EIP-AGRI Focus Group

Bee health and sustainable beekeeping

FINAL REPORT

May 2020

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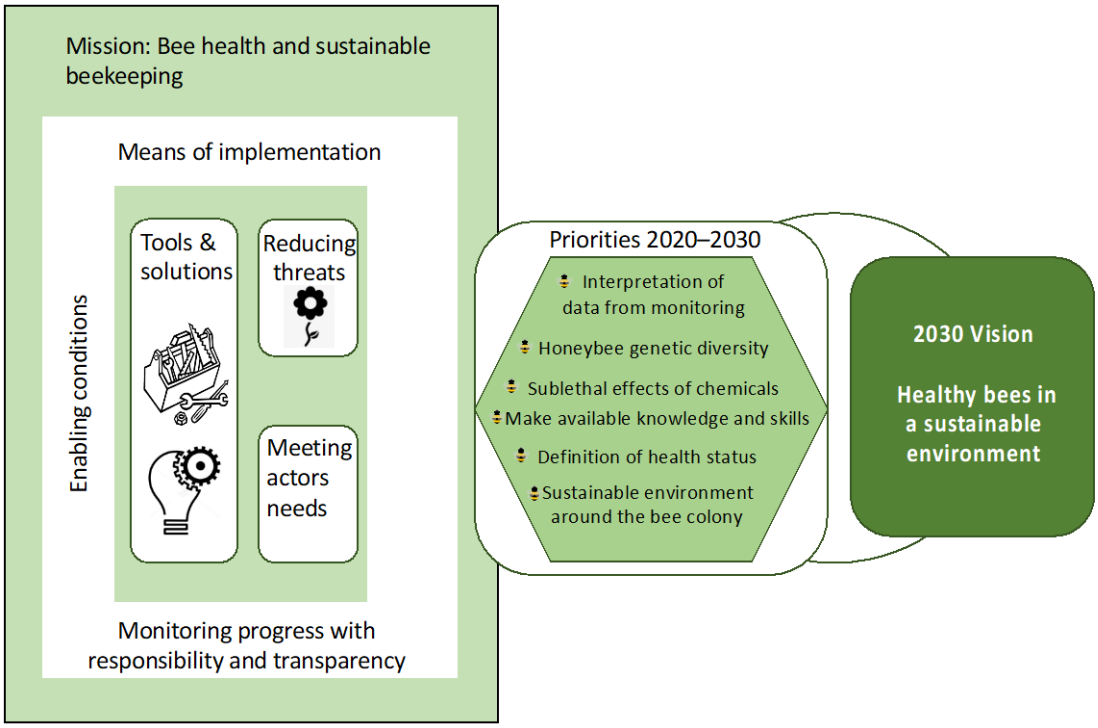
Executive summary

During 2019 the focus group on honeybee health and sustainable beekeeping has explored and compiled the state of play for different key factors important to honeybee health. The group of experts discussed the main drivers for change from today's situation to a sustainable future to answer the overarching question: **How to ensure the sustainability of beekeeping in the face of challenges linked to pests and diseases, intensification of agriculture and climate change?**

A framework that recognizes the transformative actions that are required to put in place tools and solutions for healthy honeybees in a sustainable environment: implementation and mainstreaming of the listed priorities, reducing the threats to honeybee health and to meet the needs of actors involved. These actions are supported by enabling conditions and means of implementation including financial resources, capacity and technology.



Key factors to keep healthy bee colonies identified by the focus group (Priorities):

- Make available knowledge and skills (research and practice)
- Definition of the health status of the honeybees
- Sustainable environment around the honeybee colony
- Interpretation of data from monitoring, precision beekeeping (PB)
- The honeybee genetic diversity
- Sub lethal effects of chemicals in an environment of multiple stressors

Ways forward (solutions to the problems)

To address the key factors mentioned above, the Focus Group recommended to:

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- Create a European platform better connecting research and practice
- Develop a kind of license for beekeepers, a pan European standard
- Develop and implement a "Health status index" as a practical application
- Develop and evaluate technical methods for controlling of varroa for sustainable beekeeping (e.g. trapping of mites in worker or drone brood, queen caging and artificial swarms)
- Assess the exposure to stressors from agriculture in combination with resource quality
- Identify, implement and communicate mitigation practices among beekeepers and farmers
- Managing complexity through collaboration among relevant stakeholders
- Mapping for sustainability, the landscape situation around the apiary (make available monitoring results in maps)
- Communicate the importance of genetic diversity for sustainable beekeeping

1. Introduction

Defining if a honeybee colony is in good health or not is not easy, however the following four points by Vidal-Naquet (2015) may provide a good indication:

- There are no clinical signs of disease
- The brood/adult ratio is in line with the expected development of the colony and the time of the year (there must be enough workers to rear brood)
- There is foraging activity and production of honey and bee bread
- The total quantity of pollen and honey stored surrounding the brood is estimated to match the need of the colony.

Therefore, it is not only the diseases, pests and predators that affects the honeybee health. The beekeeping practice and the environment in and around the apiary have big impact on how the colony will develop, how strong it will be and how much honey and pollen will be produced and stored.

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Figure 1 Honeybee health is an issue dependent of, not only the beekeeper but also the environmental situation in the forage area. It is a multi-actor interaction at landscape level.

The EIP-AGRI Focus Group (FG) on Bee health and sustainable beekeeping was established in spring 2019 to identify, structure and develop main replies to the main question: *How can we ensure the sustainability of beekeeping in the face of challenges linked to pests and diseases, intensification of agriculture and climate change?*

The FG consisted of 20 experts (see Annex 1) from 16 different EU countries and with different professional backgrounds. There are beekeepers, advisors, researchers and consultants coming from private businesses, universities, public authorities, NGOs and other organisations. They were selected considering their practical experience and technical knowledge on the topic and they have jointly worked for a year and a half, meeting twice during this period. Discussions in the first meeting focused on challenges for the bee health, and good practices and sources of innovation to overcome these challenges.

Based on the main question the group explored solutions and good practices in the frame of four themes, that were collectively set, based on clustering the main challenges of the FG topic:

- Beekeeping practices
- Agricultural practices
- Communication/collaboration
- Monitoring

The main ideas discussed at each table resulted in seven areas that were selected for further exploration in so called "minipapers". The list of minipapers can be found in Annex 2. The papers covered the following topics:

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1. Knowledge transfer and capacity building. What knowledge is reliable as valuable information for beekeepers? How can we bridge best available knowledge and existing beekeeping practices?

2. Beekeeping practices to improve disease control and to ensure high efficacy without any adverse effects of the chemicals used, with the lowest costs, and ensuring the highest quantity and quality of all hive products

3. Well-being of bees into the reflection on beekeeping. "Bees first" point of view, while also trying to meet the needs of the various stakeholders.

4. How to respond to the needs for training and advice that beekeepers have.

5. Monitoring of colonies and the environment to support management decisions for the beekeeping sector.

6. Impact of major stresses on bee health: pesticides and lack of food resources (quality and quantity)

7. Support management decisions for the bee breeding to maintain genetic diversity, not losing adaptation possibilities and to get resilient bees.

Following the work done at the first meeting and in the minipapers, during the second meeting the group looked at new ideas for innovation, suggesting ideas for Operational Groups (OGs) and proposed possible directions for further research.

The minipapers together with the starting discussion paper provides the base of this final report.

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2. State of play and what we can do

What do we know about the challenges for honeybee health and what can we do to solve the problems? The FG has identified the "do's" or priorities to keep healthy honeybee colonies. In order to make the key factors and their solutions easier to understand they are divided into these different levels of action: a) the honeybee colony; b) the apiary; c) the landscape; and d) the beekeeper.

3.1 The health status of the honeybee colony

The honeybee colony is regarded as a superorganism, an organism consisting of several individual organisms that jointly make rational decisions. On the honeybee colony level, the stress factors (in-hive stressors) are e.g. pathogens, poorly mated queens, bees not adapted to local conditions and inappropriate beekeeping practices.

Framing key issues

An examination of the **health status** of a honeybee colony is not entirely simple. To get the overall picture one needs to make both an internal and an external examination.

Internal means looking for clinical symptoms in the brood frames, looking for honey and pollen storage, looking for vitality signs and the colony's adaptability to stress factors, including genetic diversity, nutritional needs, varroa (*Varroa destructor*) pressure or other diseases, pests and predators and effect of chemicals used in the forage area.

External includes the activity of the bees in the apiary and in front of the hive entrances, on the ground in front of the hives, the appearance of the hive, the bottom board and the entrance as well as environmental factors. The records regarding the colony history during the seasons need also to be reviewed. In the records there should be notes of deviations from the normal actions taken and other events. However, in many cases the data are scarce and superficial.

