SMART AGRICULTURE SUPPORT SYSTEM FOR ALOE VERA

Project ID: 2025-26J-166

Project Proposal Report

Bandara H.M.A.I.

IT22338020

BSc(Hons) in Information Technology Specializing in Information Technology

Department of Computer Science
Faculty of Computing
Sri Lanka Institute of Information Technology
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Bandara H.M.A.I.

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Supervised by Ms. Jenny Krishara

Co-supervised by Dr. Dinuka Wijendra

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DECLARATION

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We are so certified that the work included in this proposal is all our own. To the best of our knowledge, no other university or higher education institution has accepted it in whole or in part for a degree or diploma. Additionally, it excludes any content that has already been written or published by someone else, unless appropriate credit is stated in the text.

Name	Student ID	Signature
Bandara H M A I	IT22338020	

....

Signature of the Supervisor

Ms. Jenny Krishara

2025/08/29

Date

....

Signature of the Co-Supervisor

Dr. Dinuka Wijendra

2025/08/29

Date

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ABSTRACT

Aloe vera (Aloe barbadensis Miller) is a highly valued medicinal and commercial plant widely used in pharmaceutical, cosmetic, and nutritional industries. Its successful growth and yield are closely linked to environmental factors such as soil quality, temperature, rainfall, and humidity. In Sri Lanka, aloe vera cultivation has potential for expansion, yet systematic studies focusing on how these environmental factors influence productivity remain limited. This research aims to analyze the effect of weather and soil conditions on aloe vera growth and to develop predictive models that can support farmers and stakeholders in making informed decisions. The methodology involves collecting soil and climate data from selected cultivation sites across different agro-ecological regions of Sri Lanka. Key variables include soil pH, moisture, texture, and nutrient composition, along with meteorological factors such as rainfall distribution, humidity levels, and temperature fluctuations. These datasets will be preprocessed and applied to machine learning algorithms to identify patterns and predict plant growth outcomes. Model training, validation, and testing will be conducted to ensure reliable performance in real-world applications. Anticipated results include the identification of the most influential environmental variables affecting aloe vera productivity and the development of an accurate predictive model. The findings are expected to highlight optimal cultivation conditions and propose data-driven recommendations for site selection and resource management. Ultimately, the study aims to contribute to sustainable aloe vera cultivation in Sri Lanka, enhancing productivity and providing long-term economic benefits for growers.

Keywords: Aloe Vera, Environmental Factors, Soil, Weather, Machine Learning

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List of Abbreviations

AI - Artificial Intelligence
CNN - Convolutional Neural Network
SDLC: Software Development Life Cycle
NPK: Nitrogen, Phosphorus, and Potassium

1. INTRODUCTION

Aloe Vera has emerged as a commercially important crop in Sri Lanka, with applications in herbal, cosmetic, and pharmaceutical industries. In 2022, Sri Lanka exported nearly 2,080 metric tons of Aloe Vera and its derivatives, generating approximately USD 15.06 million in revenue, highlighting its significant economic potential [1]. However, despite its growing demand, Aloe Vera cultivation in Sri Lanka faces several challenges such as poor soil and nutrient management, unpredictable climate conditions, pest and disease outbreaks, and volatile market prices [2–4]. These factors negatively affect crop yield, profitability, and the sustainability of small-scale farming operations.

Globally, researchers have explored solutions for similar agricultural challenges through artificial intelligence, machine learning, and smart agriculture systems. For example, studies show that deep learning and image recognition models such as CNNs and transfer learning are effective in detecting plant diseases with high accuracy [5–6]. Weather-based models using ensemble methods like Random Forest and XGBoost have demonstrated strong potential for crop yield prediction and planting recommendations [7–8]. Furthermore, nutrient management research confirms that integrated use of organic and inorganic fertilizers significantly improves Aloe Vera growth, gel quality, and sucker production, compared with single-source fertilization [9–11]. Time-series forecasting models such as ARIMA and LSTM have also been applied successfully in predicting agricultural market price fluctuations [12–13].

While these techniques exist, most solutions remain generalized and not adapted to the unique conditions of Aloe Vera farming in Sri Lanka. Farmers often lack access to localized, easy-to-use systems that integrate these technologies into actionable decision-making tools. To address this gap, our proposed solution introduces a Smart Agriculture Support System with four major components: Crop disease detection using deep learning and NLP to combine leaf images with farmer symptom descriptions in Sinhala/Tamil, Weather-based crop recommendation and yield prediction tailored to regional climate conditions, Fertilizer management system that analyzes soil profiles and recommends correct fertilizer type, dosage, and timing across different growth stages, and Market price trend forecasting using advanced ML to guide optimal selling decisions.

