

SMARTROSE: AI-IOT PLATFORM FOR SMART GREENHOUSE ROSE FARMING IN SRI LANKA

25-26J-299

Project Proposal Report

Rajapaksha R M S N R

B.Sc. (Hons) Degree in Information Technology,

Specialized in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

August 2025

SMARTROSE: AI-IOT PLATFORM FOR SMART GREENHOUSE ROSE FARMING IN SRI LANKA

25-26J-299

Project Proposal Report

B.Sc. (Hons) Degree in Information Technology,

Specialized in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

August 2025

DECLARATION

ABSTRACT

Rose cultivation in Sri Lanka faces persistent challenges due to rapid disease outbreaks triggered by sudden temperature changes and high humidity, particularly in greenhouse and polytunnel environments. Medium-scale growers largely depend on manual observation to detect plant diseases, which often results in late identification, excessive crop losses, and increased chemical usage. Since many plant stress conditions and fungal infections develop internally before visible symptoms appear, the lack of real-time, data-driven monitoring prevents timely intervention and reduces overall cultivation efficiency.

To address this challenge, the Smart-Rose platform introduces an Early Disease Alerting System, a dedicated module designed to detect early signs of plant stress and disease risk. The system continuously collects real-time data using Internet of Things (IoT) sensors that measure leaf surface temperature, ambient air temperature, and humidity. A machine learning-based classification model analyses these parameters, including the calculated temperature difference between the leaf and surrounding air, to determine whether the plant condition falls within a learned safe zone or indicates potential risk. Based on these predictions, the system provides timely alerts to growers, enabling early inspection and preventive action.

The proposed Early disease alerting system solution is scalable, modular, and well-suited for resource-limited agricultural environments such as Sri Lanka. By providing intelligent, early-stage decision support, the system reduces reliance on visual inspection, minimizes unnecessary chemical application, and improves crop survival rates. Furthermore, it enhances sustainable rose cultivation by bridging the gap between environmental monitoring and actionable insights. Ultimately, the Smart-Rose Early disease alerting system contributes to the digital transformation of agriculture by empowering growers with proactive disease management capabilities and offering strong potential for wider adoption across the floriculture sector.

TABLE OF CONTENTS

DECLARATION	iii
ABSTRACT	iv
LIST OF FIGURES.....	vi
LIST OF TABLES	vii
1. INTRODUCTION	1
1.1 Background & Literature Survey.....	1
1.2 Research Gap	3
1.3 Research Problem.....	4
2. OBJECTIVES.....	5
2.1 Main Objectives	5
2.2 Specific Objectives	6
3. METHODOLOGY.....	7
3.1 Project Execution Approach	7
3.2 Data Requirements & Collection	8
3.3 Technology Stack	9
4. PROJECT REQUIREMENTS.....	12
4.1 Functional Requirements.....	12
4.2 Non-Functional Requirements.....	13
4.3 User Requirements	15
5. BUDGET ESTIMATION	16
6. GRANTT CHART	16
7. REFERENCE LIST.....	17

LIST OF FIGURES

Figure 1: Process Flow Diagram	11
Figure 2: Grantt Chart	18

LIST OF TABLES

Table 1: Budget Estimation 18

1. INTRODUCTION

1.1 Background & Literature Survey

In Sri Lanka's floriculture sector, particularly in rose cultivation under greenhouse and polytunnel conditions, growers frequently face difficulties in identifying plant diseases at an early stage. At present, disease detection is largely dependent on manual visual inspection and the experience of the grower, without the support of an intelligent or centralized monitoring framework. As a result, disease identification often follows a trial-and-error approach involving delayed observation, reactive chemical application, and post-remote intervention. This practice is inefficient and frequently leads to rapid disease spread, significant crop losses, and increased production costs. The absence of structured, data driven decision support systems further intensify these challenges, especially for medium-scale growers who lack access to advanced climate control or automation technologies.

