BEEKEEPING DEVELOPMENT FOR SUSTAINABLE PRODUCTION, ENVIRONMENTAL MONITORING AND ENVIRONMENTAL THREATS

Abstract

Apiculture, or the art and science of maintaining bees, is essential to agricultural sustainability. Many plant and agricultural species can't reproduce or produce offspring without the help of pollinators like bees. Crop output and quality are both affected by their role in pollinating fruits, vegetables, nuts, and seeds. Apiculture is not just about getting honey; it's also about protecting bees and other pollinators. Honeybee colonies rely heavily on the care and attention of beekeepers to ensure their continued success. They work to eliminate threats to bee health, such as Varroa mites and several types of bacteria. Assuring sufficient food supplies, reducing bee stress, and maintaining optimal hive conditions are at the core of responsible beekeeping operations. There are a number of ways in which apiculture helps to promote agricultural sustainability. Ecosystems and agricultural systems benefit from bees because of the pollination services they give, which helps plant species thrive. Beekeepers will typically grow a wide range of flowers in designated forage areas to ensure that their bees always have access to a plentiful supply of nectar and pollen. Promoting biodiversity, producing revenue through the sale of bee-related products, and providing employment opportunities are all ways in which beekeeping may help local economies, rural development, and environmental conservation.The protection of pollinators and the encouragement of environmentally responsible beekeeping methods have received more focus in recent years. Protecting and restoring natural habitats, decreasing pesticide use, and educating beekeepers and the general public about bees and their role in food production are all initiatives that are now happening. Apiculture is a fascinating and significant activity because of the ways in which

Authors

Soumya Srilipta Selma
C. V Raman Global University
Mahura, Janla, Odisha.
selmasoumya2001@gmail.com

Shrutirupa Panda
C. V Raman Global University
Mahura, Janla, Odisha.

Pritismita Bhoi
C. V Raman Global University
Mahura, Janla, Odisha.

Swadhin Swaraj Choudhary
C. V Raman Global University
Mahura, Janla, Odisha.

it bridges the gap between agriculture, ecology, and human well-being through the integration of tradition, science, and environmental stewardship. It's a way to stay in touch with nature, a way to get useful things, and a way to help keep food systems going strong.

Keywords: Apiary, Apiculture, Bee, Bee Keeping, Bee maintenance, Honeybee, pollen, foraging, Hive, Biodiversity, Colony, Comb, Sustainable, Swarming

I. INTRODUCTION

Many rural locations and small farms might benefit from apiculture as a way to make a living or supplement their income. Sustainable and native-bee-friendly farming practices are becoming the norm in contemporary apiculture. However, in order to maximize the natural systems and resources upon which beekeepers rely, excellent expertise (and training) in the right management of bees is required for sustainable apiculture. In addition, cutting-edge inventions and technologies have the potential to significantly improve beekeeping practices. Bees play a crucial role in maintaining a healthy ecosystem. The most crucial agro-environmental service they provide is pollination, which helps sustain biodiversity. The pollination services provided by bees are so valuable that they are worth 30–50 times more than the honey and wax harvested from their hives. Insect pollinators are responsible for ten percent of the total economic value of agricultural output for human food, and their services are required by close to seventy-five percent of the world's crops that produce fruits and seeds for human consumption. However, external stressors frequently impede bee output and undermine the value of beekeeping. These include climate change, the growth of monocultures, globalization (implying the introduction of exotic species of pathogens), and inadequate management practices; land-use changes; disease and pests; the indiscriminate use of chemicals (veterinary medicines and/or pesticides); and so on. All of these threats reduce bee health, which in turn reduces the quality and quantity of bee products and services, which in turn reduces the revenue of beekeepers and the beneficial impact of bees on the environment.

Beekeeping can become more sustainable when: to alleviate rural poverty

- Make small-scale beekeepers more resilient Obtain only premium goods.
- Via pollination, help sustain environmental variety and crop yields.

That is to say, the Sustainable Development Goals (SDGs) set forth by the United Nations will be aided by the practice of sustainable beekeeping. The best practices for keeping beehives and harvesting honey, pollen, wax, propolis, royal jelly, and other bee products in a sustainable manner are outlined. Of course, there are a wide variety of beekeeping methods (the most relevant technical specifications are provided for beehives and feeding) and bee species (Apis mellifera spp., Apis cerana spp., Melipona spp., and Bombus spp., to name a few).

Sustainable Agriculture and Beekeeping Methods

1. **Pollination:** Bees are crucial to the success of many of our food crop varieties. Bees help flowers reproduce by transporting pollen from the male to the female section of the bloom. Fruit and seed production relies on this method, which is essential for maintaining genetic diversity and maximizing crop yield.

   Bees and other pollinators benefit from the environments created by beekeepers, which in turn increases biodiversity. Beekeepers aid the development and survival of pollinators by providing them with hospitable settings like beehives and nesting locations. This contributes to a sustainable ecology and helps keep agricultural landscapes' biodiversity under check.

Beyond pollination, bees perform important ecosystem services. Pollinating wildflowers is one way they help sustain habitats, which in turn helps many different kinds of animals. Pollination of blossoming cover crops by bees also contributes to better soil health and nutrient cycling.

Beekeeping is most commonly connected with honey production, which is a renewable and sustainable source of nutrition. Honey is a healthy alternative to refined sugars and other artificial sweeteners. Producing honey close to home also helps with food security and independence from imports.

Beeswax and propolis, two products made by bees, can improve soil fertility and can be used in eco-friendly agriculture. These organic compounds are capable of boosting soil fertility, functioning as a natural fertilizer, and improving soil quality.

