# International Partnership on Innovation

# SAMS - Smart Apiculture Management Services

Deliverable N°2.2

## User Centered Design – Results & Lessons Learnt

WP N°2 SAMS User Centered Design Cycles and Business Development

Horizon 2020 (H2020-ICT-39-2017)

Project N°780755

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## List of Abbreviations

| | |
|---|---|
| DSS | Decision Support System |
| DW | Data Warehouse |
| ET | Ethiopia |
| ICT | Information and Communication Technology |
| ID | Indonesia |
| HCD | Human Centered Design |
| PCB | Printed Circuit Board |
| QR code | Quick Response code |
| UCD | User Centered Design |
| UI | User Interface |
| UX | User Experience |

## 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 they are often used inefficient.

Three continents - three scenarios

(1) In Europe, consumption and trading of honey products are increasing whereas the production is stagnating. Beside 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 N°2) “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”
- increases production of bee products
- creates jobs (particularly youths/ women)
- triggers investments and establishes 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 behavioural response
- Implementation SAMS Business cooperation

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## Executive summary

The SAMS project was based on User Centered Design (UCD) which derived from Human Centered Design (HCD). This framework is being used to ensure, that needs, demands and limitations of users are of major focus in the project and all steps of the project development. In theory, UCD is normed by the DIN ISO 9241-2101[1] standard with the UCD cycle recommending iterations of analysing the context, specifying the user requirements, producing solutions and evaluating these solutions. Using agile development and meeting regularly is recommended. However, theory and practical approach often differs from each other. So, does applying UCD under real project implementation conditions and among a multi-disciplinary and multi-cultural team in the multi-product SAMS project. It seemed to be impossible sometimes. Unless being flexible, make experiences and learn from them. Thus, this report is dedicated to the SAMS UCD results and the lessons learnt.

Following UCD according to the DIN ISO 9241-210, all SAMS hardware, software and Api-management project solutions and results are characterized by iterations to meet the user needs and requirements. A UCD roadmap was guiding the multi-disciplinary and multi-cultural project team. The roadmap was adjusted throughout the project running time (see chapter 1).

UCD based project results range from definitions (SAMS target groups & SAMS value chain) and user research (elaboration and documentation of beekeeper and other stakeholder needs) to honey bee management rules, a SAMSwiki, a UCD Glossary, business models, SAMS partnerships and technical results like the SAMS HIVE monitoring system, the user interface of the DSS SAMS data display for beekeepers and the Data Warehouse (see chapter 2).

Applying UCD under real project implementation conditions and among a multi-disciplinary and multi-cultural team made some lessons learnt and obstacles between theory and practical realization obvious. For example, it is recommended to create the same understanding of UCD and special terms among the project team, to use a communication and collaboration platform, to have regular virtual meetings needed for the workflow and physical meetings fastening the process. Most important is to use UCD including agile development in the way that suits best for the project. Country specific lessons learnt from applying UCD and working with Ethiopian and Indonesian beekeepers are that identifying user groups as well as to keep the time frame is challenging. To plan enough time for trust building (especially in Indonesia) is also recommended. Moreover, an important lesson learnt is that UCD results are non-linear and out of the box (see chapter 3).

[1] In ISO 9241-210 the wording is always Human Centred Design. In this document User Centered Design and its abbreviation UCD is used to be conform with the Grant Agreement.

# 1. User Centered Design

User Centered Design is concentrated on not only human characteristics and perception in general, but also specific traits and features of target users to make the problem-solving potential of the designed product as high as possible in perspective of its users. This approach is being used to ensure, that needs, demands and limitations of users are of major focus in the project and all steps of the project development.

The UCD principles, adopted by the SAMS project, guided the project and its partners over the whole project duration providing an ongoing exchange of information between the SAMS project partners, the beekeepers and other stakeholders. The UCD principles affected the whole project tasks (WP3, WP4, WP5 and WP6), and ensured that the final SAMS products address the beekeeper needs and requirements in the target countries. Moreover, UCD ensured to achieve the ultimate objective of the SAMS project – to upgrade and to develop the beekeeping sector in Ethiopia and Indonesia.

## 1.1 UCD Basic Principles

DIN ISO 9241-210 recommends a four-step process to apply the user centric approach. Thus, design solutions for one product – hardware as well as software – are only produced after first, the context of use has been comprehensively analysed and secondly user requirements are thoroughly specified. Then design solutions are created and evaluated against the user requirements. This process iterates until the user requirements are met.

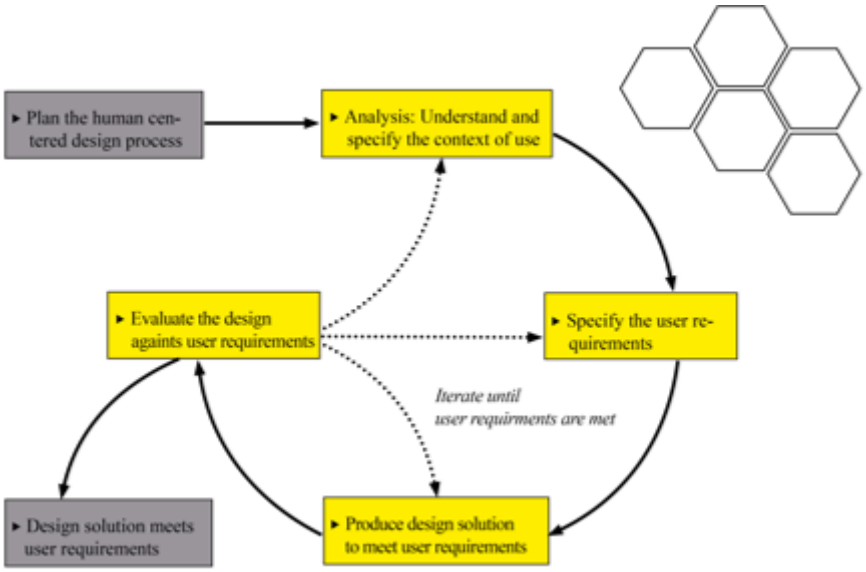



Figure 1 User Centered Design Cycle DIN ISO 9241-210

Beforehand the UCD process must be planned. Therefore, a UCD SAMS roadmap has been developed in which e.g. assessments, surveys, workshops, interviews, user requirement specification, product-development and its refinements are embedded (see chapter 1.2).

The recommended iterative approach of UCD indicates that it is well fitted to be integrated in agile product development processes.

## 1.2 UCD Working Process within SAMS

The SAMS project was characterized by a multi-disciplinary and multi-cultural team developing several products, locally adapted, when required, to the two main target countries – Ethiopia and Indonesia – with the overall objective to upgrade and develop the beekeeping sector.

Following products were developed during the project and are described in the following chapter:

- Definitions
- UCD Glossary
- Personas, As-Is scenarios and UX Nuggets
- Beekeeper needs and others stakeholder needs
- Honey Bee Management Rules
- SAMS Wiki
- Business Models
- Final SAMS Hive monitoring system
- SAMS Data Warehouse
- DSS SAMS data display for beekeepers
- SAMS partnerships

To ensure that resources are used smartly, and synergies are recognized and used, a SAMS UCD team was formed. The SAMS UCD team was meeting weekly to ensure an efficient information flow. The meetings took place virtually. Communication in the project was subject to high technical risks because of problems with internet connection and power supply (e.g. internet shutdowns in Ethiopia after turmoil to avoid fake news).

Following the DIN ISO 9241-210 UCD cycle, the User Centered Design approach of the SAMS project was planned and visualized in a UCD Roadmap. The Roadmap was a living timeline that was regularly reviewed and updated according to the progress of the project. Mayor adjustment was the decision to do only one more prototype workshop for all countries together in Bandung/ Indonesia in July 2019. This lead directly into a co-creative and iterative process of DSS design and evaluation and strengthened the collaborative approach for all fields of work. The UCD Roadmap guided the products' development:

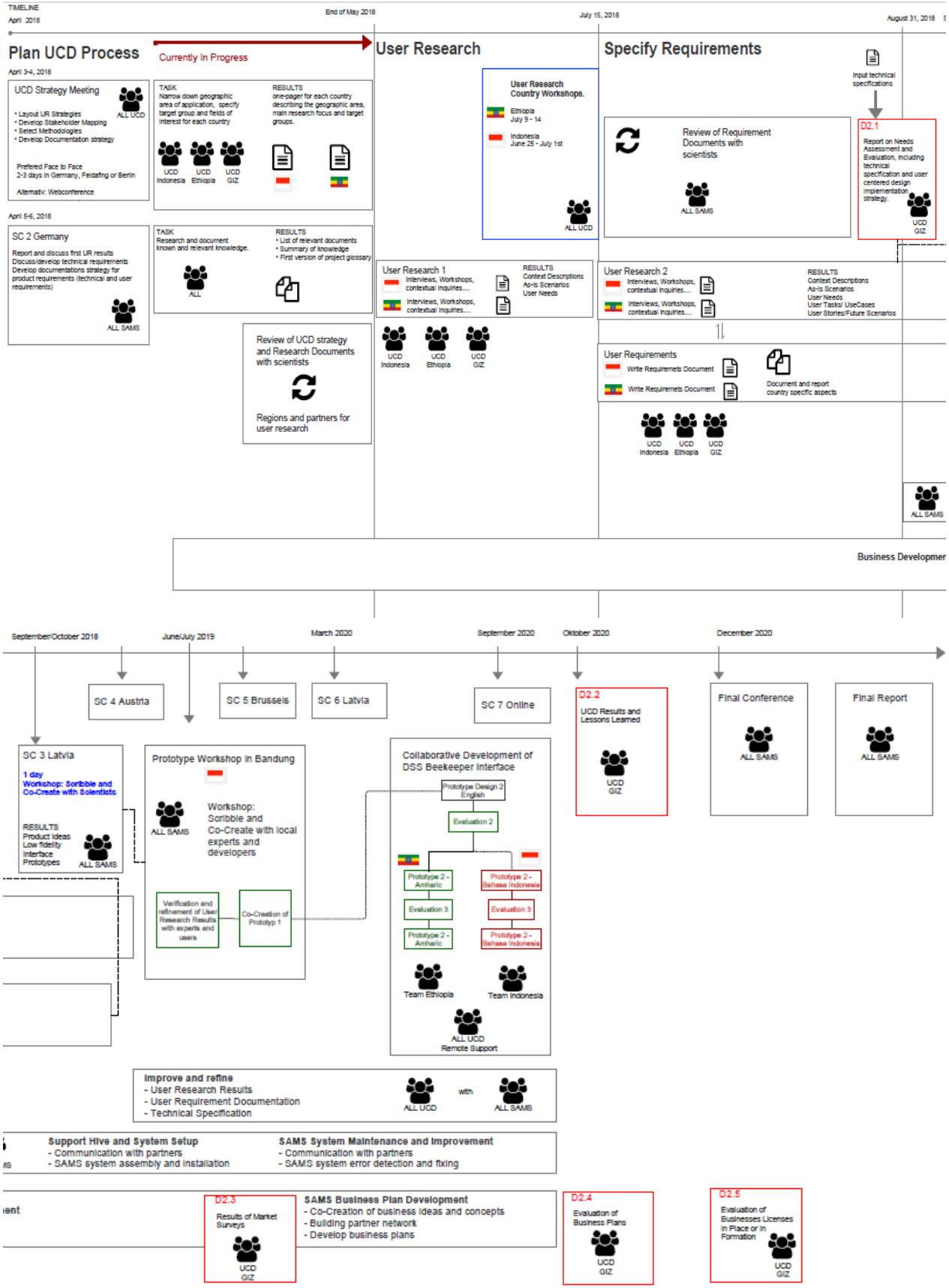



Figure 2 UCD Roadmap

# 2. UCD Results

Following the DIN ISO 9241-210 and the UCD Roadmap, within the SAMS project many UCD results have been discovered and are highlighted in this chapter, followed by overall project results which are highly influenced/ driven by the UCD research and its outcomes and findings.

The UCD approach and its principles require lots of effort and time to ensure that the end user needs are always in the focus of the product development process and lead such process. Therefore, the product development cycles/ process cannot be successful carried out without the UCD research activities, which were carried out over the complete project duration and which directly influenced all SAMS actions and products. The emerging UCD results are showing unique technical, cultural and procedural considerations that are crucial for the impact and the success of the project and its products. As those needs are not always similar and depend on cultural aspects, experiences, behavior and location of the beekeepers, the SAMS project was not able to reply to all of those in the project duration. This leaves space for start-ups and SMEs to go on and take further needs into consideration when using the already existing SAMS results. The scientific insights gained in this process assist the future improvement potential and its commercial phase. Those will assist in generating new bonds between the project countries and participants, open new markets and increase its resilience.

## 2.1 Definition of SAMS target groups & SAMS value chain

The main target group of the SAMS project is beekeepers. Beekeepers are the end-users of the developed products, e.g. the SAMS HIVE monitoring system, the DSS SAMS data display, the Data Warehouse, the Rules of Honey Bee Management. SAMS also focused on scientists as target group. Those two are the most important groups for the setup and usage of the DSS. In addition, needs of other stakeholders such as honey consumers, bee product wholesalers, traders and entrepreneurs have been considered via the market surveys.

It is important to mention two aspects concerning stakeholder identification in change to Deliverable 2.1 Report on Needs Assessment and Evaluation, including Technical Specification and UCD implementation strategy. First, especially beekeepers as main target group shaped up to be more diverse than expected, especially in relation to the motivation concerning the cultural and economic context. Therefore, a more specific decision, which beekeeper group is benefitting most from SAMS system, had to be made. Secondly, the process cleared the fact that the SAMS service requires a service design in which the technical setup and maintenance of the system is done by a technical service provider. Therefore, technical service providers are an additional stakeholder/ user group to be considered.

Accordingly, the SAMS value chain from the end-user to the market was precisely defined in a brainstorming process:

> “Next to the honey and bee-products, the SAMS value chain includes knowledgeable as well as new beekeepers, beehive designers incl. its supplier (timber, smoker, packaging, veil etc.) and hardware as well as software producers and designers, in particular for the SAMS sensor technology (sensors, technical components, power source etc.) and the software which includes data analysis. Complementary to those stakeholder groups, industrial as well as home-made

beekeeping products, consumer demands, the forestry and agriculture industry and local communities and companies, e.g. SMEs, start-ups are considered." (see Figure 3)

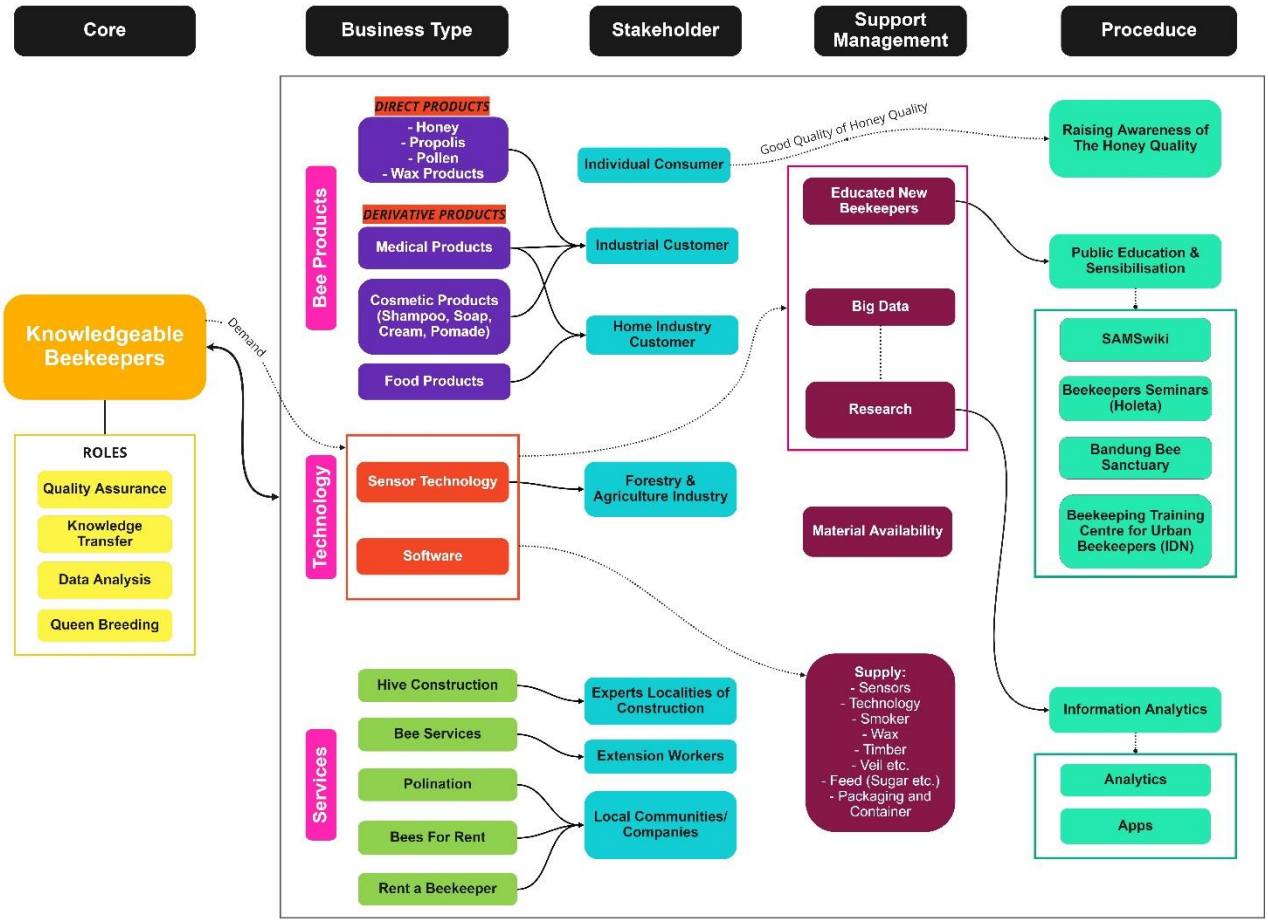



Figure 3 SAMS value chain

The definition of the SAMS value chain was important to develop, finalize and evaluate the SAMS Business Models (see chapter 2.8).

## 2.2 UCD Glossary

Within the SAMS project a UCD Glossary was developed to make sure that the project team has the same understanding of UCD terminologies. The UCD Glossary is extended with stories of how the SAMS project used the UCD terms and methodologies.

The glossary of UCD terms was first created as one of the strategies to achieve effective teamwork within the international UCD group, considering different background knowledge, understanding and way of working. It was important for the UCD team to have the same understanding/ definition of each term used in the working process; and from time to time in the research and reporting process, the UCD team in each country referred to the UCD Glossary in order to make sure that the research process is still following the agreed methodologies.

In order to make the UCD collaborative process more understandable, the UCD Glossary was enriched with stories on how the terms and methodologies were used within the SAMS project. The UCD Glossary, including its project stories, is available on SAMSwiki.