For example, the European Food and Safety Authority published in 2016 a toolbox to facilitate harmonised data collection to support the assessment of the health status of managed honeybee colonies (https://www.efsa.europa.eu/en/efsajournal/pub/4578). This **HEALTHY-B toolbox** (EFSA Journal 2016;14(10):4578) for assessing the health status is based on:

- Characteristics of a healthy managed honeybee colony
- An adequate size, demographic structure and behaviour
- An adequate production of bee products
- Both in relation to the annual life cycle of the colony and the location
- Provision of pollination services (measured in volume of bee products)

Analysing the surrounding environment, in particular land cover/use, of a honeybee colony is very important when assessing its health status, but **good tools that could be used at apiary level are currently lacking**. Therefore, how can the beekeeper make a correct analysis of the actual health status for the colony

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without proper tools? The ongoing B-GOOD project are addressing the question (**https://b-good-project.eu**).

Another challenge is how to ensure high efficacy of methods used to control diseases: a) without any adverse effects of the chemicals used; b) with the lowest costs; and c) ensuring the highest quantity and quality of all hive products.

Dream home for honeybees

The dream homes for honeybees in the wild (T. Seeley 2010) is:

- Nest entrance height above the ground: High entrance, 5 m
- Size of entrance to the nest: Small entrance, 12,5 cm^2
- Space of the cavity: Spacious cavity, 40 litres
- Entrance direction: south
- Cavity dryness: the bees can remove wet substance and waterproof a leaky cavity
- Cavity draftiness: bees can caulk cracks and holes with propolis

There is very little knowledge regarding how the **natural behaviour of honeybees** is important for the health of a colony. Honeybees are to be looked at as semi-domesticated species. The beekeepers have changed the genetics very little, but the environment changed a lot, such as the choices of beehive constructions and the location of the bee colony. What do the beehive construction means for the survival of a colony? **Management methods adapted to the local conditions** are known factors for good honeybee health.

Moreover, the **genetic diversity** of the European honeybee is at risk. Climate change, with altered season features, is challenging the adaptation capacity of honeybees. The success factor throughout the millions of years that honeybees have existed, is their ability to adapt to changes of the surrounding environment. To meet these challenges a broad genetic diversity is the key. The honeybee colony breeds (the virgin queens fly out and mate with multiple drones high up in the air) with the honeybee colonies that are in the area where the beekeepers put it. This is an important factor in the environment. Beekeepers should breed local resilient honeybees and this is not easy, since in most regions there are no regulations about what kind of honeybee races are allowed. The diversity of beekeeping in Europe should be the driver for regional regulations that allow sustainable conservation of varieties of local honeybees in Europe.

Key factors identified:

- Definition of the honeybee health status
- The honeybee genetic diversity

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Good practices, examples

BREEDING PROGRAM FOR PRESERVATION OF LOCAL RACES.

Local adaption, not the search for "the best bee", will be the key to sustainable beekeeping. Preservation of local adaptation can be done by arranging bee breeding cooperatives, running regional selection programs and promoting honey produced by regional bees. There have been several successful initiatives to conserve and/or restore original endemic bee races in Europe. Foremost are the Italian breeding program to promote *Apis mellifera ligustica* and *A.m. carnica* but not all of them in the native region of the subspecies. Beekeeping will need to become more regional and less global to allow for sustainable strategy to preserve the honeybee diversity (R. Moritz and R. Crewe, 2018).

Sustainable conservation to improve and conserve the native or locally adapted honeybee populations or subspecies is an increasing breeding approach. The basic philosophy behind this is to reduce importations and instead utilize and improve the local populations in comparison to the non-local ones (A. Uzunov, E. W. Brascamp & R. Büchler, 2017). However, it is difficult to avoid crossbreeding while both local races and more commercial breeds coexist in the same area. Within the SMARTBEES project - sustainable management of resilient bee populations -, a protocol for field testing and selection of local bee populations was produced and evaluated (http://www.smartbees-fp7.eu/Extension/Performance/). The data is collected in an online database at www.beebreed.eu (hosted by the Institute for Bee Research, Hohen Neuendorf, Germany).

PREVENTION BETTER THAN CURE

American foulbrood is a brood disease caused by the spore forming bacteria *Paenibacillus larvae*. It is considered to be of the most destructive brood diseases on honeybees and is a notifiable disease to the OIE (World Organisation for Animal Health). The spores, which can be dormant for decades, can be found on the honeybees, in the beeswax, in the honey and in the hive material. The spores might be present in a honeybee colony without resulting in clinical symptoms in the brood. By testing a colony for spore levels, the beekeeper gets an indication of the risk of an outbreak of the disease. By taking measures such as cleaning of the equipment, frequent wax renewal and conducting general hygienic management techniques in the beekeeping, the beekeeper might be able to avoid outbreaks of American foulbrood.

The goal of the American Foulbrood National Pest Management Plan is to eliminate American foulbrood in managed colonies in New Zealand (https://afb.org.nz). Some New Zealand beekeepers have shown that elimination on a national level is possible. By destroying colonies with American foulbrood instead of using antibiotics and using management techniques to avoid the spread of the disease to other hives, they have effectively eliminated the disease from their own businesses.

According to Swedish research the beekeeping practice to test bee colonies for American foulbrood spores from adult bees and by using a systematic quarantine system and cleaning of the equipment the spores can be eradicated from the beekeeping operation (Locke et al. 2019). Analysing adult honeybees for spores is also used in conjunction with contact tracing at outbreaks of the disease in Sweden.

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What can we do?

As described in minipaper 2 (Disease control and emergency situations) there are several monitoring tools for each disease, but still there is not one simple monitoring tool for all diseases, which even includes environmental factors (e.g. stressors from agriculture and nutritional quality and quantity). It is possible that the "Health Status Index" and data standardization, if established, could be a monitoring tool for predicting the fate of a colony, under specific circumstances.

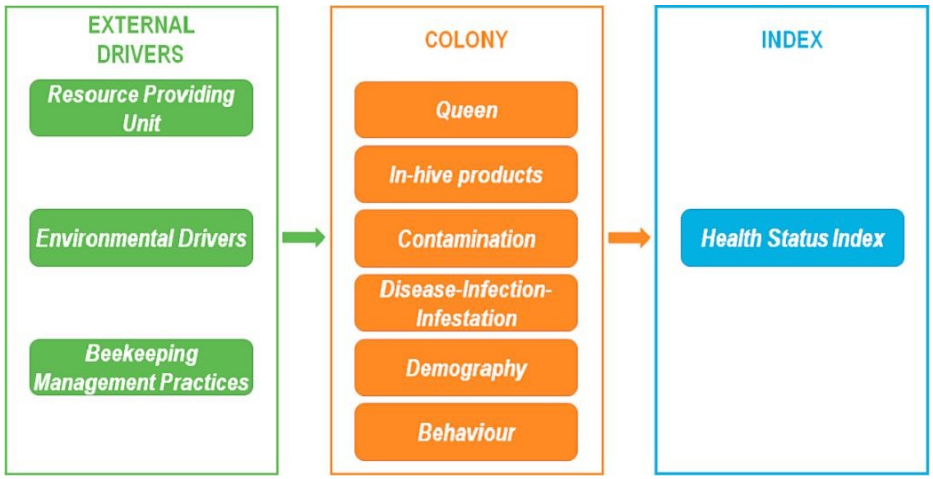

Figure 2 The Health Status Index integrates different sources of data and it can quantify the health status of a honeybee colony based on the characteristics of each scenario (Gilioli et al 2019)

In minipaper 7 (Sustainable bee breeding) the components to a holistic approach for local breeding programs are discussed. One of these factors is the importance of communication of the value of locally bred honeybees and to provide beekeepers with technical support to monitor the honeybee genetics.

Ways forward:

- Develop and implement a "Health status index" as a practical application
- Develop and evaluate technical methods for controlling of varroa for sustainable beekeeping
- Communicate the importance of genetic diversity for sustainable beekeeping

Inspiration from the minipapers

MINIPAPER 2: VARROA CONTROL THROUGH BEEKEEPING PRACTICE

Management of varroa control is key for sustainable beekeeping. Chemical control methods ('hard' or 'soft', e.g. through organic substances) may lead to varroa resistance or weakening of the colony. Sustainable varroa management calls for synchronised control in terms of period of the year, and type of application, which can minimise the risk of reinfestation in permanent/non migratory apiaries. Training is also very important in varroa monitoring or control schemes, as good beekeeping practice also includes measurements of infestations level and then control of varroa if infestation is above a certain threshold.

MINIPAPER 7: GENETIC CONSERVATION PROGRAMME IN BELGIUM

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A new association based in Belgium was founded on November 2018 which aims to become a tool for worldwide honey bee queen producers & breeders, a place where to meet, exchange ideas and experiences; conservation and sustainable breeding are the main goals (**https://www.beesources.com/en/assistenza-tecnica/international-honey-bee-breeding-network-ihbbn-founded/**) For other examples see minipaper 7.

