ENHANCING SUSTAINABLE CROP PROTECTION THROUGH MACHINE LEARNING-DRIVEN INTEGRATED STRATEGIES

Project ID: 2023-24-074

Individual Project Proposal Report

Senanayake P.M. – IT20606756

Supervisor: Mr. Vishan Jayasinghearachchi

Co - Supervisor: Mr. Samadhi Rathnayake

BSc. (Hons) in Information Technology Specializing in Data Science

Department of Information Technology

Sri Lanka Institute of Information Technology

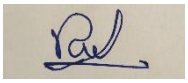
Sri Lanka

August 2023

DECLARATION OF THE CANDIDATE AND SUPERVISOR

I declare that this is my own work, and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to the Sri Lanka Institute of Information Technology the nonexclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic, or another medium. I retain the right to use this content in whole or part in future works (such as articles or books).

NAME	STUDENT ID	SIGNATURE
Senanayake P.M.	IT20606756	

Name of supervisor: Mr. Vishan Jayasinghearachchi

The above candidate has carried out research for the bachelor's degree dissertation under my supervision.

Signature: Date: 25/08/2023

Supervisor: Mr. Vishan Jayasinghearachchi

ABSTRACT

Agricultural communities around the world are confronted with a range of challenges that threaten the stability of their livelihoods and the economic well-being of their communities. In numerous rural areas, the persistence of pests presents a formidable obstacle to successful crop cultivation and economic prosperity. One such village grappling with this issue serves as the focal point of the research presented here. Inhabitants of this village contend with an ongoing and pressing threat posed by pests that inflict severe damage upon their crops, thus jeopardizing both individual incomes and community-wide economic sustainability. Among these pests, macaque monkeys have emerged as a particularly significant problem, manifesting a propensity for ravaging fruits, vegetables, grains, and flowers. The consequences of their foraging activities extend beyond direct crop losses, encompassing additional damage from trampling and the inadvertent destruction of plants. Consequently, farmers who heavily depend on these crops for their primary source of income endure substantial financial losses, creating a cascade of economic reverberations that affect the entire community. In response to this critical concern, the overarching objective of the research project detailed in the provided abstract is to address the agricultural pest-related challenges faced by the village. Specifically, the focus of this study is directed towards investigating the behavior patterns of macaque monkeys, which have proven to be a notable source of crop damage. The ultimate aspiration of this research endeavor transcends its immediate scope. Beyond providing a practical framework for addressing the issues presented by macaque monkeys, the study seeks to stimulate broader contemplation within the farming community about the safeguarding of cultivated lands. By furnishing farmers with the insights, they need to adapt and respond effectively to pest-related threats, the research endeavors to contribute to the long-term viability and sustainability of agricultural practices in the village.

Keywords – Crop protection, Prevalence, Behavior patterns, future prediction

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Background

In the village that led to this research, residents grapple with the persistent threat of pests that ravage their crops. Macaque monkeys have emerged as a significant problem, inflicting direct losses on fruits, vegetables, grains, and flowers. Their foraging activities, such as trampling and knocking down plants, exacerbate the situation, leading to substantial financial losses for farmers who rely on these crops as their primary source of income. The impact of these agricultural pests is profound, as farmers struggle to protect their crops and maximize production. Financial losses incurred due to crop damages affect the livelihoods of individuals and the overall economic well-being of the community. Consequently, addressing these issues and finding effective solutions becomes imperative to ensure the sustainability of agricultural practices in the village. The overall research project aims to identify and implement appropriate pest control measures that can mitigate the damages caused by macaque monkeys and other agricultural pests. Here is the responsibility assigned to me is to study the behavior patterns of macaque monkeys which are a significant problem for crop damage. The objectives are to give a broad idea to the farmer by identifying the patterns of their arrival or their prevalence and to inform them in advance of their expected arrival in the coming periods. There, it is explained which times of the year there is more risk from them, which directions have caused more damage to the cultivated land, clearly indicating the risk to the cultivated land from them in the coming quarters and explaining whether there is any increase in their grip. By this the farmer is expected to be prepared for the risk he faces. The major goal of this research is that this study will help the farmer to think further about the safety of the crops in the cultivated land.