## 2.3 Documentation of User Research Results

Though the SAMS monitoring system as a concept was already developed by UNIKAS, to ensure the sustainability of the project's impact, it is important to understand the beekeepers' context and background that may vary from country to country to adapt SAMS products to the local context in Ethiopia and Indonesia. Thus, user research was focused, the process is documented in three stages:

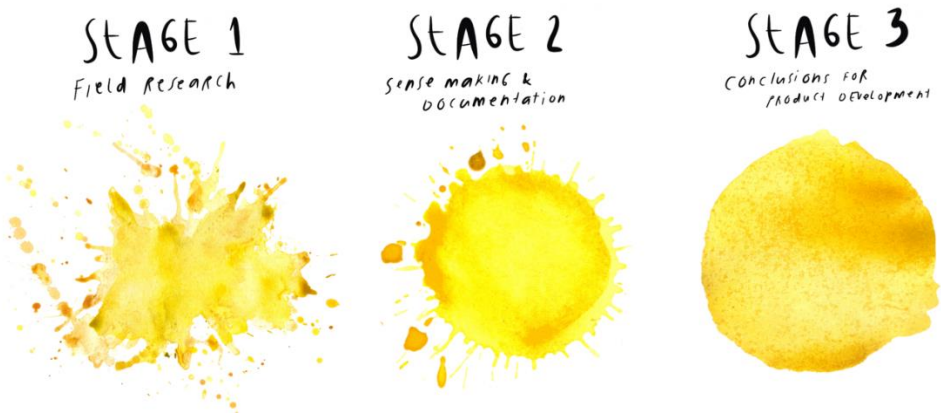



Figure 4 Stages of SAMS UCD process

- 1. Field Research: qualitative research methods such as contextual inquiry, shadowing, in-depth interview and usability testing were used;
- 2. Sense Making and Documentation: user research reports and personas were created; the research reports compiled all findings from the first stage and enabled the team to create personas and As-Is scenarios to help the UCD team to gain a common understanding of the users' workflow and to explore solutions to solve problems;
- 3. Conclusion for Product Development: UX Nuggets were created based on the previous findings and observations to formulate user needs and document metadata.

### 2.3.1 Personas

The created personas helped the UCD team as well as the complete SAMS project team to understand and analyse beekeeper needs better to develop SAMS products further.

> "Persona is a description of a user and what he or she intends to do when using an interactive system. Personas are not real; they are examples invented to stand for real users based on empirically determined data, for example, from observations or interviews. Personas typically have a name, age, some background information, goals, and desires. A persona description should include information about the persona's knowledge about and interest in the subject matter

of the interactive system. Persona descriptions often but not always include a photo." [2]

The SAMS monitoring system development depends on the beekeepers' background and context factors, for example, types of modern beehives they use, bee types they breed, electricity availability in their beekeeping site, and how deep they are personally influenced by beekeeping traditions and by their cultural environment and family traditions.

Based on results of the context of use analysis in the Field Research (Stage 1), following personas, collectively represent the major behaviours of beekeepers in Ethiopia and Indonesia.

Meet Tadesse, Aberash and Degen from Ethiopia:

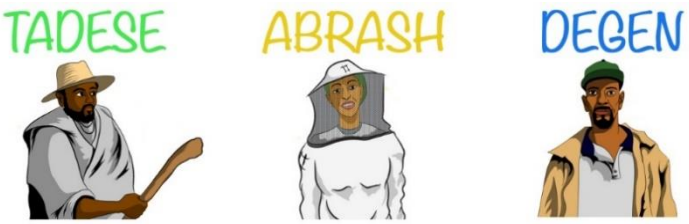



Figure 5 Ethiopian beekeeper personas

- Tadese represents beekeepers in the countryside which usually rely on their instincts and the traditional way of beekeeping;
- Aberash represents small-scale modern beekeepers, living in small towns or suburbs of the cites;
- Degen represents a modern beekeeper who is interested in large scale beekeeping and high financial incentive.

The Ethiopian personas are keeping Apis Mellifera, which is the only bee species in the country. Tadese uses a homemade traditional beehive, the traditional beehive requires very low cost and a minimum management effort to operate but it is very low in productivity. The volumes per harvest is very low comparing to modern beehives. Most of the honey harvested is consumed within Tadese's family, a little portion of the honey goes to the local market. Aberash is a modern beekeeper, she has 15 to 20 modern beehives and works as a professional beekeeper. She is skilled using modern beekeeping equipment with combining the traditional ways of beekeeping. She offers her services to other fellow beekeepers and gains moderate financial benefit from her profession. Degen is a commercial beekeeper with a major interest in large scale honey production. He has good knowledge about the market value of honey and honey product distribution. He hires beekeeping professionals like Aberash to manage his apiaries and mostly focuses on the market dynamics of the honey products.

[2] uxqb.org

Meet Kurt, Giuseppe, Dicky and Elsa from Indonesia:


Figure 6 Indonesian beekeeper personas

Kurt and Giuseppe are beekeepers who live in remote and rural areas of West Java. Though both are grassroots beekeepers,

- Kurt represents the majority of the grassroot beekeepers who have limited access to stakeholders' support; he often does his beekeeping activities with fellow grassroot beekeepers in his neighbourhood; he usually builds his beehives with recycled material (the "DIY" beehive type), each hives' dimension may vary;
- Giuseppe, though he lives close to Kurt, is privileged with his status as a member of the government's office staff; this position benefits him with more access to the beekeeping sector's stakeholders.

Dicky and Elsa represent the young generations of beekeepers,

- Dicky grows up in a beekeeper family with generations of experience; his grandfather and father are beekeepers, so it is only natural for him to continue this tradition, despite his young age; born as a digital native, Dicky uses his social media presence to promote his activities and his family business;
- Elsa, unlike the previously described personas, has no beekeeping tradition in her family; she is a curious millennial who wants to contribute in all possible ways to protect the environment, including keeping bees.

The beekeepers work with different types of bees and modern beehives (Figure 7). Kurt mostly keeps *Apis cerana*, Giuseppe and Dicky have several colonies of *Apis mellifera*, *Apis cerana*, and Trigona (stingless bee). While for Elsa, who lives in the city, it makes more sense to keep Trigona, the stingless bee – not only because it is stingless, but also its small size helps Elsa maintaining the colony easily. Kurt, Giuseppe, and Dicky have a professional interest in harvesting honey as it is one of their sources of income, Elsa harvests honey for her consumption only.

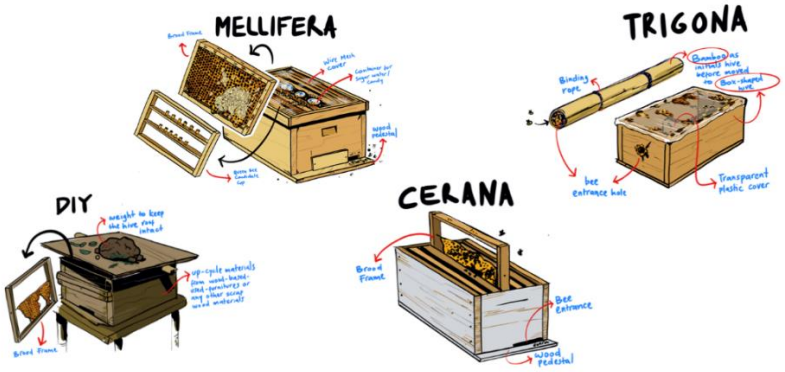



Figure 7 Types of modern beehives in Indonesia

After further user research, the Indonesian personas were refined. Elsa, Dicky, Giuseppe and Kurt were removed mainly because of the SAMS product development's focus, which is more suiting to other type of beekeepers like Usep and Sopian:


Figure 8 Refined personas in Indonesia

Meet Usep, a 53 years old grassroots beekeeper living in a remote village, a two-hour drive from Ciamis Regency in West Java. Ciamis itself is a regency area 117 kilometres away from Bandung, capital city of West Java. His mother tongue is Sundanese and he does not speak or understand English. He does bee hunting in the forest with his fellow beekeepers. He owns not more than 20 various types of modern beehives and bee types. His beekeeping methods are passed down from his mentors. He increased his beekeeping skills through shared beekeeping practices of the beekeeping community's facebook group. He is a smartphone user, like any other beekeeper in his circle. He uses his smartphone mostly for socializing via WhatsApp or facebook. Not only promoting his products, he often shares his thoughts, perspectives, or complaints regarding political or social issues through WhatsApp and uses facebook posts to promote his beekeeping activities.

Meet Sopian, a 40 years old beekeeper who lives in the peri-urban area near Bandung, capital city of West Java. He started beekeeping when he was 17 years old. He got his beekeeping knowledge from his brother and perfecting it along the way. Aside from being a beekeeper, Sopian also works as a government officer in the Regency Office. He is doing beekeeping whenever he is off duty from his office work and during weekends. Like Usep, Sopian also uses a smartphone to socialize and sell his harvested honey. Sopian creates a network of beekeepers in several rural areas near his place and considers them as his partners. Sopian will teach them his way of beekeeping, support them with logistics like modern beehives, and when the harvesting time is coming, he will help them sell their harvested honey as well with fair profit sharing. Though he is confident with his beekeeping method, Sopian eagerly learns new ways and new things related to beekeeping practices, including integrating technology in beekeeping. For selling his honey, he built a small counter in front of his house. Visitors are also welcome to discuss bee-related knowledge.

### 2.3.2 As-Is scenarios

For major beekeeping activities, As-Is scenarios were formulated to share the beekeeper's perception of his/ her daily beekeeping activities:

- Ethiopian As-Is scenarios (see Annex I):
  - Inside Inspection of Beehive;
  - Outside Inspection of Beehive;

- Harvesting.

- Indonesian As-Is scenarios (see Annex II):
  - Outside and Inside Inspection of *Apis cerana* Beehives and Honey Harvesting;
  - Outside and Inside inspection after absconding.

In July 2019, the SAMS team reviewed and refined the As-Is scenarios during the Prototyping Workshop in Bandung, West Java.

Figure 9 Refinement of the Ethiopian and Indonesian As-Is scenarios in Bandung

Some details of the Ethiopian As-Is scenario “Inside Inspection of Beehives” were changed:

- It turned out that Aberash as a professional beekeeper and also being an extension worker does not take her son but Tadesse, a traditional beekeeper, for assistance; thus, Tadesse replaced the son;
- both go by motorbike to the beehives not by car because it is not common for women to drive a motorbike, Tadesse is the driver;
- one picture was removed, and the last two steps/ processes were switched; at the end of the inside inspection of beehives, Aberash and Tadesse sit together at Aberash’s home discussing about what they have seen and what are their next steps.

In the Ethiopian As-Is scenario “Outside Inspection of Beehives” the following was refined:

- an observing step was added: looking for dead bees, pests etc.

To the Ethiopian As-Is scenario “Harvesting” some details were added:

- the beekeeper has to follow the standard cleaning process for cleaning the tools and to do a honey quality check;
- it is to recommended to take empty beehives to the site to put the honey frames in, or to change the full ones (with honey) and put spare ones; for changing the frames, spare frames must be taken to the hives; but frames for exchanging might be a further investment;
- it is recommended to take the honey extractor near to the apiary site; so far, harvesting and extracting is done at two different locations.

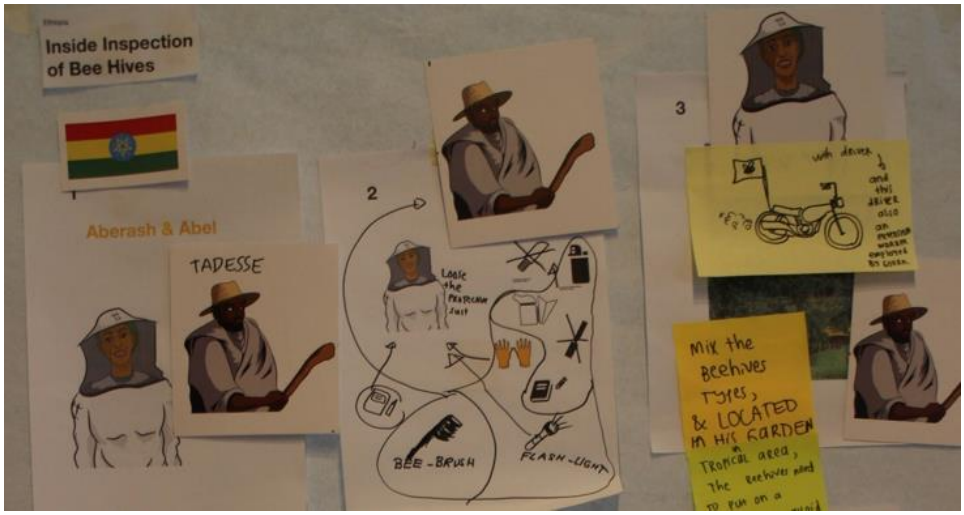



Figure 10 Example of reviewed and refined Ethiopian As-Is scenario

Some details in the Indonesia As-Is scenario “Outside and Inside Inspection of *Apis cerana* Beehives and Honey Harvesting” were refined:

- Giuseppe is not going alone to the beehive, he takes two other beekeepers/ workers with him; Giuseppe is the expert, one is cleaning the area and the other one is the honey harvester;
- the cigarette was deleted from the scenario; it was firstly described that the beekeeper smokes the beehives with his/ her cigarette smoke to make the bee colony less aggressive which is a common but contradictive practice; during the workshop an experienced beekeeper described his experience that this behaviour makes the colony even more aggressive; he suggests to treat the bee colony more gently, pick the right time to check the hives (avoid noon time), and skip the cigarette smoke; moreover, it is bad for humans and bees, it is not common and not a beekeeping tool;
- the distance between the beehives was changed, the minimum is ten meters, not five meters;
- in the further process, when Giuseppe takes out the frames, one of the two other beekeepers/ workers is cutting the grass, cleaning the surroundings of the hives and assisting to look at queen larvae, mites etc. Giuseppe and his assistant also look for pollen and are determining the quantity of the drone eggs and queens eggs, if there are too much; the third one is just responsible for harvesting the honey; he is waiting next to the others until he can harvest the honey; he extracts the honey and gives the frames back to Giuseppe;
- when putting out the frames there is no wriggling of the bees; it was deleted; normally the beekeeper is just blowing away the bees from the frame.

The Indonesian As-Is scenario “Outside and Inside inspection after absconding” was also refined:

- the title was changed, firstly it was named “When the bees have already swarmed”; the term “swarming” was changed to “absconding”;
- four steps/ processes were removed, and two steps/ processes were added;

- the cleaning step/ process was missing; to take all the SAMS partner countries into consideration, different cleaning processes for EU, ID and ET were created: In Ethiopia, beekeepers clean their hive at night, in the EU and in Indonesia beekeepers just clean if there are mites and in the EU the cleaning is done by hand fire.

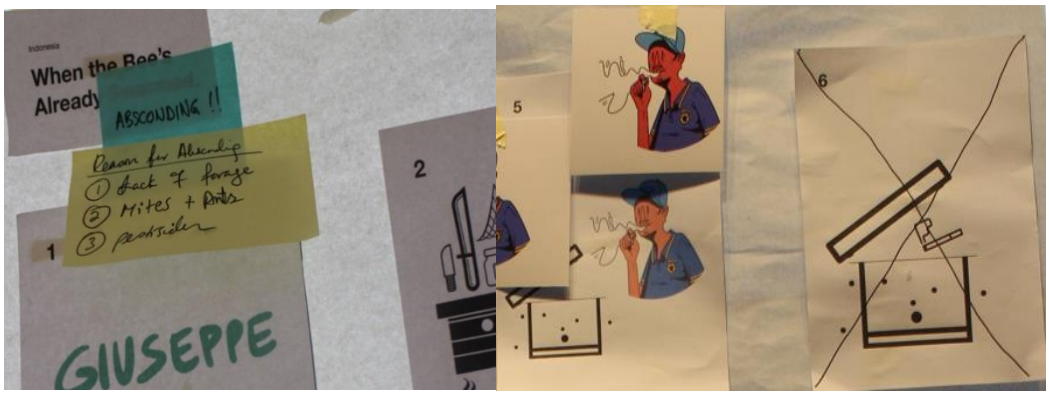



Figure 11 Examples of reviewed and refined Indonesian As-Is scenario

The As-Is scenarios were the ground to UI designers who worked on the DSS interface. With the help of the As-Is scenarios it was easy to substitute and enrich the different steps with the possible DSS usage and create a clearer understanding how it could be used.

### 2.3.3 UX Nuggets

All observations and findings describing the user needs and their contexts were collected and documented in a clear structured table. Therefore, the UX Nugget airtable was used, as it is user friendly and offers a collaborative work frame in an effective way to add metadata that can be sorted and filtered according to the researchers needs. Moreover, the UX nuggets can be documented in a way that avoids redundancies, helps to prioritize and enables the researchers to find research gaps and resolve contradictions.

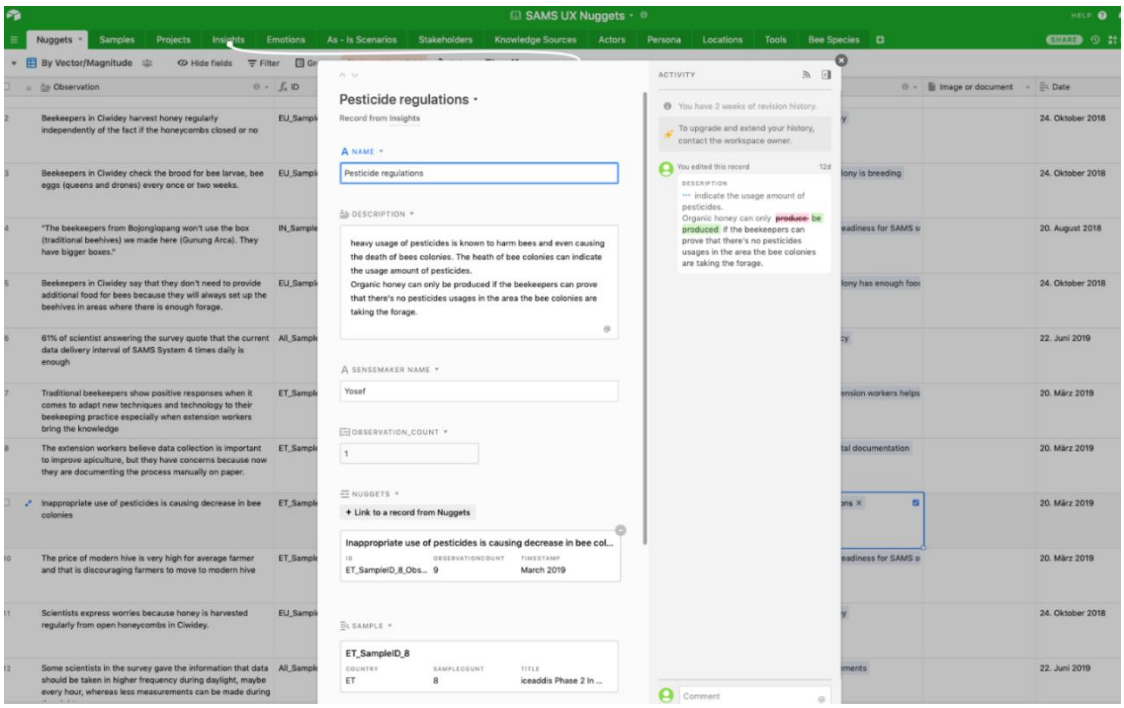



Figure 12 UX Nugget airtable and detail view of insights for one observation

All beekeeper needs extracted from the UX Nuggets airtable are presented in the next chapter. The following two examples, describe insights from observations, the user need and user requirements concerning the future DSS from the perspective of extension workers and beekeepers:

Table 1 Example of Extension worker and beekeeper

| | Insight from Observation | User Needs | User Requirements concerning the DSS |
|---|---|---|---|
| **Extension worker (Ethiopia)** | The extension workers believe data collection is important to improve the apiculture sector, currently they are documenting the data manually on paper. Because of this, they have concerns keeping their records organized and available for them on demand. As result, it is not practiced as much as it is needed. | As an extension worker, I need to collect hive data regularly for long-term use and to be able to monitor bee colonies.<br><br>As an extension worker, I want to improve apiculture from a documented data and diction support system assisted actions. | "As an extension worker, I want to note down important observations about the beehive when inspecting a beehive."<br><br>"As an extension worker I want to keep data about hives over a long time in order to analyse changes." |
| **Beekeeper (Indonesia)** | To be consistent in producing honey throughout the year, beekeepers need to know the indicators and periodization of forage vegetation in different areas. Beekeepers need to keep track of the flowering period as a minimum for one year in various locations. Every location has different flowering seasons, hence different harvesting times. If a beekeeper wants to be productive throughout the year, the need to have several locations for | As a beekeeper, I want to be informed about the flowering season, so that I can make sure that my bees have enough food. | "As a beekeeper, I want to be informed about the flowering season, so that I can make sure that the bees have enough food."<br><br>"As a beekeeper, I easily want to monitor my own hives placed in several different locations and also my beekeeping partners' hives." |

| | | | |
|---|---|---|---|
| | colony placement is required and/ or to establish partnerships with other beekeepers in several locations is valuable. | | |

## 2.4 Identification and Elaboration of Beekeeper Needs

One major goal of UCD and its user research is to collect valid information about users and their context of use in order to identify user needs. A user need is a prerequisite identified as necessary for a user, or a user group, to achieve a goal, implied or stated within a specific context of use.[3]

The user research overview (Table 2) summarizes all research phases and the methodologies used in Ethiopia and Indonesia within the SAMS project.

