YEQQOLLA-INDAHULLA		FURGUGE, QONTOMA	~	~	o	o									o	o	Fichtl & Adi, 1994
Kalanchoe marmorata	Crassulaceae	herb/shrub	INDAHULA		BOSOKE	~	~	o									o	o	o	Fichtl & Adi, 1994
Kalanchoe petitiana	Crassulaceae	herb/shrub	YEQUOLLA-INDAHULLA			~	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Kalanchoe quartiniana	Crassulaceae	herb/shrub	INDAHULLA; SHNQAQ		AMDOHALE, ANDOHAHELE , IBOSOQQE, HANCURA	~	~	o	o								o	o	o	Fichtl & Adi, 1994
Sedum churchillianum	Crassulaceae	herb/shrub	-			o	o	o	o	o	o					o	o	o	o	Fichtl & Adi, 1994
Sedum mooneyi	Crassulaceae	herb/shrub	-			o	o	o	o								o	o	o	Fichtl & Adi, 1994
Coccinia abyssinica	Cucurbitaceae	herb/shrub	-		ANCHOTE	o	~							o	o	o	o	o		Fichtl & Adi, 1994
Cucumis sativus	Cucurbitaceae	herb/shrub	KIYARE			o	o	?	?	?	?	?	?	?	?	?	?	?	?	Fichtl & Adi, 1994
Cucurbita pepo	Cucurbitaceae	herb/shrub	DUBA		ARABE, FIRI DUBA	o	o				o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Lagenaria abyssinica	Cucurbitaceae	herb/shrub	KUL			o	o										o	o	o	Fichtl & Adi, 1994
Luffa cylindrica	Cucurbitaceae	herb/shrub	LIPA			o	o										o	o	o	Fichtl & Adi, 1994

Citrullus lanatus	Cucurbitaceae	herb/shrub				o	o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Cucumis pustulatus	Cucurbitaceae	herb/shrub			HOLOTO	o	o									o	o			Admasu et al. 2014
Zehneria scabra	Cucurbitaceae	herb/shrub	AREG RESA		HIDDA ADDI	o	o									o	o			Admasu et al. 2014
Dipsacus pinnatifidus	Dipsacaceae	herb/shrub	KELM			o	o									o	o	o	o	Fichtl & Adi, 1994
Pterocephalus frutescens	Dipsacaceae	herb/shrub	HENSERASE			o	o	+	o	o	o	o	o	o	o	+	+	+	o	Fichtl & Adi, 1994
Scabiosa columbaria	Dipsacaceae	herb/shrub	YETIJA ZAGO			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Diospyros mespeliformis	Ebenaceae	tree	BTREMUSEH, AYEH			+	o		o	o	o									Fichtl & Adi, 2020
Erica arborea	Ericaceae	tree	ASTA		WADADI, SAATOO, LABASSE; QAMATE	o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2021
Euphorbia pulcherrima	Euphorbiaceae	herb/shrub	-			o	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Euphorbia tirucalli	Euphorbiaceae	herb/shrub	QNICHB			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Clusia lanceolata	Euphorbiaceae	herb/shrub	FIYELE FEJ			o	o									o	o	o		Admasu et al. 2014
Croton dichogamus	Euphorbiaceae	herb/shrub	YESIGA BETIR		MAGOO, MUKAAFULAA, ULLE FOONI		+	o	o	o										Admasu et al. 2014
Croton zambesicus	Euphorbiaceae	herb/shrub	YEFERENJ BISANA			o	o	o											o	Admasu et al. 2014
Euphorbia nubica	Euphorbiaceae	herb/shrub			AANNOO, ERGIN	~	~	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Manihot esculenta	Euphorbiaceae	herb/shrub			DEEKIKAA	+	+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014

Phyllanthus ovalifolius	Euphorbiaceae	herb/shrub	YEKEBT SHMBRA		JOLAAFA, KOTTUU		o									o	o			Admasu et al. 2014
Ricinus communis	Euphorbiaceae	tree	GULO, HABLALIT, CHIAQMAL		BAMBALTAA, HAMBALTAA, QOBBOO	o	o									o	o			Admasu et al. 2014
Croton macrostachyus	Euphorbiaceae	tree	BISANA		ALALOO, ANKOWAA, BAKANNOO, BAAKANNISAA, CACANIRAA, MAKKANISSA	o	o				o	o	o	o						Fichtl & Adi, 2022
Euphorbia abyssinica	Euphorbiaceae	tree	QULQWAL		ADAMII, HADAAMII	+	o									o	o	o		Fichtl & Adi, 2023
Euphorbia candelabrum	Euphorbiaceae	tree	KALKWOL, QOLQWAL, QULQWAL, QNCHB		ADAMI, HADAMI, AKIRSA	o	o	o								o	o	o	o	Fichtl & Adi, 2024
Sapium ellipticum	Euphorbiaceae	tree	ARBOCHE		BOSAKA, WOSANGA	o	o	o	o								o	o	o	Fichtl & Adi, 2026
Aeschynomene americana	Fabaceae	herb/shrub	-			o	o	o								o	o	o	o	Fichtl & Adi, 1994
Argyrolobium ramosissimum	Fabaceae	herb/shrub	GERENGERE			o	o							o	o	o	o	o		Fichtl & Adi, 1994
Caesalpinia decapetala	Fabaceae	herb/shrub	YEFERENJ-KITKITTA, QONTIR		HARAGAMMA	o	o	o									o	o	o	Fichtl & Adi, 1994
Caesalpinia spinosa	Fabaceae	herb/shrub	QONTIR			o	o	o									o	o	o	Fichtl & Adi, 1994
Chamaecytisus proliferus	Fabaceae	herb/shrub	-			o					o	o				o	o			Fichtl & Adi, 1994
Cicer arietinum	Fabaceae	herb/shrub	SHMBRA	SUMBURA	SHUMBURA	o	o	o	o								o	o	o	Fichtl & Adi, 1994
Desmodium intortum	Fabaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Desmodium repandum	Fabaceae	herb/shrub	-			o	o	o	o	o	o	o							o	Fichtl & Adi, 1994
Glycine max	Fabaceae	herb/shrub	AKURI ATER			~	~									o	o			Fichtl & Adi, 1994
Glycine wightii	Fabaceae	herb/shrub	YEAYIT JORO		GURAA HANTUTA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Indigofera zavattarii	Fabaceae	herb/shrub	-			o	o									o	o	o		Fichtl & Adi, 1994

Lablab purpureus	Fabaceae	herb/shrub	YEAMORA GUAYA			o	o	o	o	o	o						o	o	o	Fichtl & Adi, 1994
Lathyrus sativus	Fabaceae	herb/shrub	GUAYA		GAYYA, GAYYO	o	o	o	o	o	o	o				o	o	o	o	Fichtl & Adi, 1994
Lotus discolor	Fabaceae	herb/shrub	-			+	~	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Lupinus albus	Fabaceae	herb/shrub	GBTO			o	o										o	o	o	Fichtl & Adi, 1994
Lupinus angustifolius	Fabaceae	herb/shrub	GBTO			o	o	o	o	o	o	o				o	o	o	o	Fichtl & Adi, 1994
Macroptilium atropurpureum	Fabaceae	herb/shrub	-			o	o	o											o	Fichtl & Adi, 1994
Medicago polymorpha	Fabaceae	herb/shrub	WAJEMA, KURNCHT		KUMUTO, HAMAQITA	o	o						o	o	o	o	o	o	o	Fichtl & Adi, 1994
Medicago sativa	Fabaceae	herb/shrub	-			o	o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Melilotus alba	Fabaceae	herb/shrub	-			o	o	o	o				o	o	o	o	o	o	o	Fichtl & Adi, 1994
Melilotus suaveolens	Fabaceae	herb/shrub	-		TITAKO	o	o	o	o								o	o	o	Fichtl & Adi, 1994
Mimosa invisa	Fabaceae	herb/shrub	-			o	o	o	o	o								o	o	Fichtl & Adi, 1994
Parochetus communis	Fabaceae	herb/shrub	YEMDR-KOSO			o	o	o	o	o	o				o	o	o	o	o	Fichtl & Adi, 1994
Phaseolus coccineus	Fabaceae	herb/shrub	-			o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Phaseolus lunatus	Fabaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Pisum sativum	Fabaceae	herb/shrub	ATER		ATERA, ATERADONGOLO, DANGULLE	~	~									o	o			Fichtl & Adi, 1994
Pterolobium stellatum	Fabaceae	herb/shrub	QENTIAFFA, QONTIR		HARAGAMA, GORA	o	o	o	o	o	o	o					o	o	o	Fichtl & Adi, 1994
Scorpiurus muricatus	Fabaceae	herb/shrub	YEBEG-LAT		KOTEBAY	o	o								o	o	o	o		Fichtl & Adi, 1994
Trifolium acaule	Fabaceae	herb/shrub	AMAGET		SIDISSA	o	o	o	o	o	o	o	+	+	+	+	+	+	+	Fichtl & Adi, 1994
Trifolium burchellianum	Fabaceae	herb/shrub	ALMA			o	o	o	o	o	o				o	o	o	o	o	Fichtl & Adi, 1994