Moreover, Sri Lanka's agricultural sector has limited digital platforms that enable continuous monitoring of plant health indicators or systematic interpretation of environmental conditions linked to disease onset. This gap becomes particularly critical in greenhouse environments where sudden temperature fluctuations and high humidity can silently trigger fungal infections before visible symptoms appear. In addition, the lack of integration between environmental data, plant-level indicators, and predictive analytics prevents growers from understanding early stress signals in real time. Consequently, interventions are often delayed until irreversible damage has occurred, highlighting the need for an intelligent, scalable solution capable of bridging the gap between environmental monitoring and early disease detection

Globally, researchers have explored Internet of Things (IoT) and machine learning (ML) based approaches to address early plant disease detection and stress monitoring. Several studies have demonstrated the effectiveness of using environmental sensors combined with ML classification models to identify abnormal plant behaviour before visual symptoms emerge. Prior research has shown that parameters such as leaf temperature, air temperature, and humidity can be used to detect plant stress conditions linked to disease susceptibility. Other studies have emphasized the importance of feature engineering techniques, such as temperature difference between leaf and ambient air, in improving the accuracy of stress and disease classification models. These approaches highlight the potential of ML driven systems to provide timely alerts and reduce reliance on manual inspection.

Collectively, these studies demonstrate the growing relevance of intelligent monitoring and early warning systems in modern agriculture. However, many existing solutions are designed for large scale, high resource farming environments and are not well adapted to the practical constraints faced by medium-scale growers in developing countries such as Sri Lanka. Therefore, contextualizing IoT and ML based disease

detection approaches within the local agricultural ecosystem presents an opportunity to deliver a practical and impactful solution. By leveraging real-time sensor data, machine learning based classification, and early alert mechanisms, the Smart-Rose Early Disease Alerting System aims to enhance disease prevention, reduce chemical dependency, and promote sustainable rose cultivation with strong potential for wider adoption across the floriculture sector.

1.2 Research Gap

Existing research on plant disease detection and agricultural monitoring demonstrates the effectiveness of Internet of Things (IoT) sensors and machine learning (ML) techniques for identifying plant stress and disease conditions. Many prior studies focus on image-based disease detection or large-scale automated farming systems that rely on expensive infrastructure, controlled environments, and extensive computational resources. While these approaches achieve high accuracy, they are often impractical for medium scale growers operating in resource constrained settings.

Furthermore, limited attention has been given to early-stage disease detection based on physiological plant responses, such as abnormal leaf temperature behaviour, rather than visible symptoms. Although environmental parameters like air temperature and humidity are commonly monitored, the integration of leaf level thermal data with environmental context remains underexplored, particularly in localized agricultural environments such as greenhouse rose cultivation in Sri Lanka. In addition, many existing systems lack real-time decision-making mechanisms that translate sensor data into actionable alerts for growers.

Another significant gap lies in the localization and contextualization of existing solutions. Most current models are trained and evaluated using datasets from high resource agricultural settings and are not adapted to the climatic conditions, cultivation practices, and operational constraints of Sri Lanka's floriculture sector. As a result, there is a lack of scalable, cost effective, and locally relevant Early Disease Alerting Systems that combine IoT sensing with ML based classification to support timely intervention for medium scale rose growers.

1.3 Research Problem

Despite the availability of advanced agricultural monitoring technologies, medium scale rose growers in Sri Lanka continue to experience substantial crop losses due to the late detection of plant diseases. Disease identification is primarily based on manual visual inspection, which only becomes possible after physiological damage has already progressed. Sudden temperature fluctuations and high humidity within greenhouse environments can trigger plant stress and fungal infections long before visible symptoms appear, leaving growers unaware of the impending risk

There is currently no intelligent, real-time system that integrates leaf-level physiological indicators with environmental data to provide early warnings of disease risk in rose cultivation. The absence of a data-driven decision support mechanism prevents growers from responding promptly to early stress conditions, resulting in delayed intervention, excessive chemical application, and reduced crop quality and yield.