Central to the research objectives is the desire to impart actionable information to farmers. The intent is to elucidate the temporal and spatial patterns associated with the macaque monkeys' activities.

1.2. Literature Review

The phenomenon of agricultural pest infestation has long been a matter of concern for farming communities worldwide. In numerous locales, including the village under consideration for this research, the persistent threat of pests has consistently posed a formidable challenge to crop production and, by extension, the economic well-being of the community.

One recurring antagonist in this struggle is the macaque monkey, which has increasingly emerged as a significant agricultural pest. These primates have shown a remarkable ability to inflict direct damage upon a wide variety of crops, including fruits, vegetables, grains, and flowers. Such foraging activities, involving trampling and destruction of plants, exacerbate the impact of their presence, leading to substantial economic losses for farmers who heavily depend on these crops for their livelihoods.

This issue is not confined to the individual level; rather, the ripple effects extend to the larger community. The severe financial losses accrued from crop damages disrupt the socio-economic balance of the community, affecting both individual farmers and the overall economic stability of the village. These losses underscore the urgent need for effective pest management strategies that can mitigate the destruction inflicted by macaque monkeys and other agricultural pests.

In recent literature, studies have begun to shed light on the complex interplay between agricultural practices and pest populations. Researchers have delved into the behavioral patterns of macaque monkeys, exploring their foraging habits, movement dynamics, and temporal presence. These studies have revealed insights into the macaque monkeys' preferred crops, periods of heightened activity, and patterns of movement across agricultural landscapes. However, despite these efforts, there remains a crucial gap in translating these insights into actionable information that can empower farmers to better protect their crops. The research project outlined in the introduction seeks to bridge this gap by providing farmers with proactive and actionable insights. By understanding the behavioral patterns of macaque monkeys and their impact on crops, this study aims to offer farmers the knowledge needed to anticipate and prepare for potential risks. The identification of specific time periods during which the risk of macaque

monkey presence is elevated, as well as historical data on directions that have historically seen the most damage, will enable farmers to make informed decisions about crop protection measures.

For example, among the limited studies conducted on macaque monkey's behavioral patterns, a study conducted by Mr. Agustin Fuentes states as follows. Assessing and controlling the risk of disease transmission can be significantly aided by having a thorough grasp of the contexts and patterns of interactions between humans and macaques. In terms of interactions between people and macaques, the Padangtegal Monkey Forest in Bali, Indonesia, and the Upper Rock Nature Reserve in Gibraltar have both been subjected to a fair amount of research. The interaction patterns between people and macaques in various locations are outlined in this article, together with information on the environmental, cultural, and demographic differences between locals and visitors. Bite rates, the significance of food in aggressive interactions, and the circumstances surrounding the interactions were different across these two sites. Similarities included overrepresentation by adult male macaques in interactions and a substantial impact by local cultural and demographic factors. These similarities and differences are interpreted as resulting from differences in macaque species and behaviors, and human demography, culture, and behavioral patterns.

Considering the limited studies that have been done on macaque monkey's behavioral patterns, they have only done this related study. Because of that, the value of the study that we have focused on here is well reflected.

The our research's central objective is to empower farmers with the tools they need to bolster their resilience against the challenges posed by agricultural pests. By providing practical guidance based on scientific findings, this study aims to enable farmers to take a more proactive stance in safeguarding their crops and livelihoods. This literature review underscores the importance of such research endeavors in addressing the pressing issue of agricultural pest management and highlights the potential positive impact on farming communities.

1.3. Research Gap

There is a research gap in integrating analysis of macaque monkey presence and behavior patterns to accurately predict future risks to farmers. While some studies have focused on understanding macaque monkey behavior and its correlation with crop damage, there is a lack of comprehensive predictive models that can translate these insights into actionable predictions for farmers. Furthermore, data visualization techniques have not been used to demonstrate macaque monkey distribution and behavior, requiring more sophisticated visual representations that can effectively convey complex movement patterns and potential crop risk areas. This gap highlights the opportunity to develop integrated approaches that not only analyze macaque monkey behavior, but also provide farmers with practical tools to proactively address agricultural pest threats.