Trifolium calocephalum	Fabaceae	herb/shrub	MAGETT			o	o							o	o	o	o	o	o	Fichtl & Adi, 1994
Trifolium decorum	Fabaceae	herb/shrub	MAGETT			o	o									o	o			Fichtl & Adi, 1994
Trifolium polystachyum	Fabaceae	herb/shrub	SHAL			o	o									o	o	o	o	Fichtl & Adi, 1994
Trifolium quartinianum	Fabaceae	herb/shrub	AMAGET, YEBEG-LAT, WAZMA		SIDDISA	+	o									o	o			Fichtl & Adi, 1994
Trifolium rueppellianum	Fabaceae	herb/shrub	AMAGET		AMAQETA, SIDISA	o	o						o	o	o	o	o	o	o	Fichtl & Adi, 1994
Trifolium schimperi	Fabaceae	herb/shrub	AMAGET			o	o								o	o	o	o		Fichtl & Adi, 1994
Trifolium semipilosum	Fabaceae	herb/shrub	AMAGET			+		o	o	o	o	o	o	o	+	+	+	+	o	Fichtl & Adi, 1994
Trifolium simense	Fabaceae	herb/shrub	AMAGET		SIDDISA	o	o								o	o	o	o		Fichtl & Adi, 1994
Trifolium steudneri	Fabaceae	herb/shrub	AMAGET, YEBEG-LAT, WAZMA		SIDDISA	o	o								o	o	o			Fichtl & Adi, 1994
Trigonella foenum-graecum	Fabaceae	herb/shrub	ABSH	ABIIKAYE	ULBATA, SINQO, ABISHI	o	o	o									o	o	o	Fichtl & Adi, 1994
Tylosema fassoglensis	Fabaceae	herb/shrub	YEJB-ATER			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Vicia dasycarpa	Fabaceae	herb/shrub	-			o	o				o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Vicia faba	Fabaceae	herb/shrub	BAQIELA	BAQIELA	BAQELA	o	o									o	o			Fichtl & Adi, 1994
Vicia sativa	Fabaceae	herb/shrub	-			o	o	o	o	o				o	o	o	o	o	o	Fichtl & Adi, 1994
Desmanthus virgatus	Fabaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Trifolium repens	Fabaceae	herb/shrub	-			o	o								o	o	o	o	o	Fichtl & Adi, 1994
Stylosanthes guianensis	Fabaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Bauhinia variegata	Fabaceae	herb/shrub			KOTEE ARBA, ABAYTABATA	+	+	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Senna bicapsularis	Fabaceae	herb/shrub				o	o									o	o			Admasu et al. 2014

Senna italica	Fabaceae	herb/shrub	SENE-MEKKI	SANU		~	~									o	o			Admasu et al. 2014
Adenocarpus mannii	Fabaceae	herb/shrub					o									o	o			Admasu et al. 2014
Cajanus cajan	Fabaceae	herb/shrub	YE'RGB-ATER, YEWEF-ATER			o	o									o	o			Admasu et al. 2014
Crotalaria incana	Fabaceae	herb/shrub				o	o	o								o	o	o	o	Admasu et al. 2014
Indigofera schimperi	Fabaceae	herb/shrub				o	o									o	o	o		Admasu et al. 2014
Phaseolus vulgaris	Fabaceae	herb/shrub	ADENGWARE		BOLOKKE	o	o									o	o			Admasu et al. 2014
Psophocarpus grandiflorus	Fabaceae	herb/shrub				o	o									o	o			Admasu et al. 2014
Sesbania sesban	Fabaceae	herb/shrub	ALQM, BOFEFFIE		HARCHA, INCHINI	~	~								o	o				Admasu et al. 2014
Acacia abyssinica	Fabaceae	tree	BAZRA-GRAR	QSLTO	AMBO, DADECCA, DAGNISA, DEDECCA, GARBI, LAFTO, SONDI	o	o	o	o	o	o	o								Fichtl & Adi, 2031
Acacia albida	Fabaceae	tree	GERBI		DEROT, GARBI	o	o							o	o	o	o	o	o	Fichtl & Adi, 2032
Acacia dolichocephala	Fabaceae	tree	-		LAFTO	o	o													Fichtl & Adi, 2033
Acacia lahai	Fabaceae	tree	WTTIE, CHEBA		BURQUQQE, DEROT, SONDI, GARBI, LAFTO	o	o				o	o	o	o	o	o	o			Fichtl & Adi, 2034
Acacia negrii	Fabaceae	tree	-		TEDDECCA	o	o								o	o	o			Fichtl & Adi, 2035
Acacia persicifolia	Fabaceae	tree	-		BATE	o	o		o	o	o	o								Fichtl & Adi, 2036

Acacia pilispina	Fabaceae	tree	ACQ-GRAR		LAFTO	o	o							o	o	o	o	o	o	Fichtl & Adi, 2037
Acacia polyacantha	Fabaceae	tree	GMARDA			o	o				o	o	o							Fichtl & Adi, 2038
Acacia senegal	Fabaceae	tree	GIARI, QONTIR		QARXAFFA, SAPHANSSA	o	o	o	o	o	+	+	o	o	o	o	o	o	o	Fichtl & Adi, 2039
Acacia seyal	Fabaceae	tree	-	MAKANI, ADIQENTO	WACU, WAJJI, WAKKO-DIMO , WASIYA	o	o	o	o						o	o	o	o	o	Fichtl & Adi, 2040
Acacia sieberiana	Fabaceae	tree	-		URQUQQE	o	o				o	o								Fichtl & Adi, 2041
Acacia tortilis	Fabaceae	tree	GIRAR	BEHBEY	LOTTOBA, TEDDECCA	o	o	o	o	o	o	o								Fichtl & Adi, 2042
Albizia gummifera	Fabaceae	tree	SESA, SASA		SASA, CATTO, AMBABESSA, CAWICCO, EMELA, GORBE, KARCOFFE, MUKKA-ARBA, SANKILE, SHIMORO, SISA, YUNGO	o	o	o	o	o	o									Fichtl & Adi, 2043
Albizia lebbeck	Fabaceae	tree	LEBBEK			o	o	o	o	o	o	o								Fichtl & Adi, 2044
Albizia schimperiana	Fabaceae	tree	SESA, SASA		SASA, CATTO, AMBABESSA, CAWICCO, EMELA, GORBE, KARCOFFE, MUKKA-ARBA, SANKILE, SHIMORO, SISA, YUNGO	o	o	o	o	o	o	o								Fichtl & Adi, 2045
Calpurnia aurea	Fabaceae	tree	DGTTA		ANCABI, CEKA, CEKATA, SOLITU	o	o	o	o	o	o	+	o	o	o	o	o	o	o	Fichtl & Adi, 2046
Erythrina abyssinica	Fabaceae	tree	KORCH		WALENSU	o	o	o	o	o	o					o	o	o	o	Fichtl & Adi, 2047
Erythrina brucei	Fabaceae	tree	KORCH, QUARA		WOLLESU	o		o	o									o	o	Fichtl & Adi, 2048
Leucaena leucocephala	Fabaceae	tree	LUKINA		LUKINA	o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2049
Lonchocarpus laxiflorus	Fabaceae	tree	-		AMERA, QANQALSHA	o	o	o	o	o										Fichtl & Adi, 2050

