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## **Managing Apis Mellifera Bees' Mortality to Protect the Environmental Sustainability: Perceptions, Practices and Solutions of Beekeepers**

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### **ABSTRACT**

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#### **Keywords:**

*bees' decline, environmental sustainability, biodiversity, France, SMEs, stakeholder theory, beekeepers' managerial*

This study observes the managerial practices and perceptions of beekeepers during the decline of bees, in a context of high and increasing bee mortality that approaches 30% per year in Europe. Data collection was done through questionnaires and interviews with French beekeepers between 2018 and 2019. We analyze the results under the prism of stakeholder theory to identify all stakeholders (veterinarians, trainers, farmers, governments, associations, consumers) interacting with beekeepers. The results of the study are used to make recommendations to stakeholders. Due to the high mortality rate of 30% of bees, beekeepers renew at least 30% of their hives each year. They specifically request training on bee health and hive management (for amateur beekeepers). All beekeepers want organic farmers and want a medium-term cooperation between beekeepers, organic farmers and the government (through the application of environmental laws). All stakeholder aware of the disappearance of this pollinator-bees must act quickly to protect and conserve them on earth. This means that the stakeholders at their level must implement strategies of ecological transition in their behavior, because it is a question of saving the pollinators for the Welfare of the Society.

## **1. INTRODUCTION**

With a significant loss of bees that sometimes approaches 30% per year in Europe and 40% in the United States [1], the bees' mortality has a huge negative impact for the profitability of beekeepers, for food companies, for farmers, for the population and also for the biodiversity of our planet. In fact, 80% of fruit, vegetable, oilseed are dependent on pollinating insects, of which the bee is the leader. Thus, the bee acts as a sentinel and warns of damage to the environment and biodiversity.

The article attempts to answer three research questions that are related to the vulnerability term defined by Turner et al. [2] having three characteristics: exposure to decline, problem sensitivity and adaptive capacity. Thus, our research questions correspond to these three characteristics concerning the vulnerability of bees:

- What is the beekeepers' perception concerning the link between the bees' decline, agriculture, environmental sustainability and stakeholders' influence?
- How do beekeepers manage the impact of the bees' mortality and adapt their activity to the situation?
- What measures would be proposed by beekeepers in order to manage the bees' decline and to improve their relations with various stakeholders?

In order to answer these three research questions, we observe the beekeeper's perception and practices through questionnaires and interviews realized in 2018-2019 in France with 62% amateur beekeepers (31 amateurs) and 38% of professional beekeepers (19 professionals).

There are only several studies in management and economic academic literature on this subject. Several researches observe

the decrease of the global honey production and of the choice diversity of fruits and honey products for the final consumers [3, 4]. Other studies illustrate the economic pollination value and the importance of the pollination for agriculture [5-8]. These articles focus on the important role of bees in pollination, agriculture and economic value. Several studies present the negative impact of the intensification of agriculture and the pesticides utilization for bees and eco-systems [9, 10]. Finally, in the same spirit as the studies from [2, 11] highlight 3 types of business models that promote rural sustainability by identifying problem sourcing, co-governance implementation, and placemaking.

To the best of our knowledge, our study is the first one in the academic literature in management, observing the beekeepers' perception concerning the link between the bees' mortality, agriculture and environmental sustainability, and presenting the beekeepers' activity and proposals to manage the situation.

Several social scientists studied beekeepers' practices and they generally used interviews or questionnaires for their data collection, as we do in our study. Andrews [12] realized 54 semi-structured interviews with beekeepers, beekeeping educators, extension agents, and apiculture research scientists from United States in order to observe how beekeepers are constrained by the reality of the Anthropocene (human presence). They observe two categories of beekeepers, the first trying to save a modern beekeeping activity, the second militating to save the environment. We observe these two categories of beekeepers in our article too. Cilia [13] realized 43 semi-structured interviews with United States big beekeepers operating between one thousand and forty thousand hives to observe how large-scale beekeepers explain

and resolve the plight of the honey bee. In our article, we observe only small and medium beekeepers because they are more numerous and they feel better the negative impact of the bees' mortality. Suryanarayanan and Lee [14] realized several semi-structured interviews with the United States key players in the debate over insecticides in the honey-bee colony collapse disorder. Lorenz [15] conducted 17 semi-structured interviews in Germany, mainly with professional and amateur beekeepers, but also with representatives of their associations, in order to observe various beekeeping practices and initiatives, in urban and rural beekeeping. This study shows that new cooperations are developing between beekeepers and fruit and vegetable producers for a better beekeeping management.

Our paper contributes to the existing literature in multiple ways. To the best of our knowledge, this is the first academic study to undertake an analysis of small and medium beekeepers in France. We observe that almost all studies found in the academic literature analysed the situation in the United States and only two in Europe (in Germany). We analyse France because it is one of the biggest producers of honey in Europe and has a great agricultural diversity: intensive agriculture as in the Beauce and extensive agriculture in the Pyrenees, the Alps and the Massif Central. Furthermore, several studies analysed large beekeepers or urban and rural beekeepers, but no study was oriented small and medium beekeepers as we do in this article.

Furthermore, even if several studies discussed the importance to observe various stakeholders, no academic research was oriented to identify all stakeholders influencing the beekeepers' activity. Our study observes the French small and medium beekeepers and analyses various problems, perceptions and solutions of beekeepers in order to give a quasi-exhaustive identification of stakeholders and of various solutions to manage the bees' decline. This decline is a problem that could be solved only by working in a stakeholder team.