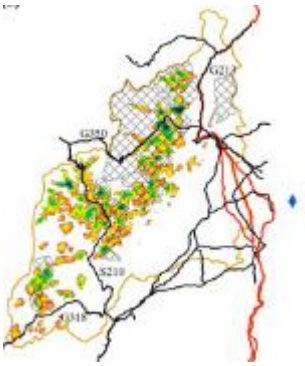
1.4. Research Problem

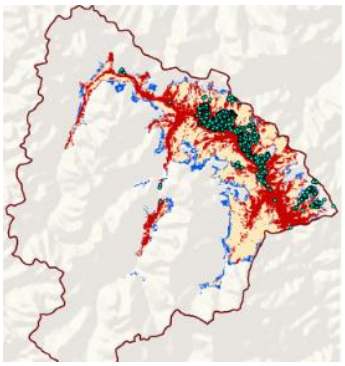
The research problem at hand centers on the lack of a comprehensive and integrated framework to answer critical questions related to macaque monkey infestations in agriculture: "When will monkeys arrive?", "From which direction will they come?", and "How will their future presence unfold?". Despite existing research on macaque monkey behavior and distribution, there is a notable gap in the development of predictive models that address these questions collectively. Current research fails to offer farmers accurate predictions about the timing of macaque monkey arrivals, the geographical routes they might take, and the potential trajectory of their presence.

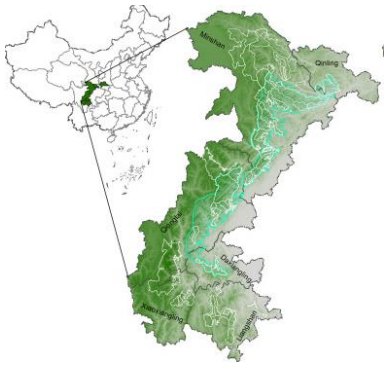
Furthermore, the existing visualization methods have not effectively translated complex monkey movement and behavior patterns into actionable insights for farmers. The challenge lies in devising visualization techniques that can not only depict macaque monkey distribution and movement but also project potential future scenarios. Bridging this gap requires the synthesis of predictive modeling and advanced data visualization to provide farmers with holistic answers to the question "When Monkeys Come?, Which Direction?, How will the future be?"

The research problem at hand is the lack of an integrated approach to predict and mitigate future risks posed by macaque monkey infestations in agricultural settings. While insights into

macaque behavior and distribution have been gathered, there is a dearth of comprehensive predictive models that combine these behavioral patterns with ecological and environmental variables to forecast the likelihood and severity of future infestations. Additionally, the challenge lies in developing effective data visualization techniques that can accurately represent the complex movement dynamics and behavior of macaque monkeys in a format that is easily interpretable and actionable for farmers. Addressing this research problem requires the development of predictive models that incorporate behavioral patterns and environmental factors, alongside the creation of advanced visualization methods that enhance farmers' understanding and preparedness in managing agricultural pest risks.







2. OBJECTIVES

2.1. Main Objectives

• Provide farmers with a comprehensive understanding of macaque monkey distribution through careful analysis of recent data. This analysis will clarify the spatial patterns of monkey movement and their distribution. By providing a detailed overview of macaque monkey distribution, this objective empowers farmers to proactively prepare for potential threats.

• To determine if there is an observable increase in macaque monkey arrivals over time. By scrutinizing historical data and employing statistical methods, this aspect aims to discern any patterns of escalation in macaque monkey infestations. This knowledge is vital for predicting potential surges in macaque monkey activity and adjusting pest management strategies accordingly.

• Studying the available data to predict the future threat posed by macaque monkey arrivals. By leveraging predictive modeling techniques and integrating variables such as historical data, environmental conditions, and potential behavioral shifts, this objective aims to provide farmers with actionable forecasts of when and where macaque monkey infestations are likely to occur. This predictive insight equips farmers with the knowledge needed to implement preemptive measures, minimizing the impact of crop damage and financial losses.

2.2. Specific Objectives

• Collect and pre-process data obtained from sound sensors and cameras deployed in the agricultural fields to accurately capture macaque monkey activity. Summarize the data to extract relevant information about monkey presence, such as timestamps and sound sensor identifiers.