Therefore, the core research problem addressed in this study is the lack of a real time, ML based Early Disease Alerting System tailored for rose cultivation in Sri Lanka that can detect abnormal plant stress patterns using IoT sensor data and provide timely alerts before visible symptoms occur. Addressing this problem is essential for improving disease prevention, enhancing sustainability, and supporting the digital transformation of medium-scale floriculture practices.

2. OBJECTIVES

2.1 Main Objectives

The main objective of this research is to design, develop, and evaluate an Early Disease Alerting System as a core component of the Smart-Rose platform, with the aim of enabling early detection of plant stress and disease risk in rose cultivation under greenhouse and polytunnel conditions in Sri Lanka. The system seeks to move beyond traditional, reactive disease identification methods by introducing a proactive, data-driven decision support mechanism that can identify abnormal plant behaviour before visible symptoms appear.

This research focuses on leveraging Internet of Things (IoT)-based sensing technologies and machine learning (ML) classification techniques to continuously monitor key physiological and environmental parameters affecting rose plants. By capturing real-time data on leaf surface temperature, ambient air temperature, and relative humidity, the system aims to identify early stress indicators that are closely linked to disease susceptibility. A particular emphasis is placed on analysing the temperature difference between the leaf and surrounding air, which reflects the plant's ability to regulate its internal temperature through transpiration. Deviations in this relationship often serve as early warning signals of stress or disease development.

Another central goal of this research is to develop an ML based classification model capable of learning normal and abnormal plant behaviour patterns under varying environmental conditions. Rather than relying on fixed threshold values, the model is trained using labelled historical data to define a dynamic "safe zone" representing healthy plant conditions. This approach allows the system to adapt to environmental variability and reduce false alerts, ensuring that warnings are issued only when sustained abnormal patterns are detected.

In addition, the research aims to deliver a practical, scalable, and cost-effective solution tailored to the needs of medium scale rose growers in Sri Lanka, who often lack access to advanced automation systems. By providing timely alerts and actionable insights, the proposed Early disease alerting system supports early intervention, reduces unnecessary chemical usage, minimizes crop losses, and promotes sustainable cultivation practices. Ultimately, this research contributes to the broader objective of digital transformation in agriculture, demonstrating how intelligent sensing and ML driven analytics can enhance productivity, resilience, and decision-making in floriculture systems.

2.2 Specific Objectives

To achieve the main objective of this research, several specific objectives are defined, each addressing a critical component of the proposed Early Disease Alerting System.

The first objective is to identify and analyse key environmental and physiological parameters that influence early disease development and plant stress in rose cultivation. This includes examining the relationship between leaf surface temperature, ambient air temperature, and relative humidity within greenhouse environments. Attention is given to understanding how sudden temperature fluctuations and humidity changes affect plant transpiration and stress responses prior to visible disease symptoms.

The second objective is to design and implement an IoT-based data acquisition framework capable of continuously monitoring the selected parameters in real time. This involves selecting suitable sensors, integrating them with a microcontroller or processing unit, and ensuring reliable data transmission for continuous monitoring. The objective also includes validating sensor accuracy and ensuring that the collected data is suitable for downstream analytical processing.

The third objective is to develop a machine learning–based classification model that can distinguish between healthy and at-risk plant conditions. The model will be trained using labelled datasets derived from sensor readings under known plant health states. Feature engineering techniques, including the computation of temperature difference between leaf and air, will be applied to improve model performance. The classification output will indicate whether the plant remains within a learned safe zone or exhibits abnormal stress patterns.

Another objective is to design an early alerting mechanism that translates ML predictions into actionable warnings for growers. This includes defining alert conditions that account for persistence over time to reduce false positives caused by short-term environmental fluctuations. The alerting process aims to provide clear, timely notifications that enable growers to inspect plants and take preventive action before disease symptoms become visible.