The stakeholder theory makes it possible to model the relationship between the stakeholders who revolve around beekeepers. Proposals for solutions could emerge from this analysis to protect bees and beekeepers' activity. Hoogendoorn et al. [16] explained that stakeholder theory is efficient when linking SMEs, and mandatory environmental legislative rules. SMEs therefore react more quickly in the act of protecting the environment than large companies when there is an environmental obligation. It is therefore interesting to use the stakeholder theory in our study, in order to find out which stakeholders interact around the beekeepers' activity and at which moment. Do these stakeholders have the same weight and importance to help beekeepers to save bees? In other words, what solutions this analysis could provide to solve the bees' decline.

The article is divided into four sections. The first one presents the theoretical framework used in our research (the stakeholders' theory), the second section exposes the methodology of our study and describes the data collection and analysis methods, the third one presents our results that are discussed in the fourth section.

## **2. THEORETICAL BACKGROUND: STAKEHOLDERS' THEORY**

The stakeholder theory enables a participatory approach to a strategical action in a company [17]. Rather than considering

the strategy only in the unique dimension of combating competition (not adequate to beekeepers' activity), the stakeholder theory advocates the integration of all partners in the approach. It is a concept based on constructive negotiation in which we arrange for each of the stakeholders to find their interest in cooperating.

This theory is the most adapted to our study because, firstly, we observe the decline of bees in small and medium-sized beekeeping activities (very high bee mortality for amateur beekeepers with less than 10 hives), secondly, it is interesting to know the perception, practices and solutions of beekeepers faced with high bee mortality, to know all the direct or indirect actors involved in the beekeeping activity and finally to know our analysis as researchers and beekeepers. In the beekeeping academic literature, we have identified only three studies concerning several stakeholders influencing beekeepers' activity and we present below their results useful for our study.

The stakeholder's theory is also linked with the environmental sustainability. Hoogendoorn et al. [16] observed that there is a positive relationship between the size of the company and the implementation of an ecological process. The smaller the company, the stronger the ecological process when there are mandatory legal rules. This study explains that the stakeholder theory is relevant to consider when dealing with SMEs and their impact on the environmental field. SMEs would be more likely and faster than large companies to have a design based on constructive negotiation so that each of the stakeholders finds its interest in cooperating especially when we take into account the environmental sustainability.

This theory is the most adapted to our study because, firstly, we observe the decline of bees in small and medium-sized beekeeping activities (very high bee mortality for amateur beekeepers with less than 10 hives), secondly, it is interesting to know the perception, practices and solutions of beekeepers faced with high bee mortality, to know all the direct or indirect actors involved in the beekeeping activity and finally to know our analysis as researchers and beekeepers. In the beekeeping academic literature, we have identified only three studies concerning several stakeholders influencing beekeepers' activity and we present below their results useful for our study.

Andrews [12] observed two categories of beekeepers. The first group is trying to save a modern beekeeping industry being in contact with conventional agriculture with its large and distant monocultures. The other group is trying to save nature and bees by moving away from an overreliance on industrial agriculture, trying out unconventional methods for sustainable stewardship, approaching beekeeping holistically and with care, and rejecting easy solutions such as removing synthetic chemicals only. For both groups, the author identified a network of professional beekeepers, researchers, educators across agribusiness, government, and academia. Freeman's stakeholder model redefined by Fassin [18] introduced a new clarification of stakeholders: stakeholder (who hold stakes), stakewatchers (pressure groups) and stakekeepers (regulators).

Suryanarayanan and Lee [14] conducted interviews at two national beekeepers' conferences, held in 2010 in Orlando, Florida and in 2011 in Galveston, Texas. They listened and spoke with beekeepers, scientists, academics, industry and government officials. Their findings show that beekeepers are marginalized; their knowledge is delegitimized as 'anecdotal', 'simply trial and error', 'ad hoc' by regulatory actors, academics and agro-industry actors. Lorenz [15] realized 17 interviews in

Germany, mainly with professional and hobby beekeepers but also with representatives of their associations, public officials and academic scientists. This study identifies several categories of stakeholders such as Government, industry, researchers, educators and growers but no analysis of the influence of these stakeholders on beekeeping activity.

In our article, we take into account these studies by identifying the perception of beekeepers concerning the stakeholders influencing the beekeeping activity and their proposals to manage the bees' decline.

### 3. METHODOLOGICAL APPROACH, SAMPLE AND DATA COLLECTION

The methodology attempts to answer three questions that are related to the problem of vulnerability characterized by three characteristics [2]: the bees' decline, the sensitivity of beekeepers and their adaptive capacity. We present also several measures useful to improve the situation. To implement this model in our study, questionnaires and interviews were realized. In the academic literature, almost all studies used semi-structured interviews to analyse the beekeepers' activity: Andrews [12] realized 54 interviews, Cilia [13] realized 43 semi-structured interviews, and Lorenz [15] realized 17 interviews. We have tried to have the maximum number of questionnaires and interviews like in the literature and we realized 55 interviews and deep answers to our survey.

The sample is formed by small and medium French beekeepers. The data was collected through a 40 questions questionnaire between 2018-2019 (Appendices 1). We consider small beekeepers those having less than 350 hives (amateur and professional beekeepers), and medium beekeepers those having between 350 and 1000 hives (professional beekeepers). We have obtained 50 answers. We have realized also five interviews with beekeepers having a long experience in managing bees (more than 40 years of activity and more than 100 hives).