MINIPAPER 3: QUANTITATIVE ASSESSMENT OF THE BEES' WELLBEING

Apicultural research is starting to embrace a "natural beekeeping" perspective and more and more results are available on the effects of such practices on the bee's well-being. But there is, in particular, a need to assess quantitatively with scientific studies the impact of each stress factor on the bee's well-being in order for beekeepers to make informed practical choices regarding for example the limitation of treatments, winter honey supplies, improvements to the beehive model, etc. (see more in minipaper 3)

3.2 Bee health from the colony to the apiary

Several honeybee colonies placed in the same location is called an apiary. The stress factors at the apiary level (in-apiary stressors) are e.g. robbery (when honeybees from one colony steal honey from another bee colony), re-infestation of varroa, transfer of brood or food frames between colonies and agricultural practices in the surrounding environment.

Framing key issues

An important part of beekeeping is to keep the honeybee colonies healthy. Part of the beekeeping is the selection of an apiary site. But how does the beekeeper know if the apiary's location is good or not? Part of the knowledge is of course to **know the basic needs for the bee colony** regarding food supply and access to water during the whole season. The area where the bees search for food is rather large, about 28 km^2 (calculated on a flight radius of 3 km). First thing is to have the possibility to **compare the development of the bee colonies** in one apiary with the development in another apiary over a certain period. This also includes that the colonies in the apiaries are supposed to be healthy, to be representative for the natural development. If they are not, then it is hard to evaluate how much other factors in the surrounding landscape actually means for the health of the honeybees. A wide range and type of variables must be monitored, such as the influence of environmental drivers, pressure of human activities and management strategies on honeybee colony health and productivity.

A helpful tool apart from keeping records manually is to continuously collect data by any automatic **monitoring** equipment, both at colony and environment level. Discussed in minipaper 5 (Monitoring - from Precision beekeeping towards Decision support systems) collecting data would not solve the problems if the data collected can't be interpreted correctly, thus translated into a practice responding to a need. By sharing information and creating tools for interpretation, the beekeeping might advance and become more exact regarding doing the right thing at the right time, this can be called '**precision beekeeping**' (PB).

The apiary is one component among others in the landscape, and the health of the bee colonies depend on the **surrounding activities**. From the honeybee's point of view, a sustainable environment is a prerequisite for survival. In most cases, the land where the apiary is located and the bees forage for food is not owned by the beekeeper. Usually one or more landowners are involved with the ongoing activities of land use. This means that all activities performed in the area around the apiary has implications for the health of the bees. The beekeeper has very little control over the activities. How can the activities and their impact on the bees become visible to both the beekeeper and the land managers?

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Key factors identified:

- Collection and interpretation of data from monitoring, precision beekeeping
- Sustainable environment around the bee colony – the surrounding activities

Good practices, examples

To choose an apiary is like choosing a home. There are a lot of demands to be fulfilled. Will the site cause a nuisance to neighbours or the general public? Is it safe from vandals? Is there forage for the honeybees? Are there any apiaries nearby? Is the environment of the site suitable for bees? Is the access convenient, with minimal carrying for the beekeeper to bring in equipment and remove honey supers? Is the space suitable for the number of hives? Is the micro clime favourable? And so on.

In many books for beekeeping beginners there are instructions on how to find a good apiary site. It might be quite easy to find if you only have a few colonies, but if you increase the number of colonies then it is not that easy anymore. Establishing good relationship with neighbours, local farmers, landowners and the general public is a major factor in finding and maintaining a successful site the bee colonies. Talk to them about the value of bees as pollinators; inform them about swarms, flight paths etc. Try to capture their interest and cooperation, gaining respect for the bees and the beekeeper.

One example of a user driven communication and coordination tool to protect honeybee health is BeeConnected (**https://beeconnected.org.uk**). It is UK based initiative and aims to connect beekeepers with farmers and inform of crop protection activities nearby. It is a voluntary Initiative, supported by the Crop Protection Association.

Another example is provided by the **EIP Operational Group NOMADI APP1**, Remote beehive monitoring, an opportunity for migratory beekeeping. It is a regional monitoring network consisting of computerised apiaries, equipped with sensors that collect data from the hives. Hive data (humidity, brood temperature) will be elaborated and integrated with other (including historical) information, such as meteorological forecasts, or data from the nectariferous species phenology (such as flowering time) to provide useful information for apiary management. They also have an acoustic sensor outside the hive to detect frequency of *Vespa Velutina*.

Bees flying to other hives than their own is called drifting. To avoid spread of disease or pests due to drifting between the colonies in the apiary, the hives can be put in different ways to help the bees finding their way back home to the right hive. The different solutions demand different amount of space.

What can we do?

As discussed in minipaper 5 electronic devices should be developed to enable new functionalities for precision beekeeping. This will be a shift from "smart" to "intelligent" hive. Intelligent hive would be able to:

- Monitor the hive for signs of trouble and send alerts before trouble hits.

1 For further information about NOMADI APP see the EIP-AGRI Inspirational idea: **https://ec.europa.eu/eip/agriculture/en/news/inspirational-ideas-monitoring-bee-health-through**

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- Monitor regional and national trends in real time and adjust for how those trends might affect your bees.
- Suggest ways to improve your production, pollination, or bee health.
- Prescribe the best management practices customized for a particular hive in a particular place at a particular time.
- Pre-emptively suggest treatments before trouble manifests.
- Identify the treatments most likely to succeed given your hive characteristics, current environmental conditions, and history.

To find out the actual situation for the honeybee colonies in an apiary, we need apart from monitoring the bee colony also measure and assess the exposure to stressors like agricultural practices and the nutritional quality and availability. The accessibility of data through mapping of the landscape situation is crucial to be able to evaluate the appropriateness of an apiary.

Ways forward:

- Measure and evaluate the exposure to stressors from agriculture in combination with food resource quality and availability
- Mapping the landscape around the apiary for its sustainability

Inspiration from the minipapers

MINIPAPER 5: MONITORING

In minipaper 5 examples of different national monitoring projects are listed and one that has been running since 2004 is the German Bee monitoring project, DeBiMo. Administrated by a number of Apicultural state institutes in Germany (**https://bienenmonitoring.uni-hohenheim.de/en/88571**). More than 100 beekeepers are involved in the collaborative project. They provide representative, up-to-date information on colony management and overwintering dynamics of their bee colonies. In addition, samples of bees, honey and pollen are supplied by these beekeepers for the analysis of bee diseases and chemical residues. Based on the results a report of the status is delivered annually.

MINIPAPER 3: QUANTITATIVE ASSESSMENT OF THE BEES' WELLBEING

In minipaper 3 a list of the stress factors with which bees are confronted are compiled. The table ranks them according to their scale, whether they are external factors, which depend on other activities less controllable by the beekeepers themselves, or internal factors on which beekeeping management methods can provide opportunities for intervention. For example, beehive materials construction and location have an impact on swarming, energy required for thermoregulation or risks of infestations by bacteria or parasites. By opting for natural material (wood or polystyrene only for nucleis), no chemical wood protection, no varnish and regular disinfection of hive material with heat and steam only we can highly contribute to the well-being of the hives.

Add the table here?

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3.3 The interaction with the landscape

The stress factors at landscape level are e.g. insufficient supply of high-quality diet, lack of sources for propolis, lack of water, exposure to plant protection chemicals, poorly coordinated land management measures and food competition or disease/parasite pressure from other beekeeper's colonies.

Framing key issues

The landscape surrounding the beekeeping practice is a complex and multi-actor environment.

Depending on the kind of landscape in which the beekeeping is performed, different elements have impact on the honeybee health. There are regulations that limit the **exposure of pollinators to plant protection products**. Despite of that, chemicals used in agriculture and other areas can cause lethal and sublethal effects on honeybees. Due to the resilience at colony level, the effects sometimes are not easy detectable. Signs like a colony being less productive or weaker in terms of nourishment and immunity, could be caused by other health problems as well. The chemicals also interact with other bee stressors like pathogens, nutritional deficiencies or adverse climatic conditions. The exposure occurs in the crops attractive for bees but also in non-attractive crops, weeds or wildflowers in the boarder zones of the cultivated fields (Simon-Delso et al 2017). This makes the current risk assessment rather limited. The mixture of different chemicals (so called 'cocktail') makes the assessment further complicated (Simon-Delso et al., 2014; Tosi et al. 2018). In 2013 EFSA published a guidance document intended to extend testing requirements for risk assessment, **https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2013.3295**

In areas with intense land use, the plant diversity is usually low. Honeybees are vulnerable to reduced flower availability, and **nutritional stress** effects the colony health by reducing its strength and fitness. Nutritional deficiencies were identified as one of the major causes of honeybee colony losses in the USA between 2007 and 2015 (Seitz et al. 2016).