Finally, the research seeks to evaluate the effectiveness and practicality of the proposed Early disease alerting system in a localized cultivation environment. This involves assessing system performance in terms of detection accuracy, response time, and usability from the grower’s perspective. The evaluation will also consider the system’s potential to reduce crop losses and chemical dependency, as well as its scalability for broader adoption within Sri Lanka’s floriculture sector.

3. METHODOLOGY

3.1 Project Execution Approach

The Smart-Rose Early Disease Alerting System is developed using an iterative and incremental project execution approach, ensuring continuous validation and refinement at each stage of development. This approach is selected to effectively manage technical complexity while allowing flexibility to improve system components based on experimental observations and performance evaluations.

The project execution begins with a detailed requirement analysis derived from real world rose cultivation challenges in Sri Lanka, particularly within greenhouse and polytunnel environments. Based on these requirements, a modular system architecture is designed, separating data acquisition, data processing, machine learning, and alerting functionalities. This modular design enables independent development and testing of each component while supporting future scalability and integration with other Smart Rose platform modules.

Development proceeds through sequential phases, including sensor integration, data acquisition implementation, machine learning model development, and alerting mechanism deployment. Each phase undergoes functional testing before progressing to the next, ensuring reliability and correctness. Experimental iterations are conducted to fine-tune sensor placement, data sampling intervals, and alert thresholds to reduce noise and false positives.

The execution approach also emphasizes prototyping and real-world validation, where the developed Early disease alerting system prototype is deployed in a controlled cultivation environment. System performance is continuously monitored, and feedback is incorporated to refine classification accuracy and alert effectiveness. This structured yet adaptive execution strategy ensures the delivery of a practical, robust, and research-driven solution aligned with the objectives of early disease detection and sustainable rose cultivation.

3.2 Data Requirements & Collection

The effectiveness of the Early Disease Alerting System depends heavily on the quality and relevance of the data collected. The system primarily relies on physiological and environmental data that are closely associated with early plant stress and disease development in rose plants.

The required data parameters include leaf surface temperature, ambient air temperature, and relative humidity. Leaf temperature data is critical for identifying physiological stress, as healthy plants regulate leaf temperature through transpiration, while stressed or diseased plants exhibit abnormal temperature behaviour. Environmental parameters such as air temperature and humidity provide essential context for interpreting leaf temperature variations and identifying conditions conducive to disease onset.

Data collection is carried out using IoT-based sensors deployed within the greenhouse environment, positioned near the plant canopy to ensure representative measurements. Sensor readings are captured at fixed time intervals to enable continuous monitoring and detection of rapid environmental changes. The collected data is transmitted to a processing unit, where it is stored and pre-processed to remove noise and inconsistent values.

For machine learning model development, historical sensor data is accumulated over extended observation periods. Each data record is labelled according to the observed plant condition, classified as either healthy or at risk, based on expert observation and cultivation records. Additionally, derived features such as the temperature difference between leaf and air are computed to enhance pattern recognition and improve classification performance. This structured data collection process ensures the availability of high-quality datasets suitable for training, validating, and evaluating the ML model.

3.3 Technology Stack

The development of the Smart-Rose Early Disease Alerting System utilizes a combination of Internet of Things (IoT) technologies, machine learning frameworks, web-based application components, and database systems to ensure real-time monitoring, scalability, and reliability. The selected technology stack is designed to support continuous data acquisition, intelligent analysis, and timely alert delivery within greenhouse rose cultivation environments. The chosen technology stack is as follows

1. Frontend Layer

- Technologies: HTML, CSS, JavaScript
- Frameworks/Libraries: React.js
- Purpose:
Provides an interactive and user-friendly interface for growers to monitor real-time sensor readings, visualize environmental trends, and view plant health status and alert notifications. The frontend enables clear presentation of leaf temperature, air temperature, humidity, and system-generated disease risk alerts.