The questionnaire and interview guidelines included open and closed questions grouped around four themes:

- (1) the beekeeping experience and managerial practices,
- (2) the legal structure (professional or non-professional),
- (3) the perception of beekeepers about their practices and the link with the environmental sustainability, and
- (4) the proposals for managing the crisis.

These themes were elaborated from the beekeeping experience of one of the authors of the article and also from various information identified in the literature, in apicultural meetings, union meetings and seminars, and from documents of the Union Nationale de l'Apiculture Française (National Union of French Apiculture).

Not all the answers to the questions are set out in the article, only those that concern the problem of the vulnerability of bees in the sense of Turner et al. [2]: bee's decline, sensitivity of beekeepers and adaptive capacity of beekeepers.

To validate our sample of 50 amateur and professional beekeepers in our questionnaire, we calculate the confidence interval of the percentages of beekeepers with bee losses (S=26) for the sample size (N=50 beekeepers).

We use the following formula with the normal distribution:

$$P \left( \frac{S}{N} - 1.96 \sqrt{\frac{\left(\frac{S}{N}\right) \left(1 - \left(\frac{S}{N}\right)\right)}{N}} < P \right. \\ \left. < \frac{S}{N} + 1.96 \sqrt{\frac{\left(\frac{S}{N}\right) \left(1 - \left(\frac{S}{N}\right)\right)}{N}} \right) = 0.95$$

With S=26 beekeepers with bee losses and N=50 beekeepers, we find that the 95% confidence interval is [0.382; 0.658]. It is 95% certain that between 38.2% and 65.8% of beekeepers have 30% bee losses. If we do the same calculation with those who have more than 30% of loss (9 out of 50, 18%), we find that the 95% confidence interval is worth [0.074; 0.286]. It is 95% certain that between 7.4% and 28.6% of beekeepers have more than 30% bee loss.

### 4. RESULTS AND DISCUSSION

We present the results in three different sections according to our three research questions formulated in the introduction. We consider that the survival of the species can only be achieved through the understanding and action of all stakeholders around the beekeepers' activity.

#### 4.1 What is the beekeepers' perception concerning the link between the bees' decline, agriculture, environmental sustainability and stakeholders?

In order to answer this question, we observe the perception of beekeepers concerning the loss of bees, the causes of bees' decline with a focus on the agricultural European policy, and the economic consequences of the bees' decline.

- Regular loss of bees in time observed by beekeepers.

100% of beekeepers have observed a regular loss of bees over time (question 26). The beekeepers perceive this strong decline since the 2000s. In Table 1, Bees' decline observed by beekeepers show that there are 52% beekeepers observing a 30% loss of bees on average per year and 18% of beekeepers observing more than 30% loss of bees.

**Table 1.** Bees' decline observed by beekeepers

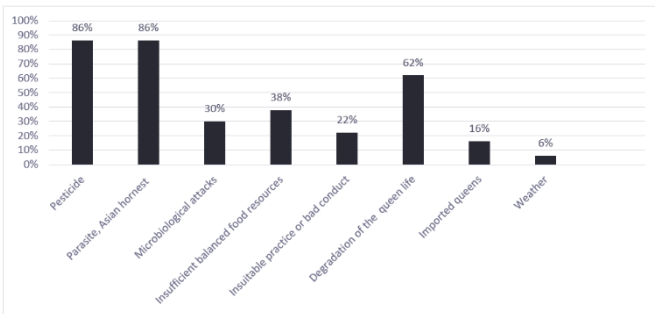
Loss of bees in %	Answers in %
Less than 10%	6%
Between 10% and 29%	24%
30%	52%
Between 31% and 90%	12%
Between 91% and 100%	6%
<b>Total</b>	<b>100%</b>

In addition to Table 1, question 29 indicates that 76% of beekeepers consider that bees are in a real danger.

- Causes of bees' decline observed by beekeepers.

There are various causes for the bees' decline as presented in the Figure 1, pesticides, parasites, microbiological attacks, insufficient balanced food resources throughout the season imported queens not adapted to the ecosystem, unsuitable practices of some beekeepers, or degradation of the life expectancy of the queen. The beekeepers consider that the

most important causes for the bees' decline are the use of pesticides in agriculture and various parasites (question 27), so a strong collaboration between beekeepers with farmers and agriculture industry is paramount.



**Figure 1.** Causes of bee population decline

- Negative impact of the Common Agricultural Policy (CAP) on the bees' life.

The Common Agricultural Policy (CAP) is a system of subsidies paid to European farmers having the main purposes to guarantee minimum levels of production, in order to have enough food to eat, and to ensure a fair standard of living for those dependent on agriculture. The specific objectives of the CAP: to increase agricultural productivity by promoting technical progress and ensuring the optimum use of the factors of production; to ensure a fair standard of living for farmers; to stabilize markets; to ensure the availability of supplies; to ensure reasonable prices for consumers.

Questions 30 to 33 of our questionnaire explain how beekeepers perceive the CAP and the link between bio-diversity, environment and bees' mortality. 68% of beekeepers consider that CAP had a negative impact on bee survival and bio-diversity (question 30). Some explain the harmful influences of the CAP: "the CAP has removed the triennial", "CAP of 1992 and 2008 advocate monoculture with tearing hedges", "drainage with loss of wetlands", "productivity research and acceptance by PAC of chemical inputs that harm bio-diversity".

- Development of green areas and bio-diversity.

