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L’insecte Sage in the Age of Global Climate Crisis: A Biocultural and Ontological Study of Vulnerability and Resilience in the Manakara Beekeeping Network

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L’insecte Sage in the Age of Global Climate Crisis:
A Biocultural and Ontological Study of Vulnerability and Resilience in the Manakara Beekeeping Network

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Abstract

The effects of climate change are felt unevenly throughout the globe. Impoverished populations with high levels of subsistence agriculture are particularly vulnerable due to their direct dependence on the land. However, these populations are also the possible agents of change and solutions, as their traditional ecological knowledge has evolved in relation to their context. The honeybee is directly implicated in climate change vulnerability due to its role in pollination services, by ensuring food security. In the past decade, honeybees have risen to international fame and scrutiny due to a global vanishing of bees, attributed in part to climate change and the increasing biological insecurity of a globalized honey market. This global event raised the questions, “what would be lost with the loss of bees, and what can be done?”

As one of the most impoverished nations and high number of subsistence farmers, Madagascar has been identified as one of the most vulnerable countries to climate change. Furthermore, its re-entrance into the global market of honey due to modernization in 2009 has exposed its bee populations to the threats of the varroa mite, exacerbating this endemic population’s vulnerability to climate change. This study seeks to examine the ontological and bio-cultural significance of the honeybee in the region of Vatovavy Fitovinany, within the district of Manakara, to understand the vulnerability of the beekeeping network and their resilience to climate change. Ultimately, this project examines the concept of entangled ecological vulnerability, of both humans and the honeybee, and how traditional ecological knowledge (TEK) can be incorporated in a multi-species framework for climate change mitigation and decision-making.
When bees cease buzzing
what will happen to this world
no longer held from pole
to pole in a network of flight

Who will tell the flowers to bloom
the seasons, the continents
to slow their drift, and the earth to hold fast to its hot core

---

1 Inspired and reformulated by beth franks
To the bees:

thank you.
Acknowledgements

Much like the buzzing’s of a hive, the production of this ISP was not an individual endeavor but rather a collaborative and collective effort by a medley of individuals. Without whom, this project wouldn’t have come to fruition.

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Introduction

“Without bees, there would be no man. We would have nothing. No food, no medicine, nothing.” The beekeeper in front of me in a shaded lychee honey grove earnestly gesticulates; a sweeping gesture with a flat palm cuts into the air at the word nothing to emphasize the finality and certainty of this statement. “Without bees, there would be no man.” This statement elucidates the entangled vulnerability of humans and these insects; bees are critical and perhaps even essential to human survival. Bees orchestrate the dance of pollination, their flower visits ultimately providing about 85% of all agricultural products, ensuring food security and ecosystem vitality.

In the past decade, honeybees have risen to international fame and scrutiny due to a global vanishing of bees. Termed “colony collapse disorder,” this phenomenon refers to the alarming reality where bees started to disappear in western, industrialized countries. Hives were discovered abandoned; worker bees had fled, leaving the queen and the young. Different scientific speculations have been raised into the different factors that may be causing this and while no single factor has been confirmed, climate change and large-scale modern honey production have been identified as two of the leading factors. This global event brought the role of honeybees to the forefront of global consciousness, raising the question, “what would be lost with the loss of bees?” (Mathews 2011) This is a question that necessitated another, “and what can be done?”

In 2015 a conference titled “Indigenous and Local Knowledge about Pollination and Pollinators associated with Food Production,” was held which vocalized the need of the recording of local traditional ecological knowledge in regards to honey bees within the context of climate change and potential loss of honeybees. The honeybee is directly implicated in climate change vulnerability due to its role in pollination services, ensuring food security. Furthermore, the honeybee is particularly essential within subsistence-based communities, whose close link to the land makes them the most ecologically vulnerable and marginalized in the face of global climate change. Traditional ecological knowledge (TEK) is defined by Berkes as, “a cumulative body of knowledge, practice, and belief; evolving by adaptive processes and handed down through generations by cultural transmission, about the
relationship of living beings (including humans) with one another and with the environment.”

This knowledge is characterized by context specificity and a respect for the linkage between nature and culture (Berkes 2012). TEK is largely linked to agrarian livelihoods, i.e. cultures that are predominantly agricultural and depend on the land for subsistence. However, these populations are not helpless. In fact, they are the potential agents of change and producers of solutions, as TEK is context specific and inherently adaptive, providing valuable insight into climate change mitigation policy and adaption management.

In response to this call, papers were sent in globally from indigenous and subsistence based agricultural communities. However, no study was completed within Madagascar. This study seeks to fill this gap by examining the knowledge network and cultural significance of the endemic Madagascar honeybee, *Apis mellifera unicolor*. Madagascar has been listed as the most vulnerable country in Africa to ecological disturbances, due to its variability in water availability and high dependency on natural resources (Cinner 2009). Furthermore, vulnerability to climate change has been directly linked to poverty levels. Madagascar exemplifies this vulnerability as it has been ranked one of the most impoverished countries, the UN Development Program ranking it 151th out of 187 countries with 71% of the Malagasy population living under the poverty line (UNEP 2014). Of this 71%, the most impoverished are subsistence farmers. Another study concluded that these smallholder, subsistence farmers within Madagascar are exceptionally vulnerable to climate change due to their direct reliance on the land, emphasizing the urgent need to study the link between agricultural production and food security of these livelihoods within the context of changing seasonality (Harvey et al 2014).

Beekeeping in Madagascar is entwined with the global story of modernization and globalization. While 80% of beekeepers still practice traditional beekeeping (Mandirola 2013), modern hives have increased in number, particularly in the upper east coast in the presence of the globalized lychee crop. Within Madagascar, beyond changing seasonality from climate change, the honeybee is also threatened by habitat loss and fragmentation, created by slash and burn agriculture, and most recently, increasing bio-insecurity due to entrance into the globalized honey market (Eardley 2009). In 2009, the trade embargo of honey between the EU and Madagascar was lifted by the efforts of a network of beekeepers,
causing a rapid increase in Apicultural activity (KTTF 2016). The year after, in 2010, the Varroa mite was introduced to Madagascar (Rasolofoarivao 2014).

The varroa mite is one of the most virulent pests to bee colonies. To imagine the presence of a varroa mite on a bee body, visualize the equivalent of a rabbit hanging on a normal sized human body. The varroa mite not only weakens honeybees, but by piercing their exoskeletons, it makes them more vulnerable to other viruses and pathogens. The threat of varroa is directly related to climate change vulnerability. The pest makes bees even more fragile to transforming seasonal conditions, including differing flowering periods and unforeseen precipitation changes. Varroa’s presence in a bee population causes massive colony die offs and has already obliterated much of the honey production in Europe, which was one of the very reasons France was receptive to removing the trade embargo (Walter 2016).

Varroa is spreading slowly in Madagascar in comparison to other countries, most likely due to the still largely decentralized, local honey market. The disease is confined mainly to the highland and upper east coast, where there is the largest presence of large-scale beekeeping and exportation. In these locations, it has caused about 60% colony loss (Rasolofoarivao 2014). However, it is not clear if this figure speaks only of industrial apiculture or if it includes traditional beekeepers as well. Through the spread of varroa, the modernization and growth of beekeeping within Madagascar may have an effect in the risks in vulnerability to climate change. This is not to demonize modernization, but rather to explore how this change can still incorporate traditional ecological knowledge to inform adaptation to the inevitable effects of climate change. In this way, this study examines the precariousness, strength and connectivity of the knowledge system surrounding the honeybee as well as what could potentially be lost biologically and culturally with the loss of the honeybee.
This study took place within the region of Vatovavy Fitovinany (V7F). This region is located on the east coast of Madagascar, adjacent to the Indian Ocean and part of the eastern humid forest corridor. V7F is split into 6 districts and 143 communes. The region V7F is predominantly agricultural, with rice, manioc and sweet potatoes as the main crops. This region was specifically selected for a multitude of reasons. Most importantly, Vatovavy Fitovinany has been identified as one of the four most vulnerable regions to climate change within Madagascar due to its coastal locality and extremely high levels of poverty and subsistence agriculture. In this region over 80% of the population lives under the poverty line, and over 90% of the population directly relies on agricultural practices (UNEP 2014). Furthermore, V7F acts as a buffer between the spread of the varroa mite from the northeastern region of Tamatave, where it was first found, and the southeastern regions of Madagascar (Rasolofoarivao 2014). Lastly, V7F is one of the largest beekeeping regions and contains the first honey cooperative, KTTF, Koperativan’ny Tsara Tantely Fitovinagny, in its capital, Manakara. Their presence has created a good representation of the process of
modernization within beekeeping, with many beekeepers in this region switching over to modern hives (PROSPERER 2016). This context of modernization can provide insight into how traditional ecological knowledge has been maintained even within the shift between traditional to modern hives.