There is an urgent need for **collaborations and partnerships** between the persons involved, farmers, other land managers and beekeepers, to create a sustainable landscape fore bees and beekeeping. The actors in the landscape need to work together on strategies and implement mitigation measures to make the surrounding landscape fit for sustainable beekeeping. The best available knowledge about the landscape level status needs to be made available beyond beekeeping and include other actors in the forage area.

Key factors identified:

- Sub lethal effects of chemicals in an environment of multiple stressors
- Sustainable environment around the bee colony and collaboration among those involved

Good practices

"Multifunctional buffer zones" are areas of land surrounding fields on which carefully combined strips of different herbs and grasses are planted. They contribute to the farm and the environment in many ways: minimising the risk of leakage of unwanted substances from arable land, increasing biodiversity by attracting pollinators and 'natural enemies', acting as field roads for farming vehicles to avoid soil compaction, and more. A Swedish Operational Group (OG) is testing this concept defining buffer strips with two different

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goals: promotion or protection.https://ec.europa.eu/eip/agriculture/en/news/inspirational-ideas-multifunctional-buffer-zones

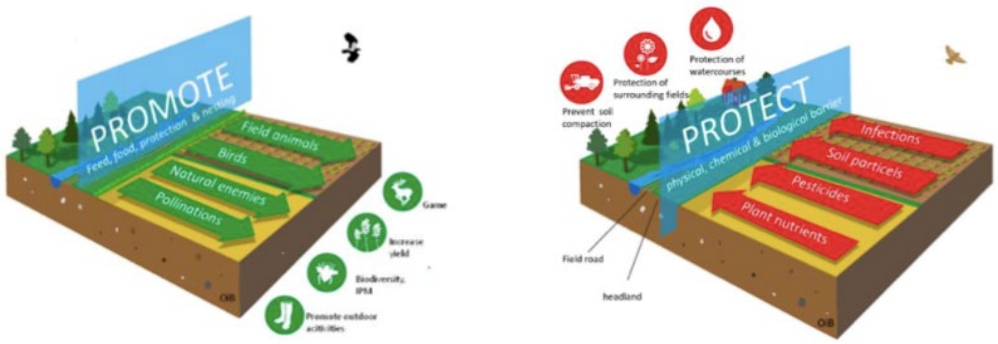

Figure 3 Multifunctional buffer zones (SamZones) by the OG, considering the two main goals: Promote feed, food, protection and nesting for field animals, birds, natural enemies, pollinators b) Protect (Physical, chemical and biological barrier) against infections, soil particles, pesticides, Plant nutrients (©odlingibalans)

What can we do?

Honeybees in agricultural landscapes need a better environment. Some ideas to achieve that goal are presented in minipaper 6 (Developing and enhancing good practices to mitigate major bee health stressors: pesticides and lack of resources)

Figure 4 Bees in agricultural landscapes need a better environment. Some ideas to achieve this goal are shown in the figure.

The landscape level is a complex reality, and complexity should not be simplified. One solution in one area might not be applicable in another area. Each given element with its connected actor has to be identified, analysed and assigned a task in the sustainable landscape system. This calls for collaboration. But who has the responsibility in a given area to initiate and develop the collaboration?

An example of a collaborative approach on landscape level is tested in the **Interreg project BioGov** (https://www.interregeurope.eu/biogov/). The project is about how to make improvement of natural

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and cultural heritage policies. The expected changes are more effective policies due to improved governance and broad stakeholder support. The different sub-projects are using participatory governance and/or policy instruments that actively encourage participatory governance as a new priority.

Ways forward:

- Identify, implement and communicate mitigation practices among beekeepers and farmers
- Managing complexity through collaboration

Inspiration from the minipapers

MINIPAPER 6: GOOD PRACTICES TO MITIGATE MAJOR BEE HEALTH STRESSORS

In minipaper 6 mitigation practises are discussed and they are essential to reduce stressors on bees in agroecosystems. Mitigation and support measures to bees must be complementary and integrated with the existing approach of Integrated Pest Management (IPM) (Figure 1). In this way, the development of Integrated Pest and Pollinator Management (IPPM) concept should be useful (Biddinger *et al*. 2015). This approach must include practices to support bees (flower strips) and reduce risks (pesticide drift, use of harmful pesticides, mowing of potential contamination sources such as wildflowers in orchards).

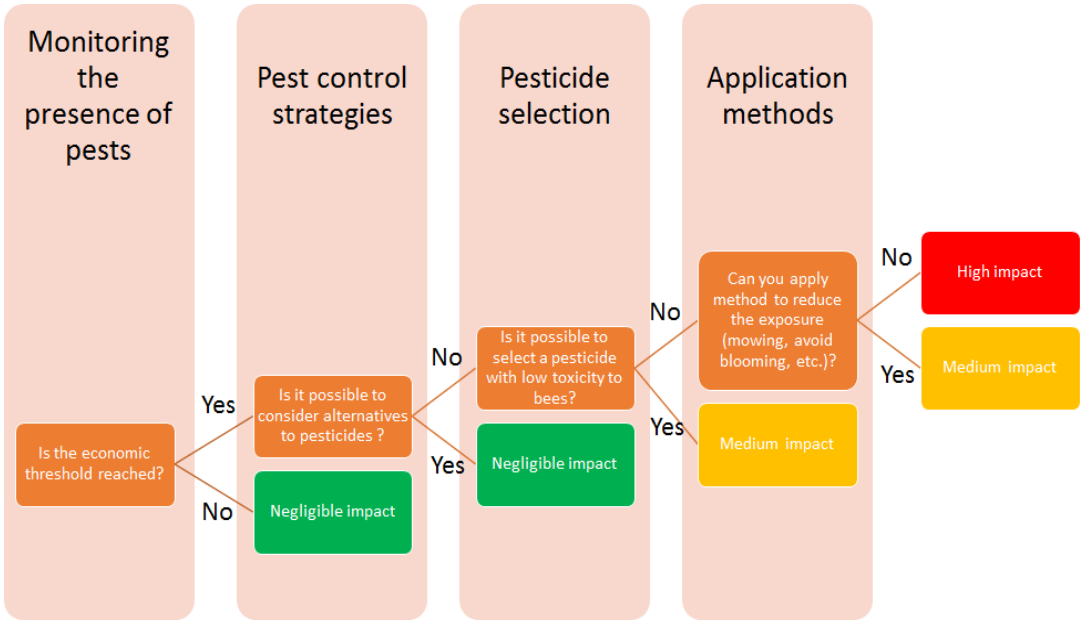

Figure 5

Some examples of existing collaborations between farmers and beekeepers:

- *Survey of apiaries in connection with farmers and advisers* - SURVapi – France
- *Platform for networking between beekeepers and farmers* - Beewapi – France
  http://www.beewapi.com/

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- *Meeting at an apiary* - ADA NA – France - **http://adana.adafrance.org/infos/Communication.php**
- *Memorandum of understanding between seed producers and beekeepers* - SEMENTI – Italy **http://www.sementi.it/comunicato-stampa/450/firmato-protocollo-intesa-per-valorizzare-colture-sementiere-e-tutelare-il-patrimonio-apistico**
- *Platform for farmers and beekeepers for pollination purposes* - Beeweb – Romania **https://www.beeweb.co/en**
- *Increase awareness of bees in several cities, collaboration with farmers* - BeepathNet – Slovenia, Greece, Italy, Portugal, Hungary, Poland **https://urbact.eu/beepathnet**

3.4 The Beekeeper: knowledge and skills for healthy bees

The beekeeper has a responsibility for the well-being of his/her honeybee colonies. To practice beekeeping, knowledge and skills are crucial to be able to do the right measures at the right time, to give the colony the best conditions for a good health. How is the actual situation for knowledge development and exchange in Europe today? How is the beekeeping sector gaining access to information? Where and how can good quality knowledge and information be found?

Framing key issues

In minipaper 1 (Platform of information at EU level) beekeeping is compared to other agricultural practices with further specific challenges within: a) a diversified target group; b) mainly micro-businesses and self-subsistence; c) rural entrepreneurs, geographically scattered; d) gender and wide age structure; e) low will or ability to pay for professional advisory services; f) lack of tradition in formalised competence development; g) trainers and educators are self-trained as pedagogues. Due to these challenges, the situation about how to get access to knowledge must be analysed. In minipaper 1 three key issues are discussed:

- Diversity of beekeeping across Europe
- Access to and quality of information
- Connection between research and practice (which is also key to introduce the following point on advisors)

Beekeepers have their beekeeping in many different environments. Every season is unique, and the beekeepers have to adapt their management techniques. If there are more than one beekeeper in the same forage area, what one beekeeper does or does not do has an effect on other beekeeping business, especially regarding honeybee health. As discussed in minipaper 4 (Beekeeping advising unit. Information and training for beekeepers) beekeepers need to be advised properly on how to overcome external factors in order to keep productive colonies. How can supporting services for beekeepers be organised in order to improve colony survival and productivity? Sustainable apiculture needs sustainable extension and advisory services. Suggestion from minipaper 4 is that the EU platform of beekeeping knowledge (discussed in minipaper 1) would serve as primary source of information and tool for training activities. Even so, it should be noticed that the scientific and research data would need to be turned into practical information, in the appropriate format and language, useful for the beekeeping practice or training.