Regarding the management of the agroecosystem, studies indicate that the presence of semi-natural environments (hedgerows, grass strips, flower strips, etc.) near the plots can increase the population of bees and especially the presence and the wealth of wild bees [19]. These wild bees have a very important interest in pollination because they stimulate the managed bees. Indeed, competition drives managed bees to visit more flowers (interaction of behaviours between species). Thus, on sunflower and seed crops, the interaction between managed bees and wild bees can double the pollination service of bees managed alone [20]. The question 34 illustrates that 90% of questioned beekeepers request green areas and thus to have both managed and wild bees in order to improve the pollination service of their managed bees.

Question 30 of the questionnaire indicates that monoculture, the loss of hedgerows, the loss of wetlands, are mentioned by many beekeepers in their explanation of the degradation of biodiversity and the bees' life (question 27).

Answers to the question 40 on bio-diversity evoke several solutions proposed by beekeepers: "to develop the local eco-type instead of importing bees", "do not destroy all the trees during the cutting of trees period, because the floral diversity disappears with the total cut", "to stop bitumen", etc."

- Bees' decline and negative consequences.

The decline of the honey production caused by the bees' mortality is observed by all questioned beekeepers. This decline in pollinators could have important consequences for the environmental, social and economic levels. Indeed, about 80% of wild plants depend on pollinators to reproduce. The disappearance of pollinators would result in the disappearance of all these species and would unbalance ecosystems [21].

The results (Table 2) of questions 12 and 8 present a 96.5% correlation between the honey production and the numbers of hives. More hives, more honey but drop in the overall amount of honey over time. This means that increasing the number of hives keeps the livestock from one year to the other, but doesn't produce more honey. Questions 8 and 17 identify a negative correlation of -30.6% between hive loss over time and bee stock increase every year. This means that beekeepers renew hives every year to offset the loss of livestock (Table 2).

**Table 2.** Correlation table among the different variables

Variables	Number of hives. Question 8
<b>Honey production</b> question 12	96,5% ** p<0,01** N=50
Variables	Hives loss over time. Question 8
<b>Bee stock</b> question 17	-30,6% * p<0,05* N=50

As it has been said, the Beekeepers observe a regular loss of bees in time. There is also a strong relationship between the bees' decline, current agriculture and environmental sustainability by having a very vulnerable bee stock exposure.

The second part of our results presents how the beekeepers manage the bees' decline and adapt their apicultural activity.

#### 4.2 How do beekeepers manage the impact of the bees' decline and adapt their activity to the situation?

We observe several characteristics of the beekeepers' reaction to the bees' decline:

Financial provisions or renewal of hives.

Different types of accounting financial provisions are made by beekeepers in order to protect them against the bees' decline: provisions for bee loss (80% of beekeepers), for risk of production decline (10%), for decline in consumer's consumption of honey (4%), no provision (6%) (question 19).

We observe a difference between amateur beekeepers and professional beekeepers. Amateur beekeepers with less 10 hives say: "if we have 2 beehives, we try to have 2 or 3 beehives all the time, so we renew 2 hives in the spring (renewal 100%)"; or, "I have few hives and a loss of 70% per year; 70% additional livestock is expected per year". In reality, the term "provision" is used by the amateurs to renew hives in order to keep the same numbers of hives.

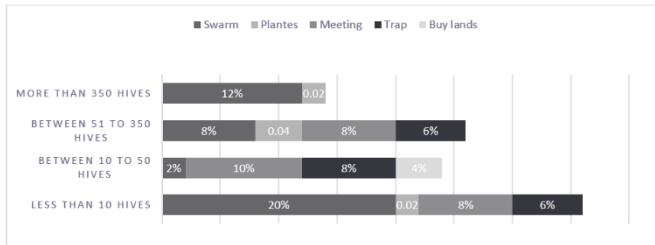
The professional beekeepers react differently: "the provision corresponds to 40% of profits" or "the equivalent of 30% of swarms". This is a recognized accounting financial provision for the estimated loss of hives.

Beekeepers have two different ways to compensate the heavy annual bees' losses. Professional beekeepers introduce a line in accounting ("provision for bee loss") for the value of the renewed hives. The amateur beekeepers renew their hives in the spring, by buying bees (hives), by buying queens, or by recreating artificial swarms. By renewing the hives for a third

on average, the amateur beekeeper pays to sustain the environmental sustainability and to protect the bees' life, while the professional beekeeper realizes financial provisions for bee loss and honey production loss and thus obtains tax advantage.

- Environmental expenses to protect the bees' life.

Question 22 presents the expenses realized by beekeepers to protect environment and bees. By crossing this question with the number of hives (question 8), we find that small beekeepers participate more actively in the protection of the environment and life of bees than medium beekeepers.



**Figure 2.** Expenses with the protection of bees' life

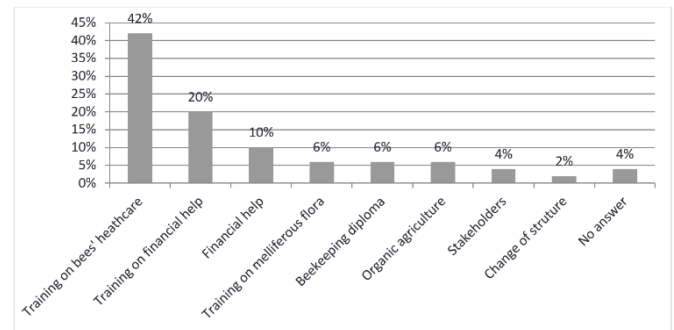
In Figure 2: Expenses with the protection of bees' life, we observe that beekeepers with more than 350 hives give only two answers to protect bees: they remake swarms artificially (12%) and plant melliferous plants (2%). Very small beekeepers (less than 10 hives) do several things to protect the life of bees: artificial swarming (20%), attend meetings of environmental organizations (8%), make traps against Asian hornet and varroa (6%), and plant melliferous plants (2%). The beekeepers between 10 and 350 hives also carry out four actions, but with less weight than small beekeepers with less than 10 hives. They remake swarms (10%), participate in meetings (18%), trap the Asian hornet and act against varroa mites (14%), buy land (4%) (beekeepers between 51 to 350 hives), and plant melliferous plants (4%) (beekeepers between 10 to 50 hives). It can be seen that small beekeepers participate with greater diversity and weight in the protection of bees and indirectly in bio-diversity and the protection of the environment.