Table 2 User Research Overview

| | Ethiopia | Indonesia |
|---|---|---|
| **User Research Phase I: Context of Use Analysis** | • Interviews and in-depths interviews with beekeepers<br>• Focus Group Discussions with beekeeping experts and beekeeping business stakeholders | • In depth Interviews and contextual inquiry with beekeepers<br>• Focus Group Discussions with beekeepers, researchers, cooperatives, and bee-related experts |
| **User Research Phase II: Context of Use Analysis** | • Different beekeepers involved, long-term contextual inquiries with some of the beekeepers | • In depth interviews and contextual inquiries with beekeepers |
| **User Research Phase III: Prototype Evaluation and Context of Use Analysis (iteration)** | • DSS usability tests with beekeepers | • In depth interview, learning from extremes methods (recorded video call) with beekeepers: (honey/colony productivity lens) 1 unproductive, 1 productive, (bee colonies quantity lens) 1 grassroot/ community beekeeper, 1 industrial beekeeper |

[3] CPUX-UR Curriculum

| | | |
|---|---|---|
| | | • DSS usability testing with recorded video call utilized lookback applications with beekeepers (grassroot beekeepers, establish beekeepers, community beekeeper) |

User Research Phase I incl. the first UCD workshop was conducted in 2018. The context of use analysis continued in Research Phase II with evaluations in the second UCD Prototyping Workshop in Bandung/ Indonesia in July 2019; the beekeeper needs, documented in the UX Nugget airtable, were assessed per country by the SAMS team in terms of (a) importance (see Table 3), (b) ability to be solved by the SAMS HIVE monitoring system, (c) ability to be solved by DSS SAMS data display for beekeepers, (d) ability to be solved by a solution on flowering information, (3) ability to be solved by another application on Beekeeping advise and capacity building (see Table 4). User Research Phase III with prototype evaluation started after the second UCD workshop.

Table 3 Beekeeper needs in detail and assessed in terms of importance

| **Nr.** | **Beekeeper Needs** | **Importance** (how one "user need" is strongly felt by the users) | | |
|---|---|---|---|---|
| | | Ethiopia | Indonesia | EU |
| 1 | As a beekeeper, I want to be informed by the season of the flower, so that I can make sure when the bees have enough food | 3 | 3 | 3 |
| 2 | As a beekeeper I want to know whether the location is convenient for the bees or not, so that i can decide if I place my colony in that place, the colony will not abscond | **5** | 3 | 3 |
| 3 | As a beekeeper, I want the forage for the bees are secured (the diversity of the forage guaranteed by policy, for example) so that I can do beekeeping without worry my colony will abscond. | **5** | **5** | 4 |
| 4 | As a beekeeper, I want my colony free from pests' attack (wasps, ants, rats etc), so that my colony can grow healthily and productively without interference. | **5** | **5** | **5** |
| 5 | As a beekeeper, if there is some new method in beekeeping, I want to adopt it if it proven can have direct benefits for me, with a minimum cost, and I can get the tools locally | 4 | 2 | 4 |
| 6 | As a beekeeper, I want my colony to be safe from thief, so that I can be freed from anxiety about the existence my colony | **5** | **5** | 4 |
| 7 | As a beekeeper, I want my colony to be safe from the impact of extreme climate/weather, so that I still can get income from beekeeping activity | 4 | 4 | 4 |

| | | | | |
|---|---|---|---|---|
| 8 | As a beekeeper, I want to have access to the beneficial beekeeping community/association so that I can gain positive benefits that can improve my entire beekeeping activity | **5** | 2 | 3 |
| 9 | As a beekeeper, I want a policy that support beekeeping activity, so that I know that the food resources for bees are secured | **5** | **5** | **5** |
| 10 | As a beekeeper I want to get some support and coaching so that I can have some direction and mentoring in beekeeping activity | 4 | 3 | 4 |
| 11 | As a beekeeper I want to get some access to the money capital so that I can start, leverage, or scale up my beekeeping activity | 4 | 3 | **5** |
| 12 | As a beekeeper, I want my customers to be honey-literate so that I could easily selling my honey to customers | 3 | 1 | **5** |
| 13 | As a beekeeper, I want to have new technology or methods that can boost the productivity of my honey apiary so that my income increases | **5** | **5** | 3 |
| 14 | As a beekeeper, I want my colony to be freed from any disease, so that my colony can work productively without any obstacle | **5** | 2 | **5** |
| 15 | As a beekeeper I want to know if anything affects bees' behaviour so that I can take an appropriate action for my colonies | **5** | 1 | 4 |
| 16 | As a beekeeper, I want to know how much honey that allowed to be harvested in a colony, so that I can harvest the honey in the right amount without suffering the colony | 3 | 1 | 3 |
| 17 | As a beekeeper, I want to know if my colony is safe enough to be checked or not, so that I can prevent their stress level to be higher than allowed. | 4 | 1 | 3 |
| 18 | As a beekeeper, I want to notify if temperature condition of the colony is too hot, so that I can move it to a place with proper temperature. | **5** | 1 | 3 |
| 19 | As a beekeeper I want to have an assistant in my activity so that I can get some help to do some work | **5** | 3 | 3 |
| 20 | As a beekeeper, I want to have a beekeeping comrades/associates that come in handy whenever I need help, so that I could carry on honey harvesting and bee hunting or another kind of works that is labour intensive | 4 | 3 | 3 |
| 21 | As a beekeeper, I want my box free of termite, so that I don't have to worry about the condition of the box when season changes | **5** | 2 | 2 |
| 22 | As a beekeeper, I want to be notified if my frames are too close to each other, so that I can prevent the frames sticks to each other and become an obstacle for my beekeeping activities | 1 | 1 | 3 |
| 23 | As a beekeeper, I want my hives box to be sturdy enough, so that I don't have to worry if it is going to fall or not | 1 | 1 | 4 |
| 24 | As a beekeeper, I want the entrance of the hive box always clear of the plants, leaves and spider-web, so that my colony can go looking for the food freely without obstacle | 4 | 1 | 3 |

| | | | | |
|---|---|---|---|---|
| 25 | As a beekeeper, I want to have an opportunity to a vast network of people, not only in beekeeping but also on other fields, so that I could increase another potential of business and explore another beekeeping methods | 4 | 1 | 3 |
| 26 | As a beekeeper, I want to have a practical knowledge about the biology and physiology of bees so that I am able to provide the best treatment for my colony | 4 | 1 | 4 |
| 27 | Beekeepers want to know if there is a pesticide chemical affecting the bee colony | **5** | 4 | **5** |
| 28 | Beekeepers want to know if there is an upcoming swarm in the colony | **5** | 1 | **5** |
| 29 | Beekeepers want to know the strength of the bee colony. This will help them to identify the colonies they have to follow up closely | **5** | 1 | **5** |

Scale: 1= not important at all; 2= not important; 3= moderate important; 4= important; **5**= very important

Reviewing all beekeeper needs in relation to its importance it becomes clear that the most prioritized need of the beekeeper is to ensure that none of the bee colonies is absconding, despite the uncertainty of the seasons, forage, and pests' threat.

Table 4 Beekeeper needs in detail and assessed in terms of SAMS HIVE, DSS, flowering information and other application

| Nr. | Beekeeper Needs | Ability to be solved by the SAMS HIVE System | | | Ability to be solved by DSS SAMS data display for beekeepers | | | Ability to be solved by a solution on flowering information | | | Ability to be solved by another application on Beekeeping advise and capacity building | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ET | ID | EU | ET | ID | EU | ET | ID | EU | ET | ID | EU |
| 1 | As a beekeeper, I want to be informed by the season of the flower, so that I can make sure when the bees have enough food. | 2 | 1 | 3 | 3 | 1 | 2 | 4 | 3 | 5 | 4 | 4 | 1 |
| 2 | As a beekeeper I want to know whether the location is convenient for the bees or not, so that i can decide if I place my colony in that place, the colony will not abscond. | 3 | 1 | 1 | 5 | 1 | 1 | 5 | 1 | 5 | 5 | 4 | 1 |
| 3 | As a beekeeper, I want the forage for the bees are secured (the diversity of the forage guaranteed by policy, for example) so that I can do beekeeping without worry my colony will abscond. | 1 | 1 | 1 | 3 | 1 | 1 | 5 | 1 | 5 | 4 | 3 | 1 |
| 4 | As a beekeeper, I want my colony free from pests' attack (wasps, ants, rats etc), so that my colony can grow healthily and productively without interference. | 5 | 2 | 3 | 5 | 2 | 1 | 1 | 1 | 1 | 4 | 4 | 3 |
| 5 | As a beekeeper, if there is some new method in beekeeping, I want to adopt it if it proven can have direct benefits for me, with a minimum cost, and I can get the tools locally. | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 3 |
| 6 | As a beekeeper, I want my colony to be safe from thief, so that I can be freed from anxiety about the existence my colony. | 5 | 1 | 1 | 4 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 |
| 7 | As a beekeeper, I want my colony to be safe from the impact of extreme climate/weather, so that I still can get income from beekeeping activity. | 1 | 1 | 1 | 4 | 2 | 1 | 3 | 1 | 1 | 4 | 2 | 1 |
| 8 | As a beekeeper, I want to have access to the beneficial beekeeping community/association so that I can gain positive benefits that can improve my entire beekeeping activity. | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 5 | 4 | 5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | As a beekeeper, I want a policy that support beekeeping activity, so that I know that the food resources for bees are secured. | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 5 | 3 | 3 |
| 10 | As a beekeeper I want to get some support and coaching so that I can have some direction and mentoring in beekeeping activity. | 4 | 1 | 2 | 4 | 1 | 3 | 2 | 1 | 1 | 5 | 5 | 5 |
| 11 | As a beekeeper I want to get some access to the money capital so that I can start, leverage, or scale up my beekeeping activity. | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 2 | 3 |
| 12 | As a beekeeper, I want my customers to be honey-literate so that I could easily selling my honey to customers. | 2 | 1 | 1 | 2 | 1 | 1 | 4 | 1 | 1 | 5 | 5 | 5 |
| 13 | As a beekeeper, I want to have new technology or methods that can boost the productivity of my honey apiary so that my income increases. | 5 | 2 | 3 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 5 |
| 14 | As a beekeeper, I want my colony to be freed from any disease, so that my colony can work productively without any obstacle. | 5 | 2 | 3 | 4 | 2 | 3 | 1 | 1 | 1 | 5 | 4 | 3 |
| 15 | As a beekeeper I want to know if anything affects bees' behaviour so that I can take an appropriate action for my colonies. | 5 | 3 | 4 | 5 | 4 | 3 | 4 | 1 | 1 | 4 | 4 | 3 |
| 16 | As a beekeeper, I want to know how much honey that allowed to be harvested in a colony, so that I can harvest the honey in the right amount without suffering the colony. | 4 | 4 | 4 | 1 | 5 | 5 | 4 | 1 | 3 | 4 | 4 | 5 |
| 17 | As a beekeeper, I want to know if my colony is safe enough to be checked or not, so that I can prevent their stress level to be higher than allowed. | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 1 | 1 | 4 | 4 | 5 |
| 18 | As a beekeeper, I want to notify if temperature condition of the colony is too hot, so that I can move it to a place with proper temperature. | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 1 | 1 | 3 | 5 | 3 |
| 19 | As a beekeeper I want to have an assistant in my activity so that I can get some help to do some work. | 5 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 4 | 3 | 1 |
| 20 | As a beekeeper, I want to have a beekeeping comrades/associates that come in handy whenever I need help, so that I could carry on honey harvesting and bee hunting or another kind of works that is labour intensive. | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 4 | 3 | 1 |
| 21 | As a beekeeper, I want my box free of termite, so that I don't have to worry about the condition of the box when season changes. | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 4 | 3 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | As a beekeeper, I want to be notified if my frames are too close to each other, so that I can prevent the frames sticks to each other and become an obstacle for my beekeeping activities. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 3 | 5 |
| 23 | As a beekeeper, I want my hives box to be sturdy enough, so that I don't have to worry if it is going to fall or not. | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 4 | 5 |
| 24 | As a beekeeper, I want the entrance of the hive box always clear of the plants, leaves and spider-web, so that my colony can go looking for the food freely without obstacle. | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 3 |
| 25 | As a beekeeper, I want to have an opportunity to a vast network of people, not only in beekeeping but also on other fields, so that I could increase another potential of business and explore another beekeeping methods. | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 1 | 1 | 4 | 3 | 3 |
| 26 | As a beekeeper, I want to have a practical knowledge about the biology and physiology of bees so that I am able to provide the best treatment for my colony. | 1 | 1 | 1 | 4 | 1 | 1 | 2 | 1 | 1 | 5 | 5 | 5 |
| 27 | Beekeepers want to know if there is a pesticide chemical affecting the bee colony. | 5 | 1 | 1 | 5 | 1 | 1 | 1 | 1 | 1 | 5 | 5 | 3 |
| 28 | Beekeepers want to know if there is an upcoming swarm in the colony. | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 1 | 1 | 5 | 5 | 3 |
| 29 | Beekeepers want to know the strength of the bee colony. This will help them to identify the colonies they have to follow up closely. | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 1 | 1 | 4 | 5 | 1 |

Scale: 1= not important at all; 2= not important; 3= moderate important; 4= important; 5= very important

## 2.5 Elaboration of other stakeholder needs

In this section needs of other secondary relevant stakeholders are described.

### 2.5.1 Scientists

Data scientists as well as environmental scientists can benefit from SAMS data for research purposes. The SAMS team identified three main groups for whom SAMS data could be interested:

- Bee Scientists
  - The data will be of use for the scientists, to make an in-deep analysis of the colony behaviour and to compare it with colonies in other regions. This can help to identify the best regions for the bee colony placement. Analysed data can also give some insight of a potential correlation between diseases (known and unknown) and parameters monitored (temperature, humidity). Collected data can help the apiologists to better understand the behaviour of the colony and find the reasons for specific states using the SAMS data.

- Plant Specialists
  - Based on weight data of bee colonies it is possible to conclude on flowering periods in different observed regions and evaluate/ differentiate the best honey plants – plants that provide the highest amount of nectar/ pollen. In such way plant specialists can gain new knowledge about plant specifics in different regions which opens up new opportunities for collaboration with beekeepers/ bee scientists.

- Climate Scientists
  - As environmental parameters are also measured, such data will be useful for climate scientists. Due to different placement of bee colonies, e.g. in forests or in places which are difficult to access (e.g. mountain areas in Indonesia) and were no climate stations are deployed, the data could provide valuable information on weather changes and influences on bees and agricultural aspects. Therefore, bee colony monitoring systems can also act as climate stations.

Beside these three groups, other scientists may also have an added value by using the collected data – the use of SAMS data is not being excluded for other disciplines (e.g. food scientists, social scientists).

In order to investigate the needs of scientists concerning SAMS data, a survey for scientists was conducted. The survey had 43 responses from mainly European scientists, but also from Indonesian, Ethiopian ones, and single responses from Australia, Argentina, Kenya and Myanmar. Scientists require data access with very diverse requirements on type and frequency depending on the scientific field:

- for most scientists, data recording during daytime will be nice if conducted every hour but during the night, it is okay if at 18:00, 0:00 (midnight) and 6:00;
- for some scientists, the more frequent the data are recorded, the better but the needed data recording frequency depends on what one wants to know and react on;

- concerning data representation, the survey results showed that even so quite a few scientists preferred to receive data in visualized graph formats, almost all of them also need raw or/ and table structured data;
- temperature and weight are the main parameters of bee colonies that should be constantly monitored; environmental temperature should be fixed as well to make a right conclusion of the colony behaviour during various seasons;
- information on location and other environmental factors are needed to contextualize the data.

### 2.5.2 Honey consumers

The conducted market surveys (see D2.3 Results or Market Surveys) on honey consumption revealed the Ethiopian and Indonesian honey consumer needs, summarized in Table 5.

Table 5 Ethiopian and Indonesian honey consumer needs

| Ethiopia | Indonesia |
|---|---|
| • Local honey<br>• Label information<br>• Extracted liquid honey<br>• Honey license and traceability for good quality<br>• Glass bottles producers<br>• Well established bee product value chain platform<br>• Value adding bee products for the local market | • Glass bottles or plastic bottles<br>• 250ml package<br>• Local honey<br>• Label information: best before, ingredients, legality, usefulness, nutritional value<br>• Information about honey quality parameters<br>• Honey license and traceability for good quality<br>• Next to forest honey or no specific type of honey, propolis is the most favoured product |

### 2.5.3 Technological stakeholders

Through the survey on technology aspects in Indonesia, the needs of beekeepers, governmental representatives, universities, research agencies, businesses, NGOs and communities concerning technology in the apiculture sector were elaborated:

Beekeeper needs

- technology that helps beekeepers in managing bee feed;
- technology that reduces the likelihood of colony/honey theft.

Government needs

- technology that can provide data about air humidity;
- technology that can help in estimating honey harvest time.

Universities / Research Institutions need

- technology that can detect diseases and pests in bee colonies;
- technology that can provide data related to the flowering season that can help with bee feed problems.

Business needs

- technology that reduces the likelihood of colony/honey theft;
- technology that can help in estimating honey harvest time.

NGO needs

- technology that can help in estimating honey harvest time.

Community needs

- technology that can provide rainfall data.

In terms of technology, the Ethiopian beekeeper needs are:

- digital tools supporting them to collect useful data and tackle problems on beekeeping activities (e.g. identifying bee disease, record and predict harvest frequency, record colony transfer events and information about the diversity of flora distribution on a season);
- a proper swarm control mechanism.

## 2.6 Honey Bee Management Rules

The 10 Rules of Honey Bee Management are available on the SAMS website and the SAMSwiki in English, Amharic and Bahasa Indonesia. The 10 rules have been developed by scientists (UNIGRA in support of UNIKAS) based on literature research, previous user research, first learnings, and are a result of the UCD approach in the Api-Management (WP5). Feedback of Indonesian and Ethiopian beekeepers, who reflect one major target user group of the SAMS system, strongly influenced the final result. Besides, UNPAD, HOLETA and experienced other beekeepers reviewed them to guarantee their validity for the tropical regions – in particular for Ethiopia and Indonesia. As good beekeeping practice is not common in Indonesia, nor in Ethiopia, the rules were formulated serving as a guideline for beekeepers to increase the quality of their honeybee products and to improve the health of the bee colonies.