By using the B-KIS (**Beekeeping Knowledge and Innovation system**) approach one gets a structural overview of the main knowledge actors, their roles and relationships. It aims to:

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- Describe the general structure and function of activities aiming for knowledge development, innovation and learning
- Better understand how today's services for beekeepers are embedded into the national B-KIS
- Provide some conceptual elements to support the development of a national or regionally adapted communication strategy for improved sustainability of apiculture.

Key factors identified:

- Make knowledge available (from research and practice)
- Skills development

Good practices

The "Certificate for European Consultants in Rural Areas" (CECRA) is the first European competence development program with an international certificate, meeting the rising demand for advisor method training. It combines practical training with tried and tested advisory techniques. The networks Internationale Akademie für ländliche Beratung (IALB) and European Forum for Agricultural and Rural Advisory Services (EUFRAS) are the providers of the CECRA Certification. This certificate is made for advisory services for farmers but could very well be applicable for beekeeping.

https://www.teagasc.ie/media/website/about/our-organisation/connected/CECRA-flyer.pdf
https://www.cecra.net/index.php/de/

Mentioned as an example in minipaper 4 BeeBase is the Animal and Plant Health Agency's (APHA) National Bee Unit website. It is designed for beekeepers and supports Defra, Welsh Government and Scotland's Bee Health programmes. The National Bee Unit, NBU has been involved in the management and control of bee pests and diseases, training and dissemination of information to beekeepers for over 60 years. NBU comprises laboratory diagnostics, programme support, research personnel and 60 home-based Bee Inspectors. On a voluntary basis a beekeeper may sign into BeeBase. By doing that the beekeeper is able to put the details of his/her bees and apiaries onto BeeBase, including inspections information, being able to arrange an apiary visit from the local inspector who can provide the comprehensive help and advice needed. The website includes quality assured information and knowledge for beekeepers **http://www.nationalbeeunit.com**

What can we do?

As suggested in minipaper 1 (Platform of information at EU level) we can organise a **network of credible and validated information** gathering in different regions of the European Union in order to be able to take the best possible account of local specificities linked to culture, climate, land use, and the main existing beekeeping practices. Facilitate the structuring and standardisation of the information received from research and practice. This information would be centralised by a European platform and made accessible to national/regional 'antennas' and/or directly to beekeepers. Another way forward could be the development of a '**beekeeping license**', a pan EU standard of beekeeping qualification for beekeepers, achieved through

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formal education, professional training and/or extension services as discussed in minipaper 4 (Beekeeping advising unit. Information and training for beekeepers).

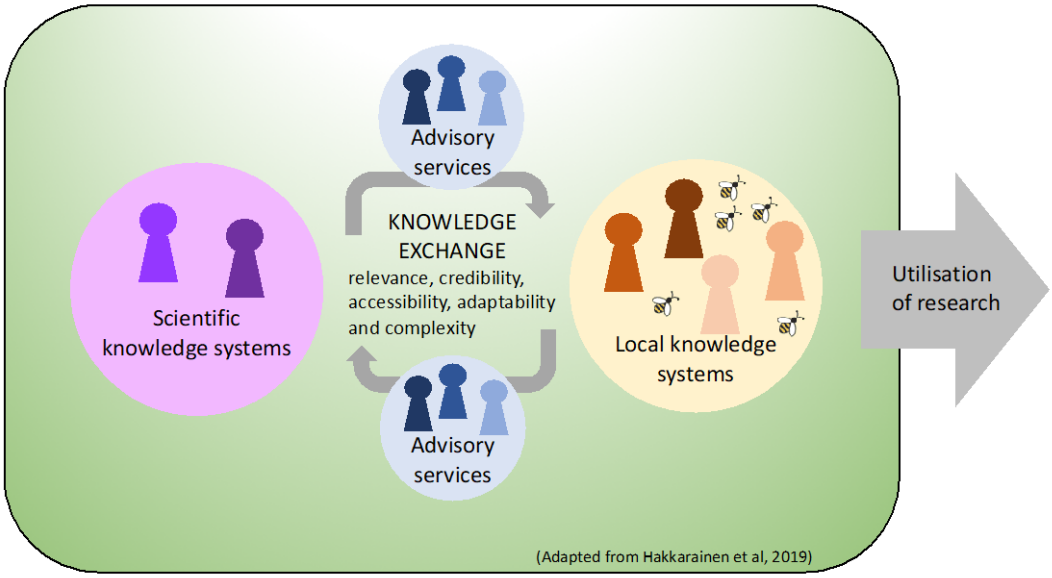

Figure 6 Bridging research and practice. A functional advisory system with the ability to make scientific knowledge available and accessible for practical use is essential and so is the knowledge and the needs generated by the beekeepers to be communicated to research through the same channels. The advisors facilitate that process.

Ways forward:

- Create a European platform for beekeeping knowledge connecting research and practice
- License for beekeepers, a pan European standard

Inspiration from minipapers

MINIPAPER 4: A GOOD ENCOURAGING NEWS STORY FROM SCOTLAND

A crisis situation in Scotland surrounding heavy levels of European foulbrood in 2009 forced a radical look at developing a strategy to deal with the situation. Initially it was felt that the beekeeping sector worked well amongst itself being kept well abreast of relevant situations. However, it quickly became apparent that this was not the case. When meetings were called to outline developing plans, it was apparent that the beekeepers were initially reticent and suspicious but as time went on the barriers broke down and a true partnership was formed.

Once the disease came under control the strategy evolved to further improve the situation. Rather than simply have a meeting some became workshops dealing with bee health issues and then an accreditation developed where the beekeepers were tested against identification of disease and treatment. Success even resulted in a certificate something some had never received.

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MINIPAPER 1: SCIENTIFIC DATABASES

The International Bee Research Association, IBRA **https://ibra.org.uk** is the best known scientific database in the field of beekeeping. It has since 1950 published the Apicultural Abstracts and continued to edit Bee World and Journal of Apicultural Research. Scientific information is structured and refers to Google scholar, PubMed, Scopus (paid) search engines, but many articles are linked to a subscription and only abstracts are accessible.

3.5 Conclusions

By moving from the honeybee in section 3.1 to the apiary in 3.2 and the landscape in section 3.3 we end up with the beekeeper in 3.4. In these sections a description of the key factors and the ways forward to reach the overall mission "healthy honeybees and sustainable beekeeping" is discussed.

Key factors to keep healthy bee colonies identified by the focus group (Priorities):

- Make available knowledge and skills (research and practice)
- Definition of the health status of the honeybees
- Sustainable environment around the honeybee colony
- Interpretation of data from monitoring, precision beekeeping (PB)
- The honeybee genetic diversity
- Sub lethal effects of chemicals in an environment of multiple stressors

Ways forward (solutions to the problems)

To address the key factors mentioned above, the Focus Group recommended to:

- Create a European platform better connecting research and practice
- Develop a kind of license for beekeepers, a pan European standard
- Develop and implement a "Health status index" as a practical application
- Develop and evaluate technical methods for controlling of varroa for sustainable beekeeping (e.g. trapping of mites in worker or drone brood, queen caging and artificial swarms)
- Assess the exposure to stressors from agriculture in combination with resource quality
- Identify, implement and communicate mitigation practices among beekeepers and farmers
- Managing complexity through collaboration among relevant stakeholders
- Mapping for sustainability, the landscape situation around the apiary (make available monitoring results in maps)
- Communicate the importance of genetic diversity for sustainable beekeeping

The key factors are the **main priorities** put forward by the focus group. What needs to be put in place to enable development and progress to reach the goal? By using a theory of change model (**https://www.theoryofchange.org**) an illustrative description of what activities or interventions, in this case the described key factors/priorities, are expected to lead to achieve the vision **Healthy honeybees in a sustainable environment**.

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For success a supporting environment for implementation and mainstreaming of the listed priorities is necessary, reducing the threats to honeybee health and to meet the needs of actors involved. These actions should be supported by enabling conditions and means of implementation including financial resources, capacity and technology.