To conclude this section, we can observe that the small beekeepers react differently than the medium ones faced to the bees' decline. Firstly, the small ones (amateur and professional beekeepers) renew their hives. The small and medium professional beekeepers create accounting financial provisions and obtain tax advantage. Secondly, the small ones have a more active participation and more diversified actions to protect bees' life and environmental sustainability than the medium beekeepers have. The reason is that professionals with more than 350 hives make a living from beekeeping and focus more on the financial management of their hives and do not have the time to attend all sustainability meetings. But this does not prevent them from being very concerned about the high mortality of bees and use the same techniques as small-scale beekeepers to protect the bees.

#### 4.3 What measures would be proposed by beekeepers in order to manage the bees' decline and to improve their relations with various stakeholders?

Beekeepers develop in question 40 their needs to participate widely in the protection of bees, of environment and of their economic activities. The answers are presented in Figure 3:

Needs of beekeepers to protect bees and environmental sustainability.



**Figure 3.** Needs of beekeepers to protect bees and environmental sustainability

Some beekeepers are asking for an improvement in their relationship with stakeholders (4%), State aids (only 10%) and organic farming (6%), but the vast majority seeks to have the maximum of information and training to better manage their bees. 68% of beekeepers want to be trained for the health of bees, financial aid, and flora. 6% even ask for a diploma beekeeping. We present in more detail below the different needs and proposals of beekeepers.

- Training of beekeepers.

Beekeepers ask different types of training: 42% of respondents want to have courses on bee health, 20% on financial aid, 6% on melliferous flora, and 6% would like to have a beekeeping diploma.

Beekeepers say that beekeepers should be trained on good apicultural practices and responsible production for the bee health (question 34). They also want to have a health assessment before and after transhumance to better control the health of bees, and to better understand the diseases of bees, how to prevent and treat them (for example, European foulbrood). Beekeepers also require training in general: management of wild and managed bees and pollination. 6% of respondents consider that a beekeeping diploma would be essential. Thus, they say that it is necessary: "to train amateurs beekeepers to be able to teach farmers about bees' life" and "to encourage beekeepers financially to have a compulsory formation (questions 34 and 40).

- Development of agri-environmental measures (AEM).

90% ask for agri-environmental measures (AEM). Questions 31 to 33 give more information about the AEM policy and the utility for beekeepers. Question 33 highlights proposals made by beekeepers to promote the AEM: "remove pesticides", "freeze land to rest the earth and let out flowers", "develop hedges, preserve trees on the edge of fields", "promote diversity and not monoculture". In addition, one respondent considers that "the beekeeper must be a stakeholder and not a simple actor to participate in the environment".

Medium beekeepers having more than 350 hives (Professional beekeepers) are the ones who made the most proposals about the AEM and who know the impact of the Common Agricultural Policy (CAP). Only 2% of them do not know the impact of the CAP on the beekeeping. 88% of beekeepers consider that financial aids are needed for farmers to go organic (question 38) and 6% of beekeepers say that they must help farmers to control pollination and to encourage them to produce organic.

- Improvement of the collaboration between farmers and beekeepers.

The pollination service is a free service but could have a significant impact from an economic point of view if the pollinators disappeared. The total value of this global pollination service for food production is estimated at €153 billion representing 9.5% of the world agricultural production value [22]. 92% of answers to the question 36 illustrate that the protection of bees and pollinators can only happen with a strong collaboration between farmers and beekeepers.

Question 33 focuses on the measures to be taken by beekeepers and farmers to develop the AEM: "to have a strong collaboration between the State, trade unions, beekeepers and farmers", "to create new green zones", "all agricultural projects should be thought with agreement between farmers and beekeepers", "to adopt more transparency in the sense of do not hide anything about what is put on plants" and "to help farmers to go organic with financial aid over 5 years with control over 5 years", "to improve the beekeeper-farmer cooperation with the help of communities or the State".

58% of beekeepers say that there is no need to change the apicultural legal structure, 28% say that a structural change is needed, and 14% don't say anything (question 39). They explain what should be done: "no legal modification of beekeeping, but meetings are essential between farmer and beekeeper to collaborate", "beekeepers could have a function in learning the knowledge of bees with farmers (especially beekeeping know-how about pollination. To conclude this section, we could say that a stronger collaboration between farmers and beekeepers is encouraged in order to protect environmental sustainability.

- Create territorial network of beekeepers.

Question 37 presents the importance of the territorial network of beekeepers by supporting associations and unions of small beekeepers. 100% of interviewed beekeepers attend apicultural meetings and attend bee protection conferences during the year. We could propose the creation of an organization that could help especially amateur beekeepers to improve their practices.

- Development of green areas and bio-diversity.

