SPARK CHALLENGE 22/23

SPARK

Electronic and Telecommunication Engineering

EC

Contents

1 Details of the Team

1.1 Group Name

Team Littlebees

1.2 Group Leader's Name

H.H.A.M. Haputhanthri

1.3 Group Members' Information

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1.4 External Support

We initially reached out to the Bee Development Unit in Bindunuwewa, where we had the opportunity to meet Mr. P. P. R. Wimukthi, the Assistant Director of Agriculture. He kindly guided us through the basics of beekeeping and introduced us to the common challenges faced by beekeepers. Mr. Wimukthi also explained how the administrative tasks are handled and how the Bee Development Unit supports beekeepers in their work.

Mr. P.P.R.Wimukthi
Assistant Director of Agriculture
0572222537

Continuing our exploration of beekeeping, we had the privilege of connecting with a highly experienced beekeeper, Mr. Himal, widely recognized as the oldest beekeeper in Sri Lanka. Our interaction with Mr. Himal proved to be a treasure trove of knowledge, as he shared invaluable insights on every aspect of beekeeping. He imparted his wisdom on beekeeping techniques, honey harvesting methods, and the numerous challenges faced by beekeepers in the industry. Moreover, Mr. Himal provided us with valuable information on recent advancements and inventions that have emerged to alleviate the difficulties faced by beekeepers, ultimately making their work more efficient and productive.

Mr. Himal
The Oldest Beekeeper in Sri Lanka
0712188446

2 Problem Statement

2.1 What is your primary area of development?

Food production and preservation

The primary focus point lies within food production and preservation. Our main objective revolves around the introduction of effective strategies for managing food culture and implementing innovative preservation techniques.

2.2 Other supporting areas of development, if any?

Environmental conservation and preservation

Aside from introducing innovative methods to enhance food culture, our project also places significant emphasis on environmental conservation and preservation. We recognize the vital role played by bees in maintaining environmental balance and biodiversity. By addressing the needs of bees and their habitats, we aim to actively contribute to the preservation of these vital pollinators and the overall health of our environment.

2.3 The problem statement

Bees play a crucial role in both the natural world and human society. As hardworking pollinators, they facilitate the reproduction of numerous plant species, contributing to the maintenance of

diverse ecosystems. This pollination process not only ensures the continuation of plant populations but also supports the growth of fruits, vegetables, and nuts that are vital for human sustenance. Furthermore, bees contribute to biodiversity by serving as indicators of environmental health and assisting in the preservation of delicate ecological balances. Their intense bond with nature and their immense value to humanity make their protection and conservation of utmost importance.

- It is estimated that bees and other pollinators contribute to the pollination of approximately 75% of globally important food crops.
- Bees contribute to the overall health and diversity of ecosystems. By pollinating a wide range of plants, they facilitate plant reproduction and help maintain plant biodiversity.
- Honey is a natural sweetener and a source of energy. It contains a blend of carbohydrates, including fructose and glucose, as well as trace amounts of vitamins. And also it has culinary and medicinal uses.
- The honey industry plays a significant role in many economies, providing livelihoods for beekeepers, farmers, and related industries. Honey production and trade contribute to local and global economies, supporting rural communities and agricultural sectors

But harvesting honey needs proper knowledge, skills, and safety measures which have become difficult to make honey on a large manufacturing scale. And also it has become difficult for someone to enter the field as a new entrepreneur without a proper experience. Because of that, nowadays honey harvesting is only limited to a small set of population who are doing the business hereditary. Therefore, harvesting honey without being poisoned by bees and without damaging bees, is a challenging work only experienced beekeepers can do. Apart from that parasite attacks have posed significant dangers to bees, impacting their health, behavior, and overall survival which have made it very difficult for farmers to protect their beehives and continue to endure in the business. [6]

- Varroa destructor mites are one of the most destructive parasites affecting honey bees. These mites attach themselves to adult bees and their brood (developing bees in the cells), feeding on their hemolymph (bee's equivalent of blood). Varroa mites can transmit viruses and weaken the immune system of bees, leading to various issues such as deformed wings, reduced lifespan, decreased reproductive capabilities, and colony collapse.
- Nosema ceranae is a microsporidian parasite that infects the gut of bees. It weakens the bees' immune system, impairs digestion and nutrient absorption, and can lead to reduced lifespan.