2. Backend Layer

- Technologies: JavaScript (Node.js)
- Frameworks: Express.js
- Purpose:
Acts as the core processing layer that manages communication between the IoT devices, machine learning models, database, and frontend application. The backend handles data ingestion, preprocessing, feature computation, ML inference requests, and alert generation logic

3. IoT & Data Acquisition Layer

- Hardware Platform: ESP32 Microcontroller
- Sensors:
 - Leaf temperature sensor
 - Environmental temperature and humidity sensor
- Purpose:
Responsible for real-time data collection from the cultivation environment. The IoT layer continuously captures leaf-level and environmental parameters and transmits the data wirelessly to the backend system for processing and analysis

4. Machine Learning & Analytics Layer

- Technologies/Frameworks: Python-based ML libraries
- ML Model Type: Supervised binary classification
- Purpose:
Performs data analysis and plant health classification using sensor-derived features such as leaf temperature, air temperature, humidity, and temperature difference (ΔT). This layer determines whether the plant condition falls within a learned safe zone or indicates potential stress or disease risk.

5. Database & Storage Layer

- Database Management System: MongoDB
- Purpose:
Stores sensor data, processed feature sets, ML prediction results, alert history, and system logs in a centralized and scalable manner. The use of a NoSQL database supports flexible data structures and efficient handling of continuous time-series sensor data

6. Deployment & Hosting Environment

- Platforms: Local server and cloud-based infrastructure
- Purpose:
Provides a reliable execution environment for backend services, ML models, and database components. The deployment setup supports real-time data processing, system scalability, and future expansion of the Smart-Rose platform

7. Testing & Evaluation Tools

- Tools: API testing tools, logging and monitoring utilities
- Purpose:
Ensures correct system functionality, reliable data transmission, accurate ML predictions, and timely alert generation. Testing is conducted to validate system performance, stability, and robustness under varying environmental conditions