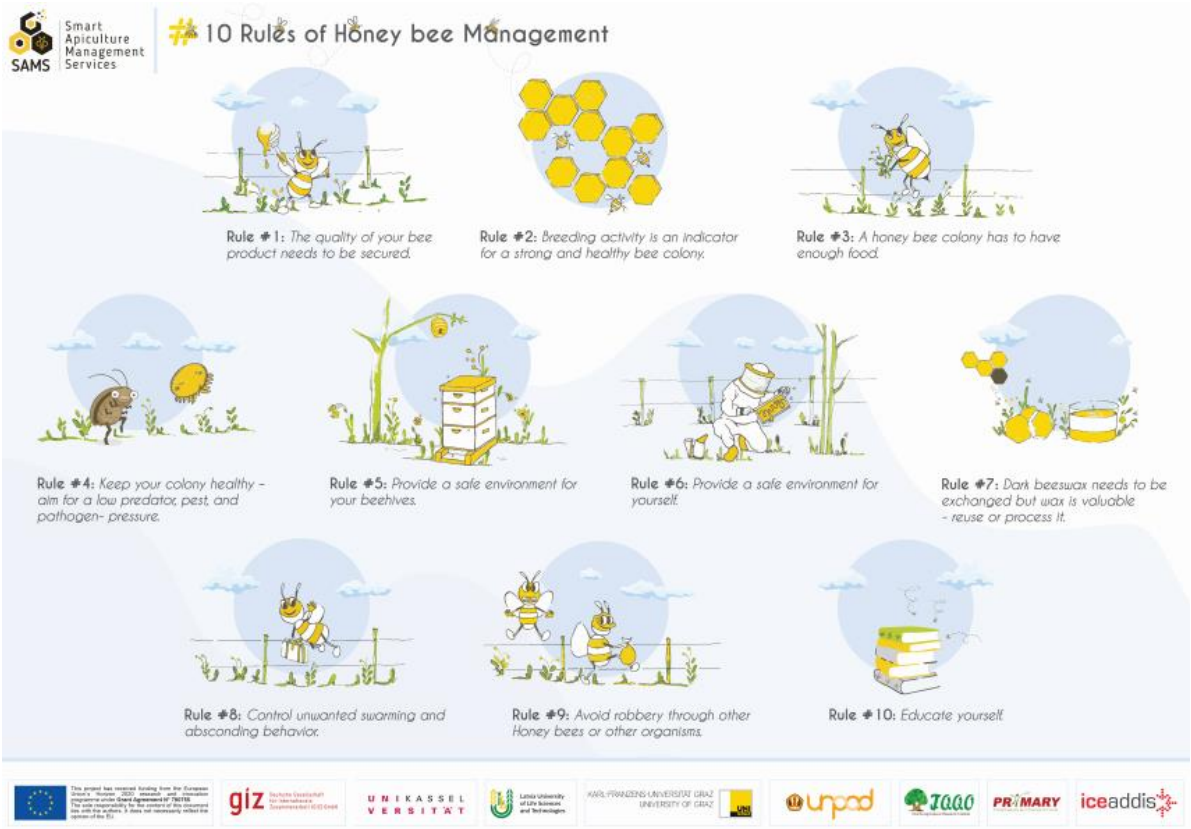



Figure 13 Rules of Honey Bee Management - English version


Figure 14 Rules of Honey Bee Management - Amharic version

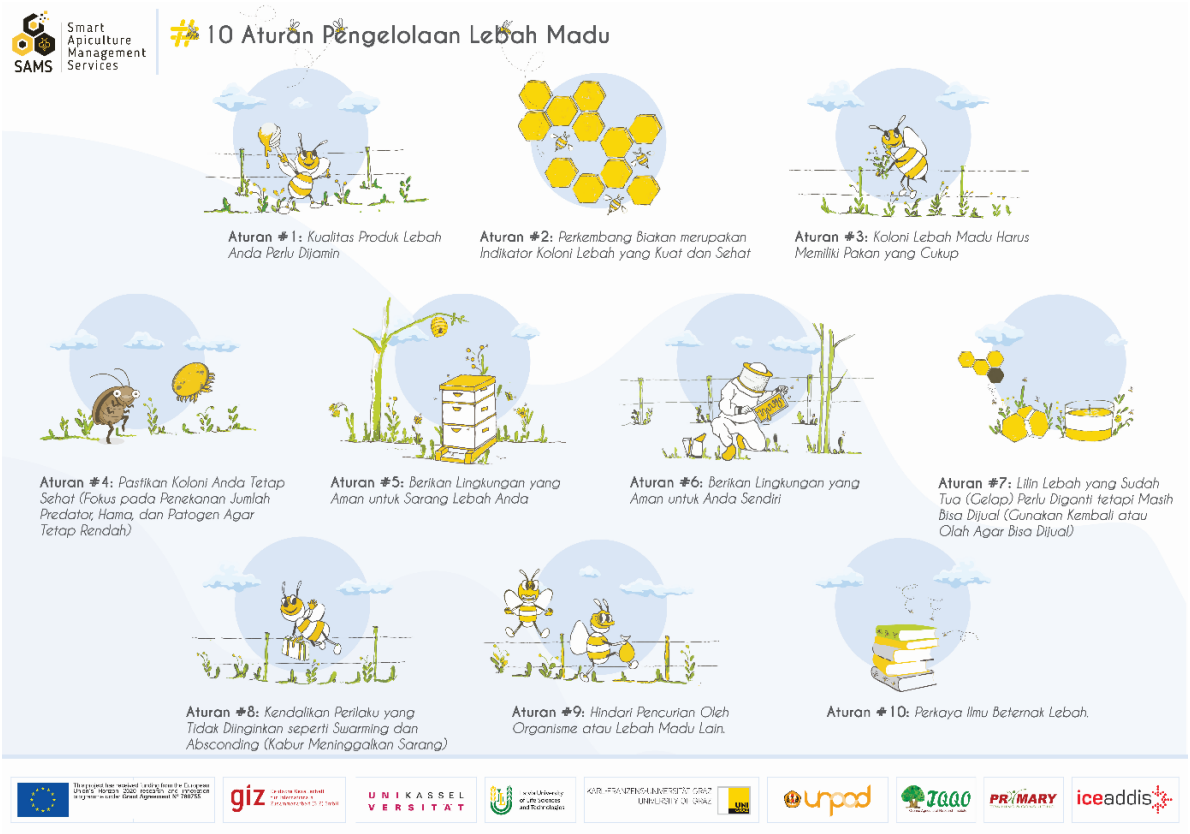



Figure 15 Rules of Honey Bee Management – Bahasa Indonesia version

## 2.7 SAMSwiki

The user research uncovered knowledge gaps in Ethiopia and Indonesia, e.g. in beekeeping management aspects, flowering seasons, pests and diseases. Thus the SAMSwiki was set up. It is a free open source database with a glossary style, aiming to collect beekeeping knowledge from around the globe. Within the SAMS project, the focus was set on the target countries Ethiopia and Indonesia. In a first phase (2018), a literature review was conducted by UNIGRA to contextualize the local systems of the two target countries. On a second stage, the acquired beekeeping knowledge was compiled by local expert opinions. Finally, the reviewed knowledge was structured by assigning it into a total of 12 main chapters and 62 sub-chapters. So far, the database includes 124 articles and 103 uploaded files.

The SAMSwiki serves as an online encyclopaedia that anyone can use and edit. The instructions on how to use the wiki and a list of contact persons are given on the website. It allows further extensions by consortium members, researchers or any interested people such as beekeepers, or people along the honey market value chain. This ongoing growing process makes the database sustainable for the future. 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 and is still in progress. The database therefore acts as a strong tool for beekeepers and researchers in all countries.

It is highly appreciated to add beekeeping knowledge for new countries and translate into local languages to make the knowledge available for everyone.

## 2.8 Business Models

The user research also uncovered business potential of the apiculture sector in the target countries. In organized physical and virtual business development activities in Ethiopia and Indonesia with beekeepers, cooperatives, input suppliers, bee related experts, facilitators, agripreneurs and SAMS data beneficiaries, with a total number of 458 participants, the participants got familiar with Business Model Canvas used for developing SAMS Business Models. Moreover, a template with questions to concrete the business idea and a self-assessment were created and filled out by the participants (see also D2.4 Evaluation of Business Plans). In total 54 SAMS Business Models were developed – 20 Ethiopian, 24 Indonesian and 10 EU. The Business Models are available on the SAMS website and on SAMSwiki.

The SAMS Business Models range from honey reselling, digital marketplaces, beekeeping supply and logistic, food and beverages (honey derivative products), beekeeping products for health and beauty to tourism, capacity building and professional consultancy, education and technology incl. remote monitoring beehives, DSS, PCB, Data Warehouse.

## 2.9 Final SAMS HIVE monitoring system

During the project the SAMS HIVE monitoring system overcome three iterations which were influenced by previous described UCD research and results (as well as capacity building activities). Figure 16 describes the adaptions of the lo-fi, hi-fi and final SAMS HIVE monitoring system in combination with the user needs and technical method to fulfil them.

| | User needs | Method | Adaptions |
|---|---|---|---|
| Lo-fi Prototype | 1: Flowering season<br>2: Proper location<br>3: Sufficient forage<br>4: Pest alert<br>5: Methods update<br>6: Theft warning<br>7: Weather alert<br>8: Community access<br>9: Policy bee friendly | 1: Scale<br>2: Network for location via APP<br>3: Scale<br>4: Big data analysis (temp., weight, (acoustics))<br>5: Network for knowledge exchange via APP<br>6: DW log, scale, (acoustics)<br>7: Outside sensors for humidity and temperature<br>8. Network for communication via APP | There is a demand for an application (APP) with a support function, both in terms of software and in general. Hardware-specific, there is a high demand for easy operation, weight data and sensors for temperature and humidity inside and outside the beehive. There is also a need for bigdata analysis and detailed logging:<br>Sensor expandability of the Lo-fi prototype can already be used to extend the system with sensors for temperature, humidity and a weighing unit. In order to reduce energy consumption, construction effort and costs as well as to increase robustness, a completely new design was developed. |

| | | | |
|---|---|---|---|
| Hi-fi Prototype | 10: Coaching<br>11: Capital access<br>12: Customer awareness<br>13: Technology access<br>14: Disease alert<br>15: Behaviour warning<br>16: Harvest information<br>17: Inspection information<br>18: Temperature condition<br>19: Assistant<br>20: Association access<br>21: Termite alert | 9. Network for public relations via APP<br>10. Network for knowledge exchange via APP<br>11: Network for support and exchange via APP<br>12: Network for public relations via APP<br>13: Network for support and exchange via APP<br>14: Big data analysis (temp., weight, (acoustics))<br>15: Big data analysis (temp., weight, (acoustics))<br>16: Scale<br>17: Big data analysis (temp., weight, (acoustics))<br>18: Temperature sensor<br>19: Network for support via APP<br>20: Network via APP | A more economical single-board computer was used (Raspberry Pi zero), which is very popular and widespread worldwide. In addition, modular components were used, which are widely used, and a large open source community is involved. This allows a wide scope for expandability and use of the system for educational purposes such as in schools and makerspaces. Thus, a complete reusability of the components is possible and fully meets the demand for sustainability. The hardware fulfils the required user needs and methods. A software adaptation is being worked on. |
| Final SAMS HIVE System | 22: Frame distance alert<br>23: Hive stability<br>24: Hive entrance warning<br>25: Network access<br>26: Practical knowledge access<br>27: Pesticide alert<br>28: Swarm alert<br>29: Strength information | 21: Big data analysis (temp., weight, (acoustics))<br>22: Big data analysis (temp., weight, (acoustics))<br>23: Big data analysis (temp., weight, (acoustics))<br>24: Big data analysis (temp., weight, (acoustics))<br>25: Network via APP<br>26: Network for knowledge exchange via APP<br>27: Big data analysis (temp., weight, (acoustics))<br>28: Big data analysis (temp., weight, (acoustics))<br>29: Big data analysis (temp., weight, (acoustics)) | Further hardware adaptations were carried out: Easy to install sensor frames were developed for the sensors and adapted for high user-friendliness. A PCB was developed to reduce costs and simplify installation. The software adaptation was completed and an easy to use user interface was programmed as well as a detailed logging function in the data warehouse. Adjustments can also be made online, enabling high specification to meet user demand. The software meets the user needs. For a Big data analysis to develop further software-based alert and warning systems more data is required. |

Figure 16 Adaption of lo-fi, hi-fi and final SAMS HIVE monitoring system

The final version of the SAMS HIVE monitoring system is the result of three major adaptation steps/ iterations, which were evolved by UNIKAS in cooperation with CV.PI, ICEADDIS and HOLETA. The placement of the SAMS HIVE system is shown in Figure 17, further information about stages of the first prototype (lo-fi), the second prototype (hi-fi) development and the final HIVE system are pointed out in D3.4 Evaluation of HIVE Prototype Design. A list of the main hardware components and costs of the SAMS HIVE Monitoring System is also available.

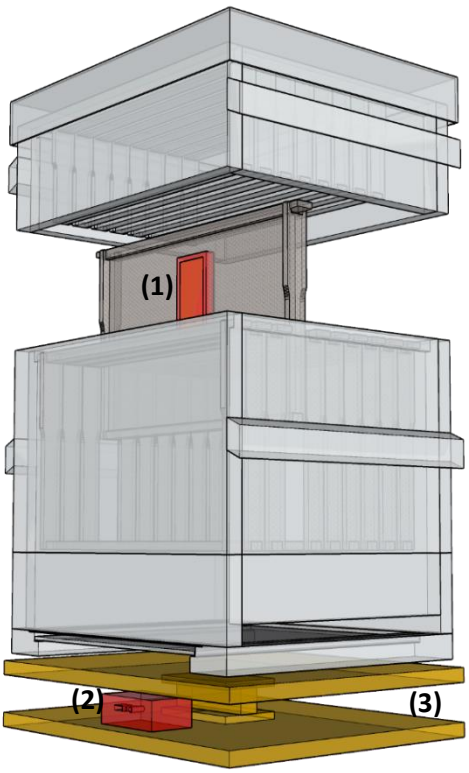


Figure 17 Placement of SAMS HIVE system in common beehive: (1) sensor frame in broodframe, (2) HIVE case, (3) scale unit

During the time the Raspberry Pi of the SAMS HIVE system was improved (updates regarding the sensor problems and router connectivity), different options were explored based on user responses locally in Indonesia by CV.PI. One of options includes an alternative for Raspberry Pi single board computer as the main data collection device – the affordable, cost-effective and energy efficient electronic platform NodeMCU (based on a WiFi microchip ESP8266) that is easy to use by and not so cost-intense for the end users. Hence such solution also reduces the overall costs of the monitoring system and consumes less energy due to the power-saving architecture (several sleep modes are available) built in the core chip of the NodeMCU platform.

UNILV in close collaboration with CV.PI tested the concept of NodeMCU based monitoring system. In overall the prototype development/ testing involved two iteration steps in Indonesia (and three steps in Latvia). For testing purposes three ESP8266 based board variants were chosen – ESP8266 with an adapter board, NodeMCU and Wemos D1 mini platform. The motivation to choose these platforms was as follows: ESP8266 with an adapter board is the most energy efficient variant (includes only the minimum necessary electronic components), but is not the best option for end users (needs more effort to set it up for uploading the program code); the NodeMCU and Wemos D1 mini are very popular modules and widely available. These modules consume a little bit more current than the ESP8266 with an adapter board (due to the fact, that there are a lot of components soldered on the board), but is more user friendly when it comes to uploading the program code (provides a convenient way to connect the platform to the computer via USB port).

The first iteration was a concept based on a breadboard and it was tested with both platforms (see Figure 18). This allowed the SAMS team to detect and eliminate possible errors in a very early stage.

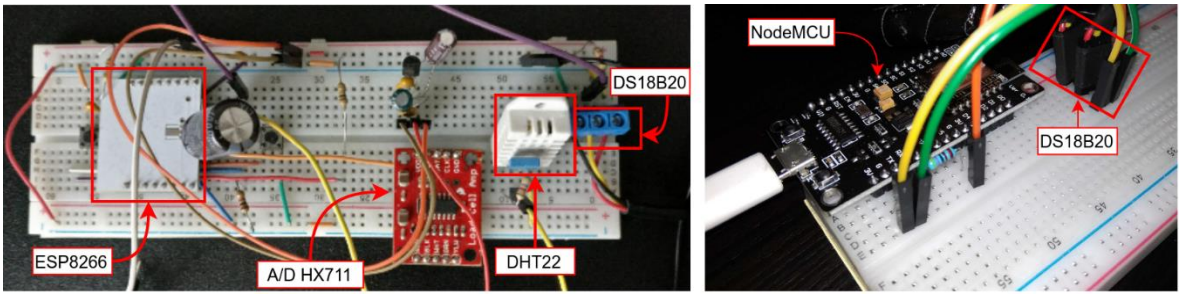



Figure 18 Breadboard iteration step with connected modules and sensors: ESP8266 with an adapter board on the left; NodeMCU on the right

When the breadboard iteration proved that the concept works, the necessary components were soldered on a perfboard, which was considered as the second iteration (see Figure 19).

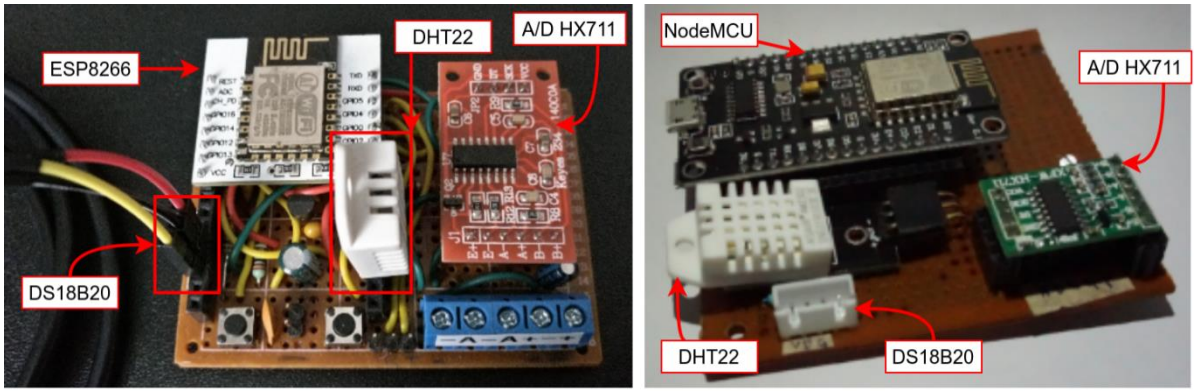



Figure 19 Second iteration – with soldered components: ESP8266 on the left; NodeMCU on the right

After the NodeMCU perfboard version was successfully tested in the laboratory environment by CV.PI in Indonesia, a second monitoring system was assembled, this time it was based on the Wemos D1 mini board. Both monitoring systems were implemented in Maribaya, Bandung, Indonesia. One of the systems was implemented by the beekeeper, therefore feedback and recommendations from his side were taken into account to further improve the system. The implementation also proved the system to be user friendly and manageable by the beekeeper.

Each of the systems were equipped with three DS18B20 temperature sensors (to monitor in-hive temperature), one DHT22 sensor for temperature and humidity monitoring outside the hive and one load cell to measure weight. Data were also successfully transferred to the SAMS DW.

Since there were still some interruptions during data sending observed, the plan for the future is to add GSM/ GPRS module, so the measurement nodes could be completely independent from a WiFi router, but connected directly to a mobile network, thus eliminating one more factor that could cause data transfer interruptions and improving the DSS outcomes/ recommendations to the beekeeper.

After the second iteration, UNILV continued to improve the monitoring system's design by developing a PCB for the ESP8266 adapter board variant, where all the components could be soldered to a designated place, easing up the whole assembling and installation process. This was considered as a third iteration for ESP8266 based monitoring system's prototype development. For more detailed information regarding the monitoring system development and

evaluation refer to D3.4 Evaluation of HIVE Prototype Designs and D3.5 Manual on HIVE Construction and Operation.

## 2.10 DSS SAMS data display for beekeepers

The DSS SAMS data display for beekeepers is based on the user research. It was scribbled and prioritized during the UCD SAMS prototyping workshop in Bandung, July 2019. The user interface (UI) prototype of the DSS SAMS data display for beekeepers (for mobile devices) was then developed in Figma software by CV.PI. The iterative development process was discussed during regularly virtual meetings dedicated to this topic with UNILV, GIZ and ICEADDIS. According to the usability tests with four Ethiopian and five Indonesian beekeepers (end-users), the interface prototype (in English, Amharic and Bahasa Indonesia) was refined. The user interface prototype in English, Amharic and Bahasa Indonesia in 8 iterations with 2 design versions of the SAMS data display for beekeepers is available open source for further elaboration and for developing an app to facilitate a business.