Parasite attacks can have devastating effects on bee populations, leading to colony decline, weakened immune systems, reduced productivity and in severe cases, even colony collapse disorder can happen. Therefore, monitoring bee colonies regularly in order to maintain their overall well being have become a very challenging issue for the beekeepers.

2.4 Explain how finding a solution to your problem directly or indirectly impacts the causes of climate changes?

1. Preserving Biodiversity: Healthy honey bee populations, protected from varroa mites, contribute to the preservation of biodiversity. Bees are essential pollinators for a wide range of plant species, including many that store carbon dioxide and mitigate climate change.

2. Promoting Sustainable Agriculture: By ensuring effective mite management, our solution supports the pollination of crops, leading to increased agricultural productivity and sustainable food production. This reduces the pressure on natural habitats for agricultural expansion, helping to mitigate deforestation and its associated carbon emissions.

3. Reducing Chemical Usage: Our targeted mite detection and removal techniques reduce the reliance on chemical treatments, minimizing the environmental impact of pesticides. This supports sustainable agriculture and reduces the release of harmful chemicals into the environment, contributing to the mitigation of climate change.

In summary, finding a solution to varroa mite infestations indirectly impacts the causes of climate change by preserving biodiversity, promoting sustainable agriculture, and reducing chemical usage in beekeeping practices.

3 Solution Description

3.1 Arriving at your solution

- Key Findings in Research

  Through extensive research, we have identified key challenges faced by beekeepers in bee culture, including varroa mite infestations, honey extraction, feeding during the winter season, brood monitoring, and timely honey harvest. Existing solutions often involve chemical treatments that can harm bees and the environment, and manual honey extraction methods can be time-consuming and disruptive to the hive.

  We critically evaluated existing alternatives and solutions available to beekeepers. While chemical treatments are commonly used, they have drawbacks such as potential harm to bees and the development of mite resistance. Manual honey extraction methods can be labor-intensive, time-consuming, and may disturb the hive, impacting bee productivity. There is a need for an innovative solution that addresses these challenges effectively and sustainably.

- Evaluation of Alternatives/Current Solutions

  1. Extracting honey

     Flow Hive is a remarkable innovation designed with the utmost convenience in mind for honey extraction, which is commercially available at the moment. The Flow Hive introduces an innovative process for honey extraction from broods. With this system, beekeepers can collect honey without the need for conventional methods that involve disturbing the bees or removing frames. The Flow Hive consists of specially designed frames with partially formed honeycomb cells. When the beekeeper activates the mechanism, typically by turning a handle, the cells are split open, allowing the honey to flow out under the force of gravity. It then travels through channels within the frames and into a collection container. This method significantly simplifies the extraction process.

     Despite the apparent utility and convenience of the Flow Hive, it is important to acknowledge several drawbacks associated with the product. While not extensively documented as a significant commercial concern, its direct impact on the well being of bees is a subject of critical consideration. One of the primary concerns, as identified by a farmer, pertains to the splitting of cells, which potentially results in trapping of numerous bees

Figure 1: Flow Hive

or larvae within the cell structure. Disrupting the frame without thorough examination can have negative effects on the overall health and vitality of the bee colony.[2]

Another significant concern we address is the absence of an internal monitoring system within the Flow Hive. Beekeepers are required to manually break open the beeswax and inspect each frame individually. The lack of a monitoring system presents challenges in determining the presence of infections or diseases within the hive and identifying the ideal timing for honey harvesting. This limitation underscores the need for additional monitoring mechanisms to ensure the health and productivity of the bee colony.[5]

Another practical drawback of the Flow Hive is using plastic foundation. It has been observed that bees may sometimes exhibit reluctance in accepting the plastic combs unless they have been coated with beeswax. This requirement for beeswax coating adds an additional step and complexity to the setup process, potentially impacting the ease of adoption and overall efficiency of the hive system.[3]