Regarding the management of the agroecosystem, studies indicate that the presence of semi-natural environments (hedgerows, grass strips, flower strips, etc.) near the plots can increase the population of bees and especially the presence and the wealth of wild bees [19]. These wild bees have a very important interest in pollination because they stimulate the managed bees. Indeed, competition drives managed bees to visit more flowers (interaction of behaviors between species). Thus, on sunflower and seed crops, the interaction between managed bees and wild bees can double the pollination service of bees managed alone [20].

The question 34 illustrates that 90% of questioned beekeepers request green areas. Question 30 indicates that the loss of hedgerows since 1945, the stopping by the CAP of the triennial for agricultural land are mentioned by many beekeepers in their explanation of the degradation of biodiversity and the bees' life (question 27).

Answers to the question 40 on bio-diversity evoke several solutions proposed by beekeepers: "to move towards the country bee adapted to the local environment", "do not destroy all the trees during the cutting of trees period, because the floral diversity disappears with the total cut", "to stop mowing to keep blooming, etc."

- Improvement of Beekeepers and Stakeholders relationship.

The beekeepers consider very important to improve their relationship with the stakeholders presented in Figure 4: Beekeepers and Stakeholders relationship, in order to manage the bees' decline. Government, agriculture, agri-food firms, associations and sustainable NGO are paramount in a long-term strategy to protect the environment and to have a good influence on the bees' decline. The Government realizes perennial acts to protect the environment by various laws, agriculture and firms should implement a long-term sustainable strategy to protect the environment, and associations and NGOs push the Government, agriculture and firms to act for the environment and sustainability economics.

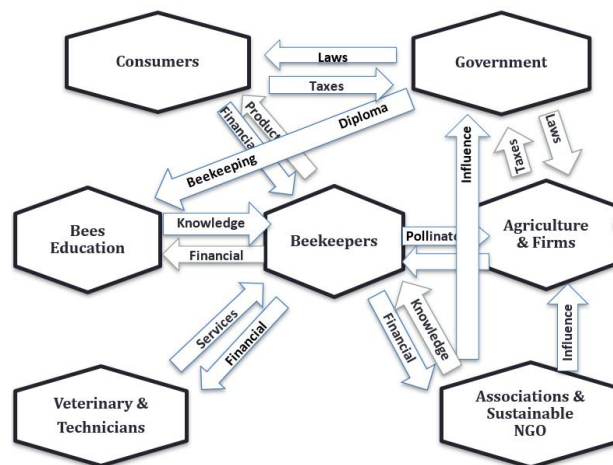


Figure 4. Beekeepers and stakeholders relationship

We analyse below the importance of stakeholders seen by beekeepers. We observe that only 4% of beekeepers consider important to improve their cooperation with various stakeholders. But in reality, there are a lot of beekeepers asking to create beekeepers' networks, to work with farmers, to improve the agriculture policy, to have a better implication of the Government, a.s.o. 92% of answers to the question 36 illustrate that the protection of bees can only happen with a strong collaboration between farmers and beekeepers. Taking into consideration these answers, we could observe a difference between the beekeepers' perception of the influence of stakeholders of only 4% and the real connection they consider necessary to manage the bees' decline is at 92%. So, we could say that several beekeepers don't really know the real meaning of stakeholders influence, even if they recognize the need to work with various stakeholders to manage the bees' decline.

In the answers to question 33, beekeepers demand "a rapid awareness of Governments and the implementation of environmental solutions", "a better relationship between different stakeholders (beekeepers, State, agriculture institutions)". Post et al. [23, 24] explained the importance of inter-stakeholder relationships, which involve a complex relationship rather than just a series of dynamic connections between stakeholders and the corporation. They try to understand who the relevant stakeholders are and whether we are talking about stakeholders or relationships among stakeholders. We try to identify all these elements below.

Agriculture interacts directly with pollinators because they act directly in flowering crops. More pollinators, more production for the farmer. In the same time, the diversity and

quality of flowers feed bees and then allow agriculture to produce quality fruits and vegetables leading to well-being of the consumer. The beekeepers expressed themselves in the questionnaire by saying: "they would be interesting to have a strong collaboration with the farmers to manage the food of the bees but also to help in the pollination of the cultures". They say that "the CAP was detrimental for pollinators". It would be very good to switch to organic farming to maintain pollinators, to attract more farmers of organic products and to satisfy consumers with quality honey and fruit. A good, pesticide-free soil product maintains the life of the bee and the production of honey. In Cuba, for example, without pesticides, a beehive produces 100 kg of honey on average per year, and there is very little mortality because no farmer uses pesticides.

Agri-food companies benefit indirectly from pollinators but they are not currently paying for it. These companies are generally sceptical of their direct responsibility for the environment. With more communication and legislative constraints, these companies could better understand the importance to participate to the indirect ecological cost of pollination.

Consumers need to have quality honey and fruits and vegetables so they need to know the quality of the honey and where it comes from. For this, the Government has an important role to legislate by putting labels on the origin of honey. If less pesticides, fruits and vegetables will be better, and therefore better for the health of consumers.

The veterinary technician and the beekeeping technicians are very important stakeholders for beekeepers because they check the health of hives to prevent the spread of diseases. In question 34, beekeepers speak about a need of a "systematic visit by a beekeeping technician", about the "developments of cantonal agents to follow up with independent veterinary control", and they ask "to be checked by independent veterinarians before and after the transhumance of the bees or before or after having exposed the hives to large-scale seeds, such as rapeseed, sunflower and almond trees." Beekeepers therefore need beekeeping technicians who check the condition of hives and advise them on the health management of the bees, but they need veterinarians who control the health of bees and prevent the spread of the diseases.

Trainers in beekeeping management are very important in explaining good beekeeping practices. In addition, with the intervention of the State, it would be interesting to implement a beekeeping diploma.