Millettia ferruginea	Fabaceae	tree	BRBRRA		YAGO, GDICCO, AKSIRA, ASRA, DEDATU, KARCECCE, KOTELLU, SARI, SOTALLO	o	o	o	o	o	o							o	o	Fichtl & Adi, 2051
Parkinsonia aculeata	Fabaceae	tree	-			+	o	o	o	o	o	o	o							Fichtl & Adi, 2052
Piliostigma thonningii	Fabaceae	tree	ALAMATI, ALAMATIE, DABDI, YEQOLLA WANZA		LILU, KORA	o	o	o	o	o	o	o								Fichtl & Adi, 2053
Pithecellobium dulce	Fabaceae	tree	NCHET			o	o	o	o	o									o	Fichtl & Adi, 2054
Tamarindus indica	Fabaceae	tree	HUMER		ROQA	o	o	o	o	+	+	+	+	o	o	o	o	o	o	Fichtl & Adi, 2055
Delonix elata	Fabaceae	tree	AMAY, YEDREDEWA ZAFF	AMAY, DINE-AMAYTO	SUKELA	~	~		o	o	o									Admasu et al. 2014
Delonix regia	Fabaceae	tree	YE-DIREDAWA-ZAF			o		o	o	o	o							o	o	Admasu et al. 2014
Dalbergia lactea	Fabaceae	tree					+	o									o	o	o	Admasu et al. 2014
Acacia brevispica	Fabaceae	tree	KENTEFA, KONTEVL, MEZAZIGN, MEZEZIYO		AMEZAZE, HAMARECHA, SOKEUSA, QWANTA	o	o									o	o			Admasu et al. 2014
Acacia etbaica	Fabaceae	tree	DERIE, DORET, QERETA		BATE, DODOTA, DODOTI	o	o								o	o	o			Admasu et al. 2014
Acacia mellifera	Fabaceae	tree	ANKUY QONTR, QONTR, SBANSA		ATNKUY, SABANSA, HARAGMA	o	o					o	o	o	o					Admasu et al. 2014
Acacia nilotica	Fabaceae	tree	ALARO		BURQUQE	o	o				o	o								Admasu et al. 2014
Acacia oerfota	Fabaceae	tree			AJO, WANAGYO	o	o									o	o			Admasu et al. 2014

Albizia grandibracteata	Fabaceae	tree			ELELE, KOFALE	+	+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Albizia malacophylla	Fabaceae	tree				+	+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Dichrostachys cinerea	Fabaceae	tree	ADER, ERGETT-DIMMO		ADESA, HATTE, JIRME, WORSAMESA		o	+	+	+	+	+	o	o	o	+	+	+	+	Admasu et al. 2014
Prosopis juliflora	Fabaceae	tree				+	o				o	o								Admasu et al. 2014
Dovyalis caffra	Flacourtiaceae	tree	KOSHM		ANKAKUTEH	o	o	o	+	+	+	+	+	o	o	o	o	o	o	Fichtl & Adi, 2027
Swertia abyssinica	Gentianaceae	herb/shrub	-			o	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Erodium moschatum	Geraniaceae	herb/shrub	-			o	o								o	o	o	o		Fichtl & Adi, 1994
Geranium aculeolatum	Geraniaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Geranium arabicum	Geraniaceae	herb/shrub	-			o	o						o	o	o	o	o	o	o	Fichtl & Adi, 1994
Monsonia angustifolia	Geraniaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Pelargonium multibracteatum	Geraniaceae	herb/shrub	-			o	o					o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Phacelia tanacetifolia	Hydrophyllaceae	herb/shrub	-			o	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Hypericum peplidifolium	Hypericaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Hypericum quartinianum	Hypericaceae	herb/shrub	AMJA		RIGA GANZI, ULLE FONI, GARAMBA		+	o	o							o	o	o	o	Fichtl & Adi, 1994
Hypericum revolutum	Hypericaceae	tree	AMJA		HENDI, EDERA, GARAMBA, GORGORO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2028
Apodytes dimidiata	Icacinaceae	tree	DONGA, CELEQLEQQA		DANNISA, MEI, ODA, ODA-BADA, ODAKYET, ODA-SEDA, QUMBALA, ULIFONI, WENDEBYO	o	o	o	o	o									o	Fichtl & Adi, 2029

Achyrospermum schimperi	Lamiaceae	herb/shrub	-		BALANDALECHA	o	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Aeollanthus abyssinicus	Lamiaceae	herb/shrub	-			o	+					o	o	o	o	o				Fichtl & Adi, 1994
Ajuga integrifolia	Lamiaceae	herb/shrub	MEDANIT, ARMAGUSA		ARMAGUSA	o	o								o	o	o			Fichtl & Adi, 1994
Becium grandiflorum	Lamiaceae	herb/shrub	MATOSCH			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Isodon schimperi	Lamiaceae	herb/shrub	YEFYEL-GOMEN			o	o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Leonotis ocymifolia	Lamiaceae	herb/shrub	RAS KMR			+	o	o	o	o		o					o	o	o	Fichtl & Adi, 1994
Leucas abyssinica	Lamiaceae	herb/shrub	DERTA, CHIDAM		KERTA TUME	o	o									o	o	o		Fichtl & Adi, 1994
Leucas martinicensis	Lamiaceae	herb/shrub	RAS KMR		JIMAERTU, BOCCUFARDA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Mentha spicata	Lamiaceae	herb/shrub	ANANA		ANANA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Nepeta azurea	Lamiaceae	herb/shrub	DAMAKA			?	?								o	o	o	o	o	Fichtl & Adi, 1994
Ocimum basilicum	Lamiaceae	herb/shrub	AJUBAN, ASHKUTI, ATUMBAR, BESOBILLA, HULKOT, TIQUR ASHKUTI, ZQAQEBI		KASI, KEFO, KENDAMA, ZAHAHENE	+	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Ocimum lamiifolium	Lamiaceae	herb/shrub	ANCHEBA, DAMMAKESSIE, YAHEYA ZIQAQEBA		HANCHABI, QORSA/QORICHA MICHII	o	o				o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Ocimum urticifolium	Lamiaceae	herb/shrub	DAMAKASSE, YECHAKA BESOBILLA		DAMO, SHOBO (Kaf); ANCHABI, CHEBICHA, ENNA, HANCHABI, KORSA/KORICHA MICHI	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Origanum majorana	Lamiaceae	herb/shrub	HASSAB			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Otostegia integrifolia	Lamiaceae	herb/shrub	MARARAJA, TENGYUT. TINJUT		TUNGI	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Otostegia tomentosa	Lamiaceae	herb/shrub	GERAM TUNGUT, NECHITA, TUNGUT		ILILI ADDI	o	o	+	o	o	o	o	o	o	o	+	+	+	o	Fichtl & Adi, 1994

Plectranthus assurgens	Lamiaceae	herb/shrub	-		AJOFTU	o	o	o	o	o						o	o	o	o	Fichtl & Adi, 1994
Plectranthus barbatus	Lamiaceae	herb/shrub	AGWASHIR, YEFIYEL DOQA, YEFIYEL DUBA, YEMARIAYAM-WEHA-QEJI			o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Plectranthus garckeanus	Lamiaceae	herb/shrub	DENGOGULE		AJAYA, AJESSA, GOGORO	o	o								o	o	o	o	o	Fichtl & Adi, 1994
Plectranthus lanuginosus	Lamiaceae	herb/shrub	AGASHUR		DAMACSE	o	o	o	o	o	o	+	+	+	+	o	o	o	o	Fichtl & Adi, 1994
Plectranthus ornatus	Lamiaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	+	+	+	o	Fichtl & Adi, 1994
Pycnostachys reticulata	Lamiaceae	herb/shrub	-			o	~										o	o		Fichtl & Adi, 1994
Rosmarinus officinalis	Lamiaceae	herb/shrub	ROSMARINO, YEITBS-QTEL		KORA	+	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Salvia leucantha	Lamiaceae	herb/shrub	-			o		o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Salvia merjamie	Lamiaceae	herb/shrub	ABBA DABBO, JEWALA, TOLELAT, YEWUSHA DINBELAL			o	o	o	o	o	o	o	o	o	o	+	+	+	o	Fichtl & Adi, 1994
Salvia nilotica	Lamiaceae	herb/shrub	BASOBILA		SOKOKSA	o	o					o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Salvia officinalis	Lamiaceae	herb/shrub	-			+	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Salvia schimperi	Lamiaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Salvia splendens	Lamiaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Satureja abyssinica	Lamiaceae	herb/shrub	SASSAG WUCHARIA, BUTTANSA, BUTLANSA, JELOMISCET, MUTANSA			o	o									o	o	o	o	Fichtl & Adi, 1994
Satureja paradoxa	Lamiaceae	herb/shrub	NADDO, ZENADDAN		TENAODAM	o	o	o					o	o	o	o	o	o	o	Fichtl & Adi, 1994
Satureja punctata	Lamiaceae	herb/shrub	TOSGN, YELOSKIT		TOSSINGO	o	o	+	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Satureja simensis	Lamiaceae	herb/shrub	-			+	o	+	o	o	o	+	+	+	+	+	+	+	+	Fichtl & Adi, 1994