Beekeeping, since some crops benefit considerably from bee pollination, can promote crop diversification. Farmers can enhance the ecological balance of their agricultural systems by growing bee-friendly crops or incorporating flowering plants into their fields.

Bees create honey, which can be used as a sweetener or added to meals. Beekeepers can do their part for the environment by leaving enough honey for the bees to consume during the winter and only taking a little amount of honey each harvest. Producing honey in a way that doesn't harm bee colonies isn't only unethical, but also threatens the honey supply in the long run.

Beekeeping can be used as a teaching tool to talk about the bees and their vital part in agriculture with younger generations. Beekeepers can encourage people to adopt eco-friendly farming methods and conservation initiatives by sharing information about the benefits they've seen from keeping bees.

Beeswax, propolis, royal jelly, and pollen are all products of beekeeping that have many different uses. Candles, cosmetics, and even food can all benefit from beeswax, while propolis and royal jelly are prized for their purported health benefits. Beekeepers may expand their businesses and make more money thanks to these goods.

Food and nutrition security, poverty alleviation, and economic growth are all greatly aided by beekeeping, the practical management of social bee species, which typically occurs within farming systems. It is essential for sustainable beekeeping enterprise development to take a novel, sustainable, integrative approach that takes into account all stages of the beekeeping value chain, from ensuring a sustainable floral resource base and breeding bees to harvesting hive products and enhancing bee services (primarily pollination services). The environment, genetics, practices, and education and extension services are the primary pillars to consider for sustainable beekeeping. Foraging activity, flowering plant availability, physical stressors, and finally the products and services offered by bees may be influenced by environmental factors such as environmental parameters and biodiversity, which together make up the "external" environment. Among these extraneous variables is weather and climate. Human interventions can sometimes affect and control the quality and quantity of nectar and pollen supplies, as well as the diversity of plants available to bees, which are crucial to the success of beekeeping systems. The genetics of bees are important for several reasons, including their productivity, health, and longevity in the hive. Some qualities can be improved by breeding activities, in addition to selecting local bees that can deal with the natural and managed environment. Therefore, the future of bee species and beekeeping businesses depends on the protection of native bee species and the preservation of local genetic diversity. It is possible that locally adapted stock is more productive and sustainable in these environmental systems than invasive bee species or genotypes because it is better suited to specific environmental constraints. It's best to use native bees rather than introducing exotic ones. Appropriate housing, the use of technologies and innovations, good beekeeping practices (GBPs), and biosecurity measures in beekeeping (BMBs) are all examples of practices used in beekeeping to manage bees for a specific outcome (such as honey production, conservation, or pollination services). When put together, these procedures provide the backbone of sustainable and fruitful beekeeping setups. GBPs refer to the broad range of methods used by beekeepers in their on-apiary operations to ensure the best possible conditions for bees, humans, and the environment. They serve as the foundation for the BMBs, which encompass all the beekeeper-implemented operational operations meant to lessen the likelihood of introduction and transmission of certain bee disease agents. Education and extension services are crucial to enhancing beekeepers' capacity for sustainability by providing the opportunity to gain the necessary theoretical and practical understanding of GBPs. Beekeepers can strengthen the honey value chain and collectively respond to new challenges in the sector by participating in effective and ongoing training activities and extension, both of which are important to the uptake and success of beekeeping systems. In conclusion, these are the cornerstones of an effective beekeeping strategy that will lead to the growth of a robust and competitive apicultural sector and higher productivity, profitability, and longevity for beekeeper businesses. Improved resilience to shock, seasonality, and stresses; increased revenue prospects; increased crop yields; and increased efficiency in the provision of profitable bee goods and services are all possible outcomes of this trend toward commercial beekeeping.

2. **Progress in Beekeeping through Synergistic Learning:** The bees and their hives are only one piece of the puzzle; the initiative as a whole must assure environmental, economical, and social sustainability. Apiculture has the potential to lift people out of extreme poverty, but only if the situation is assessed accurately and they have a solid grasp of economics and commerce.

II. ABOUT THE BEES

Only use bees of a local species or subspecies and familiarize yourself with the biology and habits of the bees in your area. Honeybees like humid environments, such as those found in tree cavities or beekeeper hives. Apis mellifera, the most prevalent species, can be found in its natural habitat north of the Arctic Circle, as well as across much of Europe, the Middle East, and Africa. This species of bee has been widely dispersed after being released into the wild. There are many different subspecies, each with its own set of adaptations that allow it to survive in environments ranging from the -20 °C of a European winter to the 40 °C of a Middle Eastern summer. However, honey, beeswax, and propolis are produced by many additional species of bees (covered in subsequent chapters) and provide the basis for human subsistence agriculture and commerce wherever blooming plants are present. Many of the world's poorest countries can be found in the tropics, which is home to a unique set of bees with very distinct biology and behavior from those of more temperate climates. Thus, apicultural methods that thrive in the temperate temperatures of industrialized nations may not be optimal in the tropical climates and outlying rural areas. Bees are wild creatures that forage and mate without restriction in natural environments. Honeybee parasites (such Varroa) and viruses have proliferated in recent years due to the introduction of bees from other regions. Since bees marry normally in the wild, introducing bees would need to be done repeatedly each year, rendering the practice unsustainable. Furthermore, it poses a threat to the native bee populations that have developed specific adaptations to the local environment. However, many bees are traded and moved around needlessly and negatively because people can make a living off of selling them and praising one variety over another. Get in touch with a trustworthy group like Apimondia if you need unbiased guidance if you're puzzled or uncertain about the information accessible in your area.