2. Varroa mite infestations

Figure 2: Adult Bee with varroa mites

Alternative solutions for varroa mite infection in bees have been explored within the beekeeping industry. However, these alternatives exhibit certain limitations and challenges that our proposed Smart Bee Hive with Varroa Mite Management System effectively overcomes.[4]

(a) Chemical Treatments:

Chemical treatments involve the application of pesticides or miticides to control varroa mite infestations in bee colonies. However, these treatments pose risks to bee health and can lead to the development of mite resistance. Additionally, concerns exist regarding the presence of pesticide residues in honey, which can impact consumer safety and trust.

(b) Screened Bottom Boards:
Screened bottom boards are installed at the bottom of hives, allowing mites to fall through and reducing mite populations. While providing some level of control, screened bottom boards as a standalone solution may not offer sufficient efficacy in managing varroa mite infestations. Regular monitoring and maintenance are required, and mites falling through can re-enter the hive, resulting in potential re-infestation.

(c) Drone Brood Trapping:
Drone brood trapping involves placing drone-sized brood frames or foundation in hives to attract varroa mites for reproduction. Once capped, the frames are removed, taking the mites with them. However, this method demands frequent monitoring and removal of frames, which can be labor-intensive and time-consuming. The potential disruption to hive dynamics during the removal process may affect bee productivity.

(d) Natural Beekeeping Methods:
Natural beekeeping methods emphasize the promotion of strong and healthy colonies through practices such as organic management, selective breeding, and optimal nutrition provision. While contributing to overall colony well-being, natural beekeeping methods may not offer standalone control of varroa mite infestations. Additional interventions are often required to effectively manage mite populations.

- Our Solution: ***Smart Bee Hive with Varroa Mite Management System***

  Our proposed solution is the development of a revolutionary Smart Bee Hive that integrates advanced technology to enhance beekeeping practices and honey harvesting efficiency while minimizing disruption to both the beekeeper and the bees in the hive.

  Honey extraction system: Our innovative hive incorporates a mechanism that enables convenient and efficient honey extraction without disturbing the bees or damaging the comb structure. The system comprises horizontal and vertical sliders with a specialized tip, allowing for safe and efficient extraction from honeycomb cells.

  Hive inspection: Our Smart Bee Hive incorporates a comprehensive monitoring system that empowers beekeepers to assess hive health, identify potential issues or diseases, and determine the ideal timing for honey harvesting. This feature enables proactive hive management and ensures optimal conditions for the bees.

  Bee acceptance: To facilitate the acceptance of frames or foundation, we have carefully selected bee-friendly materials and implemented an automatic sugar syrup application. These measures encourage bees to readily accept the hive components, eliminating the need for additional coatings or modifications.

  Hive ventilation: Our hive design includes effective ventilation mechanisms that maintain optimal airflow within the hive. This critical feature promotes the well-being of the bees by regulating temperature and humidity levels, contributing to a healthy and thriving colony.

  Hive durability: We prioritize durability by utilizing robust materials in the construction

of our Smart Bee Hive. These resilient components are designed to withstand diverse environmental conditions, ensuring longevity and providing a reliable structure for the bees.

Beekeeper-friendly features: We have incorporated several user-friendly elements to enhance the beekeeping experience. Ergonomic handles, clear viewing windows, and intuitive controls are integrated into the hive design, facilitating ease of use and simplifying hive management tasks.

Hive compatibility: Our Smart Bee Hive is designed to seamlessly integrate with existing beekeeping practices and equipment. This compatibility enables beekeepers to incorporate our hive into their operations without the need for significant modifications or adjustments.

Bee health considerations: For effective mite management, the beekeeper can manually activate the ultrasonic transducers installed within the hive. These transducers emit targeted ultrasonic waves, specifically designed to disrupt and destroy varroa mites. By combining the benefits of camera-based monitoring and ultrasonic technology, our smart hive ensures proactive intervention and healthier bee populations

Sustainability: We prioritize environmental sustainability by making conscious design choices. Our Smart Bee Hive utilizes eco-friendly materials, minimizes waste generation, and incorporates energy-efficient components. By considering the ecological impact, we strive to contribute to sustainable beekeeping practices.