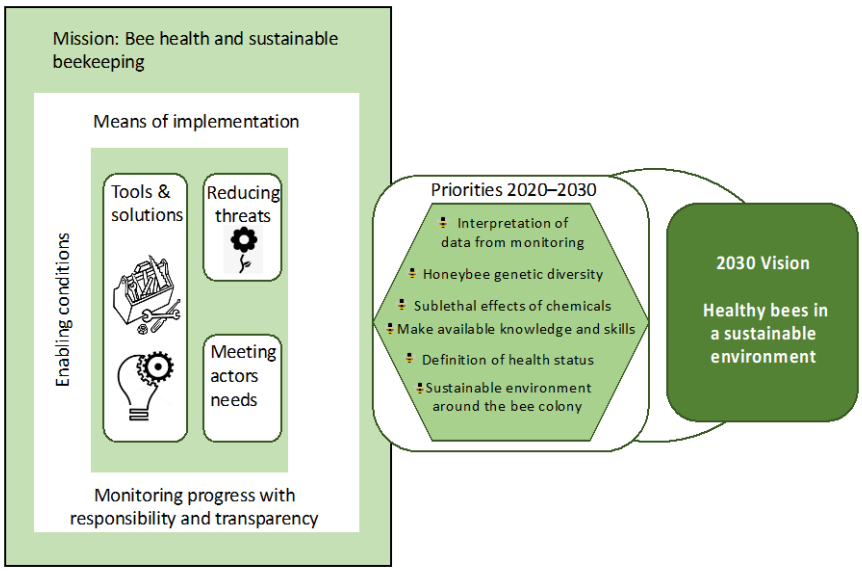

Figure 7 A framework illustrating the enabling condition and means of implementation to support the priorities defined as key factors by the focus group to achieve the vision "Healthy honeybees in a sustainable environment" in 2030.

3. Recommendations from the Focus Group

Following the work done exploring available knowledge, practices and technologies, the Focus Group experts looked at what's missing, what are the remaining needs that would need to be addressed in the future. Based on that, they have proposed new ideas for innovation, suggesting ideas for Operational Groups (OGs) and provided indication for possible directions for further research.

Most of the ideas fall into four main themes:

- Beekeeping data and their availability, management, standardisation, collection, interpretation and use.
- Beekeeper knowledge and needs in terms of training, information gaps from practice, social aspects of beekeeping.
- Beekeeping practices: health indicators, adaptation and mitigation to climate change, dealing with farming practices with impact on the bee's environment, cooperation with farmers
- Bees at the centre: health and well-being, exposure to stressors, conservation of populations, genetics, breeding, effects of beekeeping practices.

Research needs from practice

Despite the many innovations and findings, still many research results are translated into practical applications very slowly, or not reaching the ground at all. And on the other hand, professionals such as

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farmers or beekeepers may have the impression that research does not meet their needs. Therefore, the Focus Group was invited to identify remaining research needs from practice and propose possible directions for further research.

Six priority research needs from practice were highlighted by the FG. Other identified research needs can be found in Annex 4 and further articulated in the minipapers.

1. Creating a European platform better connecting research and practice and contributing to efficiently gather and exchange knowledge. It should relay and be connected to local centres to properly consider context-specific issues, and ensure accessibility, credibility and visibility of the information for the beekeepers. This would request to specifically consider issues related with language and standardisation.

2. Definition and applications of the Health Status Index for bees and bee colonies, which can be useful for several purposes. E.g. the creation of the *Bee ambulance* to provide assistance in case of emergency situations (e.g. disease outbreaks).

3. Effects of exposure to stressors from agriculture, including e.g.: knowledge of effect of novel chemicals, interactions, sub-lethal effects, resources quality e.g. from plants from hybrid seeds.

4. Technologies and methods for sustainable beekeeping, like considering the natural wax cell size at combs, drone brood removal or organic methods.

5. Effective communication on how and why genetic diversity is important to convince beekeepers that they should look for genetic biodiversity, resilient bees and sustainable bee breeding.

6. Work on identification, communication and implementation of mitigation practices amongst beekeepers, and with farmers. Test and find out best mitigation practices in terms of effectiveness, increase farmers awareness on the importance of bees and pollinators, work on agreements between beekeepers and farmers -enforced by local authorities-, etc.

4.2 Ideas for operational groups

With the aim of inspire innovative actions, seven main ideas for EIP-AGRI Operational Groups were elaborated by the FG. The proposals cover a wide range of type of projects, from testing solutions or management practices at hive level to ways of cooperation or knowledge exchange.

Theme: Varroa control

IDEA 1: TESTING THE EFFECTS OF CUTTING THE DRONE BROOD AND REDUCING THE CELL SIZE ON VARROA DEVELOPMENT

The objective is to keep the varroa level during the whole season as low as possible by properly managing drone brood and choose the most suitable combs cell size. 5,4mm is the most common size nowadays, but it is not clear whether this the best for varroa. This might also help to improve adaptation to climate change.

The project would require involvement from researchers, advisers and beekeepers. The outcomes -mainly for the beekeepers - would be:

1. Recommendation of the best comb cell size

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2. Recommendation of the best hive type (or size)

3. Recommendations on frequency and efficiency of drone brood removal

4. Low varroa infestation levels, tolerability of varroa

The activities of the project would include:

1. Testing different cell sizes of combs in 2-3 different ecotypes or conditions.

2. Testing different sizes of hives in different ecotypes or conditions

3. Testing and combining the above with drone brood removal, at different frequency

4. Monitor varroa levels and colony productivity together, and under all those different conditions, during the year

5. Formulate the recommendations based on all these trials.

This project could be implemented in different countries to test the differences.

IDEA 2: BETTER COLLABORATION FOR LESS VARROA

Varroa treatments are usually applied individually by the beekeepers. Thus, the objective of this project is the mitigation of varroa infestation across apiaries at local level by encouraging the cooperation of beekeepers to organise and implement a common calendar for varroa treatment. There's some experience about this in Switzerland and Germany, thus the idea is to adapt and replicate the example in other areas.

This is a collective approach that would require the cooperation of for example 5-6 beekeepers, who would agree and coordinate the timing of the treatments. Benefits would be the decrease of the risk of varroa, reducing chemical treatments or better monitoring of varroa especially on areas with high density of apiaries.

The practical outcome would be a communication tool (such an application) for beekeepers, associations and other relevant experts (e.g. vets, advisers) which should provide info as proposed data for treatments, current levels of infestation of the different colonies in the region, localisation of apiaries, alerts, etc.

In parallel to the platform, the project would look at potential incentives that might encourage the use of the application and coordination of treatments by the beekeepers.

Theme: Hive construction and management methods

IDEA 3: MANAGEMENT OF APIARIES IN THE WORST/EXTREME CONDITIONS

Climate change impacts are increasing all over Europe, threatening the bees and beekeeping activity. The objective of this project would be to contribute to maintain the beekeeping activity focusing on protecting the apiaries against the main threats posed by climate change on an specific area. For example, helping to overcome specific adverse conditions as very hot weather, drought or threats as birds or *Vespa velutina*. The main topic is bee health but also how to preserve pollination activities for farmers.

The expected results are two:

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1. To improve the immunity of bees based on practices of artificial nutrition, multiplication of bee colonies, management of varroa, etc.

2. Design hives and apiaries to avoid adverse conditions (e.g. covers for apiaries which could help to deal with very extreme environmental conditions as very dry and hot summers)

The idea is to run the project on a specific location and the steps towards the results would be:

1. To select the study area and identify main climate adverse conditions and threats expected on the area

2. To design the apiary with the specific material and equipment to protect the apiary against the foreseen adverse conditions in the study area.

3. To define the best management practices e.g. for nutrition, multiplication of colonies or pest management.

Participants needed for the project would be some beekeepers (or an association), advisers, manufacturing companies and researchers.

IDEA 4: SMALL CHANGES, "BEEG" OUTCOMES. DIFFERENT DESIGNS OF WALLS OF THE BEEHIVE

The objective of the project is the better understanding of beekeeping and husbandry practices, looking specifically at beehive materials and techniques, depending of the climate and local situation. For example, the thickness of walls and materials of the hive have a direct impact on isolation of the hive (so affecting temperature and humidity), propolis harvest or swarming management.

The aim is to increase resilience of bees and improve their well-being and health, thus direct beneficiaries would be first the bees, and then the beekeepers.

The expected results would be guiding material about "Do's and Don'ts" in beekeeping, and delivering advice concerning:

1. Materials to be used in beekeeping (including feeds, etc.).

2. Practices for husbandry management.

To achieve the results the project would need to collect and study the existing beekeeping practices and materials available, e.g. designs of hives and their derivatives. Then it would set up protocols and tests to study the performance of the different materials and practices and, if possible, under different environmental conditions. Finally, it would derive recommendations and disseminate the findings.

Specific participants needed for this project would be manufactures and suppliers of beehive products and equipment, engineers and designers of equipment, and practitioners such as vets or advisers with knowledge on bee health.