• Analyze the collected data to discern recurring patterns in the arrival of macaque monkeys. Identify patterns and temporal correlations in their behavior, enabling the identification of preferred arrival times, days, and locations.

- Design and implement a machine learning module that utilizes historical data to predict future macaque monkey arrivals and behavior. Train the model to recognize patterns in their past activities and apply it to forecast potential infestations during upcoming periods.

- Integrate the developed machine learning module with a user-friendly interface that offers predictions to farmers about upcoming macaque monkey arrivals and their behavior patterns. Provide clear and actionable insights to empower farmers to take preventive measures in advance.

3. METHODOLOGY

3.1. Research Area

In several villages, farmers are facing a significant issue of macaque monkeys damaging their crops. The current method employed to drive away the monkeys involves shooting, which is ineffective when dealing with a large herd of macaque monkeys. Moreover, this approach poses risks to animal lives. In response, a more humane and effective system is proposed to drive away these animals and mitigate crop damage. To address the issue of macaque monkeys encroaching on our land, we have devised a solution involving a sound system. Sound sensors strategically positioned throughout the area detect the macaque monkeys' arrival by analyzing their distinct sounds. Advanced algorithms quickly process the data, distinguishing monkey vocalizations from other noises. Once the presence of macaque monkeys is confirmed, speakers emit high-frequency and high-decibel sounds designed to deter them from staying on our property. This comprehensive system not only detects and repels macaque monkeys but also identifies patterns in their entry and exit behavior. By analyzing this data, we gain insights into their movement patterns and preferred entry points, allowing us to optimize our preventive measures. This proactive approach effectively protects our land and offers a long-term solution to the macaque monkey problem.