In particular, this study was located within the district of Manakara, located in the south of the region, found at S22° 11’, E 47° 53’. 3 geographical zones define this district, a cliff zone whose altitude reaches between 500 to 1000 m, a hilly zone whose altitude reaches between 50 to 500 m, and a zone of littoral forest, creating a humid and tropical climate which is typically split into wet, dry and cold seasons (RAZAFINDRAZAKA 2010). The study took place between the market in the city of Manakara and the agricultural lands and villages of 4 surrounding communes, Ankepaka, Marofarihy, Ambila, and Tataho. The defining ethnic group in this region and these locations is the Antemoro.

**Purpose**

This study explores the role of the traditional ecological knowledge within ecological vulnerability and resilience against global climate change through the lens of the honeybee. Specifically, this paper seeks to contextualize the role of bees in the region of
Vatovavy Fitovinany in order to answer two questions: firstly, *how can and has the traditional ecological knowledge associated with bees provide insight into climate change adaption?* secondly, *what would be lost in this region biologically and culturally with the loss of bees?* Ultimately I hope to add to a literature that engages local knowledge and understandings to adapt to climate change, which can hopefully guide future community based adaption projects.

**Methodology**

This study employed a multi-faceted research approach to understand the bio-cultural importance and knowledge status surrounding the honeybee within the context of global climate change in Madagascar. To examine the vulnerability status, knowledge network and physical resource flow associated with beekeeping and honey production, a combination of qualitative methodologies were used over 21 days between April 3rd and April 24th, 2016. This research was advised by and in collaboration with KTTF, the local honey collective within Manakara. The cooperative provided access to the beekeeping network of the region. The research included participatory methods, plant identification, as well as free-from and semi structured interviews. All research was conducted in Malagasy and French, with translation provided by a local male translator and guide.

While the ultimate project was unique in nature, previous research motivated the methods, selection of study sites and questions. The use of TEK to understand vulnerability and adaption was influenced by Karim-Aly Kassam’s research of vulnerability and adaption within indigenous communities in high latitudes and altitudes (Kassam 2009). The integrated research methodology to examine the network of TEK was inspired and adapted from Chanelle Adam’s 2013 ISP, “Mapping the Knowledge Economy of Medicinal Plants in Northern Madagascar.” The selection of sites was advised from the 2010 dissertation, “Potentialities and Constraints of Beekeeping in the district of Manakara within Vatovavy Fitovinany,” by Andrinantenaina Dimbiarimanga RAZAFINDAZAKA who determined the communes with the most prevalence in beekeeping. Questions for beekeepers posed in semi-structured interviews were influenced by the structured surveys and findings of the

The study was comprised of 53 semi-structured interviews, 9 free-from key stakeholder interviews which lasted an hour, key melliferous plant identification, 4 informal transect walks, 2 discussion groups with agriculturalists which included seasonal agricultural calendars creation, and participant observations of 4, day long, honey collections including 2 separate honey extractions as well as general observation at the local honey stalls in the Manakara market.

The combination of methods allowed a contextual understanding of the diversity of relations and knowledge associated with beekeeping and how these relations define and relate to climate change vulnerability and resilience. The participatory methods included participatory observation; transect walks, and the creation of seasonal ecological calendars. The semi-structured interviews were held with significant players in both the physical resource chain and immaterial knowledge network associated with beekeeping, identified by both their interaction with the physical commodity of honey and their role of TEK within the community. These informants were found randomly or through the personal connections of the guide. The free-form key stakeholder interviews were identified through repeated references within the semi-structured interviews as well as direction and affiliations from the local honey cooperative, KTTF. These interviews were held with various private, government and NGO organizations that directly involve beekeeping in their projects or indirectly through climate change mitigation or agriculture work. Less than 10 key questions or themes in relation to their position were written before the interview and posed if they arose in the free-form format.

Throughout the study data was collected in a notebook and then transcribed into spreadsheets in EXCEL and Word documents. No personal data was taken from informants except gender and the names of the key stakeholder interviews who gave their consent. Semi-structured interviews were recorded by questions in spreadsheets and the free-form key stakeholder interviews were individually typed up in a word document, recording general themes, findings and key quotes. None of the data has been officially coded, rather general trends and associations between responses to questions were noted for analysis.
During all participatory observations the date, time, genders were recorded at the beginning, and recorded general observations and important quotations through jottings when able. After the event, as soon I was in private and could use my computer; I expanded on observations, noting questions that arose and important themes. For the two discussion groups, as the agriculturists were not familiar with using pens, the local guide created the calendar as the farmers discussed between themselves in Malagasy the calendar. This was expanded on by questions I posed in relation to specific timing of events and key ecological signifiers of seasons. Transect walks were often conducted on bicycles or while walking to a destination with the guide, and findings from these were jotted in notebooks and included in observations that were typed up. The melliferous species that were identified by vernacular names were recorded with the surrounding geographical landscape, if they were planted deliberately or were wild, and if they were used medicinally. Scientific names were identified through previous research identification. Samples were not collected.

The combination of data and participatory methods were analyzed through the Human Ecological Lens (Kassam 2009). The human ecological lens (HEL) is an analytic device that allows a reconceptualization of human ecology. The field of human ecology explores the relations between the biological and cultural. The HEL moves beyond facile dichotomies of nature and culture towards a complex connectivity between two historically distinct, and often antagonistic, categories (Kassam 2009). The HEL seeks to understand the relations between biological and cultural diversity through the dynamisms and interconnectivity of TEK. Four discrete but interconnected components forms the framework: context, diversity and perception, relations, and phronesis.

Ethics

Research regarding traditional ecological knowledge mandates serious ethical consideration prior to its undertaking. TEK is shared and collective among local communities and can hold valuable insights that are not often considered through the western paradigm of knowledge. For this reason, this knowledge is often powerless in the face of western research, which can exploit the benefit of the knowledge without justly providing compensation or credit to the original source. In order to avoid the myriad moral dilemmas of extractive research, I collaborated with a local honey cooperative and allowed them to benefit from my research, responding to some of their own research needs. They
will receive a copy of the final product as well as a tailored French write up of their specified findings.

While none of the information collected was sensitive or put any participant in risk, I chose to protect the anonymity of the semi-structured participants and did not collect any personal information except gender. At the beginning of every interview and participatory event, all participants were explained the purpose and background of this research, and were given the option to not participate and skip any questions. At the end of every interview the participants were given the chance to ask questions to the researcher. Participants that spent an influential time participating or held a specific traditional or cultural role that demanded compensation were reimbursed in amounts determined by the project advisor and guide.

While no written personal information was collected, photos were taken often of the interviewees. Photos were only taken if the participant consented to the photo or asked for it to be taken, and to thank the interviewee for their contribution, each participant photographed received a copy of their photo at the end of the study.