III. ANALYSIS OF THE SITUATION

As a robust, sustainable, and low-risk occupation, beekeeping is prevalent in disadvantaged rural areas around the world. While beekeeping can be a lucrative business in certain regions, in others it is a necessity for survival, and apiculture and its practitioners are not universal. Find out what actual problems, if any, local beekeepers are experiencing. Recognize that progress in any direction takes time, and be willing to put in the effort required to develop abilities for the long haul. A long-lasting beekeeping program will use existing knowledge and resources in the field, as well as offer training and follow-up for at least two years. Choices about how to provide training and support afterward will need to be made. A model of head beekeepers and their followers has been effective in Bees for Development's efforts in Ethiopia, for instance. When compared to a strategy in which master beekeepers are expected to pass on their knowledge to new beekeepers, formal training offered by local trained beekeepers has proven to be more effective in Ghana. Cultural norms, the social fabric of village life, prevalent beekeeping skills, and transportation options are just a few of the local aspects that must be taken into account when determining the optimal model for each location.

IV. EFFICIENCY AND SCALABILITY

As a result of the interplay between direct costs, selling prices, indirect costs, and volume, beekeepers need to have strong business acumen. Business study has shown that shifting the emphasis from the conventional focus on price per kilogram to a greater emphasis on volume can significantly boost an apiary's annual income. Beekeepers' commercial acumen should be a priority for all projects.

V. TECHNOLOGY

It is a good idea for governments to establish programs for the modernization of agriculture, and beekeeping is no exception. Many efforts have focused on encouraging beekeepers to switch to different hive designs in the hope of increasing honey production, honey quality, and beekeeper productivity. While it is hoped that technological advancements would help alleviate poverty, little research has examined the effectiveness of initiatives aimed at this end. If a desired result does not materialize, it is typically attributed to a lack of preparation, bad timing, or other external factors rather than to the technology itself. Businesses producing and supplying equipment, as well as consultants instructing on their use with bees in the consultant's native region, stand to gain the most from projects centered on the provision of equipment. Many African countries (for example, Ethiopia, Tanzania, and Zambia) are meeting the world's tightest criteria for honey and/or beeswax exports, allowing them to sell their products in the European Union and elsewhere. All of this honey and beeswax comes straight from local-style hives, which are often regarded as the most efficient, cost-effective, all-natural, and environmentally friendly method of beekeeping. In Africa, "modern" hives are sometimes frame hives like the Rev. Langstroth's patented Langstroth hive from 1852. Their local hives, which are inexpensive, simple to construct, readily available, and very effective, are the ones that deserve this moniker. We now know that the widespread practice of natural beekeeping using simple, cylindrical beehives is responsible for Africa's thriving honeybee numbers. Beehives built in the native manner are typically crafted from logs, reeds, grass, and clay. Honeybees are attracted to the cylindrical shape because it provides a safe and secure place to nest. The bees attach their combs directly to the cylindrical walls because there are no moving components. The effectiveness of these hives has been demonstrated over a long period of time, and because they are constructed from readily available, natural materials, they are affordable to even the poorest of communities. Many people believe that in order for poor farmers to benefit from commercialization, a shift in farming technique is necessary. It is recommended that "traditional" hives be abandoned in favor of more complex "modern" ones. Inadequate examination of the situation leads to this form of action, which is often the wrong way to proceed. In certain cases, beekeepers are able to recoup the investment in a frame hive within a few years, according to cost-benefit studies; however, these estimates are rarely founded on actual field data. Poor analysis and faulty projections are blamed by Svensson (2002) for the failure of beekeeping programs. A beekeeper may be able to repay an investment after four years, but they likely wouldn't be able to do it without going into debt. It would be challenging to handle the African bees in these hives," Wainwright (2002) wrote of the apiary operated by producers in Zambia, North Western Bee Products. In particular, the beekeeper would be saddled with debt they couldn't possibly repay due to the high capital cost of the hives. Donors and non-governmental organizations (NGOs) are increasingly interested in beekeeping projects, and with good cause. NGO's are compelled to create initiatives with visible and measurable outcomes due to the requirements and expectations of donor-funded projects. An NGO can easily demonstrate that it has carried out the project as planned by delivering a predetermined number of beehives and then photographing and counting them. An acquired competency or business connection is far more difficult to see and evaluate. Beekeeping expenditures add to project budgets without adding complexity to the final product. Simple yet costly projects are appealing to implementation businesses that subsist on an overhead rate as a proportion of overall project costs. However, it is commonly assumed in development projects that "modern" hives will increase beekeepers' income. Quality-wise, there is no difference between honey produced by bees in frame hives and those produced by bees in local-style hives; the bees feed on the same flora in both cases and are housed in equal conditions. The harvesting and post-harvest procedures are what make the difference. Some beekeepers that use local hives harvest irresponsibly and sell inferior honey. Closer inspection reveals, however, that the market to which they sell is satisfied with the quality of their products, and beekeepers lack exposure to the needs of other markets. This is an appropriate spot for the project to make changes. The overall yield from frame hives consists of more honey and less beeswax than that obtained from local-style hives due to the recycling of beeswax in frame hives. But beeswax is a valuable product and, in many respects, simpler to preserve and sell than honey. It's in high demand all throughout the globe right now. When there is a high potential for financial gain from the sale of beeswax and foundation is either prohibitively expensive or unavailable, recycling comb serves no practical use. As one Ugandan beekeeper said to his neighbor: "I was advised to provide foundation for my bees because then they can spend more energy making honey, and then I can get more honey more quickly for selling." The neighbor replied: "All bees need wax comb." Also, while frame hives allow combs to be inspected and placed back in the hive, tropical bees are typically fast to abscond when managed, therefore it is preferable for the bees to make their own foundation. Honey can be extracted from frame hives by employing a centrifugal extractor; however, since centrifuges are so expensive and are only used once or twice a year, beekeepers must store and share them. This necessitates carrying heavy cardboard boxes full of frames to the central processing facility, which is a laborious, time-consuming, and potentially dusty process.