Scalability: Our hive product is designed to accommodate various hive sizes and configurations, allowing scalability and adaptability to suit different beekeeping operations. This flexibility enables beekeepers to scale their operations while maintaining the effectiveness and efficiency of our Smart Bee Hive.

- Validation of our Solution

  1. Collaboration with Experts:

     We engaged with the bee development department and sought the guidance of expert beekeepers. Their extensive knowledge and experience allowed us to validate our solution against industry standards and best practices, ensuring its practicality and relevance in real-world beekeeping operations. We did research with the help of Sri Lankan professional beekeepers about the existing bee extracting mechanisms and about the diseases that honeybees face.

  2. Sustainability and Longevity:

     Our solution aligns with sustainable beekeeping practices by minimizing the reliance on chemical interventions. Through continuous monitoring and targeted mite removal, we aim to reduce the use of conventional treatments, promoting healthier bees and long-term sustainability in beekeeping operations.

     Our Smart Bee Hive with Varroa Mite Management System represents a game-changing innovation in beekeeping, providing a comprehensive and user-friendly solution that addresses the needs and challenges of beekeepers, while prioritizing the health of the bees and the environment.

3.2 Proof of Concept

1. Extracting honey

We have developed an advanced bee hive design that facilitates the process of extracting honey. The hive incorporates three key components: linear actuators, a rack and pinion gear system, and a needle component. The gear system moves along a rack, allowing it to extract honey from both the front and back frames of the hive. The needle component, attached to one of the linear actuators, can move horizontally within a frame while maintaining a fixed vertical position. This mechanism, combined with the second linear actuator, enables efficient honey extraction from two complete honey frames. The third linear actuator allows the entire mechanism to traverse the length of the hive, ensuring comprehensive honey extraction from the entire hive. This innovative design streamlines the honey-extracting process, making it more efficient and convenient.

2. Varroa Mite Detection and Prevention

   To enhance bee hive management and ensure optimal honey harvesting, we have implemented camera systems within the hive. These cameras serve multiple purposes, including monitoring the overall health of the hive and determining the ideal time for honey collection. Additionally, a specialized camera is installed at the hive entrance to specifically detect the presence of varroa mites. Through the use of artificial intelligence, we have developed a model capable of identifying bees with varroa mite infestations based on the camera footage. When the presence of mites is detected, the system promptly alerts the beekeeper, enabling them to initiate the mite removal process.

   A recent study explored the potential of using high-frequency, high-intensity airborne ultrasound as a chemical-free approach to combat Varroa mite infestations in honey bee hives. Initial tests conducted within the hive environment demonstrated a notable increase in the number of mites dropping from bees after a mere 30 minutes of ultrasound exposure. To further assess the effectiveness of this technology for mite removal, ongoing long-term field trials are being conducted.[1]

   During the research, the scientists constructed and evaluated a prototype ultrasonic system. Interestingly, the ultrasound did not appear to have any discernible impact on the behavior or well-being of the bees. The team conducted two separate tests: one focused on observing the behavior of bees when exposed to high-frequency, high-intensity airborne ultrasonic waves, and the other aimed to develop an in-hive system for evaluating the long-term efficacy of the technique in controlling Varroa mites. Encouragingly, both tests yielded positive results, indicating the potential of this innovative approach for sustainable Varroa mite management in honey bee hives.

3.3 Sustainability

Our project aligns perfectly with the mission statement of the Spark Challenge, which focuses on investing in and supporting innovators, dreamers, and change-makers who are determined to tackle the global climate crisis and develop impactful solutions. Our project, the Smart Bee Hive with Varroa Mite Management System, contributes to sustainability and addresses environmental challenges in line with Spark's mission and the Sustainable Development Goals (SDGs).