Stachys aculeata	Lamiaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Thymus schimperi	Lamiaceae	herb/shrub	TOSGN			o	o			o	o	o	o							Fichtl & Adi, 1994
Aeschynomene abyssinica	Lamiaceae	herb/shrub	-			+	+	o	o	o						o	o	o	o	Fichtl & Adi, 1994
Lavandula angustifolia	Lamiaceae	herb/shrub				o	o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Leucas calostachys	Lamiaceae	herb/shrub			BELBELETE, DARGU	o	o											o	o	Admasu et al. 2014
Otostegia fruticosa	Lamiaceae	herb/shrub	GERAM TUNGUT		TUNGIT	+	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Plectranthus edulis	Lamiaceae	herb/shrub	OROMO DINICH, YEWOLAITA DINICH		AJAYA, DAUNECH, DINICHA OROMO, DINICHA-WELAMO, DONIKE, WALAITA DINCHOUA	o	o									o	o			Admasu et al. 2014
Plectranthus punctatus	Lamiaceae	herb/shrub	DEMBO			o	o									o	o			Admasu et al. 2014
Premna schimperi	Lamiaceae	herb/shrub	CHOCHO		CHOCHI, TWANGE, URGESSA, WEGESA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Pycnostachys eminii	Lamiaceae	herb/shrub				o	o			o	o	o	o	o	o	o	o	o		Admasu et al. 2014
Salvia tiliifolia	Lamiaceae	herb/shrub				o	o								o	o				Admasu et al. 2014
Persea americana	Lauraceae	tree	AVOCADO			o	o										o	o	o	Admasu et al. 2014
Kniphofia foliosa	Liliaceae	herb/shrub	ASHENDA, SHEMETIMATI, ABELBILLA				o				o	o	o	o	o	o				Fichtl & Adi, 1994
Kniphofia insignis	Liliaceae	herb/shrub					o							o	o	o	o	o	o	Fichtl & Adi, 1994

Linum usitatissimum	Linaceae	herb/shrub	TALBA, TELBA		KONTER	o	o	o	o	o	o	o	o	o	o	o	+	+	o	Fichtl & Adi, 1994
Tapinanthus globiferum	Loranthaceae	herb/shrub	TEKATILLA		BALEDDO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Rotala repens	Lythraceae	herb/shrub	-			o	o	o	o	o	o	o	o	o						Fichtl & Adi, 1994
Caucanthus auriculatus	Malphigiaceae	herb/shrub	-		GALLE ADDI	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Abutilon longicuspis	Malvaceae	herb/shrub	-			o	o									o	o	o		Fichtl & Adi, 1994
Abutilon mauritianum	Malvaceae	herb/shrub	FIEF'NJERA		ALKEE, DANNISA, KAASUM	o	o								o	o	o	o		Fichtl & Adi, 1994
Alcea rosea	Malvaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Gossypium hirsutum	Malvaceae	herb/shrub	TIT		JIRBI	o	o	o	o	o	o	o							o	Fichtl & Adi, 1994
Hibiscus calyphyllus	Malvaceae	herb/shrub	-			o	o										o	o	o	Fichtl & Adi, 1994
Hibiscus cannabinus	Malvaceae	herb/shrub	-		DANUNU	o	o						o	o	o	o	o	o	o	Fichtl & Adi, 1994
Hibiscus crassinervius	Malvaceae	herb/shrub	-			o	o	o	o	o	o			o	o	o	o	o	o	Fichtl & Adi, 1994
Hibiscus ludwigii	Malvaceae	herb/shrub	SANSURI			o	o									o	o	o	o	Fichtl & Adi, 1994
Malva verticillata	Malvaceae	herb/shrub	ADGUAR		LITI	+	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Pavonia schimperiana	Malvaceae	herb/shrub	-			o		o	o	o	o	o				o	o	o	o	Fichtl & Adi, 1994
Pavonia urens	Malvaceae	herb/shrub	ABLALAT		LITA	+	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Sida rhombifolia	Malvaceae	herb/shrub	GORJEJIT, KARABA		KALABA	o	o	o	o	o						o	o	o	o	Fichtl & Adi, 1994
Sida schimperiana	Malvaceae	herb/shrub	GORJEJIT		GUFTEH	o	o	o	o	o	o				o	o	o	o	o	Fichtl & Adi, 1994
Sida tenuicarpa	Malvaceae	herb/shrub	-			o	o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Hibiscus micranthus	Malvaceae	herb/shrub			ANCH'A, ANC'HI, BEZEZ, BUNAA KOROBOO, GAAJOO		+									o	o			Admasu et al. 2014

					HADABOWISSA, HOOLEE, KOOSAA, QUNCEE, SEFA															
Hibiscus panduriformis	Malvaceae	herb/shrub			HINCINII	o	o									o	o			Admasu et al. 2014
Hibiscus rosa–sinensis	Malvaceae	herb/shrub				o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Turraea holstii	Malvaceae	herb/shrub				+		o											o	Admasu et al. 2014
Dissotis canescens	Melastomataceae	herb/shrub	-				~	o	o									o	o	Fichtl & Adi, 1994
Azadirachta indica	Meliaceae	tree	-			o	o	o	o	o							o	o	o	Fichtl & Adi, 2056
Ekebergia capensis	Meliaceae	tree	LOL		SEMBO, DUDUNA, SOMBO	o	o	o	o	o	o	o						o	o	Fichtl & Adi, 2057
Melia azedarach	Meliaceae	tree	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2058
Trichilia dregeana	Meliaceae	tree	BONGA		KONU, LUYA, SHEGO	o	o	o	o	o								o	o	Fichtl & Adi, 2059
Bersama abyssinica	Melianthaceae	tree	AFFAJESHN, AZAMR		LOLCHISA	o	o	o	o	o	o	o							o	Fichtl & Adi, 2060
Morus alba	Moraceae	herb/shrub	YEFERENJI INJORIE, INJORIE		INJORRI		o								o	o	o	o	o	Fichtl & Adi, 1994
Musa x paradisiaca	Musaceae	tree	MUZ		MUZ	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2063
Maesa lanceolata	Myrsinaceae	herb/shrub	ABALIYEH, AKALUA, ALGALUA, QELEWA		ABBAYYII, CUGGII, GEESHII, MEEQWAARSAA, MERQAAQOO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Eucalyptus camaldulensis	Myrtaceae	tree	KEY BAHIR ZAF		BARGAMO DIMA	+	+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2061
Callistemon citrinus	Myrtaceae	tree	-			o	o	o	o	o	o	o								Fichtl & Adi, 2062
Eucalyptus citriodora	Myrtaceae	tree	SHITO-BARZAF		BARGAMO SHITTO	+	o	o								o	o	o	o	Fichtl & Adi, 2064
Psidium guajava	Myrtaceae	tree	ZEYTUN, ZEYITUNA	ZEYTUN, ZEYITUNA	ZEYTUN, ZEYITUNA	+	+	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2065