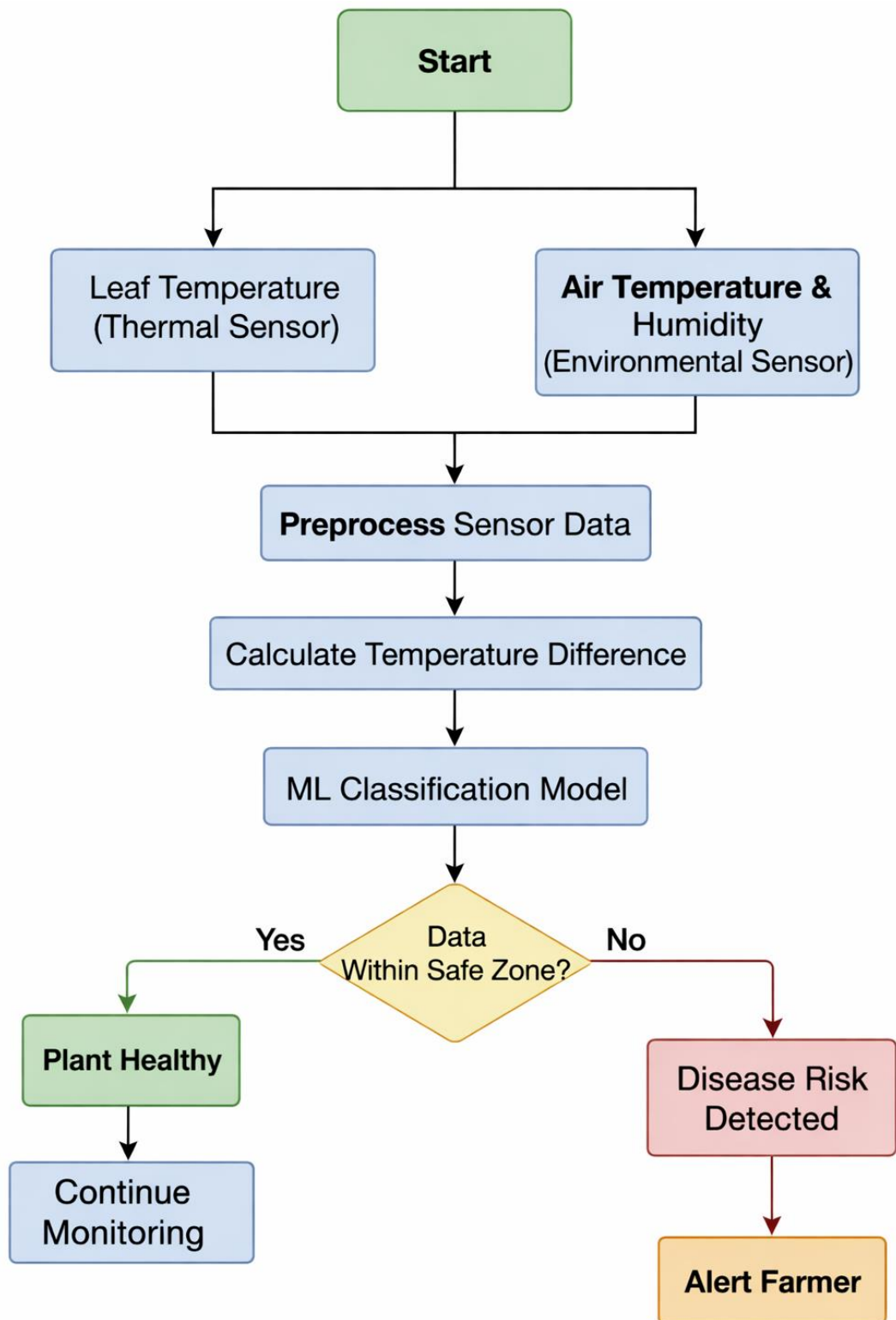


Figure 1: Process Workflow

4. PROJECT REQUIREMENTS

4.1 Functional Requirements

1. The system shall continuously collect real-time environmental data from IoT sensors deployed within the greenhouse environment.
2. The system shall acquire leaf surface temperature, ambient air temperature, and relative humidity measurements at predefined time intervals.
3. The system shall ensure that all sensor readings are accurately received, processed, and stored without data loss.
4. The system shall preprocess incoming sensor data by filtering noise and handling missing or incomplete values.
5. The system shall convert raw sensor readings into structured and standardized data formats suitable for analysis.
6. The system shall compute derived features, including the temperature difference between the leaf surface and the surrounding air.
7. The system shall analyze processed sensor data using a classification-based machine learning model to assess plant stress and disease risk.
8. The system shall determine whether observed plant conditions exceed predefined safe threshold ranges.
9. The system shall apply persistence-based logic to confirm that abnormal conditions remain beyond a defined duration before triggering alerts.
10. The system shall generate alerts when sustained abnormal plant conditions indicating potential disease risk are detected.
11. The system shall record all alert events along with relevant sensor data for historical analysis and monitoring.
12. The system shall provide a user interface that displays real-time sensor readings and plant health status.
13. The system shall display historical trends of environmental data and past alert events through the user interface.
14. The system shall notify users of alert conditions in a clear and timely manner to support early preventive action.

4.2 Non-Functional Requirements

1. Performance

The Smart-Rose Early Disease Alerting System shall operate in near real time to ensure timely detection of plant stress and disease risk. Sensor data collected from the greenhouse environment shall be processed with minimal latency, and machine learning-based classification results shall be generated within an acceptable response time. Alert notifications shall be issued promptly after sustained abnormal conditions are detected, enabling growers to take early preventive action. The system shall be capable of handling continuous data streams without performance degradation.