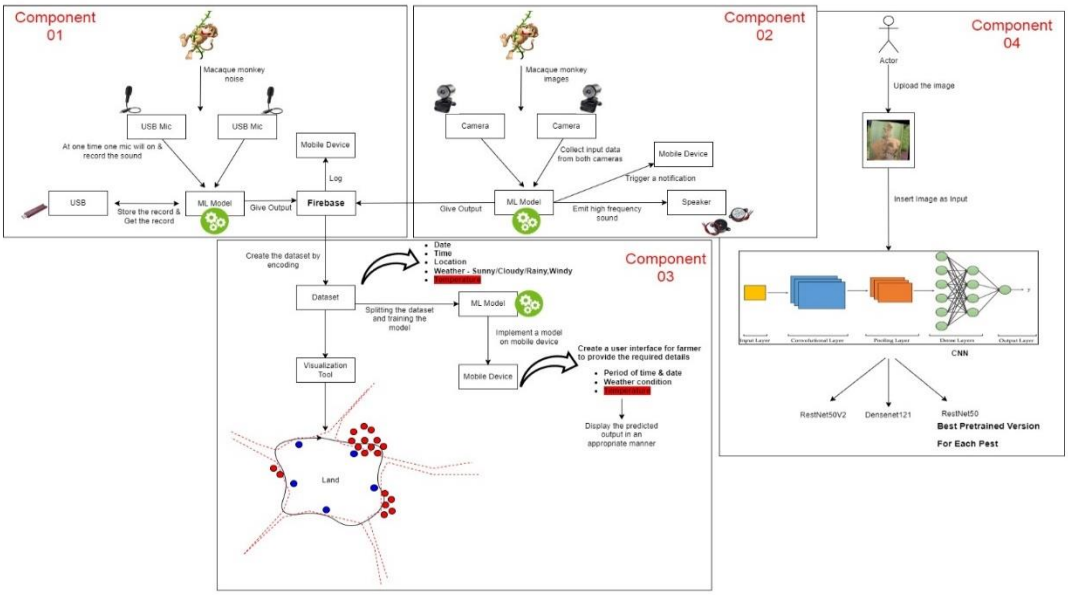


Figure 3-1. Overall System Diagram

3.2. Architecture

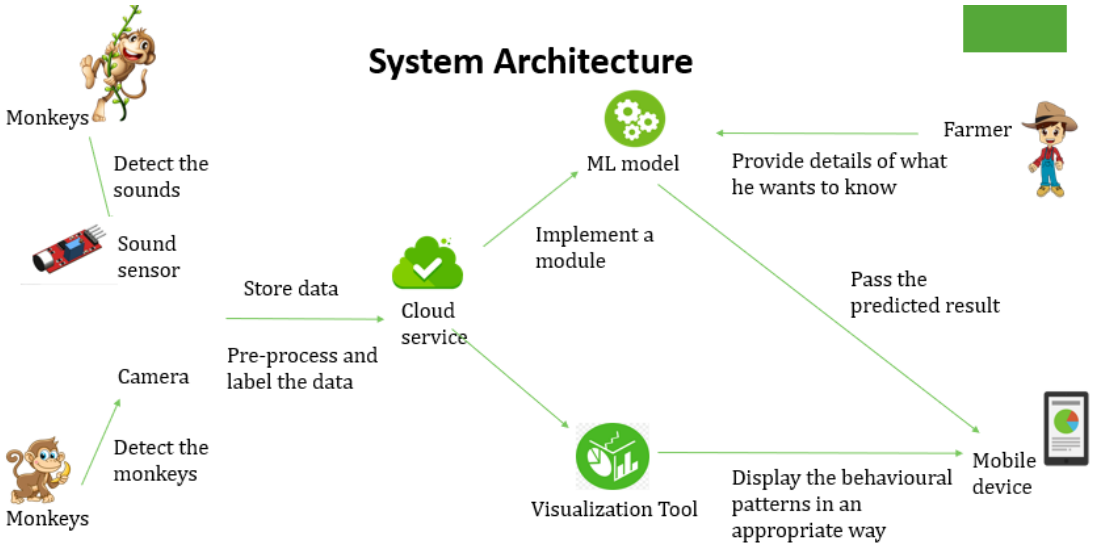


Figure 3-2. Component Diagram

The research architecture for the comprehensive macaque monkey pest management system consists of interconnected components, ensuring effective data collection, analysis, and predictive modeling. The architecture is designed to offer farmers actionable insights to safeguard their crops and livelihoods. The following is an overview of the architecture:

1. **Data Collection Layer: **

- Sound Sensors: Deploy a network of sound sensors in agricultural fields to capture audio data indicating macaque monkey presence.

- Cameras: Install cameras to capture visual information that complements the sound sensor data, aiding in accurate identification of macaque monkey behavior.

2. **Data Pre-processing and Storage: **

- Data Acquisition: Gather audio and visual data from sound sensors and cameras, respectively.

- Data Cleaning: Clean and preprocess the collected data to remove noise and ensure accuracy.

- Data Integration: Merge audio and visual data, associating sound sensor identifiers with specific timestamps.

- Data Storage: Store the processed data in a suitable database for further analysis.

3. **Pattern Analysis and Feature Extraction: **

- Time Series Analysis: Analyze the integrated data to identify patterns in macaque monkey arrivals, including time of day, day of the week, and location.
- Feature Extraction: Extract relevant features from the data, such as sound frequency patterns, timestamps, and spatial coordinates.

4. **Machine Learning Module: **

- Training Data Preparation: Utilize historical data to train a machine learning model capable of predicting future macaque monkey arrivals and behavior patterns.
- Model Selection: Choose an appropriate machine learning algorithm, such as time series forecasting or classification, to suit the prediction task.
- Model Training: Train the selected model using the preprocessed data and extracted features.

5. **Prediction and Visualization Layer: **

- Prediction Interface: Develop a user-friendly interface for farmers to input parameters and receive predictions.
- Real-time Monitoring: Continuously monitor sound sensor and camera data to provide real-time alerts about potential macaque monkey arrivals.
- Visualization Tools: Create visualizations, such as heatmaps and time series graphs, to help farmers interpret macaque monkey distribution and behavior patterns.

6. **Predictive Output: **

- Prediction Generation: Utilize the trained machine learning model to generate predictions about future macaque monkey arrivals and behavior.
- Alert and Notification: Send timely alerts and notifications to farmers via the interface or mobile applications, highlighting predicted high-risk periods.