Eucalyptus globulus	Myrtaceae	tree	NECH BAHIRZAF		BARGAMO ADI	+	+	o	o	o	o	+	+	o	o					Fichtl & Adi, 2066
Eucalyptus ficifolia	Myrtaceae	tree	-			o	o	o	o	o	o	o						o	o	Fichtl & Adi, 2067
Syzygium guineense	Myrtaceae	tree	DOKMA, DGTA		BADEESSA	+	+	o	o	o	o	o							o	Fichtl & Adi, 2068
Commicarpus plumbagineus	Nyctaginaceae	herb/shrub	-		KOKO BALA, QOBBOO BAALLAA, RAMAK RINCHE	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Nymphaea nouchali	Nymphaeaceae	herb/shrub	-	GELE-ILA	BELBATE	+	+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Jasminum abyssinicum	Oleaceae	herb/shrub	MESSERIK, TIEMBELAL, TERERAK,WEMBELEL ,I ZOHUN-KACHAMO		ELKEMME, TEO, TEMBELEL-BILU	?	?	o	o										o	Fichtl & Adi, 1994
Jasminum stans	Oleaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994
Olea capensis	Oleaceae	tree	DAMAT-WOIRA		AGERGURI	o	o	o	o	o	o									Fichtl & Adi, 2069
Ximenia americana	Oleaceae	tree	NKOY, KOL		HUDA, HUDI, MAGALA	o	o	o	o	o	o								o	Fichtl & Adi, 2070
Olea europaea	Oleaceae	tree	WEYRA		EJERSA	o	o				o	o	o							Fichtl & Adi, 2071
Epilobium hirsutum	Onagraceae	herb/shrub	YELAM-CHEW			o	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Oenothera fruticosa	Onagraceae	herb/shrub	-			~	+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Fuchsia hybrida	Onagraceae	herb/shrub					+	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Ludwigia stolonifera	Onagraceae	herb/shrub				o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Oxalis corniculata	Oxalidaceae	herb/shrub	YEBERE-CHEW		SOGIDAREA	o	o	o						o	o	o	o	o	o	Fichtl & Adi, 1994
Oxalis obliquifolia	Oxalidaceae	herb/shrub	YEBERE-CHEW			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Argemone mexicana	Papaveraceae	herb/shrub	DANDARO, NECHO, YEAHYA SUF				o	o	o	o								o	o	Fichtl & Adi, 1994

Escholozia californica	Papaveraceae	herb/shrub	MESHEDANA EDRU				+	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Sesamum indicum	Pedaliaceae	herb/shrub	MENCHA, SELIT		ZEDI	+	+		o	o	o	o	o	o	o	o	o	o		Fichtl & Adi, 1994
Olinia rochetiana	Penaeaceae	tree	TFIE, BEYE		GUNA, NOLLE, SOLLE, DALECHO	o	o	o	o	o	o	o								Fichtl & Adi, 2074
Phytolacca dodecandra	Phytolaccaceae	herb/shrub	INDOD, MEKAN INDOD		ANDODE, ANDOTE, HANDODE	o	o	o	o	o	o								o	Fichtl & Adi, 1994
Piper capense	Piperaceae	herb/shrub	TIMIZ		TUNJO, TURFO		o				o	o	o							Admasu et al. 2014
Pittosporum abyssinicum	Pittosporaceae	herb/shrub	LOLA,DENGYA-SEBBER, ANGALIT, AHOT	WEYL, SOLA	SHOLO, AMSHIKA, ARA, BONCO, CEKA, RAHA, TOSSU	o	o	o	o	o	o							o	o	Fichtl & Adi, 1994
Plantago lanceolata	Plantaginaceae	herb/shrub	GURTEB, GORTEM, YEBEG LAT, WOMEBERT		QORTOBI		o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 1994
Eleusine floccifolia	Poaceae	herb/shrub	SERDO		AKERMA, AKRIMA		o								o	o	o	o		Fichtl & Adi, 1994
Pennisetum humile	Poaceae	herb/shrub	-				+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Sorghum bicolor	Poaceae	herb/shrub	MASHILA, TINQISH, ZENGADA	DERO	BISSINGA, BOBEE, MISSINGA		o										o	o	o	Fichtl & Adi, 1994
Zea mays	Poaceae	herb/shrub	BAHR MASHILA, BEQOLO		BADALIA, BOQOLO		o						o	o	o	o				Fichtl & Adi, 1994
Sporobolus consimilis	Poaceae	herb/shrub					o									o	o			Admasu et al. 2014
Fagopyrum esculentum	Poaceae	herb/shrub				o	o	o	o	o	o	o	o	o	o	o	o	o	o	Admasu et al. 2014
Polygala persicariifolia	Polygalaceae	herb/shrub	-		BIKILTU	o	o								o	o	o	o		Fichtl & Adi, 1994
Polygala abyssinica	Polygalaceae	herb/shrub	-			o	o	o	o	o	o	o			o	o	o	o	o	Fichtl & Adi, 1994
Polygala steudneri	Polygalaceae	herb/shrub	-			o	o	o	o	o							o	o	o	Fichtl & Adi, 1994
Securidaca longepedunculata	Polygalaceae	tree	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2073

Rumex nepalensis	Polygonaceae	herb/shrub	QTELE-REJIM		BALDER, MUCHAARAB	o	o	o	o	o	o	o				o	o	o	o	Fichtl & Adi, 1994
Rumex nervosus	Polygonaceae	herb/shrub	EMBACH, EMBACHO		DANGAGO, SETA		o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Eichhornia crassipes	Pontederiaceae	herb/shrub	-			~	~	o	o	o	o	o	o	o	o	o	+	+	o	Fichtl & Adi, 1994
Portulaca quadrifida	Portulacaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Anagallis arvensis	Primulaceae	herb/shrub	-			o	o	o								o	o	o	o	Fichtl & Adi, 1994
Grevillea robusta	Proteaceae	tree	-			o	o	o	o	o	+	+	o	o	o	o	+	+	+	Fichtl & Adi, 2072
Pappea capensis	Proteaceae	tree				o	o									o	o			Admasu et al. 2014
Punica granatum	Punicaceae	herb/shrub	ROOMAN			o	o									o	o	o	o	Admasu et al. 2014
Clematis hirsuta	Ranunculaceae	herb/shrub	AZO, AZOHAREG, HASO, NECH YEAZO HAREG		FEETI, HIDDA, HIDDA FEETI	o	o	o									o	o	o	Fichtl & Adi, 1994
Clematis simensis	Ranunculaceae	herb/shrub	AZO, YEAZOHAREG		FEETI, FLAYADIMA, HIDDA, HIDDA FEETI, XIRROO, YIDDA TEELO	o	o	o								o	o	o	o	Fichtl & Adi, 1994
Delphinium dasycaulon	Ranunculaceae	herb/shrub	GEDEL-AMUQ		ILILI HURDY	o	o	o	o	o	o					o	o	o	o	Fichtl & Adi, 1994
Delphinium wellbyi	Ranunculaceae	herb/shrub	GEDEL-AMUQ			o	o								o	o	o	o	o	Fichtl & Adi, 1994
Nigella sativa	Ranunculaceae	herb/shrub	TIKUR-AZMUD, AZMUD		HABASUDU,ABOSADA, NUGI, IGURACHA, GURATI	o	o								o	o	o			Fichtl & Adi, 1994
Ranunculus multifidus	Ranunculaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Caylusea abyssinica	Resedaceae	herb/shrub	RECH, YEAROGIT MEFAKEYA		REENCHII, YERENJI	o	o	o	o					o	o	o	o	o	o	Fichtl & Adi, 1994
Gouania longispicata	Rhamnaceae	herb/shrub	-			o	o									o	o	o	o	Fichtl & Adi, 1994

Rhamnus prinoides	Rhamnaceae	tree	GESHO		RAHA, TADO	~	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2075
Ziziphus mauritiana	Rhamnaceae	tree	QURQURA			o	o	o											o	Admasu et al. 2014
Ziziphus spina-christi	Rhamnaceae	tree	GABA, GEBA, QURQURQ		GABA, Qurqura	o	o				o	o	o							Admasu et al. 2014
Helinus mystacinus	Rosaceae	herb/shrub	GALIMA		XERO	o	o									o	o			Fichtl & Adi, 1994
Rosa abyssinica	Rosaceae	herb/shrub	QEGA		GORA, INOOTO, OAOAWWE, OEOEWWI		o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Rosa x richardii	Rosaceae	herb/shrub	TSIGIE-REDA				o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Rubus apetalus	Rosaceae	herb/shrub	INJORIE		GODA, GORCO, GUMERE, HALTUFA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Rubus rosifolius	Rosaceae	herb/shrub	INJORIE		GODA, GORCO, GUMERE, HALTUFA	+	+	o	o							o	o	o	o	Fichtl & Adi, 1994
Rubus steudneri	Rosaceae	herb/shrub	ENJORI			o	o	o							o	o	o	o	o	Fichtl & Adi, 1994
Eriobotrya japonica	Rosaceae	tree	WESHMELLLA			o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2076
Prunus africana	Rosaceae	tree	AQOMA, TIKUR INCHET		BURAYU, GARBI, GURAYU, HOMI, MUKORAJA, OMI, SOSHE, SUQQE	o	o										o	o		Fichtl & Adi, 2078
Prunus x domestica	Rosaceae	tree	PRUGN			o	o										o	o	o	Fichtl & Adi, 2079
Prunus persica	Rosaceae	tree	KOK		KOKI	o	o									o	o	o		Fichtl & Adi, 2080
Malus sylvestris	Rosaceae	tree	POM			o	+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Hagenia abyssinica	Rosaceae	tree	KOSO		DUCCA, FETO, FICHO, HEXXO		+	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014