VI. COMMERCE AND MARKETS

Do your best to learn about the local market system before attempting any sort of intervention. Once the study has begun, you should create a conducive environment, consult with beekeepers, and maintain track of your findings. Scalability and productivity are prerequisites for commercial beekeeping. In order to maintain a profit margin, accurate production costs must be determined. There is little proof that beekeepers in sub-Saharan Africa who utilize frame hives actually harvest more honey than those who employ vast numbers of local-style hives, despite widespread belief that this is the case. Beekeepers will invest more time and money into the industry if they have access to markets that are convenient, lucrative, dependable, and equitable. Supply chain issues are common in developing countries due to inadequate market information and links, insufficient operating capital, a shortage of containers, insufficient investment, and inadequate communication. Therefore, projects ought to center their attention on solving these issues.

VII. QUALITY CONSCIOUS HARVESTING AND HANDLING

High-quality honey, packaged and labeled as required by supermarkets, may be produced by any beekeeper who follows basic, good procedures. Beekeepers and collection center workers need to be educated on best practices for collecting honey from a variety of hives, keeping accurate records for later product tracing, and preserving the quality of harvested goods.

Environment and Bees: The bee's surroundings is crucial to its survival. It has an immediate effect on the wellbeing of bees and the quality of their output. The bee colony gets its sustenance from the surrounding environment, and it provides an essential service to the ecosystem by pollinating plants. Pollutants in the environment can also have a significant impact on bees and honey. This is why beekeepers need to give serious thought to the locations of their hives at all times. A beekeeper's best interests lie on providing the most optimal setting for the hive, barring the use of bees in environmental monitoring. In addition to beekeeping knowledge, effective hive-environment management sometimes necessitates collaborating with others interested in managing the landscape as a whole.

VIII. INPUTS FROM THE ENVIRONMENT

The bees' surroundings can be analyzed on multiple scales, from the regional to the local, with the inputs becoming more noticeable as one gets closer to the hive. The bees can only fly around 3 kilometers from the apiary, therefore the range of some inputs is constrained by this fact. The bees can only fly around 3 kilometers from the apiary, therefore the range of some inputs is constrained by this fact. The local microclimate and the physical characteristics of the surrounding area all contribute to the overall regional climate's effect on beehives. The topography, orientation, and orientation of the land, as well as the structure of the vegetation, are all examples of physical features. These establish a local microclimate that affects the hive's performance and survival, since they determine the hive's exposure to sunlight, shade, wind, humidity, and frost. These regional climate factors will determine the relative importance of these local traits in buffering the consequences of climate change. Honeybees and other pollinators are not the intended targets of the wide range of chemicals used in agriculture, but they are nonetheless subject to the full brunt of these substances' side effects. The effects of these chemicals/pesticides on bees range from acute poisoning and instant death of adult bees and developing forms to chronic and fatal effects that are varied, sometimes very unfavorable, and difficult to quantify. More pesticides are typically utilized when farming is done on a larger scale. Despite a downward trend in chemical consumption over the past few decades, honeybee populations have been declining as newer, more hazardous insecticide families have been introduced (such as neonicotinoids). Pesticides have a significant, obvious, and growing negative impact on pollinators. The pesticide-induced loss of honeybees and other pollinators endangers ecosystems, biodiversity, and human health. Vegetational abundance is also important since bees need to be able to find nectar, pollen, honeydew, water, and other essential nutrients. Throughout the bee season (which may include or exclude wintering), the colony's survival and reproduction depend on an abundance of these items. Some flowers are rich in nectar (which the bees use for energy) while others are rich in pollen (which the bees eat for protein). The bees' requirements vary and may even be species-specific depending on the time of year and the tasks that must be completed within the colony (such as providing sustenance for the brood, accumulating resources, or extending the lives of the workers). However, bees have a limited searching period and each bloom has a limited flowering season. Therefore, bees must have access to plants that bloom at different times, even if they are some distance from the colony. Because different flowers bloom at different times, honey produced from these hives will have its own unique flavor and qualities. Natural and semi-natural regions need to have enough biodiversity, while agricultural landscapes need to have a wide variety of crops and, ideally, some wild areas for grazing.

IX. BEES AND THEIR BENEFICIAL ROLE IN NATURE

Pollination of flowers is the primary service provided by bees to the natural world. Bees are essential to the reproduction of a wide variety of blooming plants, both wild and cultivated. About 80% of flowering plant species are thought to rely on animal pollinators, most commonly insects. Pollen is transferred from the male to the female section of a flower as bees collect nectar and pollen, a process known as fructification. The renewal and sustainability of terrestrial natural ecosystems depend on fruit production, which is important for reproduction. Fruits maintain ecosystem health when they are eaten or fertilized by other plants. Pollination by bees, which hop from bloom to flower, helps spread genes and increases plant diversity. Ecosystems can draw on this genetic variety for both functionality and resilience. Some blooms require cross-pollination with other kinds of plants, which makes bees even more crucial to their survival. It has been demonstrated that honeybees play a pivotal role in the pollination of blooming plants. Because of the way they pollinate flowers or inflorescences, they not only raise agricultural production but also improve the quality of fruits and seeds (as has been demonstrated for strawberries and cocoa). As pollination rates fall, farmers are paying beekeepers to place hives in close proximity to their crops. It is important to remember that pollination is predicted to have a worldwide economic value that is considerably in excess of the value of bee products (for natural ecosystems as well as for food security and livelihoods). Nonetheless, bee products contribute to food security, health, money, and other neighborhood services, which is frequently what motivates the beekeeper. Bees and their products can play a role in the local food web. Both birds and larger animals, such as hornets and parasites, can consume bees, while predatory insects can attack bee hives and stores.