Government plays a primordial role by its coercive force linked to the environmental legal rules which must concern the safeguarding of the environment. Indeed, the Government can help farmers to switch to organic farming, train them in ecological techniques and offer them financial assistance. The Government can also protect the consumers and require beekeepers to put in place labels on the origin and the quality of honey. For beekeepers, the Government can improve legislation to encourage good beekeeping practices and the preservation of the local bee, and can create a national beekeeping diploma. In addition, the Government can legislate for the extension of green areas, for the implementation of fiscal and legal rules for the safeguarding of biodiversity (through financial provisions, through new corporate taxation which contributes to support pollination). The Government should give more weight to ecological and beekeeping associations about environmental decisions.

The perspective of stakeholders is useful in the context of SMEs and environmental practices because understanding the

influence of stakeholders is important to meet the specific demands of beekeepers. It is also necessary to have rapid interactions with stakeholders over time to safeguard biodiversity and environmental sustainability.

We propose in Table 3: Stakeholders weight and actions depending on the period, a summary of various actions realized or to be done between beekeepers and stakeholders on short term, medium term and long term to reduce the bees' decline and to maintain beekeeping activity.

**Table 3.** Stakeholders weight and actions depending on the period

Stakeholders actions	Short Term	Medium Term	Long Term
<b>1 - Survival of bee's and beekeepers</b>			
- Beekeepers alone (renewal of hives)	X		
<b>2 - Bees health, apiary managment</b>			
- Veterinary (health of bees) (skakekeeper)	X	X	
- Bees education (hives management) (skakekeeper)	X	X	
<b>3 - Essential collaboration</b>			
- Association and sustainable NGO (stakewacher)		X	X
- Agriculture (organic) (stakeholder)		X	X
<b>4 - Social pressure and law</b>			
- Government (law) (stakeholder)		X	X
- Consumers (organic foods and health) (stakewacher)		X	X

Various stakeholders do not interact with beekeepers for the protection of bees and the support of beekeeping activity at the same time. To save the bees from a rapid decline, the amateur and professional beekeepers manage alone his bees, renewing them at least 30% every year. The stakeholders involved are veterinarians and instructors on bees' health (*stakekeepers* in the sense of the stakeholder theory of Fassin [5]) by offering training on bee health, predator destruction techniques and beekeeping management. Amateur beekeepers are more present in these courses than professionals. Consumers and associations interact like pressure group (*stakewatchers*) to protect the environment and to have quality products. Finally, the stakeholders essential in the long-term strategy on the survival of bees are farmers and the Government (*stakeholders*). Pollinators can be saved on the long term only if there is a strong collaboration between beekeepers and farmers by going towards organic agriculture (100% request of beekeepers in our questionnaire). The Government must also interact through the laws on the environmental protection. In the same spirit, for businesses to adapt to a sustainable environment in rural areas, the models of Swaffield et al. [11] engage strategies such as environmental management systems, certification, ecosystem and landscape services, and spatial planning.

## 5. CONCLUSION

This article observes the beekeeper's perception of the bees'



decline, their practices and proposals to improve the situation.

First, beekeepers have observed a strong link between bee declines, agriculture, and environmental sustainability. All beekeepers have observed declines in bee numbers, with frequent loss of bees over time. 52% of beekeepers observed an average annual bee loss of 30% and 18% observed more than 30% bee loss. The main reasons for the decline in bee numbers are the use of pesticides in agriculture and the presence of various parasites (*varroa* mites or others). Beekeepers also believe that CAP has a negative impact on bee survival and biodiversity. At the same time, the decline of pollinators could have important ecological, social and economic consequences. 80% of wild plants rely on pollinators for reproduction. The disappearance of pollinators will lead to the disappearance of all these species.

Second, with regard to the adaptation of beekeeping activities to bee decline, we observe that small and medium beekeepers renew their hives, but amateur beekeepers pay to participate in environmental sustainability by replacing dead hives with their own money, while professional beekeepers get tax advantage. Indeed, amateur beekeepers renew their hives without realizing financial provisions, while professional beekeepers create financial provisions for bee loss and honey production loss, and obtain tax advantage. We observed that small beekeepers are more actively involved than medium-sized beekeepers and take multiple measures to protect bee life and environmental sustainability.

Third, concerning the measures proposed by beekeepers in order to adapt their activity to the bees' mortality, beekeepers ask to have training on bee health, on financial aid, and on melliferous flora. The most important training asked by them is about good apicultural practices (especially for amateurs) and responsible production for bee health. Furthermore, beekeepers ask to have a beekeeping professional diploma to assist farmer-beekeeper collaboration. They consider also important to help farmers to control pollination and to encourage them to produce organic products, to protect the bio-diversity and to increase green areas. The majority of beekeepers consider important to implement agri-environmental measures, with 92% agreeing that protection of bees and pollinators can only be achieved through close cooperation between farmers and beekeepers.

At the same time, it would be interesting to develop territorial network of beekeepers, environmental associations and beekeepers' unions to exchange on beekeeping practices and bee mortality issues (e.g. exchanges between amateur and professional beekeepers for better management of hives and to get practical information from veterinarians on bee health). Beekeepers are increasingly aware of the need to improve relationships with a variety of stakeholders including government, consumers, unions, farmers, trainers, technicians, veterinarians, and businesses. Given the urgency of the situation, all beekeepers are calling for a new agricultural model that limits chemical inputs and thus preserves bees, biodiversity and, with them, the future of our farmers.