**Limitations, Bias and Positionality**

The largest bias of this project was the division of interviews and observation between modern and traditional beekeepers. Interviewing beekeepers was challenging due to their geographic location and the timing of the study during the honey harvest. Thus, I relied heavily on KTTF to provide connections to beekeepers. However, as it is an organization that buys and collects honey for the large-scale market, it is motivated by modern beekeeping practices. This meant the majority of beekeepers interviewed were identified by this organization and were modern beekeepers driven by production. It was challenging to locate traditional beekeepers as they were not connected to the larger market of honey and thus could not be contacted ahead of time through organizational connections to confirm they would be present. To combat this, traditional beekeepers were identified by discussions with Chef Fokotanys, but were often not available to be interviewed. Ultimately, the majority of beekeepers interviewed were modern. All observations of honey collection and extract were modern because the traditional beekeepers were not collecting in the time of the study and the opportunity arose through the collaboration with KTTF and an offer by JAEL APICULTURE, a private company.
Further bias was formed through working with a guide. Well networked and a
terrific animator, the guide used his own connections for the users of honey, meaning the
data was shifted towards a modern, Christian population. In this context, the guide often
was hesitant to ask certain questions in regards to culture to interviewees he knew through
Church, meaning that not all semi-structured interviews of honey users were the same.
Furthermore, as in any multi-language study, data may have been affected by the translator
effect with a loss in meaning through the translation from Malagasy to French to English.

My own positionality as a white western woman, vazha, also certainly had an effect on responses. While this effect can never be fully known or quantified, access to certain knowledge was limited due to my outsider status. For example, several times I was told I could not be given the answer to a question because I was a vazha. While this omission was clearly stated, it can never be certain what other knowledge may have been omitted. Several times participants thought that I was part of an NGO or planning a project in relation to beekeeping, despite the explanation that I was just a student researcher. Thus answers may have been exaggerated to gain aid. Also, the fact that I was often the only woman in a male dominated field meant that my participation in the collections and extraction was often not to the same extent as the others. Finally, in past years in the study area there have been child disappearances, attributed in local understanding to the organ trade. In a few circumstances my outsider status and white positionality made it impossible to talk to inhabitants or remain in a few locations to do research due to general anxiety, apprehension and fear.

**Research Finding and Analysis**

This project examines the role of traditional ecological knowledge in the beekeeping
network within climate change vulnerability and resilience. In order to consider the bio-
cultural significance of beekeeping and its role in climate change adaption, the Human
Ecological Lens (HEL) will be employed. All TEK is sustained through its relationality and
continuous interactions with local ecology. It develops and shifts based on changing
contextual features, providing insight into the process of adaption and resilience. Through
the framework of the HEL, the status of vulnerability of beekeepers in the face of climate
change and the resilience of their knowledge is demonstrated, providing insight into future mitigation strategies.
i. Context

All processes are directly shaped by their context. Context is defined spatially, temporally or a combination of these two dimensions (Kassam 2009). These dimension are fixed and can be transformed by humans. Specifically, the context of this study is situated within the dynamics of climate change. This context not only informs the vulnerability of the participants but also their efforts of adaption (Kassam 2009). To gain a better comprehension of the specific context of climate change within the region of Manakara, 9 free-form key stakeholder interviews were held. Each interviewee was selected due to their direct involvement in some form of climate change resistance or their work with principle actors within the knowledge network.

Climate characteristics in Madagascar have changed in the past decade and these changes are anticipated to escalate. While climate in Madagascar has always been considered variable, the inconsistency and unpredictability of conditions has been projected to increase. The temperatures within Madagascar have followed the global trend of an increase of 2.5°C to 3°C annually for the last 5 decades (NDREMIFY 2016). These changes have effected the overall duration of seasons, with overall annual rainfall projected to decrease. In the last three decades the intensity and frequency of tropical storms has increased from about 10-20% within the Southern Indian Ocean, and this is expected to persist. Furthermore, it is estimated that the sea level will increase about .2 meters by the end of the century (UNEP 2014). Due to their location, coastal regions of Madagascar have been designated the most vulnerable to these changes (NDREMIFY 2016). These regions will face receding coastlines, increasing frequency and intensities of tropical storms and flooding. In 2014, The United Nations Environment Program in tandem with the Ministry of the Environment, Water, Forest and Tourism initiated a $5,337,500 project to adapt coastal zones management to climate change, focusing on the 4 most vulnerable regions in Madagascar to climate change. Vatovavy Fitovinany has been designated one of the four focus regions within this project (NDREMIFY 2016).

According to the head of project AINA, the region of Vatovavy Fitovinany is particularly vulnerable due to its high level of poverty and subsistence farming. This project, working within this region between 2014-2017, is specifically aimed at adapting farmers to changing agricultural conditions, specifically changing soil fertility levels that
are linked to changes in precipitation. Farmers in this region are considered particularly vulnerable, as only half of their traditional seed varieties have been re-sprouting since the beginning of the 2000s (RAKOTONTANTANAHARINTA 2016). The director of the Centre Service Agricole (CSA), a governmental agricultural program that has worked in the region since 2009, also echoed this statement, saying that food insecurity in this region has been greatly exacerbated by climate change. He also noted the traditional seed varieties are not adapted to the changing agricultural seasons, adding that the lack of road infrastructure was a driving source for food insecurity, making food relief and distribution almost impossible.

Beekeepers are explicitly vulnerable to climatic changes, as the seasonality of the flowers is changing (KTTF and JAEL 2016). In general, the blossoming of the flowers is later due to changing precipitation levels, meaning honey collections produce less honey. The increasing intensity of the hot and dry season is causing less flowers to bloom, which in tandem with the increasing levels of precipitation during the cold and rainy season mean that bees are increasingly malnourished as there are less flowers available and they are unable to leave their hives during the rain (KTTF 2016). This may increase their susceptibility to diseases such as varroa, and could have drastic effects on the agricultural system.

**ii. Diversity and Perception**

To explore and use traditional ecological knowledge, it is essential to understand how knowledge itself is created and developed. Diversity is the key to knowledge. Specifically, the recognition of difference by perception produces knowledge (Kassam 2009). Differentiation allows perception, founding the basis of knowledge. In this way differences that are interpreted and understood are crucial to producing knowledge. For knowledge to be considered traditional ecological knowledge, it must be considered in relation to its ecological context.

In this study, diversity is examined through the variety of actors who were interviewed within the knowledge chain associated with honey and beekeeping. These included both modern and traditional beekeepers, vendors of fruit and honey, buyers and users of honey, healers, traditional figures including Mena Lambas and Ampanjakas, and farmers. Perception was demonstrated in how the different actors differentiated their own
role within the knowledge system. Furthermore, the relationship between diversity and perception was exemplified by the difference in temporal context, perceived via questions that asked the participants to compare changes between past and current climatic conditions.

To illustrate the diversity of actors present and their own perception of their roles within the network and contextual changes, this section offers a detailed description of the knowledge and part that each actor plays.

**Modern and Traditional Beekeepers**

The knowledge network of beekeeping evidently begins with the beekeepers themselves. Beekeepers are the participants that deliberately keep bees, in traditional or modern hives. In this study, 21 beekeepers were interviewed, broken into 4 strictly traditional beekeepers and 18 modern beekeepers. These keepers had been practicing for a range of 2-20 years. While the mechanism of keeping the bees differed, the reasons for being a beekeeper were similar. All expressed economic necessity, and all had additional occupations. With 16 out of the 21 interviewed, the most common additional occupation was farming. The 5 that did not practice farming were either retired from farming or were involved in the business side of beekeeping as technicians.

While the divide between traditional and modern seems distinct, in reality it is a murky split. When specifically asked why they practiced modern or traditional beekeeping, the answers were all related to economic means. All traditional beekeepers expressed interest and a desire to have modern hives, as they stated modern hives produced more honey and the product was cleaner. However, they all lacked the economic capacity to purchase hives. In contrast, all modern beekeepers said they switched when they were able to purchase modern hives. A recurring answer was that modern hives were more easily regulated and that honey could be harvested more frequently due to the honeycomb not being destroyed as in traditional hives. They expressed that the product from modern hives was of higher quality, due to the extractor removing any residual wax, and for this reason they received higher price for their honey.