As it could be expected, the user needs and the feedback of the usability tests were different per county and cultural context, this is described in the following sub-chapters.

### 2.10.1 Ethiopia

Refinements of the Ethiopian DSS SAMS data display for beekeepers according to the usability tests:

- The interaction flow of the on-boarding and login to an account page was adopted – it was simplified because the first on-boarding page design was rated unintuitive by the testing beekeepers.

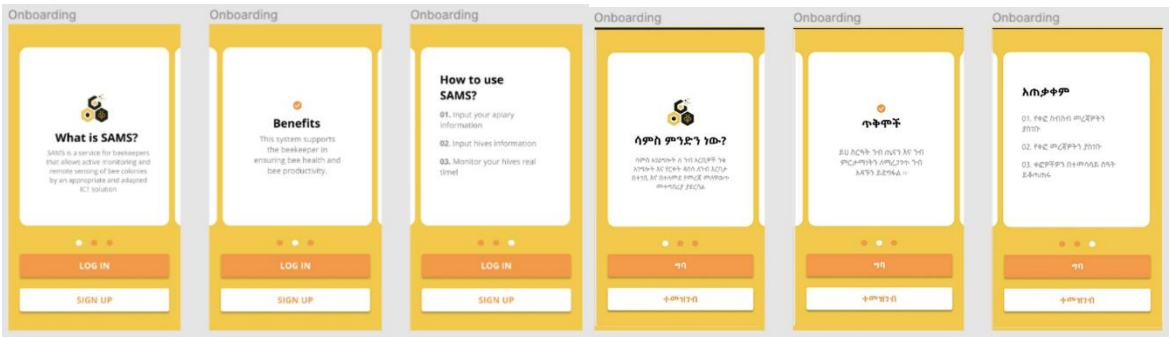



Figure 20 Onboarding and login to an account page

- Change of the UI/ UX terms to commonly known and detail expressions beekeeping terminology because the mixed standard UI/ UX terms with common beekeeping management keywords were not clear for the beekeepers.

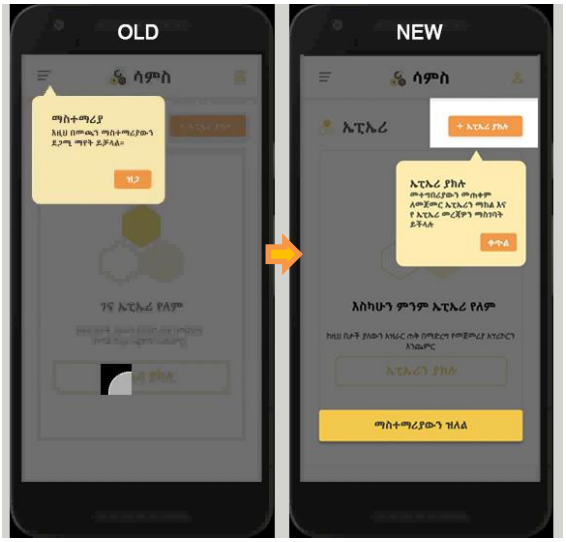



Figure 21 Change of UI/ UX terms in Amharic prototype

- Remove of the QR code function from the design because the QR code scanning function was not a familiar technique to the beekeepers and interrupts to the hive registration flow.

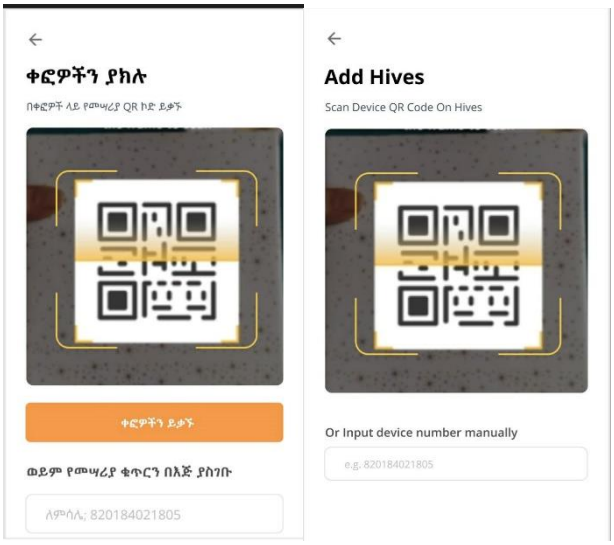



Figure 22 QR code function in Amharic and English version (was removed)

- Inclusion of hive transfer option as the beekeepers want to have hive tracking feature for hive setup locations to move hives to a different location.

### 2.10.2 Indonesia

Refinements of the Indonesian DSS SAMS data display for beekeepers according to the usability tests:

- Redesigning of the onboarding page, registration/ login to an account and its flow – it was made more simple showing the unique value proposition of the SAMS product: “SAMS helps you monitor your beehive’s weight, temperature, and humidity from your smartphone” with one button only to call for action because

- respondents have difficulties in the registration and login process in the usability test; when the testers were instructed to login, they were distracted by the slider that show basic information about SAMS;
- the testers did not intuitively understand the login and sign up button as they can press one of the buttons to start engaging with the application; after it was point out to proceed with create an account, the testers were able to access and register easily;
- they experienced further difficulties when they were requested to provide email/ phone number and password on the registration page; several testers prefer to login with phone number rather than email.

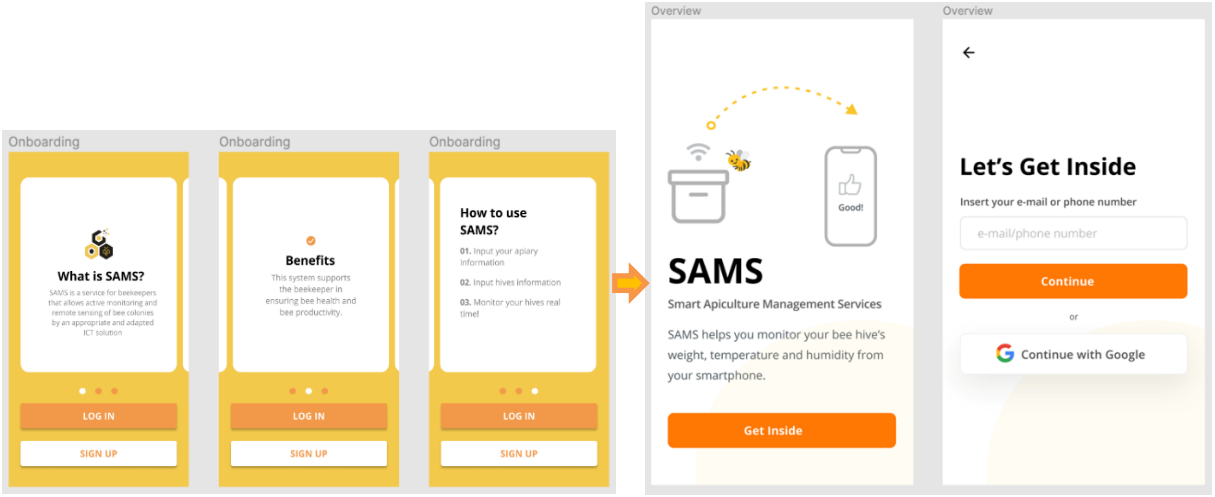



Figure 23 Onboarding page and login: first iteration and second iteration

- Redesigning of the setting up hives & apiaries section and its entire flow because there were too many steps and details that caused confusion to the testers. Thus, users' data already pre-set up when they acquire the system in the Data Warehouse. When new user wishes to get into the application, they only need verification step. Once they are verified, the next step is to manage their monitoring system in each respective location:
  - on the first iteration, when the respondents were instructed to set up apiaries and hives, most of them looked disoriented, and when asked to add the beehives, the respondents started to puzzle;
  - regardless the moderator had explained the context of barcode that will be given along with the system beforehand, confusion still occurred; respondents did not comprehend the barcode context in this "set-up" process, a lot of questions were raised to the moderator;
  - respondents also faced difficulties when filling in the information and several respondents skipped this step.

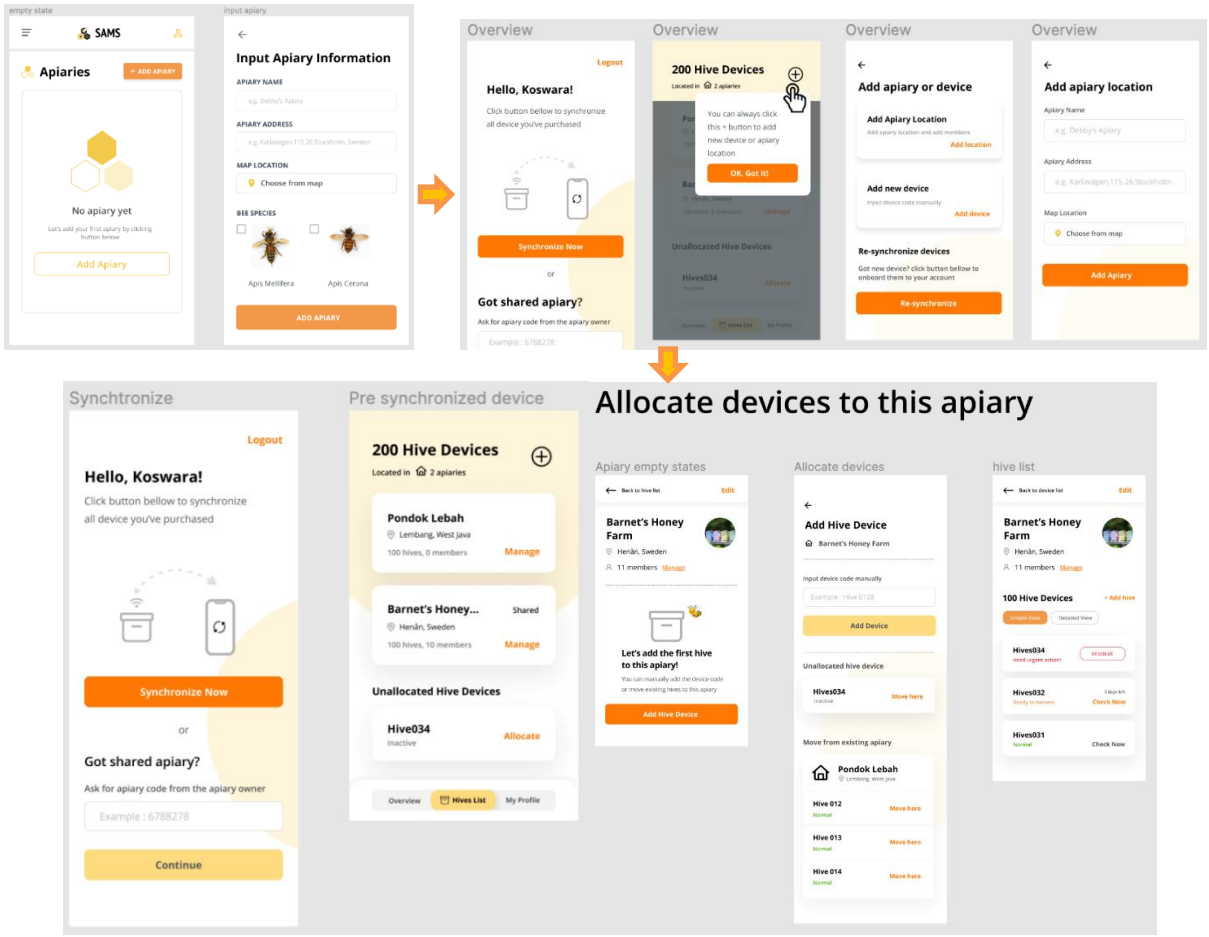



Figure 24 Final iteration for setting up hives and apiaries

- Beehive indicators showing troubles were made more prominent because
  - respondents were facing confusion identifying which apiary has troubled beehives;
  - the troubled apiary appears not obvious enough to differentiate from the entire page;
  - respondents experienced difficulties accessing highlighted apiary information;
  - respondents were found exploring the page randomly.

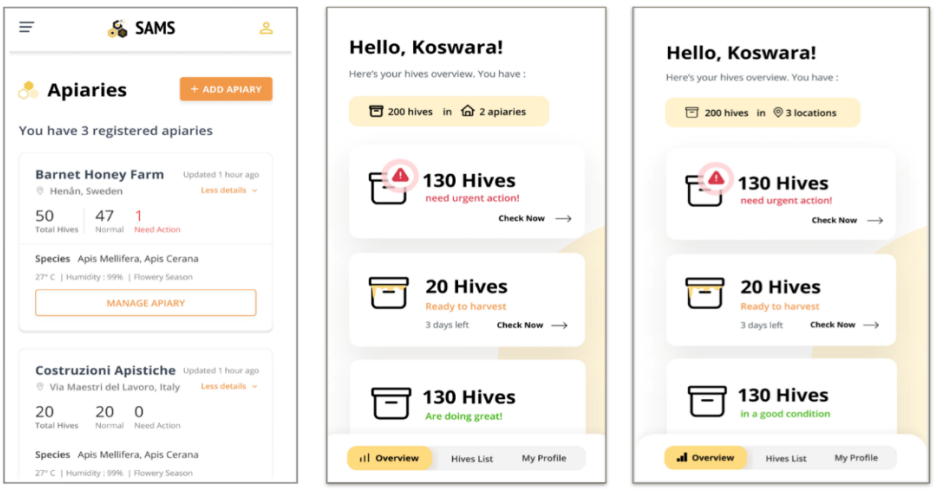



Figure 25 Three evolutions of the DSS interface indicating the troubled hives

- Creation of shared workspace and of inviting other beekeepers into shared workspace feature in apiaries because
  - several respondents were asking whether they can use the monitoring account together with their beekeeping partners;
  - many beekeepers were working collectively within a group; the sign-in/ account model for collective user might be useful.

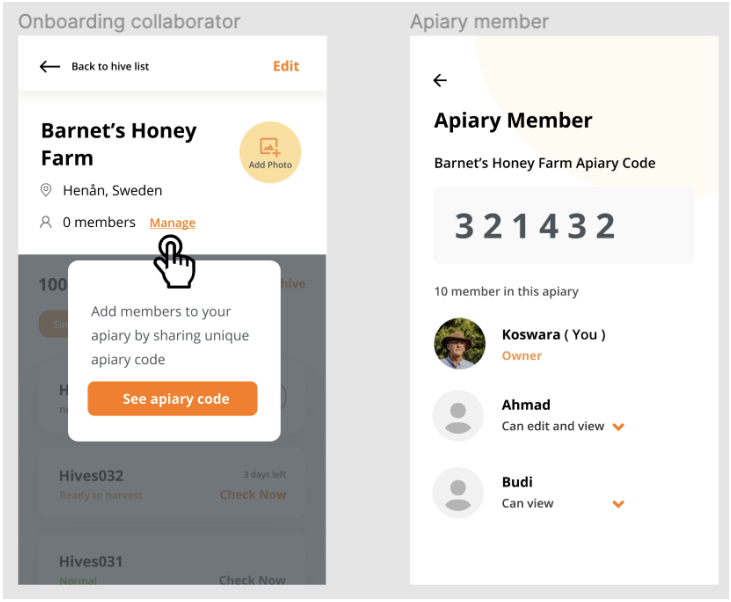



Figure 26 Final iteration of sharing workspace

The web interface of the SAMS Data Warehouse was partly adapted and updated (see also D4.3 Evaluation of Responses and Support Services) based on the UI prototype to make it more user friendly, e.g. the dashboard view is now changed to be more compatible with mobile devices (see Figure 27 on the left), similar interface elements (like buttons, list elements) are used, preview of reports can now be seen on smaller device screens (see Figure 27 on the right).

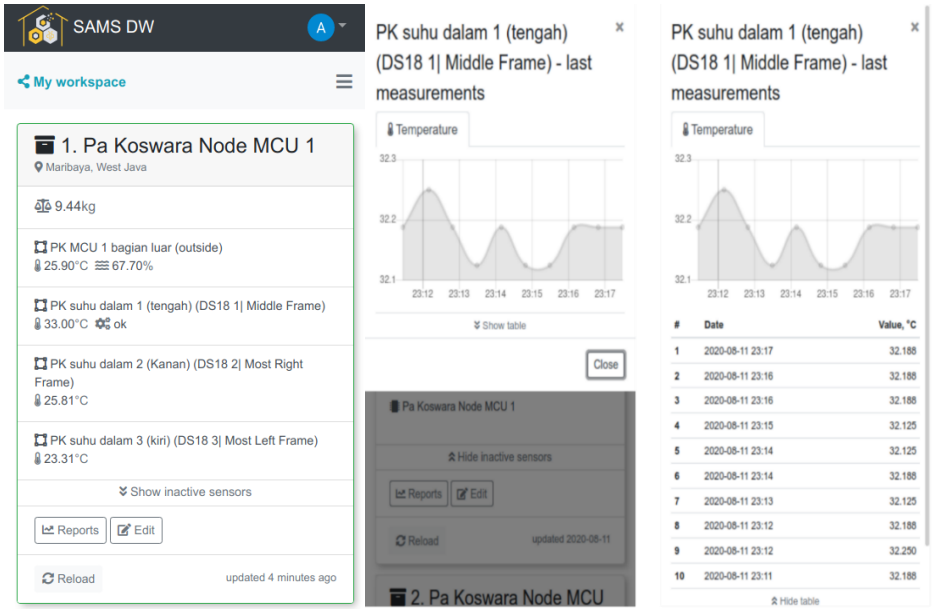



Figure 27 Example of SAMS DW mobile view and preview of reports in mobile view

## 2.11 SAMS Data Warehouse

The SAMS Data Warehouse (DW) can be considered as a universal system that deals with different data inputs, have flexible data processing algorithms and provides according output. It is the intermediate layer between data providers (monitoring systems) and data consumer systems or end-users (beekeepers) (refer to D4.1 Data Management in the Decision Support System, D4.2 Data Analysis and Interpretation in the Decision Support System, D4.3 Evaluation of Responses and Support Services).

The development of SAMS DW follows “agile-like” principles. It was continuously improved by taking into account the user needs, feedback provided by other partners and beekeepers, and ideas generated during the UCD workshop in Bandung/ Indonesia, July 2019. A manual on how to connect general bee colony monitoring hardware to the DW is available.

One of the changes/ improvements of the DW was related to the hive registration process. It was observed that some end users were confused with manual hive creating/ registration within the DW because it involved manual object (node) structuring. Since the DW is a universal system, the object definition (what parameters will be measured together with data sources) can be structured as one desire, there are no restrictions, e.g. user can decide how many sensors to put inside the hive, outside the hive, what parameters will be measured. In the DW an object is considered as node. Nodes provide flexible abstraction layer between beekeeping objects (like hives and apiaries) and monitoring infrastructure (sensors and devices) (for detailed information refer to D4.1 Data Management in the Decision Support System). Currently the DW supports (but is not limited to) following types of nodes: Group, Apiary, Hive, Hive element, Device and Other. In order to make it easier for the end user to register the beekeeping objects and monitoring infrastructure a default node structure (see Figure 28) was provided according to the measured parameters by the SAMS HIVE monitoring system. Furthermore, the user can modify this structure by her/ his needs.