3.3. Gantt Chart

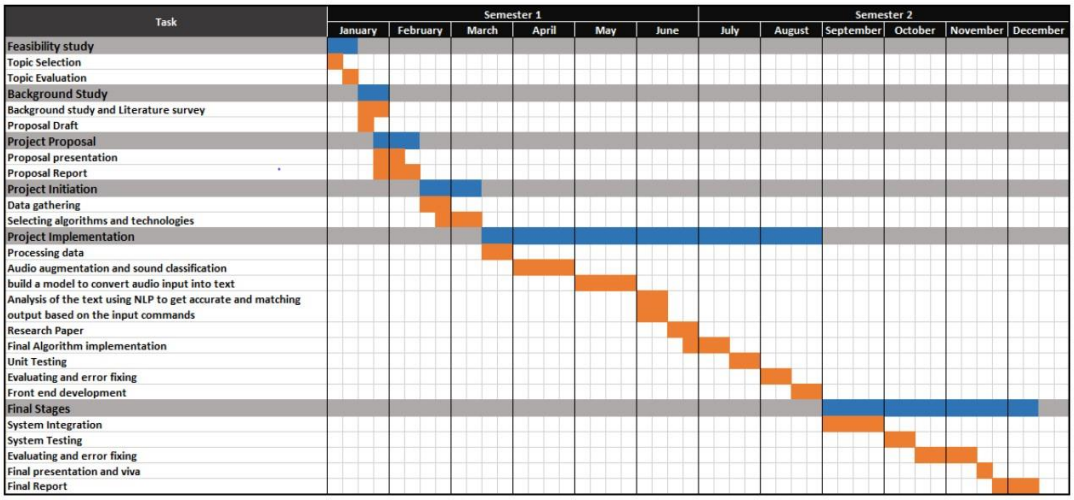


Figure 3-3. Gantt Chart

3.4. Breakdown Chart

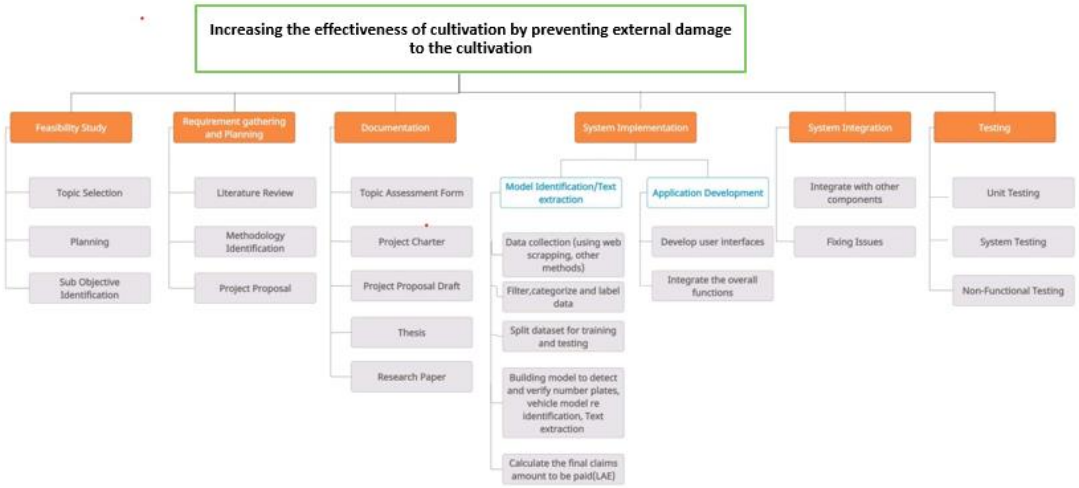


Figure 3-4. Breakdown Chart

4. PROJECT REQUIREMENTS

4.1. Functional Requirements

- Feature Extraction - Time domain extraction.
- Machine Learning Model - Implement a suitable machine learning algorithm or model.
- Behavior Prediction and Forecasting - Deploy the trained model to predict the macaque monkey behaviors based on their arrival patterns.
- Visual User Interface - Develop a user-friendly interface to interact with the system to obtain behavioral predictions or analysis results.
- Model Updates - Implement a mechanism to update and retrain the machine learning model periodically to accommodate changes in macaque monkey behavior patterns.