Unlike previous research that treats these areas separately, our system integrates AI, predictive analytics, and localized knowledge into one platform designed specifically for Aloe Vera farmers. This holistic approach not only enhances crop yield and quality but also empowers farmers to practice sustainable agriculture, manage resources effectively, and maximize income. Ultimately, the project bridges the gap between cutting-edge research and practical field-level farming needs, contributing to the modernization of Aloe Vera cultivation in Sri Lanka.

1.1. Background & Literature Survey

1.1.1. Background

Agriculture has always been more than just an occupation, it is a way of life, deeply connected to the wellbeing of families and the stability of entire communities. Yet, farming today looks very different from how it did in the past. Farmers everywhere, and especially in countries like Sri Lanka, face mounting challenges. Changing weather patterns make it difficult to plan ahead, unexpected crop failures put livelihoods at risk, and the rising cost of inputs often leaves small farmers struggling to make ends meet. At the same time, global markets continue to fluctuate, leaving farmers uncertain about the value of their produce even after a successful harvest.

Traditionally, most of these decisions when to plant, how to manage the soil, what to apply, and when to sell have relied on the farmer's own knowledge, experience, and community advice. While this wisdom is invaluable, it can sometimes fall short in the face of today's rapid environmental and economic changes. This is where modern technology can play a transformative role. By combining real-time monitoring tools with advanced data analysis, farmers can be given timely, reliable insights that reduce uncertainty and support better decision-making.

Recent innovations in IoT devices, artificial intelligence, and predictive analytics are paving the way for farming to become more precise and adaptive. These technologies allow for continuous monitoring of environmental conditions, intelligent analysis of risks and opportunities, and personalized guidance tailored to each farmer's unique context. Instead of reacting to problems after they occur, farmers can anticipate challenges, improve efficiency, and plan ahead with confidence.

In developing regions, where access to expert knowledge and resources is often limited, such systems can be particularly valuable. A farmer-friendly decision support platform that integrates data from the field with wider market and environmental trends has the potential to make agriculture more sustainable, resilient, and profitable. By presenting information in a simple and accessible way through mobile applications, even small-scale farmers can benefit from the power of technology without needing specialized training.

This research aims to contribute to this transformation by building an integrated support system that not only helps farmers protect their crops and optimize their resources but also empowers them with insights to make smarter choices for the future. In doing so, it seeks to bridge the gap between traditional farming wisdom and modern technological advancements, ensuring that farmers are better equipped to thrive in an increasingly uncertain world.

1.1.1. Literature Survey

Effective nutrient management is a fundamental practice in modern agriculture, serving to maximize crop yield and quality while simultaneously ensuring the long-term health of the soil. The global shift from traditional, generalized farming methods to precision agriculture is driven by the pressing need to optimize the use of costly fertilizers and minimize their environmental impact, such as nutrient runoff and soil degradation [16], [9]. This transition is particularly critical for high-value crops like *Aloe vera*, which has distinct and dynamic nutrient requirements throughout its growth cycle and responds significantly to precise fertilization [10].

Early research on *Aloe vera* cultivation established a strong foundation by confirming that soil composition and nutrient availability are key determinants of overall plant health and gel yield. Studies have shown that variations in soil fertility directly impact the growth of *Aloe barbadensis*, emphasizing the need for a tailored approach to fertilization rather than a one-size-fits-all strategy [14], [9]. These foundational studies, often in the form of field trials, focused on evaluating the effects of different fertilizer types and dosages. They collectively demonstrated that a balanced application of nitrogen, phosphorus, and potassium (NPK) is essential for robust growth and optimal leaf biomass, which is the primary source of the valuable gel [10], [11]. For example,[9] [10] both conducted controlled experiments that underscored the positive correlation between proper nutrient management and increased *Aloe vera* yield, providing a strong empirical basis for data-driven systems.

In recent years, the use of advanced technology has revolutionized how nutrient management is approached. Modern machine learning (ML) and deep learning (DL) models are increasingly being leveraged to analyze complex environmental and soil data to provide precise, data-driven recommendations [7], [8]. While much of the existing literature on nutrient management focuses on staple crops like maize and wheat, which have vast, readily available datasets, the techniques used are directly applicable to *Aloe vera* [7], [8]. Ensemble models, such as Random Forest and XGBoost, have proven highly effective in predicting nutrient deficiencies and optimizing fertilizer application schedules for various crops [7], [8]. These models can analyze the complex, nonlinear relationships between soil data, weather patterns, and the specific growth stage of the plant, generating prescriptive recommendations that are far more accurate and efficient than manual, intuition-based methods [12], [13].