All of the modern beekeepers that had been keeping bees for more than 5 years had practiced traditional beekeeping before or still maintained a few traditional hives for wax production. Yet, even if they practiced both types of beekeeping, they insisted on being
called modern as traditional held a negative connotation. The few that never practiced traditional beekeeping had only been keeping bees in the past 2-5 years. The rest of the beekeepers interviewed, had had fathers who had kept traditional hives and had taught them how to keep bees. The 6 who did not were the same who had only practiced modern keeping and started in the past 5 years. This reflects the growing nature of Apiculture within the region that is detached from the original, traditional ecological practices. All modern beekeepers had received additional training or information through PROSPERER or KTTF on how to use modern DADANT hives, and were instructed to perform hive checks each week to see the state of honey and health of the bees. The traditional beekeepers had not received this information and thus did not check their hives except for when they knew it was time to harvest. The modern keepers claimed that the difference was mainly in equipment and that they still relied on the same knowledge from when they practiced traditional keeping and still collected the actual bees themselves in the same way.

All beekeepers interviewed received their bees in the same way. They took traditional empty log beehives that were rubbed with wax and placed them in the forest. This placement was strategic, either somewhere where they had been told there were bees, where they themselves followed bees to, or where there were preferable melliferous trees such as lychee and niaoulis. The traditional beekeepers either placed their hives in these locations permanently or returned to this location to collect, or they transported the entire hive back to a more preferable location. The modern beekeepers all returned after around 2-3 weeks and took the entire traditional beehive, transporting them to their modern honey groves. From there, they waited for the traditional hives to swarm and repopulate a modern, DADANT hive. Several modern beekeepers also bypassed the first step and bought populated traditional hives from traditional beekeepers. All beekeepers stated that they also used multiplication, having extra beehives available for when colonies split.

The types of hives used and the form of extraction define the difference between traditional and modern. Traditional beekeepers used hives they constructed themselves through hollowed tree trunks or old reformulated pirogues, mimicking wild beehives. Inside these hives, the bees themselves create their structure, forming honeycomb from the walls of the structure. In contrast, modern beekeepers used DADANT hives exclusively. These were purchased from suppliers in Manakara, usually JAEL or KTTF. DADANT is a
European model that is created by a wooden box divided into 2 or more sections, placed on a raised stand. Each section has its own frames, which provides a surface for the bees to create their honeycomb. In modern hives, the queen bee remains in the bottom section of the hive with the eggs, whereas in traditional hives there is no distinction in location.

Modern DADANT Hive

Traditional Hive

Modern Frames

Frameless Traditional Hive

The other differentiation was in the equipment used in the collection and extraction of honey and wax. For this study I was unfortunately unable to participate in a traditional collection or extraction, so my findings are limited to the methods recounted to me by my interviews. However, I attended 4 modern honey collections and extractions and was able to see same overarching practices. While in both lemon grass smoke is used, the modern keepers use a smoker that is fed a pelleted mixture of lemongrass and the traditional set a
handful of dried lemon grass on fire, which they themselves have collected. In both, the smoke is used to calm the bees, billowing throughout the collection of either frames or honeycomb. Furthermore, both included a preparation location, created far from the hives, with the use of traveler's palm leaves laid out to place the collected frames or honeycomb. In modern beekeeping, a collection tent made of insect netting separates off this area from any rogue bees. In traditional the keepers cut the comb from the walls of the hive. This honeycomb contains honey as well as eggs and developing juvenile bees. In modern collection, each frame is removed from the top sections of the hive, leaving the bottom box with the queen, eggs and developing juvenile bees.

To extract, the traditional beekeepers use their hands and mosquito netting, squeezing the honey out into empty plastic bottles and leaving a mass of wax within the netting to be cleaned and molded. Nothing is returned to the hive after extraction, and the bees reconstruct more comb to make up what has been taken. In contrast, modern beekeepers use a professional extractor, a large metal apparatus. Inside, the frames are placed in slotted sections and spun by a hand crank. Prior to the extractor, the seal of wax over the honeycomb is carefully scraped off with a fork to allow the honey to easily detach. The honey collects in a receptacle at the bottom of the machine where there is a tap. When switched on, honey streams from the tap into sealed buckets. The frames are returned to the hives.

All keepers, both traditional and modern, situated their hives in terms of their own personal preference. Some specifically chose small forest patches due to the presence of shade or particular flowering plants. Others preferred to keep their hives close to their houses to discourage theft. The majority remarked that regardless on the placement, a clean place without garbage was essential for healthy bees that would not abandon their hives.

The knowledge of when the keeper knew to harvest was a mix of modern and traditional. The traditional beekeepers waited one to two weeks after the flowers of the melliferous species had flowered and then collected. The modern keepers also used this strategy to know the approximate time of collection, but also relied on their controlled hive visits. In these visits they checked the humidity and percolation of the comb, and when it was ready
as defined by the standards explained in the information they had received, they organized a collection.

The difference in ultimate use of the collected honey and wax differed among the beekeepers based on the number of hives they had. Traditional beekeepers had a smaller range from 6-12 hives, while modern keepers had an extensive range from 3-80 modern hives. Those with smaller number of hives sold their honey at the local market and mainly used the products personally for food. Those with more than 15 hives were often part of the KTTF collective or they sold their honey to JAEL.

All keepers knew what flowers their bees frequented. All beekeepers included lychee and eucalyptus. However, the modern beekeepers that were involved with KTTF or JAEL answered in terms of the honey they produced: lychee, niaoulis, mokarana, and poly-floral. The traditional and small-scale beekeepers that were not part of the production chain included other plant species that are incorporated into the “poly-floral,” label, such as acacia, ravenela, and orange. All of the beekeepers, regardless of the label of traditional or modern, knew when the flowers of the plants they listed flowered (Figure 2).

![Apicultural Calendar](image)

Figure 3: Apicultural Calendar
A key difference in knowledge was the difference in understanding and awareness of the spread of Varroa within Madagascar. All modern beekeepers had heard of varroa, though they did not necessarily know what it was. For the most part they expressed fear and anxiety, as they understood it killed bees. They were all aware of measures that were being taken to block the trade of bees from infected regions. Those that were part of the collective or sold to JAEL had been informed of the actual condition and were aware that it was present in Tamatave. They also said they had access to the stockage of medicine present in the collective. Traditional beekeepers had never heard of the illness and were not aware of any measures being taken. This lack of knowledge may make them ultimately more vulnerable to the disease as they are not aware of preventative measures to be taken.

Vendors of Honey

The selling of honey is done on two separate scales. The large scale is facilitated by the private companies of JAEL, KTTF and Ruche Australe. This honey is either sold nationally in Tana in boutiques or supermarkets or exported to Europe for the global market. The small-scale market is through local vendors of honey that buy their honey
from small-scale beekeepers, both traditional and modern. While honey is sold throughout local markets, a few bottles present at a time mixed with produce, there are also vendors who specifically only sell honey. For this study, the 5 vendors who specialized in honey within the Manakara market were interviewed. All vendors were female except a couple that sold their wares together. Each week they sell around 10-20 Eau Vive bottles for around 10,000 Ariary each, which is around 15-30 liters.

The knowledge of the vendors is limited to what they need to know to sell their ware and answer their customer’s questions. None of the vendors themselves were beekeepers and they none of them had visited the hives from where their honey was produced. However, they each had a relationship with a specific beekeeper that provided them with honey, transported in large water jugs. They all knew which types of honey they were selling, listing the same 4 common types that the beekeepers had said. This included lychee, mokarana, eucalyptus and niaoulis. They all stated that they bought whatever was available, but that their customers often preferred modern honey, as it was cleaner. Cleanliness is determined by opaqueness, as traditional honey is often less clear due to the mix of wax present in the honey. Despite their knowledge on the physical types and availability of honey, the vendors did not have knowledge on the purposes of honey. Their knowledge on production and demand was the most developed, all stating that the demand for honey has increased, and the amount of honey has also increased due to an increase in beekeepers. They did not mention changes in production due to climate.