4.2. Non-Functional Requirements

- Accuracy
- Usability
- Reliability
- User-friendliness
- Efficiency

4.3. Technology and Tool selection

- Programming language
  - Python

- Tools
  - Version controlling – SourceTree
  - Android Studio
  - Visual Studio Code
  - Google Colab
  - Data Visualization Tool
  - OpenCV

- Database Service
  - Microsoft Azure
  - Firebase

- Algorithms
  - CNN

5. COMMERCIALIZATION

5.1. Commercial potential

- Market Analysis:

  Conduct thorough market research to understand the demand for agricultural pest management solutions.
  Identify target markets, such as regions with significant macaque monkey populations and reliance on agriculture.
  Analyze existing competitors and their offerings to identify unique selling points.

- Value Proposition:

  Clearly articulate the benefits of the system to potential customers, emphasizing accurate predictions, proactive pest management, and reduced crop losses.
  Highlight the user-friendly interface, real-time alerts, and data visualization capabilities that empower farmers.

- Product Positioning:

  Position the system as a comprehensive and intelligent solution that combines data analysis, machine learning, and predictive modeling for effective pest management.
  Differentiate the system from traditional methods by offering proactive insights and actionable recommendations.

5.2. Business potential

- Market Demand:

  Agriculture remains a vital sector in many regions, making the demand for pest management solutions a constant requirement.
  The system caters to the demand for advanced, technology-driven tools that offer a comprehensive approach to pest management.

- App Licensing:

  Licensing Fees: Offer different tiers of licensing for the system, granting users access to its features based on their chosen plan.

One-time Purchase: Farmers can opt for a one-time purchase of the app license, gaining access to the system's capabilities with a single payment.
Feature Differentiation: Create tiered plans with varying features. For instance, a basic plan might provide predictive alerts, while a premium plan includes advanced data visualizations and historical trend analyses.

- Subscription Model:

  Recurring Revenue: Implement a subscription-based model where farmers pay a recurring fee to continue using the system.
  Tiered Subscription: Offer multiple subscription levels, each providing a different level of access and support.
  Benefits: Subscribers could enjoy benefits like automatic updates, priority customer support, and access to new features as they are developed.

- Pay-Per-Use Points:

  Usage-based Pricing: Introduce a pay-per-use model, where farmers are charged based on the frequency and extent of their system usage.
  Flexibility: This model accommodates users with varying needs. Farmers can pay only for the services they actively use.
  Data Usage: Charge based on the amount of data processed, encouraging efficient use of the system's resources.

6. BUDGET

Activities	Amount (Rs.)
App registration	9000.00
Travelling Cost	5000.00
Internet Bill	2500.00
Total	**16500.00**

Table 6-1. Budget

REFERENCES

[1] http://www.colombopage.com/archive_23B/Jul02_1688316295CH.php#:~:text=According%20to%20that%20report%2C%20it,especially%20in%20the%20coconut%20triangle.

[2] Bayne K.A.L., H. Mainzer, S. Dexter, G. Campbell, F. Yamada, and S. Suomi. 1991. The reduction of abnormal behaviors in individually housed rhesus monkeys (Macaca mulatta) with a foraging grooming board. Am J Primatol 23:23–35. [PubMed]

[3] Lutz, C.K., Davis, E.B., Ruggiero, A.M. and Suomi, S.J. (2007), Early predictors of self-biting in socially-housed rhesus macaques (*Macaca mulatta*). Am. J. Primatol., 69: 584-590. https://doi.org/10.1002/ajp.20370

[4] Fuentes, A. (2006), Human culture and monkey behavior: assessing the contexts of potential pathogen transmission between macaques and humans. Am. J. Primatol., 68: 880-896. https://doi.org/10.1002/ajp.20295

[5] Kaburu, SSK, Marty, PR, Beisner, B, et al. Rates of human–macaque interactions affect grooming behavior among urban-dwelling rhesus macaques (*Macaca mulatta*). *Am J Phys Anthropol*. 2019; 168: 92–103. https://doi.org/10.1002/ajpa.23722

[6] Sha, J.C.M., Gumert, M.D., Lee, B.P.Y.-H., Jones-Engel, L., Chan, S. and Fuentes, A. (2009), Macaque–human interactions and the societal perceptions of macaques in Singapore. Am. J. Primatol., 71: 825-839. https://doi.org/10.1002/ajp.20710

Thank you!