X. CONCERNS FOR THE ENVIRONMENT

Both bees and the plants they necessitate are affected by climate change. It has an impact on plant diversity, production, and phenology, as well as bee physiology and activity. Shifting flowering due to climate change can shorten the time that bees have access to nectar and pollen. Because to shorter flowering times, longer intervals between flowering periods, and insufficient products in terms of quality and quantity, this situation might become serious, especially if the number and variety of species is reduced. Pollinator and bee declines are linked to the elimination of forested areas rich in flowering plants (from herbs to trees) around or within agricultural landscapes, the reduction of crop diversity, and the increase in plot sizes. Chemical treatments and the abuse or incorrect application of pesticides also limit diversity and may play a direct role in the death of bees in some circumstances. The same holds true for bee diseases (such varroosis, Aethinosis, and nosemosis) and invasive species that alter biodiversity as a result of globalization. The honeybee can have both positive and bad effects on their ecosystem. The honeybee has the benefit of being a generalist since it can obtain food (in the form of nectar and pollen) from a wide variety of flower types. However, there are local bees and wild pollinators that are pickier or less flexible than others. If there is less variety in the plants available, their host plant could go extinct or pollinator competition could rise. Wild pollinators, in many circumstances and for some plants, have been proven to perform as well as, or even better than, honeybees. Honeybees aren't always the best pollinators, and their presence can actually cause harm to a flower's reproductive organs, preventing it from producing fruit. Sometimes honeybee swarms compete with native bees, leading to aggressive behavior. Given these factors, beekeepers need to strike a delicate balance when deciding where to set up their hives.

XI. HOW TO MAKE THE WORLD SAFE FOR BEE AND POLLINATOR INDIVIDUALS

The importance of environmental resource availability to bees has been emphasized. Wild pollinators, which rely on the landscape for both food and shelter, can attest to this fact. Rich ecosystems in the surrounding terrain are important, but the connectivity between these habitats is just as crucial to the availability of environmental resources. Pollinators are negatively impacted by habitat fragmentation because they are unable to freely travel from one area to another. Intercropping and nectar-rich crop provision, as well as hedgerows or other larger natural or semi-natural regions, are examples of pollination-friendly landscape management practices that benefit pollinators, especially when diverse natural habitats are otherwise limited and isolated in plant production systems. Evaluating pollinator variety and abundance in the landscape, learning about their biology, making use of and integrating potential indigenous local knowledge, and monitoring their numbers through time is very valuable (albeit challenging). Fortunately, there are tools available to help count populations, set up monitoring systems, and practice sustainable landscape management with a focus on improving pollinator health and availability. These evaluation and monitoring techniques and tools should be required to prevent environmental degradation in situations where exotic bees are introduced to an ecosystem, the number of colonies is raised, or there is a mass arrival of bees. Hivelog and HiveTracks are two examples of user-friendly monitoring systems for domesticated pollinators. Beekeepers can play a significant role in landscape management and are thus an important stakeholder group.

Regular nature observation, expertise, engagement with other stakeholders, legitimacy through shared benefits from their beekeeping and collaborations, and awareness-raising can help them better the environment and persuade others to help, too. Beekeepers, farmers, pastoralists, foresters, people with local and indigenous knowledge, watershed managers, and scientists are just few of the groups that can contribute to landscape management. Maintaining and promoting essential components on which pollinators depend and ensuring links between them is suggested at the landscape level, particularly to prevent the establishment of large distances without favorable habitats. To accomplish this, natural regions with native flora, including dense and varied flowering plants to function as nectaries, can be established. Natural areas can form in agricultural and urban environments along streams, around fields or inhabited areas, or even within fields and surrounded by trees and bushes. When agricultural systems are maintained using an ecological approach, pollinators may reap benefits from interactions between agroecosystems and weed management. The presence of woods in a landscape affects pollination services for many wild plants and crops since many pollinators rely largely on woodlands for nesting and feeding. The patchiness and variability of the landscape should be preserved and encouraged through the use of a variety of management techniques that account for ground-nesting bees and flowering times. This improves the availability of nesting resources and habitats for flowers and pollinators. It is crucial to maintain healthy ecosystems year-round, especially in areas where honeybees are relocated seasonally, to ensure reliable pollination services. Combining spatial diversity with temporal diversity is a particularly effective way to foster heterogeneity and connectedness in agricultural fields, in addition to the aforementioned landscape strategies. Growing different types of crops on small plots of land and using different farming techniques to cultivate a wide range of plant, flower, and soil types might help achieve spatial variety. Growing plants with staggered mowing or harvesting and interim flowering can create temporal variation. Forest management has a substantial impact on pollinator abundance and diversity, can promote spatial and temporal variation in tree groups and habitats, and rehabilitate degraded forests. Selective logging, thinning, and coppicing; regulated mowing and grazing; and prescribed burning, maintaining a mosaic of burned and unburned areas, all contribute to the maintenance of heterogeneity. Cavity-nesting and ground-nesting bees can benefit greatly from woods with plenty of dead standing and lying wood and enough bare ground. Pollination is a crucial process for both nature and people, and bees are remarkable organisms because of their organization and collective intellect. Many people enjoy beekeeping because it's rewarding both financially and personally. If beekeeping is to endure, however, it must take into account the bees' natural habitat for their mutual benefit. Beekeepers must consider the local ecosystem and the effects of their hive management practices. Honeybee keepers have a duty to protect the health of the environment and to modify their methods so as not to upset the delicate balance necessary for the survival of their hives. Bees and other pollinators, as well as the natural world as a whole, benefit from their ability to intervene in landscape management and enhance the ecosystem. Farmers, meanwhile, should be cognizant of the harm that pesticides and other environmental toxins might do to bees. The health and environment ministries of each nation must check that newly introduced pesticides pose no threat to human or animal health. Responsible action is needed by beekeepers, farmers, and other stakeholders, as well as policymakers, to save biodiversity, improve environmental quality, and enhance bee protection. That's probably the only way to make sure future generations always have enough to eat.