**Users and Buyers of Honey**

The buyers and users of honey are involved in both small and large-scale market of honey. In the large-scale market this includes international companies. However, for the purpose of this study, to understand the local usage and cultural importance of honey, only local users were interviewed. Originally, I had hoped to interview buyers who came to the vendors. However, after spending several afternoons as an observer with the honey vendors, there were no buyers. People only stopped and looked at the honey and left without purchasing. These buyers were women, and often held the honey up to the light, demanded the price and walked on to continue their shopping, and my guide deemed them too busy to be interviewed. The vendors explained that the buyers were either locals who would buy a single bottle per purchase or men from Antananarivo or Fianantsoa who buy all
their wares at once and resell it in their respective city. My guide explained that honey is not bought often in families, as one bottle can last a long time depending on the use. Thus, unable to find physical buyers in the market, I interviewed 7 users of honey who confirmed that they bought their honey locally at the market. 4 out of the 7 were connected socially to my guide, through his family or church connections. Out of the 7 users, only one was male, and they were all part of the Antemoro ethnic group.

All users stated that they used honey for both nutritional and medicinal purposes. For beverages the users reported using honey in tea with lemon to combat coughing. Each user had different preferences for use of honey in cooking, however they all stated that rice mixed with honey was an important dish. One user said she ate a spoonful of honey a day to prolong her life. All the users said they used both healers and doctors, depending on the severity of ailment. They all independently used honey to treat their own symptoms, including stomach pains, swellings and arthritic pain, and fever. One user said she used bee stings deliberately to reduce fever.

The 4 users that were connected to my guide said that they did not have any religious or cultural events, which used honey. The three other users said that honey played a role in certain cultural events. One woman explained that honey is given to newlyweds in the traditional marriage ceremony of that region, to ensure sweet relations through their marriage. Two other participants said that eating honey together strengthens bonds, echoing the theme of unity brought by honey.

All users had their own preferences of the type of honey they preferred. They all stated they would buy any type of honey, but the majority said they preferred modern, as it was cleaner. This cleanliness is determined by how clear the honey is, reflecting the different modes of extraction. 2 users explicitly said that the more opaque, traditional honey was dirty because it was extracted by hand. However, one user said she preferred traditional because it was the type she has always used throughout her life. The users that understood and explained the process of extraction and collection were also the users that knew beekeepers personally. Users were also aware of the changing levels of production of honey. They all reported a large increase in the availability of honey, all citing an increase in the number of beekeepers. One user stated that while the overall production is higher
the actual individual hives are producing less due to deforestation and a limited supply of floral resources.

**Healers**

Altogether, 4 healers were interviewed during this study, 2 of whom were brothers and healed together. One of the healers was also locally known as an ombiasa, but presented himself as a healer for the interview. All of the healers were part of a long, male family lineage of healing. The sole female healer was an exception, as she had no male siblings to accept the *lova*, or heritage. All healers received their knowledge through a physical transmission of power, when their predecessor decided it was time. The ombiasa became a healer when his grandfather decided that he would be his processor as a baby. At this time, his grandfather spit into his mouth, and through this action the ombiasa explained he had the force to heal others. The brothers stated they became healers at the age of 18 when their grandfather passed away, physically tapping them. The female healer received her father's practice and clients at her father's deathbed, when he clasped her hands and pronounced her ready. Despite this knowledge and power transmission, all four healers learned from watching their predecessor heal and two of the healers said they also used books to know the plant names and uses.

All healers said they use honey specifically to treat patients. They all said that honey could treat too many ailments to be named, but listed honey as a cure for coughs, body aches and fever. The brother healers said they used honey when a baby is premature, covering the baby in honey and placing it in a warm location as honey resists, “bad things.” The ombiasa told me he used honey for secret things as well which he couldn’t disclose. My guide informed me later that he was referring to love potions, *odyfitia*. When someone wanted to profess their love but was worried it was unrequited, the ombiasa could place a spell in the honey and if the professor rubbed it over their body, the recipient would also admit their love. The ombiasa was the only healer who refused to use modern honey, saying that it was the norm and that it has properties that modern honey may not.

All healers stated they saw a diminishment in the availability of medicinal plants and flowers, due to slash and burn agriculture, *tavy*. One healer reported that the loss of plants is due to cities and villages getting larger and their being an increased strain on
resources. However, none of the healers had any thoughts on what this would mean for bees.

While the healers stated that bees did not have any role in the production of medicinal plants or flowers, they did list the group of melliferous flowers that the bees frequented: mokarana, eucalyptus, lychee, niaoulis. For each they gave the specific uses of the flowers, which can be found in Appendix 1.

Traditional Figures

In order to understand the cultural importance of bees and their products, 5 traditional figures were interviewed. They all described their role as the guardians of traditions, setting the example of leading a respectful life and watching the actions of others to make sure no one commits a fady, or taboo. One ampanjaka said, “when you become an ampanjaka, you become the parent of everyone.” One of these Ampanjakas was the Mena Lamba, the head of the other Ampanjakas. All of the traditional figures were selected to serve this role in the community when it was their family’s “turn.” Over the generations, each family in the village took turns having a male representative play this role. 2 of the Ampanjaka’s stated they took their father’s turn when it arose because he was too old and sick. However, all young men at the age of 15 begin learning the traditions through a hierarchical teaching process that consists of attending rituals and observing the roles of the current ampanjakas. This means that if the turn arises for their family, they are ready automatically, and if it doesn’t, they will know the rules when they have their own families to lead. The Mena Lamba was selected 56 years ago by a unanimous decision of the community, when the last Mena Lamba passed away.

When asked directly if bees or honey played a cultural or traditional role or was used in any ceremonial manner, they all said no. However, in their answers to other questions, they explained that specifically honey was used in sacrificial ceremonies. Additionally, one ampanjaka explained that there is a specific, secret location in their commune that is forbidden. If someone enters this location and falls, they will fall ill and die. To protect individuals from this place, rice and honey are offered together to the ancestors.

2 out of the 5 ampanjakas, including the Mena Lamba, said that with modernization, people respected traditions less, meaning that more sacrifices were needed to appease the
ancestors. However each ampanjakas supported the shift from traditional to modern beekeeping, explaining that this progression was welcome and good because it produced more. The Mena Lamba explained that it was the natural process of modernization, an “evolution,” and that it did not change the nature in which honey was used.

All of the ampanjakas recited the same proverbs that incorporated honey, the salient themes being the unity and sweetness that honey brings to life. The most important proverb, *tantely vaky andambana, samy milefadelatra*, was explained as representing the unity that honey brings. While it was not directly translated, it was expressed as when honey is collected in a palm leaf, the leaf is placed in in the middle of the house, and the entire family takes turns licking the honey that spills. The second proverb, *tantely amambahoana ny fiainana, misy ny mamy avy misy ny mangidy* was explained that life is honey with aloe, where there is sweetness there is also biterness. The third proverb, *laso amina siramamy, mihotratka amina tantely*, was roughly translated as sweetness brings sweetness. The last proverb, *tantely afa-dakotra*, was translated as “all the world can profit.” These proverbs reflect the importance of honey in community unity, and the reasons that honey is used within traditional ceremonies: to bring people together and to share life’s sweetness.
Two discussion groups with farmers were held with the purpose of creating an ecological calendar reflecting changing climatic conditions and the role of bees within this dynamic (Figure 4). In total, 9 farmers participated. All were men who farmed on their family’s ancestral lands. They all learned to farm since they were children, following their parents to the fields to farm until they were deemed old enough to participate. Their main crops were rice and manioc, and they supported this with additional fruits and vegetables. They sell their produce at the local market, but mainly use their crops for subsistence.
Both groups stated that bees were inseparable from agriculture, explaining that bees transform flowers into fruit. They deliberately plant lychee, eucalyptus and niaoulis to draw the bees to their lands. However, while they were creating the ecological calendar, they did not include the flowering of these trees.