Sustainability:

Environmental Impact: *Our solution aims to minimize the negative impact of varroa mite infestations on honey bee colonies. By effectively managing mite populations, we help maintain*

healthy honey bee populations, which are essential for pollination and ecosystem balance. This contributes to the preservation of biodiversity and the overall health of the environment.

Reduced Chemical Usage: *The Smart Bee Hive system promotes natural pest control methods by minimizing the reliance on chemical treatments. By using targeted mite detection and removal techniques, we reduce the use of pesticides, thereby minimizing the environmental impact associated with chemical intervention.*

Long-Term Solution: *By focusing on continuous monitoring, detection, and elimination of varroa mites, our project provides a sustainable long-term solution for beekeepers. This reduces colony losses, increases honey production, and supports the economic viability of beekeeping operations, ensuring the longevity and sustainability of the industry.*

Alignment with the Spark Challenge and SDGs:

Climate Crisis: *The Spark Challenge aims to address the global climate crisis, and our project directly contributes to this mission. By safeguarding honey bee populations, which play a crucial role in pollination and the health of ecosystems, our solution helps mitigate the negative impacts of the climate crisis on biodiversity and food security.*

Innovation and Education: *Our Smart Bee Hive system incorporates advanced robotic technology and intelligent mite detection mechanisms, exemplifying innovation in the field of beekeeping. Through the implementation of our solution, we also introduce and teach innovation to students, inspiring them to think creatively and develop sustainable solutions to global challenges.*

SDGs: *Our project aligns with several SDGs, including:*

- Goal 2: Zero Hunger - By promoting healthy honey bee populations, our solution supports the pollination of crops, contributing to increased agricultural productivity and food security.
- Goal 12: Responsible Consumption and Production - Through reduced chemical usage and sustainable beekeeping practices, we promote responsible and sustainable production methods.
- Goal 15: Life on Land - By preserving honey bee populations and biodiversity, we contribute to the protection and conservation of terrestrial ecosystems.

4 Social and Environmental Impact Assessment

Society:

Beekeepers: *Our solution alleviates the challenges faced by beekeepers in managing varroa mite infestations, reducing the economic losses caused by colony losses and the need for chemical treatments. It enables beekeepers to maintain healthier colonies, leading to increased honey production and improved livelihoods.*

Consumers: *By ensuring healthier honey bee populations, our solution contributes to the availability of high-quality honey and other bee-related products for consumers. It promotes food security and supports local economies by providing a reliable supply of natural and sustainable products.*

Researchers and Educators: *Our innovative solution opens up new avenues for research and education in the field of beekeeping. It serves as a valuable tool for studying bee behavior, mite dynamics, and sustainable pest management strategies, furthering scientific knowledge and fostering educational initiatives.*

Environment: Honey Bees and Native Pollinators: *Our solution protects honey bees, which are vital for pollination and the survival of countless plant species. By effectively managing varroa mite*

infestations, we safeguard honey bee populations and preserve their important role in maintaining ecosystem balance. This indirectly benefits native pollinators by ensuring competition-free access to floral resources.

Biodiversity and Ecosystem Health: *Healthy honey bee populations contribute to maintaining biodiversity and ecosystem health. The improved pollination services provided by thriving bee colonies enhance plant diversity, fruit and seed production, and ecosystem resilience.*

Reduction in Chemical Usage: *Our solution aims to minimize reliance on chemical treatments, reducing the environmental impact of pesticides in beekeeping practices. By utilizing targeted mite detection and removal techniques, we promote natural pest control methods, fostering a healthier environment for bees and other organisms.*

Overall, our Smart Bee Hive with Varroa Mite Management System positively impacts society by supporting beekeepers and consumers, advancing research and education, while simultaneously benefiting the environment through the preservation of honey bee populations, biodiversity, and the reduction of chemical usage.

5 Logistics

5.1 Task breakdown and time frame

Name	Main Focus Area
T.L. Abeygunathilaka	Internal Monitoring System
W.H.P. De Silva	Honey extracting system
H.H.A.M. Haputhanthri	Designing Process
A.S.N. Ranasingha	Varroa Mite Detecting System

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