It should be noted that the project recognises the benefits of the standardisation of practices or equipment, thus it's not aiming to look for new developments, but it would try to deliver recommendations about what might perform better, within the wide range of existing practices and materials, depending on the local conditions.

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Theme: Collaboration

IDEA 5: CREATING BRIDGES BETWEEN FARMERS AND BEEKEEPERS FOR BEE-FRIENDLY FARMING

Motivation of the project is the lack of communication and awareness of the importance of bees for agriculture. Do we have a common understanding about what is 'bee-friendly' farming?

Expected results are:

1. Developing an app/platform to share information in real time between farmers and beekeepers. The platform would include all relevant information as for example land use, pesticide application or crops.

2. To get a common agreement on what is a "bee friendly" strategy. For example, nectar sources in the late season should not be considered a bee friendly practice, because it shorts the life of the worker bees. These late food sources delay the overwintering of the workers. As a consequence, colonies are too weak after winter and likely too small for building up a strong colony in time for spring crops.

Participants welcomed for the project would be beekeeping associations, advisory services, local farmer associations, organic farming associations, among others.

IDEA 6: BRIDGES BETWEEN FARMERS AND BEEKEEPERS, TO TALK TOGETHER AND COMMUNICATE TO ADAPT THE PRACTICES ON A LOCAL SCALE

Bees in agricultural landscapes need a good environment, thus the idea is to improve the implementation of bee-friendly practices by farmers. The idea for this project is to develop a communication guide to farmers and beekeepers, at a very local scale. This guide could be disseminated later on to another district with similar conditions.

The steps to follow will be, first to test and select agricultural practices to be implemented by farmers and which benefit the health of bees. Secondly the project would focus on communicating those practices amongst famers, e.g. through guideline, visits, joint meetings with beekeepers, etc.

For this the project would need to characterise, at a very local scale:

1. The landscape (forage availability, pesticides use, etc.)

2. The colonies' health (impact of pesticides, pathogens, food quality and quantity, colony strength, etc.).

Apart from beekeepers and farmers, the project would benefit also indirectly citizens and public administration.

IDEA 7: FOOD FOR BEES

The motivation of this project is the lack of food for bees in some places, as for example in The Netherlands, where due to the high density of apiaries, bees are suffering from shortage of food. Also, there's a shift in food sources due to climate change. This lack of food is affecting not only the honeybee but also wild bees and lies behind the bad reputation that beekeepers are having in some contexts.

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This as some other project ideas, include a cooperation aspect amongst farmers, beekeepers and other actors, but with the main focus on increasing the availability of food for bees (not looking, for example, at reducing the impact of pesticides etc.)

The expected results would be:

1. A better organisation and distribution of hives over the area of study
2. The description of the nutritional value of the landscape features and crops
3. The increase of the number of flowering plants and trees
4. The increase of biodiversity and building a better reputation for the beekeepers

The beneficiaries would be not only beekeepers but also citizens, as the project aims to improve the quality of the ecosystems and environment.

Some of the tasks the project would carry out are:

1. Study the impact of climate change on plants which are supplying food for bees, including gardens
2. Establish "bee gardens" also for public awareness
3. Establish regulations for landscape design (agriculture, forestry, etc.) favouring bee food sources
4. Monitor honeybee health and wild pollinators in different landscape features.

The participants of the project would be local governments in charge of landscape developments, researchers, beekeeping organisations, agricultural organisations. Additionally, "community influencers" might be a good asset to boost dissemination and raise awareness about the topic amongst citizens, farmers and beekeepers.

4. Other recommendations

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5. Annexes

Annex 1: List of members of the focus group

Name of the expert	Professional background	Country
Simone Tosi	Researcher	France
Fabio Sgolastra	Researcher	Italy
Marc Bock	Farmer	Finland
Florence Aimon-Marie	Adviser	France
Aleš Gregorc	Researcher	Slovenia
Stephen Sunderland	Civil servant	United Kingdom
Fani Hatjina	Researcher	Greece
Petko Simeonov	Farmer	Bulgaria
Salvador Garibay	Adviser	Switzerland
Louis Hautier	Researcher	Belgium
Ulrich Bröker	Adviser	Germany
José Antonio Ruiz-Martínez	Adviser	Spain
Frens Pries	Researcher	Netherlands
Etienne Bruneau	Working at an NGO	Belgium
Pilar De la Rua	Researcher	Spain
Ana Paula Sançana	Working at an NGO	Portugal
Anna Dupleix	Researcher	France
Constantin Dobrescu	Working at an NGO	Romania
Zeid Nabulsi	Farmer	Italy
Robert Chlebo	Researcher	Slovakia
Facilitation team		
Charlott Fabricius Kristiansen	Coordinating expert	Sweden
Beatriz Guimarey Fernández	Task manager	Spain
Eike Lepmets	Back-up manager	Estonia

You can contact Focus Group members through the online EIP-AGRI Network.
Only registered users can access this area. If you already have an account, you can log in here
If you want to become part of the EIP-AGRI Network, please register to the website through this link

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Annex 2: List of minipapers

Minipaper	Title	Contributors
1	Platform of information at EU level	Etienne Bruneau (Coord), Salvador Garibay, Florence Aimon-Marie, Ana Paula Sançana, Aleš Gregorc, Ulrich Bröker, Petko Simeonov
2	Disease control and emergency situations	Hatjina, Fani (Coord.), Marc Bock, Pilar De la Rua, Constantin Dobrescu, Aleš Gregorc, Zeid Nabulsi, Ana Paula Sançana
3	Taking into account the well-being of bees in production	Anna Dupleix (Coord.), Etienne Bruneau, Ulrich Bröker, Robert Chlebo, Salvador Garibay, Petko Simeonov
4	Beekeeping Advising Unit. Information and training for beekeepers -	Stephen Sunderland (Coord.), José Antonio Ruiz, Louis Hautier, Zeid Nabulsi, Aleš Gregorc
5	Improving the bee health status through monitoring of the colonies and the environment	Petko Simeonov (Coord.), Frens Pries, José Antonio Ruiz, Rober Chlebo, Louis Hautier, Fabio Sgolastra, Zeid Nabulsi, Simone Tosi
6	Developing and enhancing good practices to mitigate major bee health stressors: pesticides and lack of resources	Simone Tosi and Louis Hautier (Coord.), Frens Pries, José Antonio Ruiz, Florence Aimon-Marie, Zeid Nabulsi, Fabio Sgolastra
7	Sustainable bee breeding	Frens Pries (Coord.), Pilar De la Rúa, Ana Paula Sançana, Fani Hatjina, Salvador Garibay

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Annex 3: List of ongoing honeybee research projects and operational groups

This is a list of projects (past or ongoing) related to bee health and monitoring compiled during the second meeting of the FG.

1=Pest and diseases
2= Pesticides, agricultural practice
3= bee food supply and landscape
4= Well- being of bees
5= Monitoring
6= Breeding, local races
7 = Knowledge exchange, advise
8 = Beekeeping practice

Project		**Expert**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
LIFE4POLLINATORS		Fabio		X					X	
SmartBees	Smarthives (part of FRACTAL) online support system that will help beekeepers in their everyday beekeeping activities and duties. The basis of the concept is an ERP system customized for beekeepers to facilitate better handling and management of bees (sites and families), equipment, expenditures and revenues. The software is operational on itself, but, for automatization reasons, beekeepers can connect sensors to the system as well. http://www.r-key.eu/		X				x	x	x	x

POSHBEE	PoshBee - Pan-european assessment, monitoring, and mitigation Of Stressors on the Health of BEEs (Jun2018-May2023) –Address the issue of agrochemicals to ensure the sustainability of bees, integrate knowledge, assess exposure to chemicals and their co-occurrence with pathogens and nutritional stress, air sensors, integrate info with MUST B to develop dynamic landscape model for risk assessment €9 million https://cordis.europa.eu/project/rcn/215953/factsheet/en	Pilar	X	x	x		x	x	X	
APENET		Fabio	X	x	x	x	x			
BEENET			X	x	x	x	x			X
POLBEES		Louis		x	x		x			
BEESYN		Etienne, Louis	X	x	x		x		x	
DNA marker for VSH genes		Frens	X					x		x
GREEK QUEENS		Fani						x		
BEEPAHTNET		Fani				x			x	
RESCUE-B		Simone		x		x	x		x	
INSIGNIA				x						