Pavetta abyssinica	Rosaceae	tree	DINGAYSEBER, KAMADUA, YETOTA BUNA		BUNUTII, MUKA-BUNNA, QAQESSAA	o	o							o	o					Admasu et al. 2014
Pavetta gardeniifolia	Rosaceae	tree	KAMADUWA, YETOTA BUNA			o	o									o	o			Admasu et al. 2014
Galineria saxifraga	Rubiaceae	herb/shrub	SOLIE, IOTAKOLLA		ADAMO, MITO, DIDU	?	?									o	o	o	o	Fichtl & Adi, 1994
Pentanisia ouranogyne	Rubiaceae	herb/shrub				o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Pentas schimperiana	Rubiaceae	herb/shrub	WOYINAGIFIT		QAASII	+	+			o	o	o	o							Fichtl & Adi, 1994
Spermacoce sphaerostigma	Rubiaceae	herb/shrub	-			o	o					o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Coffea arabica	Rubiaceae	tree	BUNA		BUNA	+	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2081
Ruta chalepensis	Rutaceae	herb/shrub	TENA-ADAM		CHIRAKOTA	o	o	o	o	o	o	o						o	o	Admasu et al. 2014
Casimiroa edulis	Rutaceae	tree	ABOKAR, KAZAMORA			o	o	o	o	o	o	o	o	o	o	+	+	+	+	Fichtl & Adi, 2082
Citrus aurantifolia	Rutaceae	tree	LOMI		TUTTO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 2083
Clausena anisata	Rutaceae	tree	LIMICH		IMBRICCO (Kaf); ULUMAY, URMAYA, ADESSA, WALAYA	o	o	o	o	o	o	o						o	o	Fichtl & Adi, 2084
Vepris dainellii	Rutaceae	tree			ADESSE, HEDHESSA, KULASA		o	o											o	Admasu et al. 2014
Salix subserrata	Salicaceae	tree	AHAYA, HAYA, RIGA		ALALETI, ALANCA, ALELTU, BORODO	o	o	+	o	o	o	o	o	o	o	o	+	+	+	Fichtl & Adi, 2085
Osyris quadripartita	Santalaceae	herb/shrub	QUERET		REGA, WATO, ASASO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Allophylus abyssinicus	Sapindaceae	tree	LN'MBS		ABAR, ABERRA, ARAJE, DRUBA, HIRKAMO, HIRKUM, KEKAYI, SARAGI, SARARA, SEÖ	o	o					o	o	o	o	o	o	o		Fichtl & Adi, 2086

Dodonaea angustifolia	Sapindaceae	tree	KITKITA		ETTECCA, ITTICCA, TEDDECCA, TLEM	o	o	o								o	o	o	o	Fichtl & Adi, 2087
Haplocoelum foliolosum	Sapindaceae	tree			CHANA	o	o	o											o	Admasu et al. 2014
Sideroxylon oxyacantha	Sapotaceae	herb/shrub	ATAT, TIFFE		BITTE	o	o			o	o	o								Fichtl & Adi, 1994
Aningeria altissima	Sapotaceae	tree	QERERO		KARARO, KURO, GUDUBA	+	o	o	o									o	o	Fichtl & Adi, 2088
Alectra sessiliflora	Scrophulariaceae	herb/shrub	-			o	o										o	o	o	Fichtl & Adi, 1994
Bellardia trixago	Scrophulariaceae	herb/shrub	-			o	o	o	o							o	o	o	o	Fichtl & Adi, 1994
Celsia scrophulariaefolia	Scrophulariaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Craterostigma plantagineum	Scrophulariaceae	herb/shrub	BABUN			o	o		o	o	o	o	o	o						Fichtl & Adi, 1994
Hebenstretia dentata	Scrophulariaceae	herb/shrub	GALELO			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Verbascum sinaiticum	Scrophulariaceae	herb/shrub	KETETINNA, YEAHYA-JERO, DABAKADET		GURRA-HARRE, AMBOKANA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Veronica persica	Scrophulariaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Striga hermonthica	Scrophulariaceae	herb/shrub	AKNCHERA, ATQUR			o	o									o	o	o	o	Admasu et al. 2014
Brucea antidysenterica	Simaroubaceae	herb/shrub	ABALO, WAGNOS		ABALO, HADAWEY, QOMOGNO, TAMICHAA	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Datura arborea	Solanaceae	herb/shrub	-			~	~									o	o	o	o	Fichtl & Adi, 1994
Capsicum annuum	Solanaceae	herb/shrub	BERBERE, SCHIRBA, MITMITA, QARYA		BERBERE	~	~	?	?	?	?	?	?	?	?	?	?	?	?	Fichtl & Adi, 1994
Cyphomandra betacea	Solanaceae	herb/shrub	AMBARUT			o	o	?	?	?	?	?	?	?	?	?	?	?	?	Fichtl & Adi, 1994
Discopodium penninervium	Solanaceae	herb/shrub	ALUMA, AMERARO		MARARO	o	o	o	o	o	o					o	o	o	o	Fichtl & Adi, 1994
Lycopersicon esculentum	Solanaceae	herb/shrub	TIMATIM				o	?	?	?	?	?	?	?	?	?	?	?	?	Fichtl & Adi, 1994

Nicandra physalodes	Solanaceae	herb/shrub	MOGNE ASTENAGER		AZANGIRA	~	+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Solanum giganteum	Solanaceae	herb/shrub	MBWAI				~	o	o							o	o	o	o	Fichtl & Adi, 1994
Solanum incanum	Solanaceae	herb/shrub	EMBWA'Y	KODADAHE, KOHOSS-ADA	HIDDEE		~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Solanum indicum	Solanaceae	herb/shrub	IMBWAY, MKOKO		HANCUCU	~	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Solanum nigrum	Solanaceae	herb/shrub	TIKUR AWUT, YEABESHA AWUT		SAMAREYE		~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Datura stramonium	Solanaceae	herb/shrub	ETSE FARS, ASTENAGER			o	o	o	o						o	o	o	o	o	Admasu et al. 2014
Solanum anguivi	Solanaceae	herb/shrub	YEWUSHA QARIYA, ZERECH EMBWAY				o									o	o			Admasu et al. 2014
Solanum marginatum	Solanaceae	herb/shrub				o	o	o	o							o	o	o	o	Admasu et al. 2014
Withania somnifera	Solanaceae	herb/shrub	GIZAWA	OUBAOULT O	HIDDI FEROFTU, KUMO	o	o									o	o			Admasu et al. 2014
Brugmansia suaveolens	Solanaceae	tree	YETRUNBA ABEBA			o	o									o	o			Admasu et al. 2014
Dombeya torrida	Sterculiaceae	tree	WULKEFA		DANNISA	o	o										o	o	o	Fichtl & Adi, 2089
Dombeya aethiopica	Sterculiaceae	tree	YEQOLLA WANZA		DANNISA	o	o	?	?	?	?	?	?	?	?	?	?	?	?	Admasu et al. 2014
Dombeya kirkii	Sterculiaceae	tree				o	o	o										o	o	Admasu et al. 2014
Tamarix nilotica	Tamaricaceae	tree					o									o	o			Admasu et al. 2014
Gnidia glauca	Thymelaeaceae	tree				o	o									o	o	o		Admasu et al. 2014