The calendar they produced is split into two, corresponding with the two types of rice (see the purple and yellow in figure 4). Both groups stated that the year started in July with the planting of Variosy and Kajaha, manioc, which are harvested in November and December. The second type of rice, Vatomsandry, is planted between October and November and harvested in May. They know it is the start of the second half of the year, and time to plant the Vatomandry, based on the call of the bird species *taontaonkafa*, whose name translated means, “another year.” While the timing of this call has not changed, farmer’s expressed anxiety about the likelihood of this happening in coming years when the migration pattern of this species changes. From August to Mid October it is usually the hot and dry season, from November to April the rainy season and from May to July the Cold season including cyclones. They know to plant the Variosy at the end of the cold season when all the leaves have fallen from the trees to make room for the newly sprouting leaves.

Originally, the months of November and May were the months of surplus due to harvest, where the farmers were able to save food to help in the months October, April and March, where there is shortage. However, due to climatic changes in the past 15 years, the divisions in seasons have not been the same, changing harvest time and food security. While cyclones were typically only present during the rainy season, they are now present in the cold season, meaning that flooding now affects the harvests of Vatomsandry in May. Furthermore, the dry and hot season has increased into the month of November and even December, affecting the harvest of Variosy. Thus, now the months of surplus no longer provide adequate supplies for the months of scarcity. To combat this scarcity, farmers have begun planting more land to provide for their families, increasing the rates of *tavy*. The reduction in forest increased burning and changing precipitation has changed the fertility of the soil, and the plants are no longer growing in the same amount as they did.
12 fruit vendors were interviewed in this study within the Manakara market to explore the connection between bees and food security. Out of these vendors, 9 were women and 3 were men. Only one of them was a beekeeper. All 3 of the men and 4 of the women were farmers themselves whose fruit came from their own fields. The rest bought fruit from others in their villages to sell in the market. None of the vendors came from Manakara, and they all traveled into the city each day to sell their goods. While there was no consensus in the exact trends of the changing climate, each vendor enthusiastically explained that they had noticed changes in the weather patterns. Some said that the rainy season was longer while others said there was less of a rainy season due to an increasing dry season. Nevertheless, they all said that each season was getting more intense, “the hot is more hot, the cold is more cold,” and that the cyclones and flooding were increasing in frequency and intensity. Related to this, all of the vendors had noticed a change in the seasons of fruit, explaining that the harvests are now coming later. Yet, none of them
articulated the link between the seasonality of the fruit and the later flowering of the plants. Half of the vendors believed that there was an increase in the amount of fruit produced due to increased rain and a larger number of fruit trees presented, while the other half believed that the amount of fruit had diminished due to an increased number and intensity of cyclones, which damaged the fruit trees.

8 of the vendors believed that bees played a role in agriculture, mentioning that they had seen bees visit flowers. However, they were unable to explain the exact importance of this visit, just insisting that without bees there would be no flowers and without flowers there would be no fruit. The other 4 said they did not know the role of bees in agriculture. Despite this, all vendors were able to list melliferous plant species. Each vendor included lychee in their list, and the rest of the list was defined by the tree’s fruit (for example, mango, oranges).

iii. Relations

Entangled with diversity and perception that allow knowledge production are the relations that sustain and exchange knowledge. The roles of each actor in the knowledge network are made real by their relationships with the other actors, specifically among their differences. In other words, to define each actor within this knowledge network, each individual is seen in relation to other beings; one is something because it is not another (Kassam 2009). Through the pluralisms of relationality, knowledge is constantly produced and reinforced. These relationships are often kindred, implying a common ground. In this case study, the network is created via the common thread of beekeeping and products alongside a shared context. It is vital to examine these relations, as climate change impacts are likely to affect different actors unevenly, increasing the vulnerability of some actors to ecologically driven socio-cultural change.

The defining relation of this study is between the honeybee and humans. It is not just the humans but also the bees, their entanglement that mutually brings TEK knowledge into being. While all actors are somehow linked to the bee, not all are in direct contact. However, each actor acknowledged the importance of the bee. Their knowledge and understanding of the importance of the bee reflected their relation to bees. Those that are economically linked to the bee, such as all the beekeepers and vendors of honey, cited monetary importance. For small-scale beekeepers, with fewer than 15 hives, the majority
also highlighted the environmental importance of bees. The users, healers and traditional figures expressed the importance of the uses of honey, referencing medicine and the unity it brings. For the farmers and vendors of fruit, they all listed the pollination services of the bee, some linking their crops’ success exclusively to the bee. The differences in significance of the honeybee to different actors demonstrate how their relation shapes their knowledge of the role and purpose of bees.

In addition, the relations between actors within the knowledge and production network displays the complex connectivity of knowledge, and how it is exchanged and developed through physical and non-physical interactions. This is demonstrated in the knowledge and resource chain pictured in **Figure 5**.
While all actors contribute to the knowledge network of bees, this diagram explicitly traces knowledge through the physical entity of honey. For the modern beekeepers, they receive information from JAEL and KTTF on specifically how to manage modern beehives. The traditional beekeepers are not part of this knowledge exchange. In return, the large-scale beekeepers sell their wares to the two companies, while the small-scale beekeepers sell their goods to the local vendors of honey. Often, specific beekeepers have a particular connection to a particular vendor, choosing to only sell to her. In the exchange between the vendors and beekeepers, knowledge regarding demand from the buyers is given to the beekeepers and the vendors receive information about the goods and the challenges they face in production. One vendor explained that there has been a decrease in the overall number of bees in relation to the amount of hives present. She did not know why, explaining that there have always been cyclones and rain and did not understand why the bees were reacting to this now. She explained that the beekeeper had told her it was due to deforestation, but she said she wasn’t sure if this was the case and wondered if it was because of increasing weather conditions. The vendors in turn serve as the connectors between the beekeepers and buyers of honey, most of who do not know beekeepers. In this exchange, the buyers buy honey, learning about the particular type and location. The vendor receives information on the preferences and uses of honey. One vendor specifically stated that she tries to purchase more modern honey, deliberately passing this demand onto a beekeeper, because of her client’s preferences for clearer, modern honey.

Not depicted in this diagram are the relations that shape the general knowledge and demand of honey. Ampanjakas and healers both culturally reinforce the importance of honey. Buyers stated that they purchased honey specifically for marriage ceremonies overseen by ampanjakas, and while all did not list healers directly prescribing honey to them, the general knowledge of the medicinal benefits of honey is well known. Farmers, who are often beekeepers themselves, actively work with certain beekeepers, hosting beehives on their property to boost the agricultural production. These goods are bought and sold by the vendors of fruit, sometimes farmers themselves, who understand the fluctuations in availability of produce through their exchanges with farmers. All together, this creates a large, complex system in which the different actors needs and knowledge shape and mold the other actors actions and knowledge.
A further relationship that can be remarked upon in this study is the gendered
dynamic of knowledge. A clearly divide in gender was demonstrated within the knowledge
chain with a heavier representation of males present. Knowledge exchanges by lineage
appear to be passed down between fathers to sons, excluding females unless another male
is not present. In this fashion, all healers and ampanjakas were male. The sole female healer
did not have a male sibling to inherit the duty. The farmers in the focus groups were all
men. Additionally, all beekeepers were men, except 1. The female beekeeper did not
actively attend to her hives herself. In fact, she labeled herself a beekeeper because she
inherited her husband’s hives after he passed away, and is waiting until her son is old
enough to take over. In the interim, she pays a man to tend to the hives. Furthermore, the
authorities of KTTF and JAEL, key organizations within the large-scale distribution of
honey were all male. In contrast, all small-scale vendors of honey and fruit were female, as
were the majority of the buyers interviewed and observed. This gendered dynamic creates
a gendered ethos to the knowledge that is exchanged, which can create uneven
vulnerability and resilience to a changing context due to certain members having a more
active role in knowledge production and adaption.