The application of artificial intelligence (AI) in agriculture extends beyond simple prediction. [17], AI can be used to improve every aspect of an aloe plantation, from planting to harvesting. This includes using data-driven insights to optimize nutrient delivery, which can reduce costs for farmers while simultaneously improving crop quality and yield [17]. These advanced systems move beyond providing a simple "yes/no" answer, offering a comprehensive solution that can adapt to changing conditions and provide actionable insights. The integration of various data sources and advanced models allows for the development of a unified system that can continuously learn and improve its recommendations over time.

Despite the growing body of research on precision agriculture and the clear benefits of data-driven approaches, a significant gap exists in the literature regarding a dedicated, comprehensive system for the precision fertilizer management of *Aloe vera*. Most existing studies either focus on a single parameter or provide general guidelines [15], [16]. For instance, sources like Wikifarmer [15] provide valuable but broad recommendations on nutrient needs, while other academic works may focus on specific fertilizer trials rather than a complete, integrated system. There is a pressing need for a unified platform that integrates various forms of data and applies advanced analytics to provide specific, actionable, and plant-stage-specific fertilizer recommendations. This would not only enhance the profitability and sustainability of *Aloe vera* farming but also serve as a crucial step in modernizing the cultivation of this economically significant crop.

1.2 Research Gap

The existing body of literature on fertilizer management for Aloe Vera reveals several research gaps that our project aims to address. While studies have explored the general benefits of nutrient management and the potential of modern technologies, there is a lack of integrated, localized solutions designed specifically for the unique conditions of Sri Lanka's Aloe Vera cultivation.

Research by Patil et al. [9] [10] confirms the effectiveness of integrated nutrient management (INM) and highlights the specific nutrient requirements for Aloe Vera. However, these studies are primarily experimental and focus on the effects of different fertilizer types and dosages under controlled conditions. They do not propose a real-time, data-driven system that can adapt to changing soil profiles or regional climate variations. Similarly, Gupta and Choudhary [11] discuss nutrient management strategies, but their work is a review and does not involve the development or implementation of a practical, field-level system.

While the broader field of precision agriculture, as explored in recent studies, demonstrates the power of IoT and AI for managing soil conditions and optimizing nutrient application [17, 18], these models are often generalized or applied to staple crops like maize and rice. Limited to a single parameter (pH) for an automatic soil pH control system for Aloe Vera, the research does not offer a complete fertilizer management solution that considers all essential nutrients (NPK), dosage, and timing. [18, 19]Furthermore, a significant gap exists in applying these technologies to the local context of Sri Lanka. The unique soil compositions, agro-climatic zones, and small-scale farming operations in Sri Lanka require a tailored solution that integrates localized knowledge with advanced analytics. The existing research, while valuable, does not bridge the gap between global, generalized techniques and the practical, on-the-ground needs of Sri Lankan Aloe Vera farmers.

In summary, the research gap lies in the absence of a holistic, localized, and AI-driven fertilizer management system specifically for Aloe Vera. While the foundational research on INM and precision agriculture exists, a practical, integrated platform that analyzes soil profiles and provides real-time, actionable recommendations for NPK, dosage, and timing, adapted to Sri Lankan conditions, has yet to be developed. Our project aims to fill this critical gap by creating a comprehensive and accessible solution for local farmers.

Table 1.2: Research gap table

Research Gap	Research [9] & [14]	Research [10]	Research [11]	Research [17]	Proposed System
Specific focus on Aloe vera	✓	✓	✓	✓	✓
Use of advanced ML/DL for recommendations	✗	✓	✗	✗	✓
Provides real-time, data-driven recommendations	✗	✓	✗	✗	✓
Integration of multiple data sources for a unified system	✗	✓	✗	✗	✓
Generates actionable, prescriptive advice for farmers	✗	✗	✗	✗	✓

1.3 Research Problem

Aloe vera is economically important in Sri Lanka, but its cultivation is hampered by improper soil and nutrient management systems [2, 9]. An absence of precision agriculture strategies and systematic soil analysis undermines aloe vera crop and gel yield, as well as the sustainability of the farming operations. Farmers tend to follow old practices that ignore the nutritional requirements of the plant in its various growth stages, the plant's nutritional requirements, and the soil peculiarities. This results in waste of inputs with mounting costs and variable crop yield.