Grewia ferruginea	Tiliaceae	herb/shrub	ALENQOZA, LENKOATA		BURURI, DOKONNU	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Sparmannia ricinocarpa	Tiliaceae	herb/shrub	WULKFA		ANCIN	o	o	o	o						o	o	o	o	o	Fichtl & Adi, 1994
Triumfetta pilosa	Tiliaceae	herb/shrub	SCIAMHEGIT			o	o							o	o	o	o	o		Fichtl & Adi, 1994
Triumfetta rhomboidea	Tiliaceae	herb/shrub	WEEO			o	o									o	o	o	o	Fichtl & Adi, 1994
Grewia bicolor	Tiliaceae	herb/shrub	SEFA, SOMAYA, TEYE		ARAARSAA, HARORESA		o									o	o			Admasu et al. 2014
Grewia kakothamnos	Tiliaceae	herb/shrub			ARAARSAA	o	o	o											o	Admasu et al. 2014
Grewia velutina	Tiliaceae	tree	MAJITE, SEFA		ARORESSA, ARORIS	o	o									o	o			Fichtl & Adi, 2090
Grewia mollis	Tiliaceae	tree	MAJITIE		QAAWAA	o	o			o	o	o	o							Admasu et al. 2014
Grewia trichocarpa	Tiliaceae	tree			ARAARSAA		+	o											o	Admasu et al. 2014
Tropaeolum majus	Tropaeolaceae	herb/shrub	-			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Girardinia bullosa	Urticaceae	herb/shrub	-		DOBI		o								o	o	o	o	o	Fichtl & Adi, 1994
Urtica simensis	Urticaceae	herb/shrub	SAMMA		DOBI		o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Urera hypselodendron	Urticaceae	herb/shrub	LANQSH		LANGUSTO, LANQISSA, HALILA, TOKONU		+									o	o			Admasu et al. 2014
Clerodendron cordifolium	Verbenaceae	herb/shrub	MISSIRICH			o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Clerodendrun myricoides	Verbenaceae	herb/shrub	SULTHE, ABEKA, MISSIRICH, BUSHADUBSIS		MUSERICH, SOYYOMA HARMAL ADI, ITIRRO	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Duranta erecta	Verbenaceae	herb/shrub	KOMBOLCHA, MITISH, MUATISH		KOMBOLCHA, SIDAMU	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994

Lantana camara	Verbenaceae	herb/shrub	YEWOF KOLO		KASE, KASEH, KUSAYE, MIDANA-BERA, SUKE	~	~	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Lantana trifolia	Verbenaceae	herb/shrub	YERENGNA QOLO, YEWOFKOLo		MIDANI-BERA, SUKE	~	~		o	o	o	o	o	o	o	o	o	o		Fichtl & Adi, 1994
Lippia adoensis	Verbenaceae	herb/shrub	KOSERET, KESSIE		KASEY	o	o	o	o			o	o	o	o	o	o	o	o	Fichtl & Adi, 1994
Verbena officinalis	Verbenaceae	herb/shrub	AKKORAGAG, ATTUCH			o	o		o	o	o	o	o		o	o	o	o		Fichtl & Adi, 1994
Verbena bonariensis	Verbenaceae	herb/shrub	ATUCH			o	o									o	o	o	o	Admasu et al. 2014
Cyphostemma adenocaule	Vitaceae	herb/shrub	GNDOSH		QALQALLO	o	o				o	o	o							Fichtl & Adi, 1994
Vitis vinifera	Vitaceae	herb/shrub	WEYN		INASA		o													Fichtl & Adi, 1994
Cissus rotundifolia	Vitaceae	herb/shrub	CHAMBIE		CHOBII, CHOBII-QAURA	o	o	o											o	Admasu et al. 2014
Tribulus terrestris	Zygophyllaceae	herb/shrub	AQAQMA		KURUMSHIT	+	+	o	o	o	o	o	o	o	o	o	o	o	o	Fichtl & Adi, 1994

Flowering calendar of important melliferous plant species in West Java, Indonesia

All content was retrieved from: Bunyamin, A., Purnomo, D., Supriyadi, Y., Pratama, I., & Nawawi, M. (in prep). Flowering Plants Time and Maps of West Java Area as Basic Data in Supporting Beekeeping Activities.

Table 6: Flowering calendar of important melliferous plant species in West Java, Indonesia. “o” means flowering, “o” nectar or pollen source. Content was retrieved from Bunyamin et al., (in prep.).

Species	Plant family	Growth form	Bahasa	Nectar source	Pollen source	J 01	F 02	M 03	A 04	M 05	J 06	J 07	A 08	S 09	O 10	N 11	D 12
Mangifera indica	Anacardiaceae	tree	Mangga	o	o						o	o	o				
Mangifera altissima	Anacardiaceae	tree	Embacang (sejenis mangga)			o	o	o	o	o	o	o	o	o	o	o	o
Annona muricata	Annonaceae	tree	Sirsak			o	o	o	o	o	o	o			o	o	o
Salacca zalacca	Arecaceae	tree	Salak			o	o	o	o								
Cocos nucifera	Arecaceae	tree	Kelapa			o	o	o	o	o	o	o	o	o	o	o	o
Arenga pinnata	Arecaceae	tree	Aren			o	o	o	o	o	o	o	o	o	o	o	o
Helianthus annuus	Asteraceae	herb/shrub	Bunga Matahari	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Ceiba pentandra	Bombacaceae	tree	Kapuk Randu							o	o	o					
Ananas comosus	Bromeliaceae	herb/shrub	Nanas			o	o	o	o	o	o	o	o	o	o	o	o
Carica papaya	Caricaceae	tree	Pepaya			o	o	o	o	o	o	o	o	o	o	o	o
Garcinia mangostana	Clusiaceae	tree	Manggis										o				
Citrullus lanatus	Cucurbitaceae	herb/shrub	Semangka	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Hevea braziliensis	Euphorbiaceae	tree	Para											o	o		
Archidendron pauciflorum	Fabaceae	tree	Jengkol										o	o			
Calliandra calothyrsus	Fabaceae	tree	Kaliandra			o	o	o	o	o	o	o	o	o	o	o	o
Dalbergia latifoliaa	Fabaceae	tree	Sonokeling					o						o			
Acacia mangium	Fabaceae	tree	Akasia	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Glycine max	Fabaceae	herb/shrub	Kedelai	o	o	o	o	o	o	o	o	o	o	o	o	o	o

Leucaena leucocephala	Fabaceae	tree	Lamtoro			o	o	o	o	o	o	o	o	o	o	o	o
Tamarindus indica	Fabaceae	tree	Asam jawa						o	o	o	o	o				
Mimosa pudica	Fabaceae	herb/shrub	Putri Malu			o	o	o	o	o	o	o	o	o	o	o	o
Gnetum gnemon	Gnetaceae	tree	Melinjo			o	o	o					o	o			
Persea americana	Lauraceae	tree	avocad	o	o	o	o	o	o								
Durio zibethinus	Malvaceae	tree	Durian								o	o	o	o			
Lansium domesticum	Meliaceae	tree	Duku			o	o								o	o	o
Parkia speciosa	Mimosoideae	tree	Petai										o	o			
Artocarpus heterophyllus	Moraceae	tree	Nangka			o	o	o	o	o	o	o	o	o	o	o	o
Musa sp.	Musaceae	herb/shrub	Pisang			o	o	o	o	o	o	o	o	o	o	o	o
Syzygium aqueum	Myrtaceae	tree	Jambu Air									o		o			
Psidium guajava	Myrtaceae	tree	Jambu Biji									o	o	o			
Averrhoa carambola	Oxalidaceae	tree	Belimbing	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Passiflora edulis	Passifloraceae	tree	Markisa			o	o	o	o	o	o	o	o	o	o	o	o
Zea Mays	Poaceae	herb/shrub	Jagung			o	o	o	o	o	o	o	o	o	o	o	o
Gramineae	Poaceae	herb/shrub	padi-padian			o	o	o	o	o	o	o	o	o	o	o	o
Portulaca spp.	Portulacaceae	herb/shrub	Kroklan			o	o	o	o	o	o	o	o	o	o	o	o
Malus domestica	Rosaceae	tree	Apel	o	o	o											
Coffea arabica	Rubiaceae	tree	Kopi Arabika	o	o					o	o	o	o				
Citrus maxima	Rutaceae	tree	Jeruk Bali										o			o	o
Citrus tangerina	Rutaceae	tree	Jeruk Siam										o			o	o
Nephelium lappaceum	Sapindaceae	tree	Rambutan												o	o	o
Dimocarpus longan	Sapindaceae	tree	Lengkeng								o	o	o				
Manilkara zapota	Sapotaceae	tree	Sawo			o	o										o
Vitis vinifera	Vitaceae	herb/shrub	Anggur		o						o				o		

Important crops and insect pollination

Species and English names were retrieved from: "Klein, A.M. et al. (2007). Importance of pollinators in changing landscape for world crops. Proc. R. Soc. 274(1608): 303–313." Klein et al. (2007) selected the leading global crops on the world market from the FAO crop production list of 2004 and assessed them into groups (crop species that are essentially, highly, moderately, slightly or not depending on insect pollination). The list may help beekeepers to better understand their bees and which crops are in dependence to or benefit from honey bees and their pollination ability. So far, the crops names were only translated into English (Klein et al., 2007) and Bahasa (by UNPAD), but it is also planned to include Amharic and Oromo sections in the SAMSwiki.