Beewood/SAPIC		Anna				x	x			x
NO PROBLEMS						x				x
SURVapi				x	x				x	
Bee Wallonie		Louis	X	x			x		x	
AGROAPIS*		Constantin		x	x	x	x			
APISANA*		Constantin	X	x		x	x			
PUROWAX*		Constantin	X	x						x
B-GOOD	B-GOOD - Giving Beekeeping Guidance by cOmputatiOnal assisted Decision making - EU wide bee health and management data platform - digital bee data logbook, database for automated data acquisition and web portal	Robert				X	X		X	X
HIVEOPOLIS	Hiveopolis – Futuristic beehives for a smart metropolis (2019-2024)-https://cordis.europa.eu/project/rcn/218714/factsheet/en – ES/FET - € 7mio	Robert					X			X
BPRACTICES	BPRACTICES - (ERA-NET SUSAN) New indicators and on-farm practices to improve honeybee health in the Aethina Tumida ERA in Europe - Develop new management practices (Good Beekeeping Practices – GBPs) adopting new clinical methods, biomechanical and innovative biomolecular techniques respecting the natural behaviour of bees –economic impact on beekeeping industry will be quantified and beekeepers and consumers will be aware of	Robert	X				X		X	X

	the project results thanks to a cutting-edge traceability system using the QR-code/RFID technology € 0,7 million									
SAMS	SAMS - International Partnership on Innovation in Smart Apiculture Management Services – (Jan2018-Dec2020)	Robert					X		X	X
IOBEE	IoBee - Beehive health IoT application to fight Honey Bee Colony Mortality (2017-2020) – http://cordis.europa.eu/project/rcn/210011_en.html - FTIPilot - €1,43mio	Robert	X				X		X	X
WARMHIVE	WarmHive - SMART thermotherapy solution for varroa mite treatment (Jan-Jun2019) -https://cordis.europa.eu/project/rcn/220042/factsheet/en - LEIT/SME - €0,05mio	Robert	X				X			
BEEHOME	BeeHome - Automated beekeeping platform powered by AI that increases honey production by 50%, reduces labour use by 90%, and reduces colony loss by 80% (Jan-Apr2019)-https://cordis.europa.eu/project/rcn/220635/factsheet/en - LEIT/SME - €0,05mio	Robert					X			
FOG	FOG - Frequency protector generator for honeybees (Jan-Jun 2019) https://cordis.europa.eu/project/rcn/220056/factsheet/en - LEIT/SME - €0,05mio	Robert					X			
BeeXML		Robert					X			
Hostabee	Hostabee.com, «B-Keep's» processor is capable of managing LoRa and Sigfox communication formats and its protocol can provide low consumption, high autonomy and broad coverage. Additionally, Hostabee has implemented its own IoT backend based on FIWARE enablers. The real time data collected by «B-Keep» is stored in the Google Big Query platform									

	to be treated by IBM Watson and API's to generate decision trees, used to provide proactive advices and alerts about the beehive's condition. 1000 units produced in 2017. https://youtu.be/jmVYbDXf3Fg https://youtu.be/-L9IBD6CDVQ									

*Assessment in progress

Annex 4: Full list of research needs per minipaper

This annex lists the 3-4 key research needs coming from the ground that the experts have identified, grouped by minipaper topic. For further details, check the minipaper.

MP 1: PLATFORM OF INFORMATION AT EU LEVEL

- Creating a European platform better connecting research and practice and contributing to efficiently gather and exchange knowledge. It should relay and be connected to local centres to properly consider context-specific issues, and ensure accessibility, credibility and visibility of the information for the beekeepers. This would request to consider particularly issues related to language and standardisation.
- Better knowledge on the social perspective of beekeeping and profile of beekeepers across Europe might contribute to a more effective and reliable platform
- How to deal with the data collection and management and standardisation of the information at EU level.

MP 2: DISEASE CONTROL AND EMERGENCY SITUATIONS

- Definition and potential applications of the Health Status Index for bees and bee colonies, which can be useful for several purposes. E.g. the creation of the *Bee ambulance* providing quick assistance in case of emergency situations (e.g. disease outbreaks).
- Biotechnological methods for sustainable beekeeping, like opting for wax cell size closer to the cell size in nature, drone brood removal or organic methods.
- Buffer capacity of the colony -e.g. in case of intoxication or disease- and the recovery time needed

MP 3: TAKING INTO ACCOUNT THE WELL-BEING OF BEES IN PRODUCTION

- Better knowledge of the environment around the bees, especially agriculture-related (crops, chemicals, biodiversity, etc.).
- Adaptation of beehive and apiary practices to climate change: e.g. natural wax comb production, study the effect of the climate change on the thermoregulation of bees or influence of shape or material of the hive on its isolation.
- Effects of bees' artificial nutrition and supplementary feeding in well-being (e.g. depending on time or frequency of feeding or composition of the food, organic feed)
- Breeding and reproduction aspects and their impact on the bees' well-being, as the effect of the natural swarming process or future implications of some genetic and breeding practices (e.g. introduction of foreign queens).

MP 4: 'BEEKEEPING ADVISING UNIT'. INFORMATION AND TRAINING FOR BEEKEEPERS

- Establish an EU database of beekeeping advising and training courses, centres, and resources.
- Establishing a set of common standards for beekeepers training

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- Developing a 'beekeeping license', a pan-EU standard of beekeeping qualification for beekeepers achieved through formal education, professional training and/or extension services.
- Knowledge on exchange opportunities, which would also be supported by the EU database on training and advising.

These research needs are closely linked and complementary to MP1 (EU platform). Hence, the EU platform of beekeeping knowledge would serve as primary source of information and tool for training activities. Even so, it should be noticed that the scientific and research data would need to be turned into practical information, in the appropriate format and language, useful for the beekeeping practice or training.

MP 5: FROM PRECISION BEEKEEPING TOWARDS DECISION SUPPORT SYSTEMS

- Improve the interpretation of data (especially from sensors) and translate this into practical advice for the beekeeper.
- Information gap from beekeepers. What information they actually miss, which is not currently provided/monitored? E.g. swarming monitoring, time of treatments, time of feeding, etc.
- Establishing an open source database of data (from sensors), but led by a public institution (e.g. Apimondia), rather that private companies. It would request a standardisation of the data (the existing BeeXML project might be a start for this) so that sharing and interoperability is possible.

The FG pointed out a lack of data standardisation across Europe, and a single repository or platform to access the information. To address this issue for example, Horizon 2020 research projects are required to use open data standards and encouraged to cooperate concerning data management.

It was mentioned that, for beekeeping, the B-GOOD project, together with the European Bee Partnership, is also working towards the standardisation and interoperability of data.

MP 6: DEVELOPING AND ENHANCING GOOD PRACTICES TO MITIGATE MAJOR BEE HEALTH STRESSORS: PESTICIDES AND LACK OF RESOURCES

- Effects of exposure to stressors from agriculture: e.g. knowledge of effect of novel chemicals, interactions, sub-lethal effects, resource quality e.g. pollen or nectar from plants from hybrid seeds.
- Work on identification, communication and implementation of mitigation practices amongst beekeepers, but also with farmers. For example, to test and find out best mitigation practices in terms of effectiveness, increase farmers awareness on the importance of bees and pollinators, work on agreements between beekeepers and farmers -enforced by local authorities-, etc.

The group mentioned that the Health Status Index proposed in MP2 could also consider effects of stressors from agriculture, in addition to pest and diseases.

MP 7: SUSTAINABLE BEE BREEDING

- Comparison of breeding practices and establishing quality indicators and criteria for breeding.
- Effective communication on how and why genetic diversity is important to convince beekeepers that they should look for genetic biodiversity, resilient bees and sustainable bee breeding.

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- Characterisation and conservation of local populations to increase the gene pool, also looking at feral bees, local breeding practices or study of relation between behaviour and ecotypes, etc.

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Annex 5: EIP-AGRI Operational Groups working on bee health

The table below compiles the Operational Group (OG) projects currently listed at the EIP-AGRI database (https://ec.europa.eu/eip/agriculture/en/eip-agri-projects/projects/). Date of consultation April 2020.

This is not an exhaustive list and more projects can be found at the national and regional databases of Operational Groups. See here the list of other available sources https://ec.europa.eu/eip/agriculture/en/links-existing-operational-groups

Title	Country
BeeOShield_An innovative biomolecular defence against bee parasites	Italy
Selection and Establishment varroa tolerant bee colonies VSH / SMR - short SETBie in BW	Germany
Control and minimization of damage by the invasive species *Vespa velutina nigrithorax* (Vespa velutina) in beekeeping	Portugal
Remote beehive monitoring, a new opportunity for nomadic beekeeping (NOMADI-App)	Italy
PICA: Innovative Platform for beekeeping	Spain
"Beekeeping, Agriculture and Environment" - Associate fruit growing and beekeeping for an agro-ecological and innovative management of production	France
DivInA- Diversification and Innovation in Beekeeping	Portugal
Biodivers Fruit Growing Limburg	Netherlands
BeeScanning 2.0 - monitoring a biological system	Sweden
Pasture for pollinators	United Kingdom
Pollinators for fruit growers and fruit growers for pollinators	Slovenia
Stimulation Pollination mix for climate adaptation	Netherlands

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