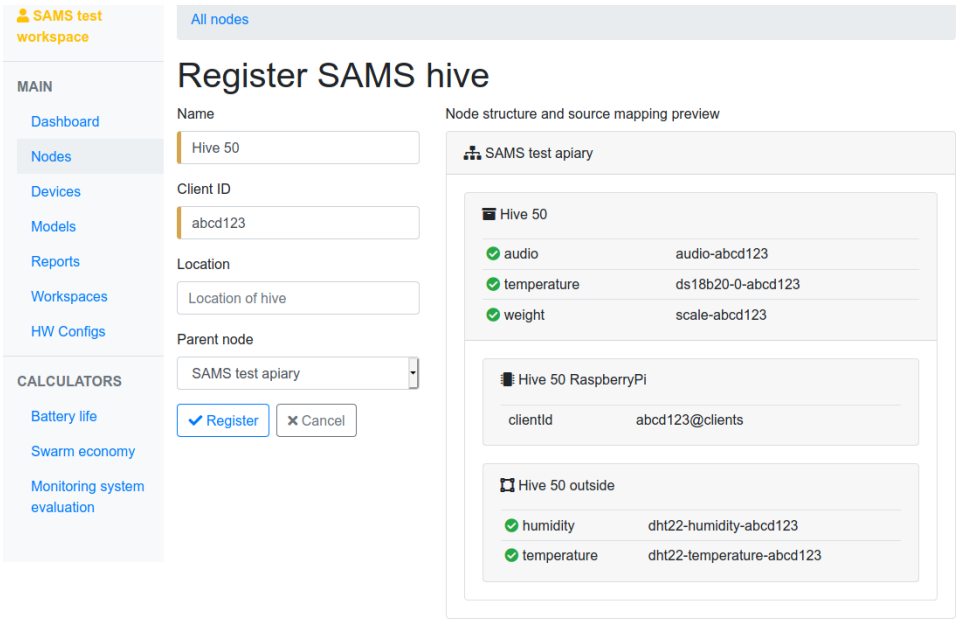



Figure 28 Example of SAMS hive registration within DW

To improve the user experience, SAMS DW dashboard was adjusted showing collected data per hive in a more convenient way.

### 2.11.1 Calculators for decision support

The SAMS DW also includes a calculators section, where the calculators can be considered as decision support systems, supporting the user in different kind of decision processes, e.g. comparing power consumption of various monitoring systems to choose the one that fits the user's needs; letting the user to consider, if it pays off to catch a swarm in certain situations; letting the user to consider various options and see the potential benefit when implementing IT systems within the user's apiary to monitor beehives. The motivation to develop such calculators was based on conclusions after regular contacts with the beekeepers and monitoring system users (including engineers who helped installing the systems). Several questions were raised by the end users (clearly highlighting their needs) like: What is the cost of such a monitoring system? What is the benefit of a monitoring system? What is the power consumption of these systems, meaning, how often the batteries should be changed/ recharged? etc.

Currently there are three calculators available that allows to:

- evaluate bee colony monitoring system's battery life;
- evaluate potential benefit and loss, when catching a bee swarm;
- economically evaluate the benefit of monitoring systems.

The calculator section of the SAMS DW is available not only for the registered users, but also to anonymous ones – it is not required to log in to the DW. The user interface of the developed battery life calculator is depicted in Figure 29.

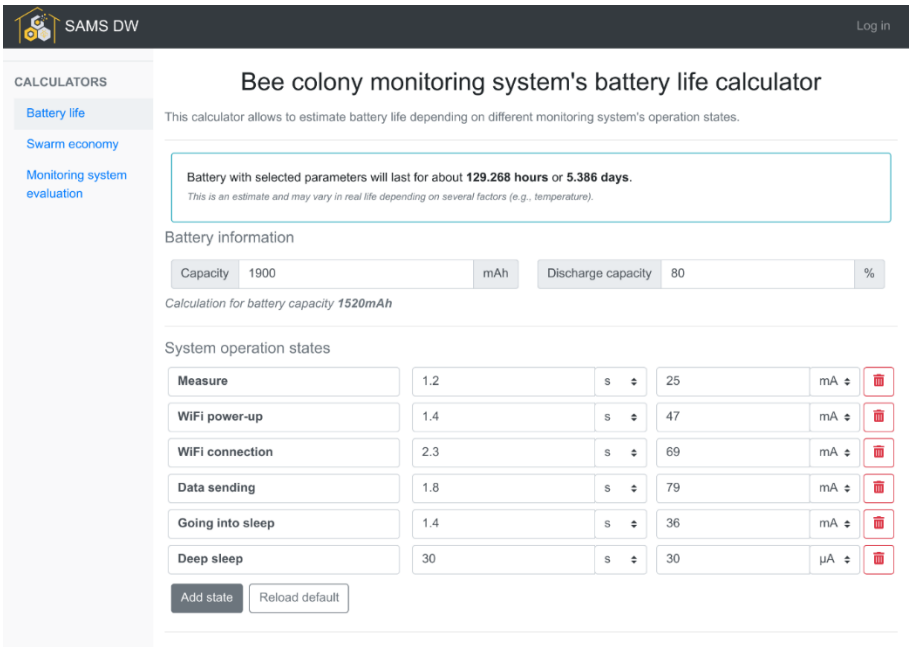



Figure 29 Developed battery life calculator

In case there is a bee colony that has swarmed, beekeeper can evaluate, if there will be a benefit for him, if the beekeeper decides to travel to the apiary to catch the swarm. Such an evaluation is provided by the developed swarm economy calculator (see Figure 30).

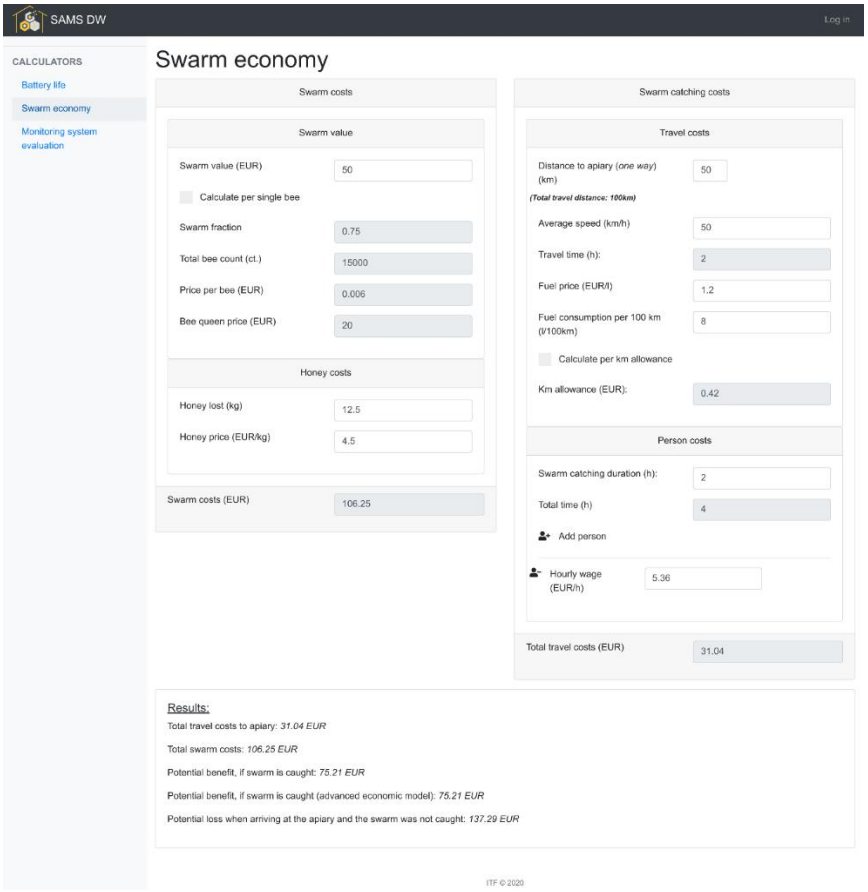



Figure 30 Developed swarm economy calculator

Since some beekeepers are still not convinced and have concerns regarding the potential benefit that a remote bee colony monitoring system can provide, it is possible for the beekeeper to evaluate the economic gain of a monitoring system implementation for real-time and remote bee colony monitoring. Such an evaluation is provided by the particular calculator within the SAMS DW (see Figure 31).

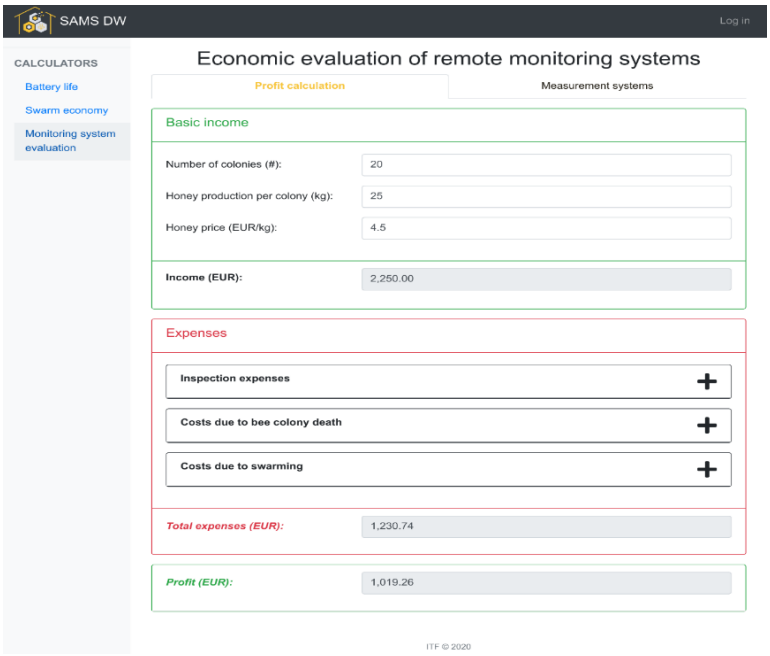



Figure 31 Developed economic evaluation calculator for remote monitoring systems

### 2.11.2 SAMS DW back-end improvements based on user feedback

SAMS DW improvements also involved the back-end or server side that is not visible by the users. Many of these changes were based on observations/ discussions made during the development and testing phase of the SAMS HIVE monitoring systems involving the partners responsible for monitoring system development and partners responsible for system implementation.

To extend the variety of devices that can connect to the DW and send bee data, changes were made to the WebApi module (provides number of HTTP interfaces for machine-to-machine interaction). By default, SAMS HIVE monitoring systems include timestamp of the measured parameters, when sending data. But since extra requests are needed to regularly update time (after the monitoring system is turned on again or if other systems are used, where the logging devices do not have or do not handle a proper date and time management (like NodeMCU that was used in monitoring systems in Indonesia)), the SAMS DW WebApi was adapted to accept data without a timestamp, but registers the time (UTC time zone) on the server side, instead. Besides that, it is possible to send multiple measurement values by indicating the time interval between them. This allowed data to be sent in a more efficient way from monitoring systems based on NodeMCU platform. An example, when sending data (temperature and weight) together with a timestamp (and without), is shown in the Annex III.

These changes also affect the data packet size that needs to be transferred, thus lesser bytes are being sent (crucial if limited mobile data plan is used).

Another functionality that was implemented within the SAMS DW based on end user feedback was workspace sharing. The principle of this functionality is to let other (known) user(s) to see and use the same workspace – access bee colony data. The sharing process itself does not require a lot of effort from the user perspective. The user, who wants to share her/ his workspace, just needs to create a sharing link (see Figure 32 and Figure 33) and send it to the interested party via any communication tool (e.g., e-mail, Slack, Skype).

This user need was expressed by beekeepers, when the monitoring systems were implemented and suggested during the DSS SAMS data display for beekeepers' usability tests. This feature is important to them because beekeepers want not only to see the hive status by themselves, but also share it with family members or other beekeepers (or beekeeper groups) (refer also to chapter 2.10). Besides, researchers were also interested in such data.

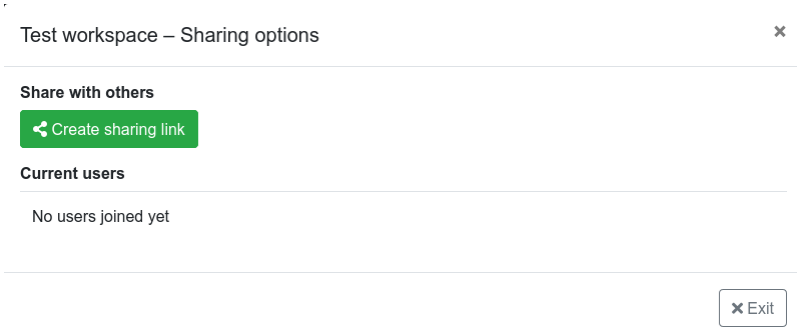



Figure 32 Creating shareable link of a specific workspace

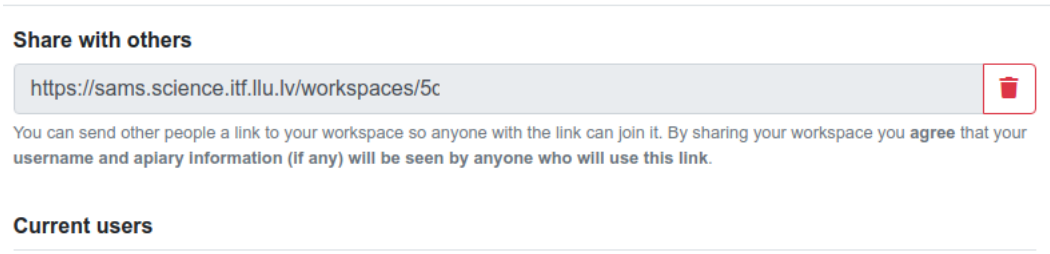



Figure 33 Workspace sharing link

A regular feedback loop between UNILV and UNIKAS, as responsible SAMS system developer, led to the implementation of another functionality – hardware configuration (HW Configs) management. In general, it is needed so there could be several hardware configurations for SAMS devices, allowing to test different configuration settings (software version, measurement intervals, enable/ disable sensors etc.). To give an example: new configuration can be assigned to one particular device (or group of devices) for testing (e.g., in lab environment or nearby apiary). Therefore, multiple configurations can be run in parallel to test their robustness on new changes. If this specific configuration passes the tests, then it can be set as a default one and provided for all devices as the new default configuration. This allows the software updates and improvements of the SAMS HIVE to be more flexible and in a controllable way and should resolve some issues the system user(s) might face and eliminates the confusion with latest stable software version (e.g. when working with different software versions, sometimes the engineers, implementing the system, were not aware of a new release of the software. When using the HW configuration files it was possible to specify the working version and enable/ disable auto update functionality). The principle of the HW configs is shown in Figure 34.

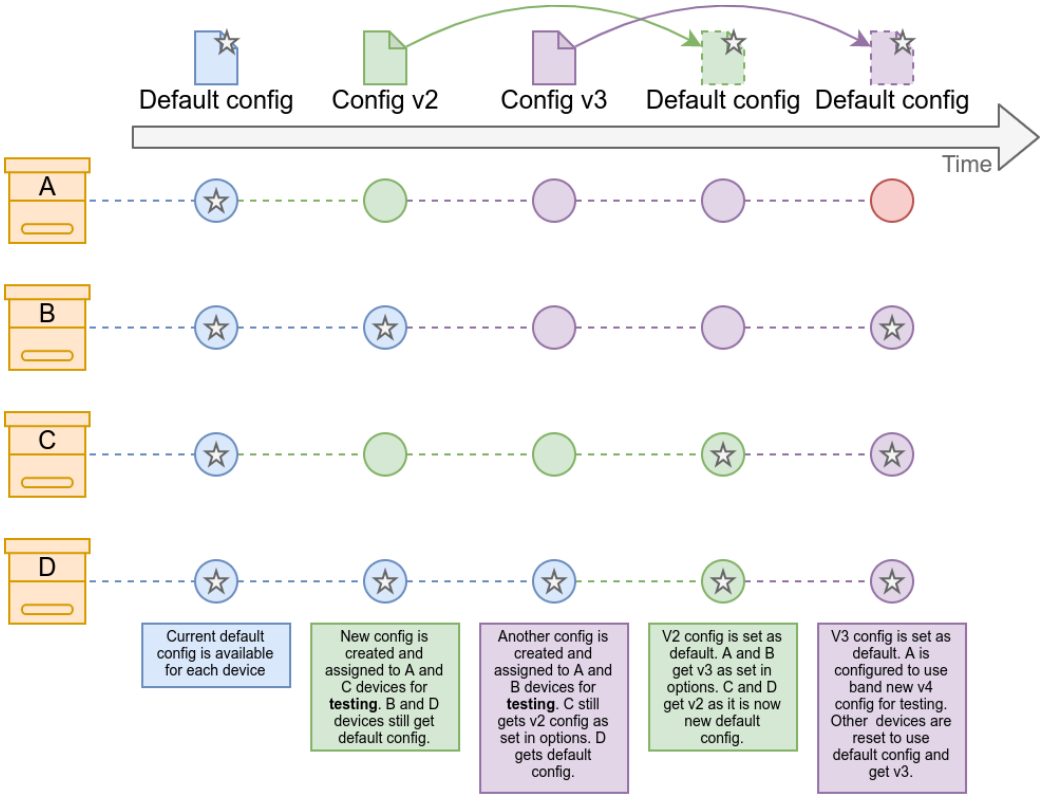



Figure 34 Principle of hardware configuration file management

### 2.11.3 SAMS DW further maintaining and sustainability

After the project end SAMS DW source code will be licensed under MIT free software license and will be hosted on GitHub (provides source code hosting and version control) and publicly available (refer to D6.3 Transfer Study on Data Utilisation and D4.3 Evaluation of Responses and Support Services). Therefore, being open source, any interested party will be able to contribute to the further development of SAMS DW by cloning the repository. This also gives the opportunity for the interested party to build and host their own DW. Graphically this process is shown in Figure 35.

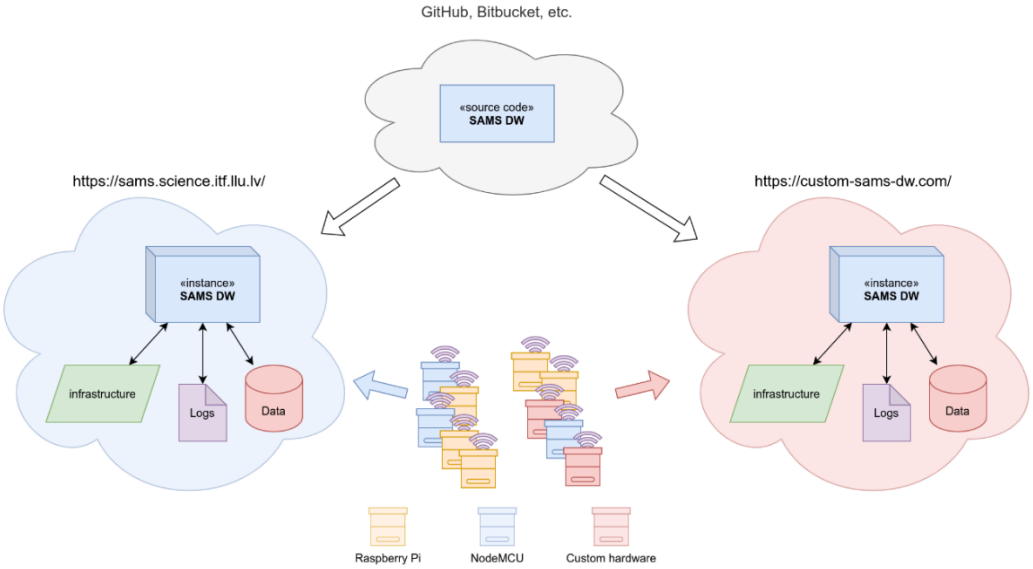



Figure 35 Example of several instances of SAMS DW

As shown in Figure 35, multiple instances of SAMS DW can be created. For example, if a beekeeper wants his/ her bee data to be processed elsewhere (locally or on different cloud server), he/ she can deploy the DW on the dedicated server, connect respective monitoring systems and maintain the whole infrastructure by himself/ herself. Instructions on how to deploy the DW will be prepared and made available for public.

Regarding further development of the SAMS DW, contributors can make improvements, add additional algorithms and methods for bee colony state detection, by committing new changes to the repository. It should be mentioned, that the new changes won't be automatically included in the SAMS DW source code, but only after the issued pull requests will be reviewed by the repository maintainers, trusted developers.