*Table 7: List of globally important crops that are essentially, highly, moderately, slightly or not depending on insect pollination. Note: The latter category may affect foraging insects anyway by providing pollen that is often of low quality. The species and English names were retrieved from Klein et al., 2007 and the translation into Bahasa was made by Marlis Nawawi from the Universtity of Padjadjaran, Bandung, Indonesia. A translation into Amharic is planned in the future. * indicates that the species in not present in the country.*

Essential			
Scientific name	**English**	**Amharic (Ethiopia)**	**Bahasa (Indonesia)**
Actinidia deliciosa	kiwi		Kiwi
Bertholletia excelsa	brazil nut, para nut, cream nut		Kacang brazil
Citrullus lanatus	watermelon		Semangka
Cucumis melo	cantaloupe, melon		melon
Cucurbita maxima, C. mixta, C. moschata, C. pepo	squashes and pumpkins		Labu
Macadamia ternifolia	macadamia		Macadamia*
Passiflora edulis	passion fruit		Markisa
Sorbus aucuparia	rowanbarry		Rowanberry*
Highly dependent			
Scientific name	**English**	**Amharic**	**Bahasa**
Amygdalus communis	Almond		Almond
Anacardium occidentale	Cashew nut, and Cashewapple		Kacang mete
Brassica rapa	Turnip rape, Canola		Sawi bunga
Castanea sativa	Chestnut		Kastanya
Coriandrum sativum	Coriander		Ketumbar

Elettaria cardamomum	Cardamom		Kapulaga
Foeniculum vulgare	Fennel seed		Adas
Pimenta dioica	Allspice, Pimento		Merica Jamaika
Prunus armeniaca	Apricot		Aprikot*
Prunus avium	Sweet cherry		Ceri manis
Prunus cerasus	Sour cherry		Ceri asam
Prunus domestica, P. spinosa	Plum, Greengage, Mirabelle, Sloe		Plum, Greengage*, Mirabelle*, Sloe
Prunus persica, Persica laevis	Peach, Nectarine		Persik, Nektarin*
Pyrus communis	Pear		Pir
Rosa spp.	Rose hips, Dogroses		Mawar
Rubus spp.	Berries		Beri
Sorbus domestica	Service-apple		Apel layanan*
Vaccinium corymbosum, V. angustifolium, V. ashei, V. myrtillus	Highbush blueberry, Lowbush blueberry, Rabbiteye blueberry, Bilberry		Blueberry, Blueberry liar, Rabbiteye blueberry, Bilberry*
Vaccinium macrocarpon, V. oxycoccus	American cranberry, European cranberry		American Kranberry, European Kranberry*
Moderately dependent			
Scientific name	**English**	**Amharic**	**Bahasa**
Abelmoschus esculentus	Okra, Gumbo		Okra/Bendi
Arbutus unedo	Tree-strawberry		Stroberi pohon
Brassica alba, B. hirta, Sinapis alba, B. nigra, Sinapis nigra	Mustard seeds		Sesawi putih, Sesawi hitam
Brassica napus oleifera	Rapeseed, Oilseed rape		Rapa/Kanola
Canavalia ensiformis, C. gladiata, C. marittima, C. microcarpa, C. virosa	Jack bean, Horse bean, Sword bean		Kacang parang, kacang kuda, kacang koro pedang
Carum carvi	Caraway		Jintan
Cocos nucifera	Coconut		Kelapa
Coffea arabica, C. canephora	Coffee		Kopi
Dolichos biflorus, D. lablab	Hyacinth bean, Horsegram, Lablab		Kacang eceng gondok, Horsegram, Lablab*

Fragaria spp.	Strawberry		Stroberi
Glycine max, G. soja	Soybean		Kedelai
Gossypium hirsutum, G. barbadense, G. arboreum, G. herbaceum	Seedcotton		Benih kapas*
Helianthus annuus	Sunflower seeds		Bunga matahari
Mammea americana	Mammee		Mammee*
Psidium guajava	Guava, Guayaba		Jambu biji
Punica granatum	Pomegranate		Delima
Ribes nigrum, R. rubrum	Black currant, Red currant		Anggur hitam, redcurrant*
Sambucus nigra	Elderberry		Elderberry*
Sesamum indicum	Sesame		Wijen
Solanum melongena	Eggplant, Aubergine		Terong
Vicia faba	Broad bean, Faba bean, Field bean, Horse bean		Buncis*
Vitellaria paradoxa	Karite nuts, Sheanuts		Kacang karite, Sheanuts*
Zizyphus jujuba	Jujube		Jujube
Slightly dependent			
Scientific name	**English**	**Amharic**	**Bahasa**
Arachis hypogea	Peanut, Groundnut		Kacang Tanah
Cajanus cajan	Pigeon pea, Cajan pea, Congo bean		Kacang merpati, kacang Cajan, kacang Kongo*
Capsicum annuum, C. frutescens	Chile pepper, Red pepper, Bell pepper, Green pepper		Cabai merah, Cabai hijau, Cabai rawit
Carica papaya	Papaya		Pepaya
Carthamus tinctorius	safflower		Kesumba, safflower
Citrus spp.	Lemmon, Lime, Grapefruit, Oranges, ...		Jeruk, Lemon, Lime, Jeruk limau
Crataegus azarolus	Azarole, Azzeruolo		Azarole, Azzeruolo*
Cyamopsis tetragonoloba	Guar bean, Goa bean		Kacang guar, Kecipir*
Dimocarpus longan	Longan, Lungan		Kelengkeng, Lengkeng
Diospyros kaki; D. virginiana	Persimmon		Kesemek

Elaeis guineensis	Oil palm		Kelapa sawit
Linum usitatissimum	Flaxseed		Rami
Litchi chinensis	Litchi, Lychee		Leci
Lycopersicon esculentum	Tomato		Tomat
Nephelium lappaceum	Rambutan		Rambutan
Phaseolus spp.	beans		Buncis
Spondias ssp	Hog plum, Mombin		Kedondong
Tamarindus indica	Tamarind		Asam jawa
Vigna subterranea	Bambara beans, Bambara groundnuts, Earth pea		Kacang bogor
Vigna unguiculata	Cowpea, Blackeye pea, Blackeye bean		Kacang tunggak, Cowpea, Blackeye pea*
no effect			
Scientific name	**English**	**Amharic**	**Bahasa**
Avena spp.	Oat		Haver, Oat
Beta vulgaris	Sugar beet		Bit gula
Cicer arietinum	Chick pea, Bengal gram, Garbanzo bean		Kacang arab
Hordeum disticum	Barley		Jelai
Olea europea	Olive		Zaitun
Oryza ssp.	Rice, Paddy		Padi
Phoenix dactylifera	Date palm		Kurma
Pisum sativum, P. arvense	Pea, dry and green like Garden pea, Field pea		Kacang polong, Kacang ercis
Saccharum officinarum	Sugar cane		Tebu
Spinacia olearacea	Spinach		Bayam
Triticale spp.	Triticale		Triticale*
Triticum spp.	Wheat		Gandum
Zea mays	Maize, Green corn, Sweet corn		Jagung

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