Integrated nutrient management (INM) along with proper NPK ratios are essential for the growth of Aloe vera [9, 10, 11]. However, most of the research conducted so far is of an experimental nature; there is a gap between research outputs and the actual farming tools needed in the field. With reference to precision agriculture, other crops have been studied with the aid of advanced IoT and AI technologies [17, 18]. However, there is no targeted, all-encompassing form of IoT and AI precision agriculture for Aloe vera. Existing systems are overly simplistic and focus only on soil pH without offering comprehensive soil evaluation coupled with advanced and adaptive recommendations for fertilizer types and quantities. [18, 19]

2. RESEARCH OBJECTIVES

2.1. Research Question

How can a smart fertilizer management system be developed for Sri Lankan Aloe vera farms that utilizes real-time soil analysis (e.g., pH and NPK levels) and integrates advanced Machine Learning models to provide accurate, localized recommendations on fertilizer type, dosage, and timing, thereby optimizing crop yield and ensuring sustainable farming practices?

2.2. Main Objectives

The main objective of this research is to develop a decision support system that assists farmers in making data-driven agricultural decisions by integrating IoT-based monitoring, predictive analysis, and personalized recommendations.

2.3. Specific Objectives

Establish a Data Collection Framework: Set up a system to collect real-time data from Aloe vera fields. This includes identifying and deploying appropriate sensors to measure critical soil parameters like pH, nitrogen (N), phosphorus (P), and potassium (K) levels. We will also gather information on different fertilizer types and their costs.

Build an Intelligent Recommendation Model: Develop and train a machine learning model that processes the collected soil data. This model's purpose is to recommend the correct type and amount of fertilizer needed at each stage of the Aloe vera plant's growth cycle.

Create a User-Friendly Interface: Design a simple and clear dashboard or mobile application where farmers can view their soil data and receive the fertilizer recommendations. The system will provide actionable advice, such as "Apply 50 grams of NPK 20-10-10 per plant next week."

Validate the System's Impact: Conduct trials on Sri Lankan farms to test the system's effectiveness. The goal is to prove that our recommendations lead to healthier plants, higher yields, and a reduction in fertilizer costs compared to traditional farming methods.

3. METHODOLOGY

The proposed smart system will recommend appropriate fertilizer types and dosages for Aloe vera plants to optimize their growth and yield. The system will first collect real-time data on soil properties, including NPK levels and pH, using IoT sensors. This data will be used to understand the current nutrient status of the soil. Next, the system will process this information through a machine learning model that analyzes the soil data against the specific nutrient requirements of Aloe vera at its current growth stage. This analysis will determine which nutrients are lacking or in excess. Based on this, the system will calculate the precise amount of fertilizer needed. Finally, the system will recommend the most suitable fertilizer type and dosage, along with the optimal timing for application, to ensure efficient nutrient management and sustainable cultivation.

3.1. System Architecture

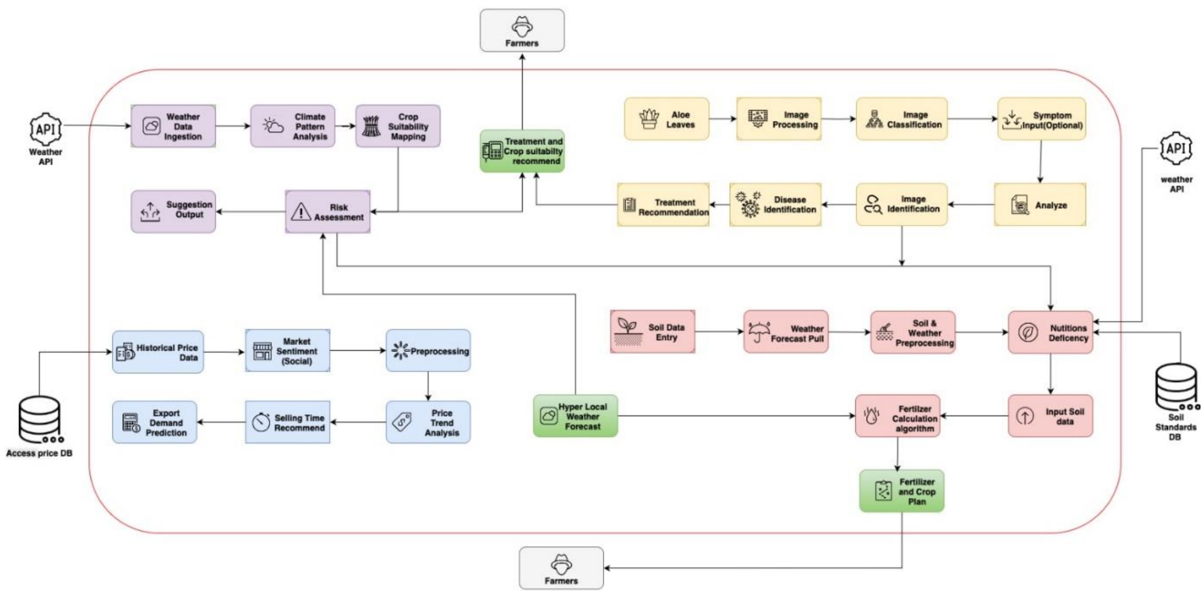

Figure 3.1: Overall system diagram

This diagram provides a high-level overview of the proposed Smart Agriculture Support System for Aloe vera, which is comprised of four key components. The process begins with a farmer using a mobile application to either capture or upload an image of their crop and input key data such as soil properties and current weather. The system then processes this information through its specialized services. These include Crop Disease Detection to identify any pests or diseases from the plant image, Fertilization Management to provide nutrient recommendations based on soil data, Yield Prediction and Weather-Based Crop