2. Scalability

The system shall be designed to support scalability at both the hardware and software levels. It shall allow the integration of additional sensors, plants, or greenhouse units without requiring major architectural changes. The backend and database components shall efficiently manage increased data volumes as the number of monitored plants grows. This ensures that the Smart-Rose platform can be expanded from pilot-scale deployment to larger cultivation environments.

3. Reliability and Availability

The Smart-Rose Early disease alerting system shall provide high reliability and system availability to ensure uninterrupted monitoring of plant health conditions. The system shall be resilient to temporary network failures or sensor interruptions and shall recover automatically where possible. Data collection, processing, and alerting functionalities shall remain operational during critical environmental conditions when disease risk is highest.

4. Security

The system shall ensure secure handling of all data collected from IoT devices and transmitted across the network. Communication between sensors, backend services, and user interfaces shall be protected against unauthorized access. Stored data shall be safeguarded from tampering or unauthorized modification. The system design shall follow best practices in secure software development to prevent data breaches and system misuse.

5. Usability

The system shall be designed with a user-centric approach to ensure ease of use for growers with varying levels of technical expertise. The user interface shall present sensor data, plant health status, and alerts in a clear and understandable manner. Alerts shall be concise and actionable, enabling users to quickly interpret system outputs and respond appropriately without the need for technical knowledge.

6. Maintainability

The Smart-Rose early disease alerting system shall be easy to maintain and update. The system architecture shall be modular, allowing individual components such as sensors, backend services, or machine learning models to be modified or replaced without affecting overall system functionality. Clear documentation shall be maintained to support troubleshooting, updates, and future enhancements.

7. Portability

The system shall be portable across different deployment environments, including various greenhouse setups and hardware configurations. Software components shall be platform-independent where possible, enabling deployment on different operating systems or hosting environments. This portability ensures that the solution can be adopted by a wide range of growers without extensive reconfiguration.

8. Ethical and Regulatory Compliance

The Smart-Rose early disease alerting system shall adhere to ethical standards and relevant regulatory guidelines related to data usage and system deployment. Data collected shall be used solely for agricultural monitoring and research purposes. The system shall be designed to support environmentally responsible practices by promoting early intervention and reducing unnecessary chemical usage, aligning with sustainable agriculture principles.

9. Accuracy and reliability of recommendations

The system shall provide accurate and reliable plant health classification results based on validated machine learning models. The ML model shall be trained and evaluated using representative datasets to minimize false positives and false negatives. Alert recommendations shall be based on sustained abnormal conditions rather than isolated sensor fluctuations, ensuring that users can trust the system's outputs when making cultivation decisions.

4.3 User Requirements

1. The system shall be designed for rose growers who require timely and actionable insights into plant health conditions.
2. The system shall allow the user to view real-time environmental and plant-level data, including leaf temperature, air temperature, and humidity.
3. The system shall present real-time data through a simple and intuitive user interface that does not require technical expertise to understand.
4. The system shall provide clear and timely alerts when early signs of plant stress or disease risk are detected.
5. The system shall ensure that alerts are clearly distinguishable from normal system updates and explicitly indicate the need for inspection or preventive action.
6. The system shall enable the user to monitor historical trends of sensor data and alert records.
7. The system shall support informed decision-making by allowing users to analyze recurring environmental patterns and disease risks over time.
8. The system shall not require the user to manually analyze raw sensor data or interpret complex technical metrics.
9. The system shall translate analytical results into simple plant health status indicators and actionable recommendations.
10. The system shall function as a decision-support tool that complements, rather than replaces, the user's agricultural expertise.
11. The system shall assist users in taking early preventive actions to reduce crop losses and minimize unnecessary chemical usage.

5. BUDGET ESTIMATION

Requirement	Estimation Cost (LKR)	Justification
Traveling Cost	18,000.00	For data collection visits, stakeholder interviews, and project-related travel.
Development Cost	To be finalized	Includes frontend, backend, ML model development, and integration.