Colonies of Honeybees as Environmental Sensors: It is crucial for humans to monitor environmental conditions and predict future shifts in the environment. They provide this service by conducting analyses in the areas of chemistry, physics, chemistry and physics, electronics, and biology. Predetermined points, stationary automatic monitoring stations, and mobile stations are typically used to track the levels of pollutants in the environment. When certain pollutants surpass legal threshold levels in one or more areas, action is taken to curb their emissions via air pollution control units, whose systems directly assess the quantities of pollutants in air samples taken from the atmosphere. However, there are significant drawbacks to this kind of monitoring due to the high upfront and ongoing expenditures associated with automatic control systems. It's important to remember that the cumulative impacts of multiple contaminants are far more than the sum of their individual concentrations, so measuring them separately isn't enough to get a full picture of environmental deterioration. Synergistic interactions can be taken into account and, in some situations, the existence of unlawfully released chemicals can be revealed by using biological indicators. Bees are regarded as reliable bioindicators of environmental pollution (including pesticides, polyaromatic hydrocarbons, heavy metals, and radionuclides) due to their biological, morphological, physiological, and ethological properties. Foraging bees go up to three kilometers away from the hive as they constantly explore a 30-square-kilometer region, collecting samples of the plant, soil, water, and air along the way. The materials from the various natural resources they encounter are also effectively retained by their hair. Since a healthy honeybee hive may house 8,000 foragers, and since each honeybee visits 1,000 flowers per day during the productive season, a colony of bees makes approximately 8 million microwithdrawals per day, and this doesn't even account for the transport of water, which on hot days can even reach a few liters. Directly, through mass death, as in the case of insecticides or other pesticides; and indirectly, through the presence of pollutant residues on and inside their bodies or in hive products (honey, pollen, wax, propolis, and royal jelly). Honeybees can serve as a biological indication of environmental health. Honeybee colonies can be utilized as a biosampling method for environmental monitoring, allowing for the detection of a wide range of toxins. Honeybees have potential as a biosampling instrument, but it's important to keep both their strengths and weaknesses in mind. Honeybees can be used for biomonitoring of the environment by having foragers collect biosamples of the contaminants as they forage for food and bringing them back to the hive, where they can then be sampled invasively or non-invasively for the presence of the target contaminants. Unwanted pollutants are collected from flowers alongside pollen, nectar, water, and propolis.

In the same way that honeydew, extrafloral nectar, and water can be gathered, so too can contaminants found on leaves and in water sources. Airborne deposition, drift, direct spraying, and the uptake of systemic pesticides all contribute to the presence of contaminants in flowers and on foliage. Flowers can be contaminated in a number of ways, including by the attachment of foreign particles, the binding of lipophilic pollutants to the waxy coating of pollen, and the dispersion or dissolution of additional contaminants in nectar, honeydew, and guttation fluid. Foragers of nectar and pollen have distinct habits. Pollutants in the nectar are what nectar-gatherers typically pick up, although particles from the flowers and the leaves can also get stuck in their hair. This group seldom ever cleans up after itself before out foraging, so they bring home a lot of pollen and other potential toxins stuck in their hair and on their feet. In their honey stomachs, they carry the dissolved and scattered toxins found in the nectar. Intruders may be filtered out by their proventriculi and eliminated in their feces if the particles are small enough. However, pollen foragers are constantly cleaning their pollen baskets of debris, including stray hairs and dust. Pollen and other contaminants may still be stuck in their hair and on their feet, though. Flowers can either provide nectar or pollen, but not both. If we assume that the maximum weight of pollen and nectar taken in a single flight is roughly the same, then we may infer that there are around five times as many nectar foragers as pollen foragers. Furthermore, there is usually a group of scout bees flying around in search of new food sources, bringing in pollen, nectar, and perhaps even harmful substances. As a result, it stands to reason that insects seeking nectar and pollen would visit different plants and, thus, be exposed to a wider variety of toxins.