Recommendation to forecast future harvests and suggest optimal farming practices, and Market Price Trend Forecasting to provide insights into future market prices. All of these services work together to offer a comprehensive, data-driven solution that is delivered directly to the farmer's mobile app, enabling them to manage their crop more effectively.

3.2. Component Methodology

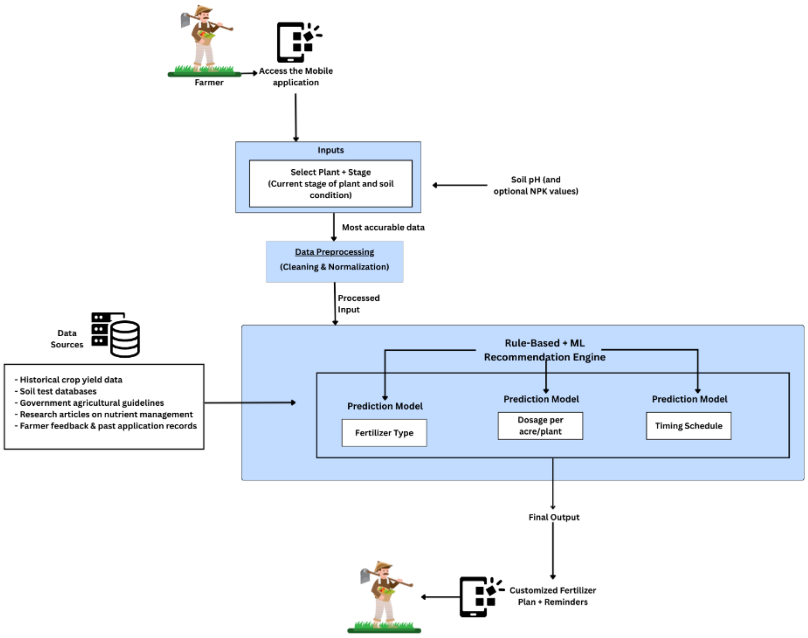

Figure 3.1: Component Diagram

Summary of technologies, techniques, architectures, and algorithms used for the classification of insect infestation in button mushrooms shown in the table below.

Table 3.1: Technologies, techniques, architecture, and algorithms used

Technologies	Python, TensorFlow, Google Collab, Jupyter Notebook, Jira, VS code
Techniques	Machine Learning, Deep Learning, Image Processing, Data Augmentation
Algorithms	CNN ,Time-Series Forecasting Algorithms(ARIMA),Natural Language Processing (NLP) Algorithms
Architectures	CNN Architectures (for Leaf Disease Detection) RNN / LSTM Architectures (for Forecasting & NLP)

3.2.1. Software solution

The Software Development Life Cycle (SDLC) is a structured process used to design, create, and test high-quality software. It minimizes risk by providing a clear plan that helps meet customer expectations. Traditional methodologies, however, are rigid and do not allow for returning to previous steps, making it difficult to adapt to changes. To address this, many teams now use the Agile methodology, which is flexible and allows developers to adapt as needed. Scrum, a popular and lightweight Agile framework, is widely used to facilitate this adaptable approach.

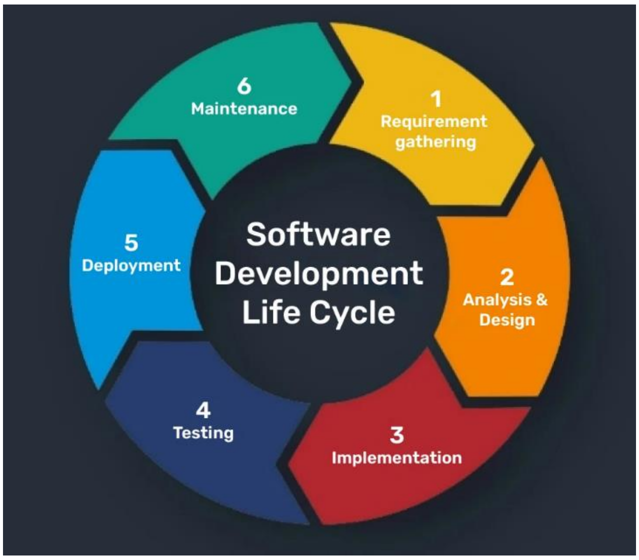

Figure 3.2.1: Agile Software Development Cycle

- Requirement gathering

    - Data Gathering
      To gather data, our group visited a farm situated in the lunugamwehera. The farmers currently maintain their records manually, but we will later be able to obtain soft copies of this data. In addition, we have already collected information through our farm visits.