Nevertheless, the already running SAMS DW will still be kept operating after the project end and will be maintained and supported by Latvia University of Life Sciences and Technologies, Faculty of Information Technologies within the SAMS Partnership 2 (PS2 - International Partnership on Data Management and Utilization). Therefore, interested beekeepers with a monitoring system could still connect their devices to the SAMS DW.

## 2.12 SAMS partnerships

As identified during the UCD process missing networks and exchange option may hinder future beekeepers to become one. Therefore, the SAMS project has established the following three partnerships:

- PS 1: International Partnership on SAMS Business Development
- PS 2: International Partnership on Bee Colony Data and Knowledge Exchange
- PS 3: International Partnership on Apiculture Technology & Services

Besides the fact that those partnerships act as exchange and network possibility for beekeepers and relevant stakeholder, they become a knowledge hub and ensure the sustainability of the SAMS project.

# 3. UCD Lessons Learnt

Theory and practical approach often differ from each other. Thus, this chapter is dedicated to the lessons learnt of following the User Centered Design approach under real project implementation conditions – concrete in the international and interdisciplinary teamwork of the SAMS project.

## 3.1 Most important success factors for UCD in international contexts

Some important factors for following UCD in an international context got obvious during the SAMS project:

### 3.1.1 Same understanding of terms

➔ **Create the same understanding of terms, e.g. by elaborating a UCD Glossary**

Within the first project months it became obvious that the international and interdisciplinary project team do not have the same knowledge and understanding of UCD terms. Thus, a UCD Glossary with important and used UCD terminology was set-up. This served for internal use to create the same understanding of terms.

To show others the working style and the realization of the UCD approach within the SAMS project, the UCD Glossary was updated with examples and stories at the project end by GIZ, ICEADDIS, CV.PI and Labtek Indie (AB member) (see chapter 2.2).

### 3.1.2 Formation of UCD team

➔ **Form a UCD working group**

The SAMS project team consisted of seven different project partners and about ~45 project members have been working on the project. However, not all project members were involved in all processes going on in the project. Thus, a UCD working group was formed to focus more on user research. Nevertheless, due to member dropouts or relocation of work duties, the UCD team was reformed during project live time which led to the fact that each new member needed to be “onboarded” again. Saving time, making processes as efficient and successful as possible it is indicated to consider such team to be stable.

### 3.1.3 Documentation

➔ **Document your project findings and results and make them available to all by storing them online in a cloud, e.g. MS teams, SharePoint, Airtable**

**! Pay attention to the different clouds available and chose one that is easy and available for everyone (without regulations, data protection etc.)**

Over the SAMS project running time different processes were going on – research, hardware cycles, software development, business development etc. Not everyone was directly involved in all processes, and from time to time some project members changed. Thus, a proper documentation of project steps, findings and results was necessary, available for everyone – for SAMS MS teams was used since it allows document storing, application integration and collaborative work.

### 3.1.4 Collaborative writing

➔ **Write reports together in a collaborative way to consider different points of views, and use a collaborative writing tool (e.g. MS teams) for this, otherwise you will be lost in a mountain full of different versions and waste a lot of time**

**! Pay attention to the different collaborative writing tools available and chose one that is easy and available for everyone (without regulations, data protection etc.)**

As SAMS is an European Union funded project which requires regular updates on project activities towards the EU, the team had to write a number of reports. It took some time until a good tool and way of exchanging documents and working collaboratively on such documents was identified especially under different regulation aspect. Being lost in a mountain full of different versions (documents have been shared via mail for review and additions) during the first project months, a collaborative work on MS teams brought the success. This enabled the SAMS team to work simultaneously on the same reports and saved time.

### 3.1.5 Communication

➔ **Communicate very often but do not only stick to E-Mail-communication, sometimes it is faster to use other communication ways, e.g. telephone, WhatsApp, Slack, MS teams**

**! Pay attention to the different communication ways available and chose one/ the ones that are easy and available for everyone (without regulations, data protection etc.)**

Realizing that not all SAMS project partners like to communicate via E-mail and are checking mails every day, Slack communication platform was used to exchange ideas and information informally. This enabled the team to communicate fast and easy as a mobile app was also available. After MS teams was available, Slack was replaced by MS teams.

### 3.1.6 Regular virtual meetings

➔ **Organize virtual meetings regularly, on the same day and same time, using the same virtual communication tool and link, e.g. every week on Wednesday at 9**

**AM German time/ 10 AM Ethiopian and Latvian time/ 2 PM Indonesian time via MS teams**

**! Pay attention to time differences**

**! Pay attention to the different communication tools available and choose one that is easy to use, meets institutional restrictions as well as data security aspects and is available for everyone**

The SAMS project team is international and interdisciplinary with seven partners from Austria, Ethiopia, Indonesia, Germany and Latvia. To apply the UCD approach it became clear that regular meetings were required as physical meetings were no option when it comes to travel time and budgets. Instead, virtual meetings were organized and the SAMS UCD team meets every week on Wednesday at 9 AM German time/ 10 AM Ethiopian and Latvian time/ 2 PM Indonesian time using the communication tool MS teams.

Because of the time differences, e.g. Germany – Ethiopia: 1 hour (from October to March 2 hours); Germany – Indonesia: 5 hours (from October to March 6 hours), within the SAMS project the UCD meetings were scheduled in the European morning times. In the beginning Skype for Business was chosen as communication tool as this was the common tool of the coordinator (GIZ) and partners could dial in with telephone, too. However, partners sometimes had troubles to connect. After MS teams was made available for GIZ, allowing to include also externals, MS teams was used as the main communication tool.

### 3.1.7 Physical meetings

➔ **Organize physical meetings, at least once a year in the target countries**

Virtual meetings with videos, sharing screens etc. are helpful but do not totally replace face-to-face meetings. Thus, the SAMS project team had three physical meetings dedicated to UCD. The physical meetings ensured that all project members understand the UCD approach and are updated what is going on in the project regarding UCD, brought all project members to the same level, and fastened the UCD approach.

Moreover, meetings in the target countries – Ethiopia and Indonesia – gave the project team more insights in how to organize and adapt the UCD approach.

### 3.1.8 Field visits with all SAMS team members

➔ **Take the opportunity (of physical meetings) to visit beekeeping sites**

The opportunity to explore the apiaries in different countries and regions together with local beekeepers and SAMS specialists was very valuable for the project team and a very efficient way to create a mutual understanding of local context and different requirements/ framework.

## 3.2 Obstacles by implementing UCD internationally

UCD is a set of recommended process steps, it is not a detailed recipe how to cook user friendly products and it is not easy to adapt to real project conditions. Moreover, it is a long process, full of adaptions.

The SAMS project faced different organisational and methodological challenges to apply UCD in an appropriate and effective way. Internal team and organisational challenges while implementing UCD were:

- organisation over different time zones and holiday cultures;
- frequent changes of persons responsible for project tasks in almost all partner organisations;
- personal resources;
- diverse knowledge base about UCD and UX and diverse practical planning, implementation skills and workflow;
- differences in organisational culture – lateral versus hierarchical structures which resulted in time consuming redundancies and different research philosophies;
- challenge to find an agile process organization.

Besides internal team challenges even greater challenges had to be met during the actual implementation process as not each methodological approach fitted to the different local contexts, but the identification and engagement of stakeholders is relying on these approaches:

- finding beekeepers for collaboration – this took a long time, especially in Indonesia, because it is a long process of trust-building;
- challenge of selecting suitable beekeepers in ability to be implementation partners technically as well as in ability to cooperate long-term with understanding the benefit of a long-term cooperation;
- building up relationships to important stakeholders is, depending on the cultural context, a very intense aspect but prepares the ground for actual actions and receiving feedback as well as requirements;
- interviews being delayed (because of finding the right partners, trust building, long distances to beekeeping sites and long drives);
- trust building process with beekeepers itself;
- delay of hive system implementation (because of unavailability of hardware parts, long distances/ drives, corona, unforeseen context factors);
- finding the suitable way to collaborate agile;
- comparability of research and evaluation results in different regions.

Thus,

➔ **Be flexible and select UCD methods that are suitable to support your project in order to establish UCD processes**

Realizing that the UCD approach had to be adjusted several times to the SAMS project according to personal resources, country specific circumstances and discrepancy between theory and praxis in general.

➔ **Use agile development, e.g. SCRUM in a way that it is best for your project**

During the project duration the team discussed several times to use SCRUM incl. the three SCRUM roles (product owner, SCRUM master, SCRUM team). At the end it could not be realized because SCRUM was not suitable for the SAMS framework as:

- the SCRUM roles could not be figured out – will there be one product owner and SCRUM master and SCRUM team per target country or for the whole international project team?
- SCRUM requires daily meetings and sprints – not suitable due to different time zones, different working habits, etc.

In the end a SAMS appropriate iterative and agile process could be implemented for DSS interface prototyping by defining design goals, regular walkthroughs to evaluate the design followed by usability evaluations with users.

## 3.3 UCD with beekeepers in Ethiopia and Indonesia

When collaborating with Ethiopian and Indonesian beekeepers, it is good to consider several aspects.

### 3.3.1. Ethiopian Lessons Learnt

- In the UCD process one of the first challenges was to identify user groups for the Ethiopian context because most beekeepers are at early stage applying technology in their beekeeping activities.
- When creating the first personas not all necessary parameters of the user groups could be considered, as a result the personas were not expressed accurately. During later iterations in close collaboration with the international SAMS UCD team the personas were refined.
- While doing in-depth interviews, user research and documentation of the insights, the level of the users' experience with any technology was not close to the estimated experience that is expected by the research planning phase. During the user research phase, it became clear that for some individuals of the target groups (beekeepers, extension workers) it was the first time using any digital technology products. Based on that it was challenging to capture the user needs in a conclusive manner for the next UCD phases as most of the user needs identified in the research could not directly be addressed with a digital solution (e.g. financial support). Thus, in the following it was required to do continuous interviews with a small number of user groups (beekeepers and extension workers) to get to the heart of the needs and identify the most suitable ones which can be addressed by SAMS.
- As it was mentioned in the persona section, identifying the user group for SAMS technology was challenging. The user groups were first identified with site selection exercise. In Ethiopian context, it was mandatory that users (beekeepers, extension workers and bee biologists) from different regions were considered (especially when a government institution is a key partner in the project implementation). In the Ethiopian case, were 80+ languages are spoken, and different cultural aspects influence the research, subsequently it became difficult to reach those users within the original planned time frame, which led to adaptions and extensions of phases.

- Regarding the work culture there was a notable difference using digital tools in daily life. Physical interaction is always expected as a norm which makes it difficult for the UCD team to arrange satisfying digital communication experience for user groups.

### 3.3.2. Indonesian Lessons Learnt

- As most of the interviewees are senior beekeepers, more supple interviews instead of rigid interviews were done, as senior beekeepers would provide information rather through story on which information was extracted and concluded.
- The ability of directing/ manoeuvring the story to the topic and data needed to be captured is essential since the story told by senior beekeepers might disperse.
- In the process of finding beekeeper interviewees and build their trust, an approach via acquaintance link was needed.
- During the UCD process, various users were mapped out, not limited to beekeepers but also including other beekeeping stakeholders such as the government, businessmen, residents.
- The users who belong to the beekeepers' group were dominated by permanent beekeepers, who rely on forest as their bee forage sources.
- Youth interest in beekeeping is high, but not in the form of beekeeping in general. It takes a different business model approach (environmental sustainability, environmental issues, foodstuffs, etc.) thus young people can join/ participate in the apiculture sector.
- An innovative business model approach; such as the Bandung Bee Sanctuary business model (see D2.4 Evaluation of Business Plans); is an essential method for Indonesia beekeeping activities.
- Findings from these creative processes led to results that are non-linear and out of the box.

# Annexes

## Annex I: As-Is scenarios Ethiopia

Outside Inspection of Beehive:

1

Aberash

1

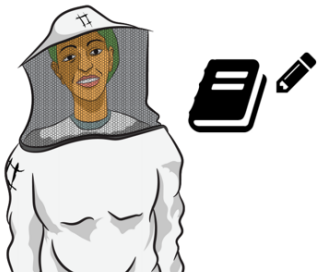
**Intention: „I want to check if my hives are in good condition.“**

Some hives are quite far away from the house. Regular inspection is needed to detect disturbances and damages from predators, theft, diseases etc.

It is also important to check on bee activity and behaviour regularly.

Today Aberash will go to a site with 20 beehives to perform the regular daylight check.

2



2

**Preparation for checking the hives during daylight**

As Aberash is not intending to open the hives, she only takes the veil hat with her to protect her in case she needs to get closer to the bees.

She also takes her report book to record her observations.

3

3

**Getting to the hives**

The hives Aberash is checking today are 10 km away from her home.

For the first 8 km to a junction she can take the minibus. She has to pay 15 Birr for the ride.

From the junction she walks another 2 km following an unpaved path until she reaches the hives.

4

4

**Checking the hives**

After arrival at the hive site, Aberash performs a regular external hive inspection ritual:

- First she checks the beehives surroundings if there is any sign of damage or theft, for example by larger animals or humans.

For each hive:
- She checks, if the normal flying in/out of the colony can be categorised as high, medium or low forager
- She investigates the type of food source being brought to the hive by the honeybees
- She records, if the bees are accumulated on the hive entrance, which can be due to swarm preparation, ants or other enemies attack, and ripening of honey
- She looks for dead bees (extra ordinary number of dead bees) found on the entrance of the hive because this can indicate starvation or poisonous by different chemicals
- She records the observations for each hive by the hive ID in her record book

5

5

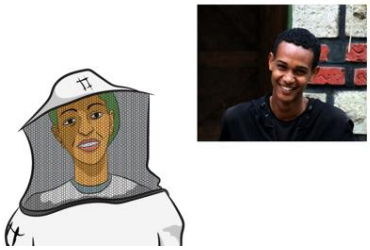
**Analysing the Observations**

As soon as she sits in the bus home Aberash analyses her observations and decides, if she has to schedule one or more hives on the site for an insight inspection tomorrow night.

Inside Inspection of Beehive:

1

Aberash & Abel



1

**Intention: „I have to inspect 8 of my 20 beehives because I fond unusual amount of dead bees on the entrance“**

Inside inspection requires a lot more equipment and work compared to the outside inspection.
To help with everything she decides to take her eldest son Abel with her.

2

2

**Preparation for inspecting the hives inside at night**

For inside inspection the beehives, Aberash needs full body protective clothing with gloves and also following tools:

- Smoker
- Lighter
- Knife
- Chisel
- Log book

3

3

**Getting to the hives**

The earliest time Aberash can start the inside inspection of the beehives only after sun set at 7:30 pm.

At 7 pm Aberash and Abel take the minibus for the first 8 km and walk for another 2 km to reach the beehives.

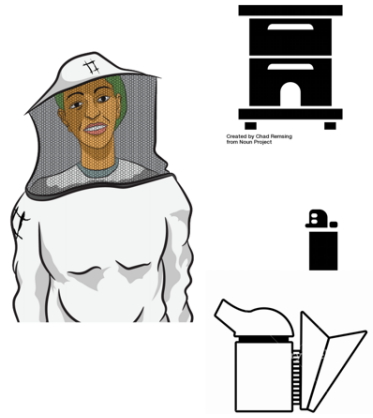
4

4

**Prepare for the inspection**

After arrival at the hive site, Aberash and Abel get ready for inspection of the beehives by dressing in the protective clothing.

5



5

**Prepare the hives for opening**

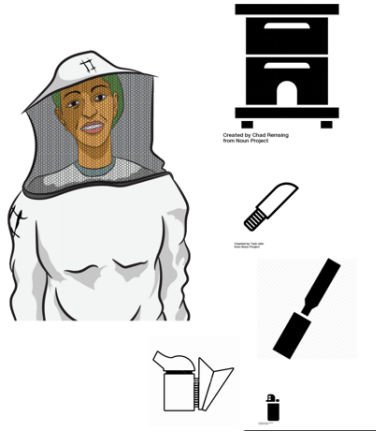
To minimise the danger of stings, Aberash and Abel will always approach the hive from the side or from the back. They will not approach from the line of flight of the bees to the hive entrance.

Abel uses the lighter to start the smoker. In order to suppress (calm down) the bees, smoke of good quality must be puffed into the entrance. A few good puffs of smoke create communication barriers in the guard bees and this in turn disorganizes the defence system of the hive.

Using smoke also prompt the bees to gorge themselves with honey and in this satiated condition they are less likely to sting.

Aberash waits one or two minutes for the smoke to penetrate to the corners of the hive to ensure that the disorganization of the colony is complete, before she opens the hive.

6



6

**Open the hive**

- The first step to open the hive is to remove the outer cover and the inner cover underneath which when in position still effectively seals the hive.
- The bees with propolis, a sticky resin material, usually seal these type of covers. To break the propolis seal and to open the hive, Aberash forces the hive tool into the line of the union between the lid (inner cover) and the adjacent hive body and at the cover.
- As the lid is first raised Abel forces a few puffs of smoke into this opening. In the case of well-sealed lids it may be necessary to pry (force open) each of the corners in turn before the lid can be removed without damaging it.
- After removing the outer cover, Aberash puts it up site down alongside the hive to serve a convenient rest on which to place hive bodies. These hive bodies must be placed across the unturned cover so that as few bees as possible are squashed. The inner cover and most other types of covers other than the telescopic type have to be levered up to get them off.

7

7

**Inspecting the hive (30 min / hive)**

- **The presence of the queen:** the queen is mostly found around the warm brood, nearer to the egg laid, moreover, she could be recognized by the fresh eggs and newly hatched out larvae
- **Brood pattern:** if the brood pattern is dense (combs are filled with eggs) the queen is said to be young, good, prolific or vigorous. On the other hand, if spotty brood pattern, many drones egg etc. are observed, the queen is said to be non vigorous and the brood is said poor pattern
- **Swarm preparation:** when bees form several /numerous peanut shaped wax cells which contain immature queen and the hive is quite populous, it indicates swarm preparation.
- **Starvation:** when there is no stored food (pollen and nectar) the colony is in need of supplementary food.
- **Health condition:** it is important to observe the presence of any pests and diseases of bees in the hive (such as wax moth, ants, lizards and disease symptoms).
- **Ripening of honey:** honey is said to be ripened when at least ¾ or the comb mass is sealed (capped) with a newly secreted bees wax

**Actions**

- **Provide enough space in the hive:** during opening, if the beehive is full with bees and combs, and if the upcoming seasons are also expecting more flowers, the colonies might give swarm. Various measures should be undertaken,
- **Optimize the arrangement of frames containing honey, pollen and brood.** Frames of brood should be placed together in one area (at the middle) of the nest to optimise the proper brood temperature. The honey will naturally be stored in the upper portion of the combs or the brood comb if placed between pollen and brood it cold prevent the queen from expanding the brood in nest

8

8

**Closing the hive**

Finally the hive must be closed. Abel uses occasional puff of smoke to control the bees. Aberash carefully replaces the frames and covers them in their respective places in the hive.

She makes sure that during this operation the queen is not injured and the bees are not squashed.

9

9

**Getting home at night**

Minibusses only run until 9 pm. Therefore Abel asks his friend to pick them up at the junction with his private car.

In case Aberash and Abel do not find a transportation, they have to walk home the 10 km at night time with all their equipment.

10

10

**Analysing the Observations**

Next morning Aberash sits down with her report book and analyses the inspection results.

Based on the results she decides about the follow-up actions. These could be health treatments, swarm protection measures but also a decision about fixing a time for honey harvest.

Continue with harvesting

Harvesting:

1

Tadesse

1

**Intention: „I want to harvest 2 of my 10 beehives because it is the time of the year to harvest honey“**

Harvesting requires to wear full body cover protective clothes, and to have equipments to open the hive; in a modern hive use a case, a honey extractor is also needed.

To make sure everything he does is correct he booked in advance Asnake, the local extension worker to help him on the task.

The weather is dry, and rain is not expected this evening. It is a good day for the harvest.

2

2

**Preparation for harvesting the hives at night**

For harvesting the beehives, Tadesse needs full body protective clothing with gloves and also following tools.