Finally, the contaminated foods and other items that were collected are delivered into the hive. Foragers and hive bees both directly ingest nectar and store some of it in their cells. The pupae eat it too. Some of the pollutants that have been dissolved can adhere to the beeswax inside the cells. Honey is made from some of the nectar that has been kept. A process termed "trophallaxis" ensures that this nectar gets distributed evenly throughout the colony. Pollen foragers travel to cells to provide pollen to them. The combination of these routes, as well as the extra interchange of particles trapped in the hairs, via physical contact and auto- and allogrooming, results in the rapid spread of nectar, pollen, and pollutants throughout the entire colony in a matter of hours or days. The colony is sampled in order to learn more about its living conditions, such as its diet and exposure to harmful substances. Sampling strategies are tailored to the specific nature of the investigated substance. Careful attention must be paid during the sampling process at all times to guarantee accurate collection of the pollutants of interest. In order to maintain the integrity of the biomonitoring equipment, it is essential that honeybee colonies are disturbed as little as possible while sampling for monitoring studies. Both invasive (at the cost of the colony) and non-invasive methods are used to collect samples from honeybee colonies. As if the moral complications of destroying honeybee colonies or stealing their food weren't enough, invasive sampling also upsets the test system's natural buffer capacity for the bee colony. In addition, there is a lot of variance in the pollutant load and the spread of bee samples (especially those taken from the flight entrance) makes them hard to standardize. This obstacle can be bypassed with in-hive bee monitoring because pollutants are dispersed among all the bees, however the sample size is essential here. The concentration of contamination may be undetectable if the sample size is too small. If it's too loud, it could interfere with the measuring device. These problems with sampling can be avoided by using passive samplers. The molecules that flow through or through a passive sampler are bound either physically or chemically, thus the sampler has no effect on the surrounding environment. The first generation of honeybee passive samplers were tubes put outside the hive entrance to collect pollen and contaminants left behind by bees as they entered and exited the hive. Exposure to the elements may reduce the binding and contact capacity of passive samplers when they are placed outside the hive. Bees coming and going from the hive are the only source of contact and passive samples. Because of how stable circumstances are inside the hive, passive samplers used there are protected from the weather outside. Although the amount of particles carried by any given bee is typically too small to be detected, because bees are constantly on the move throughout the hive, passive samplers such as the APIStrip in a bee lane will be touched by a large number of bees over the course of their exposure time. With a longer time frame, additional opportunities to interact with the samplers will arise. Experiments with plant pathogens and pollen showed that particles injected into a colony only once will be greatly diluted after two weeks as a result of the birth of new bees and the death of older bees. Therefore, time is a major element in addition to the appropriate sampling method and tools when employing honeybee colonies for biomonitoring. Several methods have been described for using honeybee colonies for biomonitoring; however, the optimum practice is to adhere to a rigid methodology that guarantees a consistent "sample to data" approach. The samples must be collected in the right way and then stored, transported, coded, analyzed, recorded, and archived correctly. All of this needs to be founded on excellent laboratory practice, especially with regards to sample traceability from collection to final data presentation and accountability of all those involved. The outcome of biomonitoring and the decision to sample honeybee colonies either invasively or not depends on the matrix and the purpose of the research. Colony data must be "translated" into information about the natural world. Careful planning of where, how, and how large a sample size to take is especially important when conducting invasive sampling. Some biomonitoring tools, such APIStrips and pollen traps, are already on the market. The honeybee colony must remain undisturbed and unaffected by the biomonitoring equipment for the process to be successful. Pollen can be collected with a pollen trap. Invasive samples can be taken without any special beekeeping tools.

XII. CONCLUSION

The study of how to convert honeybee colony biomonitoring data into information about environmental conditions is an emerging topic that needs more study. Before using bees or hive products in a research of pollutants, there are a few things to keep in mind.
Meteorological events, such as rain and wind, can either wash pollutants out of the air or move them to new ecosystems and resources.
Because bees are opportunistic insects, they avoid locations with abundant nectar because of the potential for contamination, depending on the season.

Honey's Botanical Roots: nectar from open flowers is more vulnerable to contamination than nectar from closed blooms, which often has more protection from the corolla.

Pollutants' chemo-physical properties are being taken into account in this research; for instance, pesticides are more likely to be detected in beeswax than honey, and vice versa. Long-term biomonitoring programmes not only increase scientific knowledge but also provide crucial information for environmental policies and so should be considered fundamental components of economic policies, which is why their use by project planners who want to use honeybees for biomonitoring purposes is so important.