- Feasibility study (Planning)
    - Economic Feasibility

      The proposed subcomponent is expected to function smoothly without errors or failures, ensuring higher reliability while also being more cost-effective.

    - Scheduled Feasibility

      The proposed subcomponent plays a crucial role in the project and must be completed within the specified timeline. Additionally, it is essential that this component delivers effective results within the given period to ensure the overall project is finalized by the deadline.

    - Technical Feasibility

      To implement this solution, an individual needs skills, resources, and expertise in mobile application development, system architecture, and relevant frameworks. This specialized knowledge defines the technical feasibility of the solution.

- Design

  Following the requirement gathering and feasibility study, we are proceeding to the design phase. During this stage, software documents related to the system's design are prepared.

- Implementation

The following sub-functionalities will be carried out during this implementation phase:

- Implementation of mobile applications using React Native.
- Identification of the fertilization types for the different levels of aloe vera plant based on the data collected by using a trained machine learning model.

- Testing
    - Verify that the system has all the expected requirements.
    - Conduct testing for errors and bugs.

4. PROJECT REQUIREMENTS

4.1. Functional Requirements

Data Input: The system should receive or allow the user to select the plant type and input real-time soil data, including pH and NPK (Nitrogen, Phosphorus, Potassium) levels.

Data Analysis: The system should analyze the received soil data and compare it against the optimal nutrient requirements for the specific growth stage of the Aloe vera plant.

Nutrient Status Identification: The system should identify and report if there are any nutrient deficiencies or excesses in the soil.

Recommendation Generation: Based on the soil analysis and the selected plant type, the system should recommend the appropriate fertilizer type, precise dosage, and optimal schedule for application.

4.2. Non-functional Requirements

- **Usability:** The mobile application will be designed for seamless use on both Android and iOS platforms. It will feature an intuitive and visually appealing interface to ensure all users, regardless of their technical background, can easily navigate and utilize its features.
- **Security & Reliability:** The system will prioritize the confidentiality of all user data, employing robust security measures to protect sensitive information and build user trust. It will be developed to operate without glitches or malfunctions, ensuring a reliable and error-free experience.
- **Performance:** The system must deliver speedy and accurate results, providing recommendations and information with optimal efficiency. This includes quick data processing from sensors and a responsive user interface that meets high-performance standards.
- **Accessibility & Availability:** The application will be continuously available to all authorized users, 24/7. It will be designed for universal accessibility, ensuring there are no limitations for users who need to access the system at any time or from any location.

4.3. System requirements

Required software requirement to proposed system,

VS code - To implement the code in python.

React Native – To design a cross platform mobile based application.

Python - To implement the backend.

5. Commercialization

Our proposed smart agriculture support system for Aloe vera is intended to be commercialized as a mobile application to address the specific needs of the Sri Lankan agricultural sector. The target audience includes Aloe vera farmers, agricultural researchers, and stakeholders in the cosmetic and pharmaceutical industries.

The system will be offered in a freemium model with two versions. The Community version will be freely available and will include essential features such as basic disease detection, simple fertilizer recommendations, and general weather alerts. This version aims to establish a broad user base and demonstrate the system's value. The Premium version will be available through a subscription and will offer advanced functionalities. This includes real-time fertilizer management with AI-driven alerts, predictive analytics for market price trends, and more comprehensive yield forecasting.

Our system is designed with a user-friendly interface that does not require advanced technical knowledge or have age restrictions, making it accessible to a wide range of farmers. Our development team, composed of technically proficient graduates with industry experience, is well-equipped to build and maintain this robust platform.

The required funding is estimated at $20 per month, which will cover the operational costs for development and maintenance. Our marketing strategy will focus on targeted outreach within the farming community through agricultural workshops, partnerships with government bodies like the Department of Agriculture, and advertising via local media and social media platforms to ensure maximum visibility and adoption. Revenue will be generated primarily through subscriptions to the premium version, with potential future income from partnerships with agricultural input suppliers and data-driven insights for industry partners.