The general objective pursued by the interviewed beekeepers can be defined as "beekeeping in harmony with nature". Indeed, the analysis of the questionnaire indicates that the desire for the protection of nature is shared by all beekeepers interviewed, which implies that the understanding of nature goes beyond a simple factor of production. For beekeepers, the importance of natural sites' extension to protect the bees and other pollinators is also high.

In addition, stakeholder theory (Clarkson [25]) is based on constructivist negotiation, in which each participant is interested in working together. Firstly, the beekeeper renewing the hives avoids the disappearance of the bee and needs stakeholders such as veterinarians and instructors to manage the apiary and the health of bees. Secondly, environmental associations and consumers push for organic products and environmental protection. However, the maintenance of the beekeeping activity on the long term requires a strong collaboration between beekeepers and farmers (This would avoid the use of pesticides, improve pollination and provide a regular income for the professionals) and by enacting sustainable environmental laws by the Government.

This article could be useful for beekeepers to improve their economic activity, for other countries in the world facing the bee crisis, for researchers interested in further analysing beekeepers' practices and perceptions, and for stakeholders to better understand the role beekeepers play with farmers, food companies, and consumers. In other words, this article proposes solutions both in the design of good beekeeping practices and in the possible solutions for stakeholders. The bees can only be saved if all involved work together.

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## APPENDICES

### 1: Survey “Save the bees!”

- 1- Name of the company and / or beekeeping number  
Your answer:
- 2- Date of creation of the company or activity  
Your answer:
- 3- Type of company:  
SNC; SARL; UARL; Other:
- 4- Are you:  
Company; Family producer; Amateur; Other:
- 5- Did you kept the structure or type of your company from the initial creation date?  
Yes; No
- 6- If no, give the types of companies and the date of change of the structure.  
Your answer:
- 7- Number of employees now and in time (with dates)  
Your answer:
- 8- How many hives do you have now? Could you specify the evolution over time?  
Your answer:
- 9- What kind of hive?  
Dadant; Warré; Voironot; Langstroth; Straw; Other:
- 10- What are your main production activities?  
Honey production; Royal jelly; Pollen; Propolis; Wax; Other:
- 11- These main activities have always been the same? Otherwise please give the main activities from the past.  
Your answer:
- 12- How much honey per hive do you produce, per year and on average?  
Your answer:

13- Is this evolution declining?  
 Yes; No

14- Do you make processed products? If yes, which ones?  
 Gingerbread; Nougat; Drink; Various

15- Do you make livestock production? If so, what type?  
 Swarms; Queens; Other:

16- Do you pollinate fruit trees?  
 Yes; No

17- Have you lost beehives each year or over the years? If so, in what proportion (in%)?  
 Your answer:

18- The loss mentioned above it is visible in your financial statements? Which? How?  
 Your answer:

19- Do you take provisions?  
 For bee loss; For risk of production decline; For a decline in consumers' share of honey consumption; Other:

20- If you do provisioning, please provide the amount for each category.  
 Your answer:

21- Do you have biological or ecological assets in your accounting?  
 Yes; No

22- Have you spent money to protect the environment to ensure better living conditions for bees? If yes, how?  
 Your answer:

23- Do you have quality certifications or environmental certifications for your products ("organic", "fair", etc.). If yes, which one?  
 Your answer:

24- Does your financial result (profit or loss) on your activity increase / decrease each year?  
 Your answer:

25- Please provide the evolution of the result of your activity over time in % (since the creation of the company if possible).  
 Your answer:

26- Have you observed a bee loss over time?  
 Yes; No

27- If yes, what do you think are the causes of bee losses (several choices are possible):  
 Pesticide; Parasite (Varroa, others); Microbiological attacks (viral bacteria); Insufficient balanced food resources throughout the season; Imported queens are not adapted to the ecosystem; Unsuitable practice of some beekeepers; Degradation of the life expectancy of the queen; Other:

28- Do you think that bees are in danger and that they may disappear in the short term?

Yes; No

29- Do you think that bees live alone, or is it the beekeeper who keeps them alive?  
 Your answer:

30- Did the different Common Agricultural Policy (CAP) policies of 1992, 2008 and 2014 have an effect on biodiversity and an impact on the life of bees? If yes, at what time?  
 Your answer:

31- Have you had contracts between farmers and beekeepers for pollination, plants and / or fruit trees, as part of the Agro-Environmental Measure (AEM)?  
 Yes; No

32- Would you find it interesting to develop this AEM in the context of the CAP in your area?  
 Yes; No

33- If yes, how can these AEM are developed?  
 Your answer:

34- Do you think it is necessary to extend on a large scale the natural site of compensation and green areas, in order to protect the bees?  
 Yes; No

35- Do you think that a tax should be imposed on businesses and the community (through the state) to invest in ecological sustainability in the very short term?  
 Your answer:

36- Do you think that a strong collaboration between farmer and beekeeper is essential?  
 Yes; No

37- Do you attend meetings or are you part of some associations that try to protect bees and / or the environment?  
 Yes; No

38- Do you think that it would be interesting to help, through the governmental actions, the farmers (financial means, traineeship over 5 years, and other means) so that they can switch to organic agricultural production or a reasoned agricultural production?  
 Yes; No

39- If yes, do you think that a change in the structure of beekeeping activities is essential for a strong collaboration between the farmer and the beekeeper?  
 Your answer:

40- What kind of actions the producers from apiculture would need in order to participate more widely in the biodiversity?  
 Traineeship; Change of the structure of the activity; Financial assistance to develop the activity on large areas; Others