This relation is specifically important as women have been identified as more
vulnerable to climatic changes than men within this region according to the director of the
Regional Office of the Ministry of Population and Protection and Promotion of Women
(MPPPW 2016). Within Vatovavy Fitovinany, women are increasingly being abandoned
with their children, as their husbands leave their farms due to increasing soil infertility,
growing precipitation and changing seasons (Director MPPP 2016). Consequently, there
has been an increase in single mothers. These women are the most effected by the changing
living conditions in rural areas and are tasked with independently trying to provide for
their children. This has led to an increase in female farmers, who are taking up their
husband’s abandoned land (Director MPPPW 2016). Furthermore, women produce
vendors are also particularly vulnerable to climate change as their livelihood is based on
the availability of agricultural goods. In recent years, with a stated decrease of agricultural
products, these women are struggling to earn enough for their families (Director MPPPW
2016).
iv. Phronesis

While the label of “traditional,” can imply fixed or rigid, traditional ecological knowledge is intrinsically adaptive as it is modified and developed in response to context change. Through reflexivity and interpretation, knowledge is altered to serve the circumstances. This dynamic process of knowledge is called phronesis (Kassam 2009). Phronesis is brought about through the cyclic process of learning and knowing (Figure 6). Within this cycle, two forms of knowledge, knowing how and knowing that, are informed through learning, ultimately leading to knowledge adaption.

While knowing that is learned through straight knowledge transmission and is context independent, such as knowledge gleaned through memorization, knowing how is when this original knowledge is applied via contextual and experiential learning (Kassam 2009). In this way, once one knows how they can impart their adapted knowledge and someone else is able to learn from them, or in other words, learn that. Through the active interplays of this cycle knowledge is refined and reformulated by reflexivity and leads to changes in behavior. Thus, through phronesis, resilience is demonstrated and vulnerability is re-negotiated (Kassam 2009).
In this study, resilience has been demonstrated in the changing practices of beekeepers and farmers in response to changing climatic conditions, proving that TEK can provide insight into adaption strategies. In this case, the knowing that is the information that they originally received on how to keep bees or cultivate land, including the timing and procedures they should use. This knowledge was passed down both through father to son transmission and in the case of modern beekeepers, workshops. However, in seeing that these practices were either not enough or needed reinforcement due to the changing seasonality and precipitation, both farmers and beekeepers have adjusted their practices through their experiential learning. In this way, old knowledge has been adapted to knowing that to fit the context of climate change.

The changing seasons brought by fluctuating precipitation levels and the increasing weather intensity has caused large ecological changes. With the seasonal shifts, the flowering season for melliferous plants has become later and has extended throughout the year, not allowing the bee’s adequate time for rest. Furthermore, the soil has become increasingly infertile due to floods, which also ruin harvests. With rising frequency and intensity of storms, bees spend more time within the hives consuming their honey. Multiple beekeepers have remarked that their bees seem more tired and aggressive, signs that they may not be getting adequate nutrition, weakening them to the potential of Varroa and other diseases.

While the vulnerability of farmers and beekeepers to climate change is quite high due to their direct reliance on their honey and agricultural harvests for food and finances, this study has demonstrated that there is resilience to be found within these very actors. The beekeepers and farmers have adapted their original knowledge to the changing climatic context. Both farmers and beekeepers have reported that they have shifted their agricultural and apicultural calendar later in response to the changes, harvesting and planting at different times than before. Beekeepers stated that they have begun reserving honey to feed to their bees during periods with much rain to combat malnutrition. Farmers have switched to using different seed varieties that sprout more frequently, so that harvests can be gathered more often to protect against degradation from flooding and unknown storms. Lastly, multiple farmers and beekeepers stated that they have begun planting melliferous tree species, including acacia and eucalyptus, to increase the amount
of nourishment available for the bees. This ensures more honey production for the beekeepers as well as healthy bees for pollination for the farmers. Several also stated that this reforestation combatted climate change directly, although they were unsure of the mechanism.

![Combined Apicultural and Agricultural Calendar](image)

**Figure 7: Combined Apicultural and Agricultural Calendar**

**Conclusion**

This study evaluated the biological and cultural vulnerability associated with the loss of bees and honey within the region of Vatovavy Fitovinany to climate change, and explored the role of traditional ecological knowledge as a means of possible resilience. In short, this study demonstrated a strong bio-cultural significance of the honeybee and shows that indeed *much* would be lost with the loss of the honeybee. Biologically, the honeybee ensures food security via pollination services and enables the high levels of agriculture within the region. Culturally, the honeybee has a notable role. It is used commonly within medicinal practices, regardless of traditional or modern medicinal use. Furthermore, culturally honey is perceived to create unity, as seen through its use in traditional marriage and sacrificial ceremonies to connect to the ancestors.
The honeybee links together a large network of actors who together formulate a complex system of knowledge. The traditional ecological knowledge sustained through this network has been shown to be useful for climate change adaption, particularly in regards to food security, as its dynamic and flexible nature alongside its deep-rooted background in the location provide behavioral alternatives that can combat vulnerability.

**Opportunity for Further Study**

While individually it is clear that both farmers and beekeepers are illustrating the process of phronesis, it is possible that the TEK of each of the separate processes could be combined in a further study to inform additional adaptive measures because of their overlapping vulnerability. To demonstrate the potential of this, the two separate calendars created have been superimposed (Figure 7). The development and analysis of a more vigorous, combined calendar could inform how the changes within the two livelihoods from seasonal variation are linked, and can provide possible mutually beneficial adaption strategies. Furthermore, a theme that emerged within this research was the differing vulnerability of the key actors within the network of the honeybee. Of particular vulnerability are women who have been identified as ultimately more susceptible to the detrimental effects of climate change. As they do not play a direct role within the process of phronesis because of the heavily gendered aspect of the network they are unable to actively participate in adaption. Further study to access the vulnerability of women to climate change within this region, in relation to food security, is suggested to develop a way for them to take part in the resilience to climate change.
Appendix 1: Charts

Chart 1: Melliferous Plant Identification

<table>
<thead>
<tr>
<th>Vernacular Name</th>
<th>Scientific Name</th>
<th>Medicinal Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>Eucalyptus sp.</td>
<td>Headache</td>
</tr>
<tr>
<td>Lychee</td>
<td>Litchi chinensis</td>
<td>Albanime</td>
</tr>
<tr>
<td>Mokarana</td>
<td>Macaranga alnifolia</td>
<td>Against supernatural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>forces</td>
</tr>
<tr>
<td>Niaoulis</td>
<td>Melaleuca leucadendron</td>
<td>Headache, Relaxation</td>
</tr>
</tbody>
</table>

Chart 2: Medicinal Use of Honey Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Medicinal Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honey</td>
<td>Premature baby, coughing, body ache, fever, headache</td>
</tr>
<tr>
<td>Stingers</td>
<td>Fever, Swelling, Arthritis</td>
</tr>
</tbody>
</table>
Appendix 2 : Interview Guide

**Beekeepers**

*Knowledge*
- Combien des années avez-vous été un apiculteur?
- Est-ce que quelqu'un d'autre dans votre famille garder les abeilles?
- Comment avez-vous appris comment être apiculture?
- Comment décrivez-vous une abeille?
- Quels sont les genres d’une abeille?