REFERENCES

[1] Anderson, M.B., Brown, D. & Jean, I. 2012. Time to Listen: Hearing People on the Receiving End of International Aid. Cambridge, MA, CDA Collaborative Learning Projects.
[2] Andonov, S., Costa, C., Uzunov, A., Bergomi, P., Lourenco, D. & Misztal, I. 2019. Modeling honey yield, defensive and swarming behaviors of Italian honey bees (Apis mellifera ligustica) using linear-threshold approaches. BMC Genetics, 20(1): 78. https://doi.org/10.1186/s12863-019-0776-2
[3] Apimondia. 2019. Apimondia Statement on Honey Fraud [online]. [Cited 6 May 2021]. https://www.apimondia.com/ docs/apimondia_statement_on_honey_fraud.pdf
[4] Apitherapy.com. undated(b). Apitherapy e-library [online]. [Cited 6 May 2021]. https://apitherapy.com/apitherapy-data-base/
[5] Bendem-Ahlee, S., Kittitornkool, J., Thungwa, S. & Parinyasutinun, U. 2014. Bang Kad: A reflection of local wisdom to find wild honey and ecological use of resources in Melaleuca Forest in the Songkhla lake basin. Silpakorn University Journal of Social Sciences, 14(3): 77–99
[6] Camargo, J.M.F. 2013. Historical biogeography of the meliponini (Hymenoptera, Apidae, Apinae) of the neotropical region. In P. Vit, S.R.M. Pedro & D. Roubik, eds. Pot-honey: A legacy of stingless bees, pp. 19–34. New York, NY, Springer.
[7] Camargo, J.M.F. & Pedro, S.R.M. 2013. Meliponini Lepeletier, 1836. In: Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region – Online Version. [online]. [Cited 27 July 2020]. http://www.moure.cria.org.br/catalogue
[8] Camargo, J.M.F. & Wittmann, D. 1989. Nest architecture and distribution of the primitive stingless bee, Mourella caerulea (Hymenoptera Apidae, Meliponinae): Evidence for the origin of Plebeia (s. lat.) on the Gondwana Continent. Studies on Neotropical Fauna and Environment, 24(4): 213–229. https://doi.org/10.1080/01650528909360793
[9] De Jong, D. 1984. Africanized bees now preferred by Brazilian beekeepers. American Bee Journal, 124(2): 116–118.
[10] De Jong, D. 1994. The African experience. Bee Culture: The Magazine of American Beekeeping(2): 453–461.
[11] De Jong, D. 1996. Africanized honey bees in Brazil, forty years of adaptation and success. Bee World, 77(2): 67–70. https://doi.org/10.1080/0005772X.1996.11099289
[12] De Jong, W. 2000. Micro-differences in local resource management: The case of honey in west Kalimantan, Indonesia. Human Ecology, 28(4): 631–639. https://doi. org/10.1023/A:1026443915926 De Jong, D. & Gonçalves, L.S. 1981. The Varroa problem in Brazil. American Bee Journal, 121: 186–189.
[13] Eardley, C.D. 2004. Taxonomic revision of the African stingless bees (Apoidea: Apidae: Apinae: Meliponini). Plant Protection, 10(2): 63–96.
[14] Eardley, C.D., Kuhlmann, M. & Pauly, A. 2010a. The bee genera and subgenera of sub-Saharan Africa. Abc Taxa, 7. (also available at http://www.abctaxa.be/volumes/vol-7-bees).
[15] Eardley, C.D. & Urban, R. 2010b. Catalogue of Afrotropical bees (Hymenoptera: Apoidea: Apiformes). Zootaxa, 2455(2454): 1–61. https://doi.org/10.11646/ zootaxa.2455.1.1 East African Community Secretariat. 2000. EAS 36:2000 Honey – Specification.
[16] Food and Agriculture Organization of the United Nations (FAO). undated. Bees and other pollinators: FAO's Global Action on Pollination Services for Sustainable Agriculture [online]. [Cited 6 May 2021]. http://www.fao.org/pollination/background/bees-and-other-pollinators/en/
[17] Food and Agriculture Organization of the United Nations (FAO). undated. TECA – Technologies and Practices for Small Agricultural Producers [online]. [Cited 6 May 2021]. http://www.fao.org/teca/en/
[18] Food and Agriculture Organization of the United Nations (FAO). 2006. Honey bee diseases and pests: a practical guide. Agricultural and Food Engineering Technical Report 4, TC/D/A0849E/1/11.06/550. Rome. 42 pp.
[19] Food and Agriculture Organization of the United Nations (FAO). 2018. Beehives. In: FAOSTAT [online]. [Cited 13 March 2019]. http://www.fao.org/faostat/en/#search/beehives Food and Agriculture Organization of the United Nations (FAO). 2020a. FAO's Global Action on Pollination Services for Sustainable Agriculture. In:
[20] Food and Agriculture Organization of the United Nations (FAO) [online]. [Cited 3 June 2020]. http://www.fao.org/pollination/en/ Food and Agriculture Organization of the United Nations (FAO). 2020b. Towards sustainable crop pollination services: Measures at field, farm and landscape scales. Rome. https://doi.org/10.4060/ca8965en

[21] Kellert, S.R. 1998. Kinship to mastery: Biophilia in human evolution and development. The Quarterly Review of Biology, 73(4): 544–545. https://doi.org/10.1086/420520 Ken, T., Danyin, Z. & Shaoyu, H. 2003. Apis cerana provides a living in the Yunnan Mountain area of China. Bees for Development Journal, 72.

[22] Kevan, P.G. & Baker, H.G. 1983. Insects as flower visitors and pollinators. Annual Review of Entomology, 28: 407–453. https://doi.org/10.1146/annurev.en.28.010183.002203

[23] Khazaei, M., Ansarian, A. & Ghanbari, E. 2018. New findings on biological actions and clinical applications of royal jelly: A review. Journal of Dietary Supplements, 15(5): 757– 775. https://doi.org/10.1080/19390211.2017.1363843

[24] Vit, P., Pedro, S.R.M. & Roubik, D., eds. 2012. Pot-honey: A legacy of stingless bees. New York, NY, Springer. 654 pp.

[25] Walton, A. & Toth, A.L. 2016. Variation in individual worker honey bee behavior shows hallmarks of personality. Behavioral Ecology and Sociobiology, 70(7): 999–1010.

[26] Wang, H. 2020. Travel marketing during COVID-19. In: Skrift Research [online]. [Cited 6 May 2021]. https://research. skift.com/report/travel-marketing-during-covid-19-crisis/

[27] World Health Organization Department of Child and Adolescent Health and Development. 2001. Cough and cold remedies for the treatment of acute respiratory infections in young children. Geneva. 43 pp.

[28] Yamaura, K., Tomono, A., Suwa, E. & Ueno, K. 2013. Topical royal jelly alleviates symptoms of pruritus in a murine model of allergic contact dermatitis. Pharmacognosy Magazine, 9(33): 9–13. https://doi.org/10.4103/0973-1296.108127

[29] Zhang, S.W., Bartsch, K. & Srinivasan, M.V. 1996. Maze learning by honeybees. Neurobiology of Learning and Memory, 66(3): 267–282. https://doi.org/10.1006/ nlme.1996.0069