- smoker
- lighter
- klife
- chisel
- big jar
- honey extractor
- Light bulb

Care in hygiene should be taken to prevent any form of contamination while processing honey. Therefore, Tadesse takes into account this general requirement in all the steps.

The honey extractor needs to be clean as well as the space where the honey supers or combs are stored prior to processing. If processed outside, processing should not be done during a windy or rainy day.

Tadesse cleans all surfaces, hands and containers coming into contact with the honey.

3

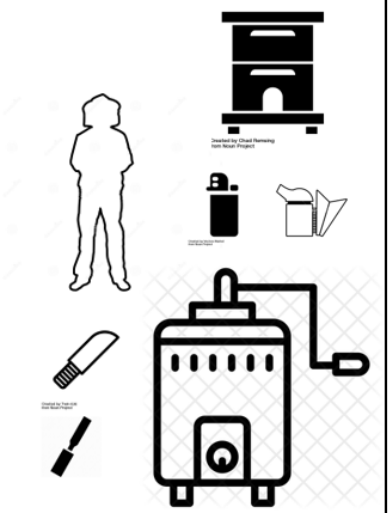
3

**Getting to the hives**

The earliest time Tadesse can start the harvesting is only after the sun set at 7:30 pm.

At 7 pm Asnake arrives at Tadesse's house and together they walk for 10 minutes to get where the hives are located on Tadesse's farm field.

4

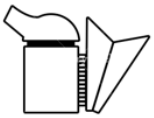


4

**Preparing for the harvest**

After the arrival at the hive site, Tadesse and Asnake get ready to harvest the beehives by dressing the protective clothing and setting up their equipment.

5



5

**Prepare the hive for opening**

To minimize the danger of stings, Tadesse and Asnake will always approach the hive from the side or from the back. They will not approach from the line of flight of the bees to the hive entrance.

Asnake uses the lighter to start the smoker. In order to suppress (calm down) the bees, smoke of good quality must be puffed into the entrance. A few good puffs of smoke create communication barriers in the guard bees and this in turn disorganizes the defence system of the hive.

Using smoke also prompt the bees to gorge themselves with honey and in this satiated condition they are less likely to sting.

Tadesse waits one or two minutes for the smoke to penetrate to the corners of the hive to ensure that the disorganization of the colony is completed, before he opens the hive.

**In the further process Asnake will use the smoker as little as possible to prevent the honey from adapting the flavour of the smoke.**

6

6

**Opening the hive**

- The first step to open the hive is to remove the outer cover and the inner cover underneath which, when in position, still effectively seals the hive.
- The bees usually seal these type of covers with propolis, a sticky resin material. To break the propolis seal and to open the hive, Tadesse forces the hive tool into the line of the union between the lid (inner cover) and the adjacent hive body and at the cover.
- In the case of well-sealed lids it may be necessary to pry (force open) each of the corners in turn before the lid can be removed without damaging it.
- After removing the outer cover, Tadesse puts it up site down alongside the hive to serve a convenient rest on which to place hive bodies. These hive bodies must be placed across the unturned cover so that as few bees as possible are squashed. The inner cover and most other types of covers other than the telescopic type have to be levered up to get them off.
- When the inner cover removed, the colony is exposed from the top.

7

7

**Harvesting the hive (60 min per hive)**

Tadesse removes the frames with honey combs.

His first actual step of harvesting then is uncapping, it is the removal of the thin wax layer that seals the honey cells. Tadesse slices the wax caps off with a sharp, thin, long knife.

The next very important step is the comb selection. Tadesse eliminates pieces of comb with pollen or even brood.

Tadesse gives Asnake the frames to do the honey extraction and continues to retrieve the frames.

Asnake extracts the honey with the manually extractor they brought and brings back the empty frames. Asnake is careful to keep the extractor close during extraction to prevent losses of flavour.

8

8

**Reassembling and Closing the hive**

After all frames are extracted Tadesse and Asnake reassemble the hive and close it. Asnake uses occasional puff of smoke to control the bees. Tadesse carefully replaces the frames and covers them in their respective places in the hive.

He makes sure that during this operation the queen is not injured and the bees are not squashed.

9

9

**Getting home at night**

Tadesse and Asnake pack all equipment and the bucket with 15 kg of honey they have harvested and carry everything to the home of Tadesse.

10

10

**Processing and selling the honey**

At home Tadesse's wife will transfer the honey into smaller jars.

On the next day Asnake, the extension worker, will inform his network of buyers how much honey is available from Tadesse and buyers will contact Tadesse directly by phone call to make their offers.

## Annex II: As-Is scenarios Indonesia

Outside and Inside Inspection of Apis Cerana Beehives and Honey Harvesting:

**1**

GIUSEPPE

**1**

**Intention: "I need to check my hives"**

Giuseppe needs to inspect his hives once every 1 or 2 weeks, because that is how his predecessors did before him in beekeeping and tell him on how it should be done.

Regular inspection is needed to detect disturbances and damages from predators, pests, theft and diseases.

It is also important to check on bee activity, behavior, and their productivity level on honey making, eggs and larvae quantity.

Today Giuseppe goes to check each of his 25 hives - who knows, some honey is probably ready to be harvested.

**2**

**2**

**Preparing for checking the hives**

His predecessors told him that every time he inspects his hives, it is expected to check not only the bee health and activities, but also if honey is ready to be harvested.

Then he collects his tools, they are:
- cigarette
- machete
- small knife
- net veil
- match sticks / lighters
- empty beehive
- mineral water
- lunch
- plastic jar/container for honey

**3**

**3**

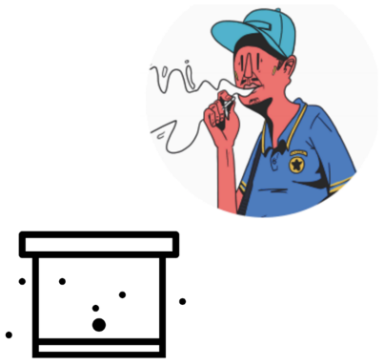
**Going to the hive**

Giuseppe lives in the mountain area, near the forest. The hives are located more or less 1 km from his house, further into the forest area.

Every time he is operating hives' inspection, he carries all the tools he already collected and walks to the hives location.

One hive to another is within 5-10 meter.

4



4

**Checking/Observing bees & hives condition/activities**

When he arrives, he quickly checks if his hives are all there, if there is any hive missing, or taken by theft. Then he looks at the hives and is observing the bee's activities outside and around the hives.

Is the colony still active in and out the hive, are the colony bringing some pollen, etc.

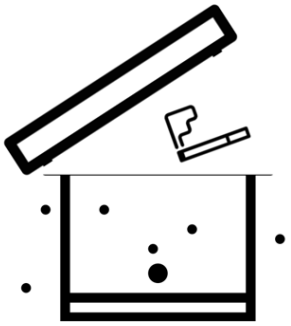
5

5

**Opening the hive**

Not long after he observes the hive from the outside, he puts his beekeeping tools beside him on the ground and starts to open the beehive.

6



6

**Smoke the hive**

Then he smokes the open hive with his lighted cigarette. He does this to make the bees less aggressive.

7

7

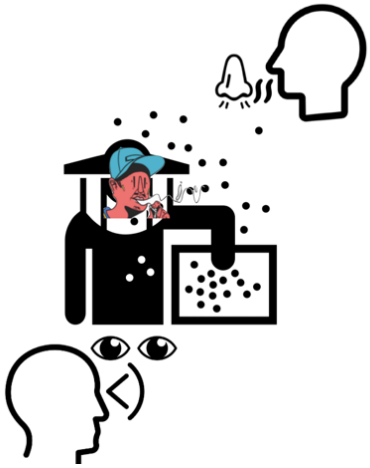
**Separate each of the brood-frame**

He is then wiggling the brood frame carefully to separate one from each other.

Sometimes he needs to use a knife to cut the propolis that make each of the brood frames stick together.

Then he looks through and inspects every brood frame inside the hive.

8



8

**Observing each of the brood frame**

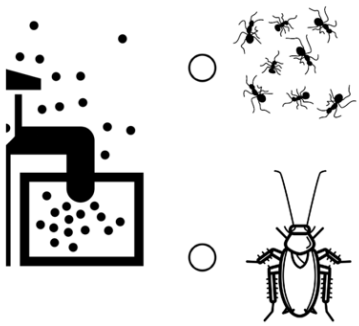
As he pulls each of the frames, he inspects the honey comb carefully with his bare eyes.

He identifies eggs, larvae, and mites (rarely) with his eyes, and senses the readiness of the honey with his nose by smelling them.

He relies so much in his sight and smell.

There are 3 standard procedures for checking:
1. Check for the pest
2. Check for the larvae and the eggs of drone bees and queen bees
3. Check for the honey

9



9

**Observing bottom of the hives for pests**

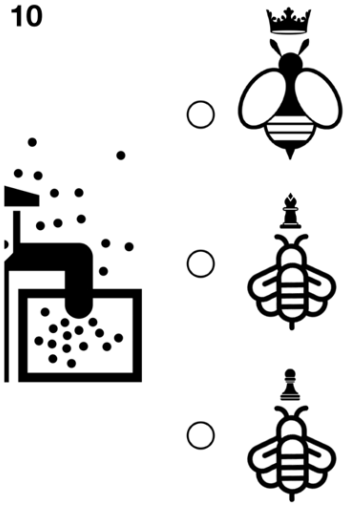
If Giuseppe notice there are colonies of ants coming in and out of the hive he will check the hive's bottom quickly.

He then checks:
1. are there colonies of ants present.
2. if there are other pests present, for example cockroaches, geckos, etc.
3. if the combs still containing honey, or not

If the bees are already gone,

continue to **Cleaning the Empty Hive**

10



**10**

**Observing the brood frame for bee larvae, eggs: queen, drone, and worker**

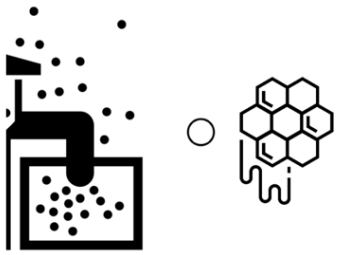
If there is no pest inside the hives, Giuseppe takes out each of every brood frames to check the presence of larvae, bee's eggs, drone bees, and queen bee.

There shouldn't be many eggs of queen bees. If there are too much queen bee's eggs, it will increase the probability of bees swarming led by a new queen.

And there shouldn't be many drone bees either because they will eat too much honey.

Then Giuseppe also checks the presence of the queen bee to make sure the colony will stay.

11



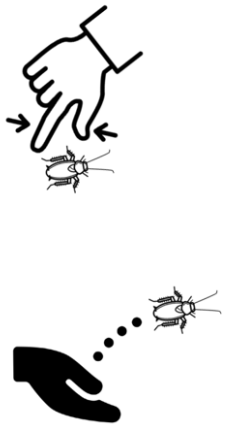
**11**

**Observing the brood frame for honey harvesting**

After every larvae, eggs, and bees are checked, he checks the availability of the honey.

He has already detected the honey by smelling them (step number 8), now he affirms this.

12



**12**

**Pick the pests with hand & removed it**

Pests are one of many main threats to the beehive, there are various types of pests Giuseppe can find inside the beehives; ants, spiders, wasps, and cockroaches. Even though he's diligently check their bee colonies, and managed to put some prevention beforehand (such as smearing oil on to the beehive foundation) but spiders and cockroaches always finds its way to go inside the beehives.

Giuseppe sure that the spiders are using its web to swing inside, looking for a bee larvae for an afternoon snack. Where as the wasps are flying through the entrance and coming inside, they are interested with the honey and eager to steal whenever the colonies are remiss. While the cockroaches are flying and coming through the entrance of the beehive, also seeking the honey, and most of the times whenever they feel enough, the cockroaches are leaving the beehives with its stinky smells of its urines.

So if Giuseppe find a cockroach inside the hive, he will take it with his bare hand, terminate it, and throwing it out of the hive.

13

13

**Terminate drone bee & queen bee's eggs if there are too many**

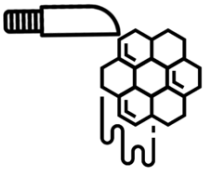
Giuseppe understand that one colony of beehives can only lead by one regime of queen bees, accompanied by several drone bees that are ready to mate with the queen bees.

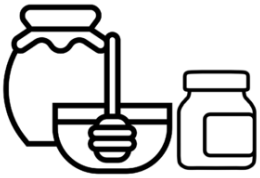
So whenever he sees there is too much queen bee's eggs on one colony, and too many drone bees are born, he will terminates it.

If there are more than one queen bees, and too much drone bees, it will lead to disharmony of the existing colony, since a new-born queenbee might be much stronger and healthier from the existing queen bees. She might lead nearly half of the colony for a rebellion.

Using only thumb and index fingers, Giuseppe directly crushed those bees.

14





14

**Cut the comb full of honey**

Giuseppe once again take out his knife to cut the top structure of a comb, part of the comb where the honey is existed.

Giuseppe's left hand grab the wooden part of comb and his right hand grab the knife, pointing the corner of the honeycomb and slice it horizontally, leave almost a half of the comb. It doesn't take much time, since he knows he only need to cut the above one, where honey are presence, while the below part is for the bee's eggs and larvae. A wired separated those parts, so the lower comb attached to the wire can hold on to the brood frame.

A slice comb full of honey are ready, smells good and thick. He placed a new harvested honey combs inside the plastic container or a plastic jar.

15

15

**Put back the brood frame and arrange the space between brood frames**

Giuseppe then put the brood frame back to the hives and arrange the space between each frame.

16

16

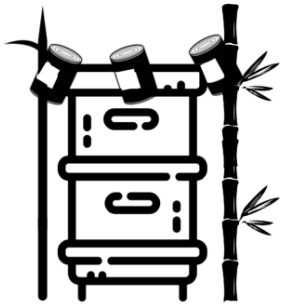
**Close the hive / Putting rock / something heavy on top of the hives**

After the brood-frame are all inside the hive, Giuseppe make sure that no bees are hanging out above the brood frame. If there is some, he will shoo those bees, ask them to move aside, thus he can close the hive safely.

to make sure the beehives won't be blown by the wind, he put some weigh on top of the beehive cover like stone or other heavy things.

Then it's time to say goodbye to the bees, checking procedure are finished; the colonies are safe and healthy, and the he get some honey.

17



17

**Put sound alarm, many ally prevent Chivet**

At the final step, Giuseppe has to make sure that his beehives are safe, considering that his beehives are located deep in the forests, home for various mammal species that might be do harm for the bees, for example civet might be one of them.

Similar to us, civet also loves honey, but it seems that civet get the honey with the way that beekeepers doesn't like; most of the time, civet steals the honey and disrupting the colonies. Giuseppe wouldn't like his beehives being damaged.

Giuseppe try to outsmart the civet by putting four wired spikes around the beehive. Along with the wired-spikes, he hang some of empty cans, so whenever the wire are move, noisy sounds will come out. Assuming that the civet will be afraid and feels threatened by the sounds.

By experienced he now knows that the analogue sounds alarm are worked, civet won't do any harm anymore to the beehive.

Outside and Inside inspection after absconding:

**1**

GIUSEPPE

**1**

**Intention: "I need to check my hives"**

Giuseppe needs to inspect his hives once every 1 or 2 weeks, because that is how his predecessors did before him in beekeeping and tell him on how it should be done.

Regular inspection is needed to detect disturbances and damages from predators, pests, theft and diseases.

It is also important to check on bee activity, behavior, and their productivity level on honey making, eggs and larvae quantity.

Today Giuseppe goes to check each of his 25 hives - who knows, some honey is probably ready to be harvested.

**2**

**2**

**Preparing for checking the hives**

His predecessors told him that every time he inspects his hives, it is expected to check not only the bee health and activities, but also if honey is ready to be harvested.

Then he collects his tools, they are:
- cigarette
- machete
- small knife
- net veil
- match sticks / lighters
- empty beehive
- mineral water
- lunch
- plastic jar/container for honey

**3**

**3**

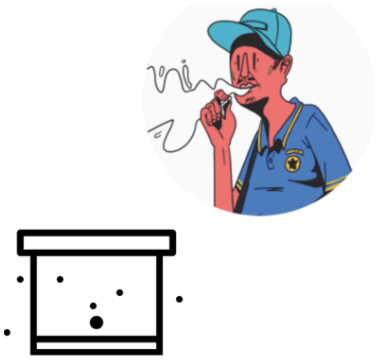
**Going to the hive**

Giuseppe lives in the mountain area, near the forest. The hives are located more or less 1 km from his house, further into the forest area.

Every time he is operating hives' inspection, he carries all the tools he already collected and walks to the hives location.

One hive to another is within 5-10 meter.

4



4

**Checking/Observing bees & hives condition/activities**

When he arrives, he quickly checks if his hives are all there, if there is any hive missing, or taken by theft. Then he looks at the hives and is observing the bee's activities outside and around the hives.

Is the colony still active in and out the hive, are the colony bringing some pollen, etc.

5

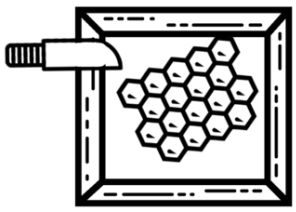
5

**Opening the hive**

Usually when he found colonies of ants huddling one the beehive, he has this instant instinct that the bee colony might already swarmed.

By then he will puts his beekeeping tools beside him on the ground and starts to open the beehive.

6



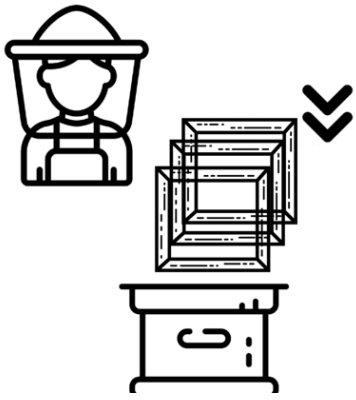
6

**If the bees are gone, then the comb are cut to clean the hives**

Giuseppe instinct was right, the bee colony already swarmed. He then now take out his knife to cut the empty, dry, and pale comb from the brood frames.

Even though Giuseppe is heartbroken seeing one of his bee colony gone, this circumstance are somehow familiar for him. Luckily, his sadness doesn't linger much, so he move on and managed to cut those dry and pale comb entirely, cleaning the whole brood frame to only leave its wooden part.

7

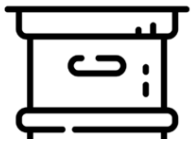


7

**Put back the brood frame and arrange the space between brood frames**

He then put those wooden part of the brood frame to the beehive, arrange it neatly, giving some spaces on one another, making sure it is clean and ready to welcoming upcoming bee colonies.

8



8

**Close the hive**

Giuseppe then close the beehive and continue to inspect on another beehives of him.

**Annex III: Example for SAMS DW back-end improvements based on user feedback: when sending data (temperature and weight) together with a timestamp**

```
[
    {
        "sourceId": "ds18b20-0-deviceX",
        "values": [
            {
                "ts": "2020-01-10T10:15:00+02:00",
                "value": 25.2
            },
            {
                "ts": "2020-01-10T10:16:00+02:00",
                "value": 25.3
            }
        ]
    },
    {
        "sourceId": "scale-deviceX",
        "values": [
            {
                "ts": "2020-01-10T10:15:00+02:00",
                "value": 27.58
            },
            {
                "ts": "2020-01-10T10:16:00+02:00",
                "value": 27.92
            }
        ]
    }
]
```

The same example without a timestamp, but a 60 second interval between measurements:

```
[
    {
        "sourceId": "ds18b20-0-deviceX",
        "tint":60,
        "values": [
            {
                "value": 25.2
            },
            {
                "value": 25.3
            }
        ]
    },
    {
        "sourceId": "scale-deviceX",
        "tint":60,
        "values": [
            {
                "value": 27.58
            },
            {
                "value": 27.92
            }
        ]
    }
]
```

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