*Practices*
- Avez-vous une autre profession?
- Où avez-vous votre matériel d’apiculture?
- Où sont vos ruches?
- Pourquoi avez-vous mis vos ruches où ils sont?
- Dans quelle mesure vivez-vous loin de vos ruches?
- Quels sont les produits des abeilles récoltez-vous? Comment?
- Que faites-vous avec vos produits de l’apiculture?
- Où trouvez-vous vos abeilles? Comment savez-vous comment les trouver?
- Comment obtenez-vous vos abeilles des ruches? Comment vous collectez vos abeilles ne?
- Comment savez-vous quand récolter le miel? Quand pensez-vous de récolter normalement le miel? Quel type de miel est récolté quand?
- Comment extrayez-vous votre miel? Avec quel outil?
- Où et à qui vendez-vous votre miel?
- Quelles plantes / fleurs faites vos abeilles fréquentes? Quand est-ce qu’ils fleur? Sont-ils utilisés pour le pollen, nectar ou de miel?
- Pourquoi utilisez-vous des pratiques modernes ou traditionnelles? Souhaitez-vous changer? Pourquoi ou pourquoi pas?

*Importance*
- Pourquoi êtes vous un apiculture?
- Quelle est l’importance des abeilles?
- Quels personnels utilisations des abeilles gagnez-vous?
- Si vous avez perdu vos ruches, ce que cela signifierait pour vous?
- Quel rôle jouent les abeilles dans l’agriculture?

*Sickness*
- Est-ce que vos ruches ont été malade? De quoi?
- Qu’est-ce que les maladies ruche ne vous connaître? Ce qui les provoque?
- Est-ce que vous donnez à vos abeilles tout médicament? D’où et comment savez-vous quoi offrir?
- Avez-vous eu des abeilles ou des ruches meurent avant? De quoi?
- Savez-vous au sujet de la maladie des abeilles du varroa? Quelles sont les causes de cette?

*Changes*
- Avez-vous vu des changements dans les conditions de temps normales dans votre temps comme un apiculteur? Si oui, de quel type? Changements dans les floraison des fleurs ?
- Y at-il des changements dans votre temps comme un apiculteur dans la production ou le comportement des abeilles été? Si oui, quoi ?
- Comment avez-vous changé vos pratiques pour refléter cela?
• Est-ce que le changement de la production de miel quand il est une année très sèche ou il y a beaucoup de cyclones?
• Avez-vous changé vos pratiques pour lutter contre cela? Comment ?

Healers
• Quand avez-vous un guerisor?
• Pourquoi êtes-vous devenu ombiasa?
• Comment avez-vous appris comment traiter les patients?
• Comment avez-vous appris les noms et les utilisations des plantes
• Combien d’années avez-vous étudié / apprenti?
• Est-ce que quelqu'un d'autre dans votre famille à guérir?
• Utilisez-vous des produits de la ruche dans votre guérison?
• Quels traitements utilisez-vous les produits apicoles pour?
• Où proposez-vous qu’ils obtiennent les produits de la ruche?
• Utilisez-vous des types spécifiques de miel de fleurs médicinales spécifiques?
• Quelle est l’importance des abeilles pour les plantes que vous utilisez pour les traitements?
• Avez-vous remarqué un changement de disponibilité dans les plantes ou les produits de la ruche pour la guérison? Si oui, pourquoi pensez-vous que ce soit?
• Avez-vous remarqué un changement dans la quantité de maladies? Les maladies spécifiques qui sont plus fréquentes au cours des dernières années?
• Parmi ces plantes énumérées, quelles sont leurs valeurs médicinales?

Ampanjakas
• Comment êtes-vous devenu ampanjaka?
• Quel rôle jouez-vous dans votre communauté?
• Comment avez-vous appris d’être un ampanjaka?
• Quel est le rôle des abeilles dans vos traditions et pratiques culturelles?
• Quelles fêtes ou célébrations spécifiques utilisent le miel ou les abeilles?
• Quels proverbes savez-vous qui incorporent les abeilles?
• Que pensez-vous sur le changements d’apiculture, traditionel à moderne?
• Est-ce que les gens gardent les traditions assez fortes?

Farmers
• Comment avez-vous appris à la ferme?
• Quelles cultures vous cultivez-vous?
• Quelles cultures vendez-vous? Où?
• Avez-vous des ruches? Si oui, pourquoi?
• Quel est le rôle des abeilles dans agriculture?
• Comment comptez-vous où vous planter les cultures?
• Quelles sont les espèces mellifères que vous plantez? Quand est-ce qu’ils fleurissent?
• Avez-vous vue des changements dans les floraison des fleurs ?
• Sont-ils utilisés pour pollin, nectar ou de miel?
• Comment avez-vous votre terre? Est-il de votre famille?
• Quels changements avez-vous remarqué dans la production depuis que vous avez commencé à l’agriculture?
• Comment vous répartissez-vous votre année?
• Quand commencez-vous votre année?
• Qu’est-ce que les modèles météorologiques associés à vos saisons?
• Quels sont les plus frais, le plus sec, le plus humide?
• Quelle marque les changements entre les saisons?
• Avez-vous vu des changements dans les horaires des saisons?
• Quand est-il surpilus, quand est-il pénurie?
• Avez-vous changé vos pratiques pour lutter contre cela? Comment?

Guide d'entrevue pour un fournisseur de produits apicoles
• Combien de miel / cire vendez-vous habituellement dans une semaine?
• Connaissez-vous le type de miel que vous vendez? Quels types?
• Demandez-vous des marchandises particulières ou de prendre ce qui est offert?
• Qui achète habituellement le miel / cire? Qui sont les acheteurs? Les genres?
• Avez-vous vu des changements dans la disponibilité dans le miel et les produits apicoles dans votre temps en tant que vendeur?
• Les besoins d’acheteurs? Avez-vous vu une augmentation ou une diminution de la demande en produits de la ruche dans votre temps en tant que vendeur?
• Est-ce que vos clients vous posent des questions sur l’origine de votre miel?
• Où trouvez-vous vos produits d’abeilles? Si vous l’achetez, de qui? Comment avez-vous établi votre lien avec la personne qui fournit le miel?
• Avez-vous déjà visité les endroits où vous recevez vos produits de la ruche?
• Combien des années est-ce que vous avez vendu le miel?
• Est-ce que les abeilles importantes à vous? Si oui, pourquoi?

Guide d'entrevue les acheteurs de produits apicoles
• À quelles fins utilisez-vous le miel?
• Utilisez-vous le miel à des fins médicinales?
• Avez-vous des repas ou des boissons spécifiques que vous utilisez le miel dans?
• Avez-vous des événements religieux ou culturels que le miel joue un rôle important?
• Avez-vous acheter un certain type de miel ou n’importe de miel?
• Lorsque vous êtes malade, voyez-vous un médecin ou obiasa, ou les deux?
• Avez-vous remarqué des différences dans la disponibilité de miel?
• Savez-vous comment le miel est collecté ou récolté?
• Connaissez-vous des apiculteurs?
• Pourquoi est-ce que les abeilles sont importantes?

Guide d'entrevue pour un fournisseur de produits de fruits
• Quels sont les fruits en saison maintenant?
• Est-ce que vous êtes une agriculture vous-même?
  • Si oui, est-ce que ces fruits ici sont les fruits de vos jardins ou champs?
  • Sinon, d’ou est-ce que vous recevez vos fruits?
• Est-ce que vous avez vu des changements dans les saisons des fruits? D’après vous,
pourquoi ça change ?
• Est-ce que vous avez vu des augmentations ou des diminutions dans la disponibilité des fruits ? D’après-vous, pourquoi ça change ?
• Est-ce que vous avez vu des changements dans le temps dans les années passés ? Quels types ?
• Est-ce que les abeilles a un rôle dans l’agriculture ? Si oui, quel est son importance ?
• Quels fruits sont les fruits des plants mellifères ?
• Est-ce que vous avez eu des ruches ?
  o Modern ou traditionnel ?
  o Si oui, vendez-vous du miel ?
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