6. GANTT CHART and Work Breakdown Structure

6.1. Gantt Chart

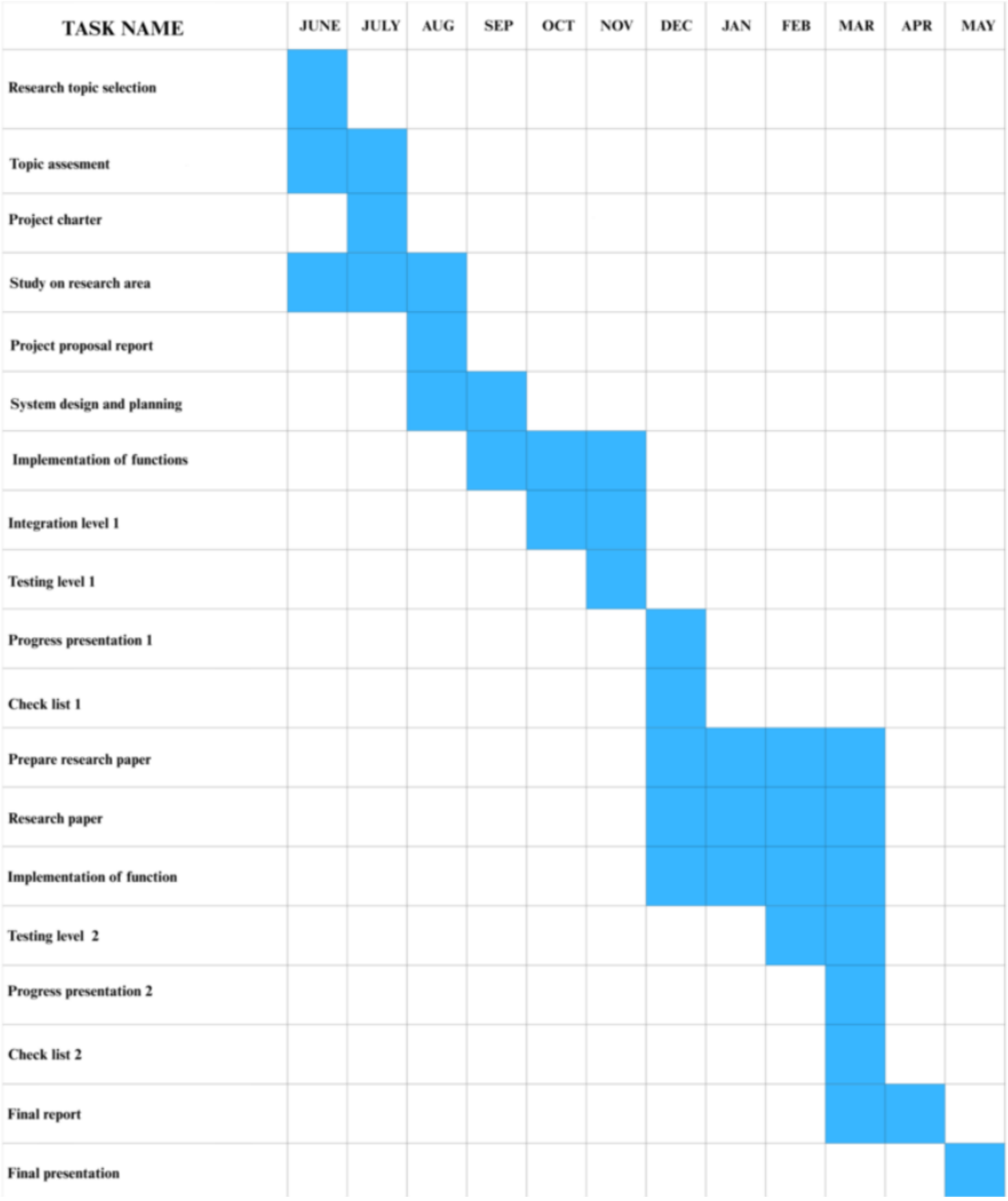

Figure 6.1: Grantt Chart

6.2. Work Breakdown Structure

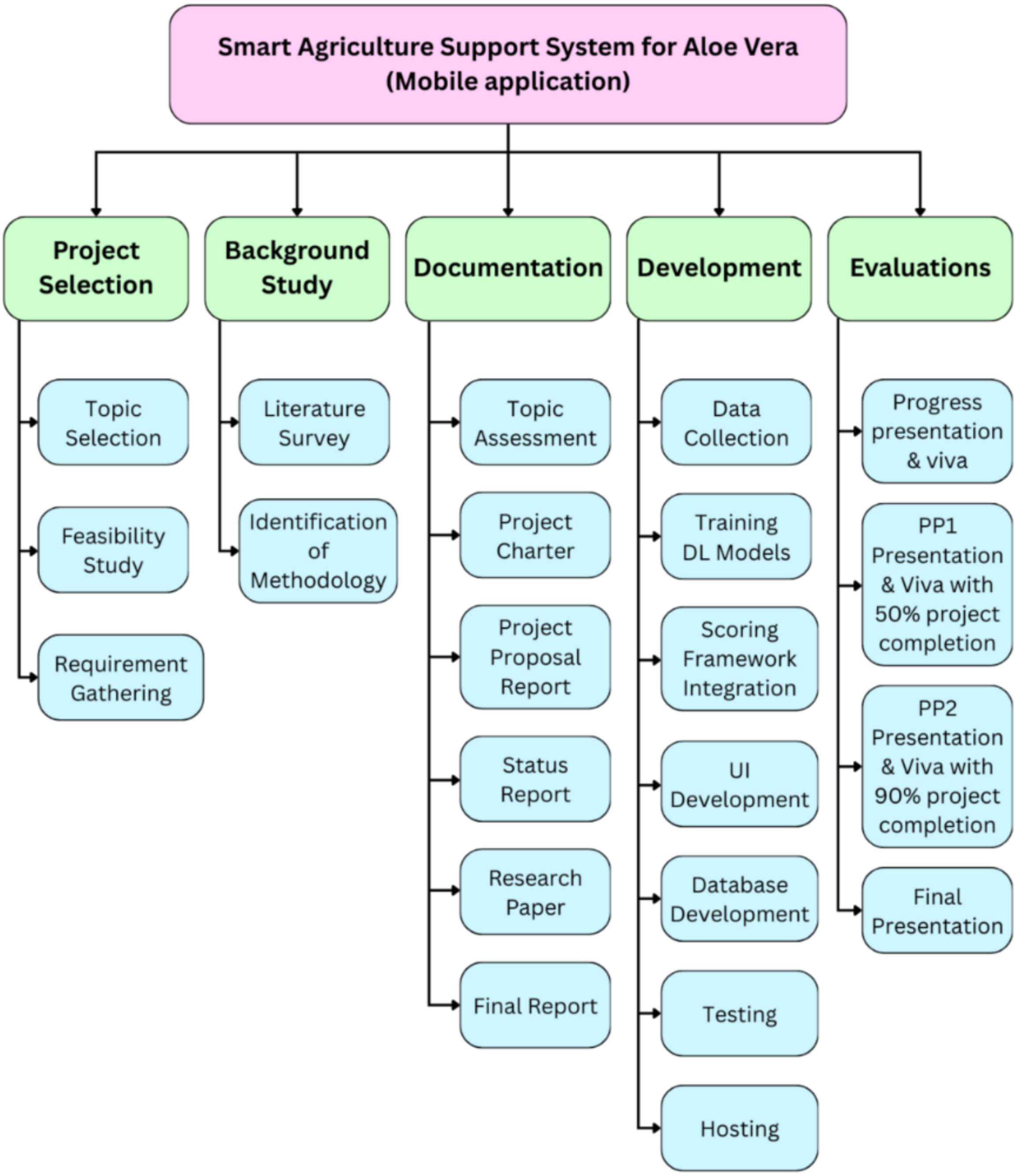

Figure 2: Work Breakdown Diagram

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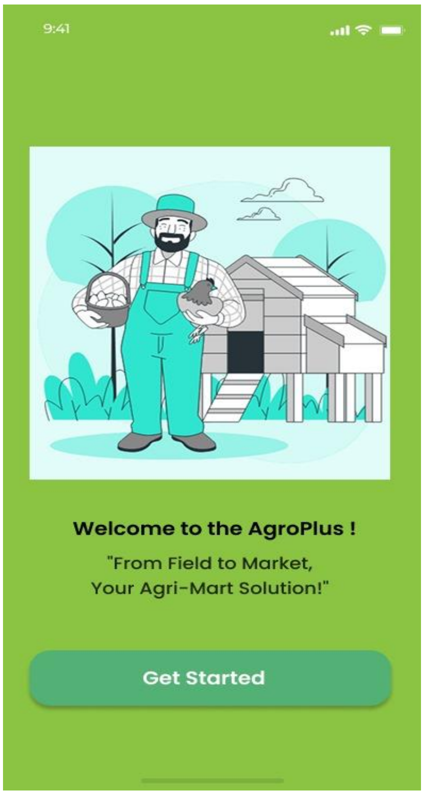
APPENDICES

Appendix – A : AleoGreen Logo

Appendix - B: Field Visit Images

Appendix - C: User Interface



Appendix D: Plagiarism Report

Amanda Proposal draft.pdf

ORIGINALITY REPORT

7%	6%	3%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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