Table 1: Budget Estimation

6. GRANTT CHART

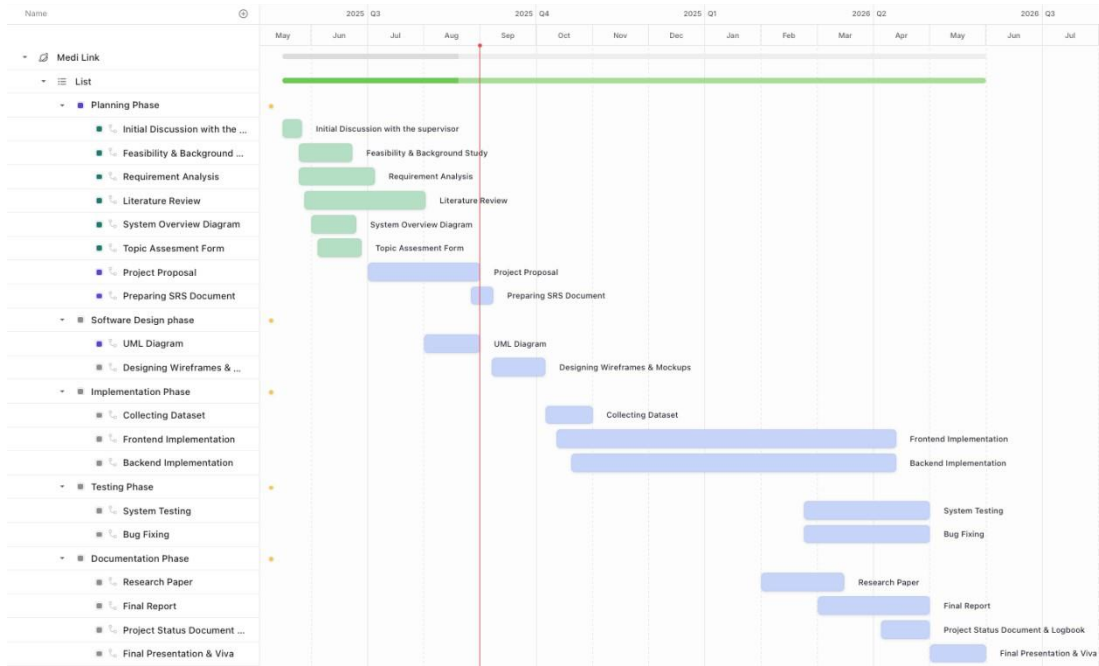


Figure 2: Grantt Chart

7. REFERENCE LIST

- [1] A. K. Mahlein, "Plant disease detection by imaging sensors," *Computers and Electronics in Agriculture*, vol. 100, pp. 1–10, 2014. DOI: 10.1016/j.compag.2013.08.005
- [2] J. W. Jones, L. Smith, and R. Brown, "Thermal imaging for plant water stress detection," *Sensors*, vol. 20, no. 3, pp. 681–695, 2020. DOI: 10.3390/s20030681
- [3] S. Sladojevic, M. Arsenovic, A. Anderla, D. Culibrk, and D. Stefanovic, "Deep neural networks for plant disease recognition," *Computers and Electronics in Agriculture*, vol. 147, pp. 1–9, 2018. DOI: 10.1016/j.compag.2018.02.001
- [4] A. Kamilaris and F. X. Prenafeta-Boldú, "Deep learning in agriculture: A survey," *Computers and Electronics in Agriculture*, vol. 147, pp. 70–90, 2018. DOI: 10.1016/j.compag.2018.02.016
- [5] A. Khanna and S. Kaur, "IoT-based smart agriculture monitoring system," *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 2121–2131, 2019. DOI: 10.1109/JIOT.2018.2872489
- [6] Food and Agriculture Organization of the United Nations, "Early Warning Systems for Agriculture," FAO, Rome, Italy, 2018.