Smart System for Optimized Organic Crop Rotation Using Precision Agriculture Data.

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Project Proposal Report

Ranasinghe R. A. D. M

B.Sc. (Hons) Degree in Information Technology

Specializing in Software Engineering

Department of Computer Science

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DECLARATION

We declare that this is our own work, and this proposal 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 our 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.

Name	Student ID	Signature
Ranasinghe R. A. D. M	IT20244552	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

[Appendix 1](#) 03/18/2023

Signature of the supervisor: Date

ABSTRACT

This research proposal aims to address the challenge of crop rotation planning for organic farmers by developing a rule-based knowledge base system that considers various factors affecting crop growth and health, such as soil health, weather and climate data, and pests and diseases. By providing a tailored crop rotation plan for each farm or land, the system aims to improve the productivity and sustainability of organic farming practices, thereby contributing to the overall development of the agricultural industry. To develop this system, the research team will use IoT devices to gather real-time data on soil health and climate conditions and integrate this data with farmers' inputs to generate a crop rotation plan that optimizes yield and sustainability. The knowledge base will be developed based on the expertise of agricultural professionals, with a user-friendly interface for updates and maintenance. By continuously updating the knowledge base with new information and expertise, the system will maintain its accuracy and effectiveness over time. This research project involves a team of four members, with each member assigned specific tasks to accomplish. One member will be responsible for gathering knowledge from agricultural experts and creating a user-friendly interface for knowledge base updates. The other three members will be responsible for data retrieval on soil health, climate, and pests and diseases. Through collaboration and coordination, the team aims to develop a comprehensive and effective crop rotation management system that will benefit the organic farming community and contribute to sustainable agriculture.

- **Keywords - Crop Rotation, knowledge base, Crop recommendation, Rule based Expert System, Organic farming.**

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LIST OF ABBREVIATIONS

Abbreviation	Description
SLIIT	Sri Lanka Institute of Information Technology
CRM	Crop Rotation Management
IOT	Internet of Things
DB	Database

1. INTRODUCTION

1.1. Background Study and Literature

As a sustainable alternative to conventional agriculture, organic farming has attracted growing interest in recent years. To maintain soil health and fertility, increase biodiversity, and reduce the use of synthetic pesticides and fertilizers, it involves the use of natural fertilizers, biological pest management, and crop rotation [1]. By alternating various crops on the same plot of land over time, crop rotation is a crucial part of organic farming because it helps to control pests and diseases, enhance soil structure, and retain soil nutrients [2].

But for farmers, coming up with a thorough and effective crop rotation strategy can be a difficult process. Several aspects are taken into account during the process, including soil health, past pest and disease activity, crop nutrient needs, climate and weather patterns, market demand, and financial viability [3]. Crop rotation planning traditionally relied on experience and intuition, which may not necessarily produce the most useful plans.

There is a rising demand for software solutions that can help farmers create and optimize crop rotation plans to solve this issue. These solutions make use of data from precision agriculture, machine learning, and software engineering concepts to give farmers tools that are simple to use, scalable, and accessible [4]

The future of organic farming depends on the creation of such a tool. Many issues, such as climate change, degraded soil, and dwindling biodiversity, face the agricultural sector [5]. Innovative solutions that can increase agriculture's sustainability and profitability while minimizing its detrimental effects on the environment and human health are required to address these concerns. By maximizing crop yields, improving soil health, and reducing the use of synthetic inputs, a crop rotation planning tool for organic farming can aid in the achievement of these objectives. The UN Sustainable Development Goal 2 is to "eliminate hunger, ensure food security and enhanced nutrition, and promote sustainable agriculture," and these solutions are in accordance with that objective [6].

Crop rotation planning tools have gained in popularity in recent years as farmers seek to increase crop yields while improving the sustainability and health of their land. Many tools with unique combinations of features and technology have been developed to aid farmers in developing efficient and effective crop rotation plans.

In recent years, the research and development of crop rotation planning tools has grown in popularity as farmers look to maximize crop yields and enhance the sustainability and health of their soil. To help farmers create efficient and optimal crop rotation plans, several tools have been developed, each with an own combination of features and technologies.

CropRotationPlanner is one such instrument, created by academics at the University of Wisconsin-Madison (Chang et al., 2014). With the help of this tool, farmers may enter details about their fields, such as crop history, soil types, and nutrient levels, using an interactive web-based interface. Based on this data, the program creates a personalized crop rotation plan that takes economic profitability, pest and disease management, and soil health into account. In comparison to conventional crop rotation planning techniques, the tool has been found to dramatically boost crop yields and reduce fertilizer runoff. It uses linear programming algorithms to optimize the plan.

The University of Guelph team also created the Crop Sequence Calculator (Schoenau et al., 2013). This application creates crop rotation plans that maximize soil health and crop yields using a database of crop yields, nutrient needs, and pest and disease susceptibility. Farmers can use the tool to create personalized plans by entering details about their own land and crop management techniques. The device has been demonstrated to increase agricultural yields and economic viability while enhancing soil health and reducing weed and insect burden.

Another popular tool for crop rotation planning is the Decision Support System for Agrotechnology Transfer (DSSAT) (Jones et al., 2003). Many models for modeling crop development, nitrogen uptake, and pest and disease pressure are part of the software suite known as DSSAT. Farmers can use the program to simulate various crop rotation scenarios and assess how they will affect the health of the soil, crop yields, and financial success. As compared to conventional crop rotation planning techniques, the tool has been employed in multiple studies and has been demonstrated to increase soil fertility and crop yields.

The Agricultural Production Systems Simulator (APSIM), the CropSyst model, and the Integrated Farm System Model (IFSM) are other crop rotation planning tools that have been developed (Gassman et al., 2010; Stockle et al., 2003; Rotz et al., 2010). To simulate crop growth, nutrient uptake, pest and disease pressure, and to provide optimized crop rotation schedules, each of these tools makes use of a different collection of technologies and algorithms.

In conclusion, as farmers work to maximize crop yields and enhance the sustainability and health of their land, crop rotation planning tools have grown in importance in recent years. Using a range of technologies and algorithms to model crop growth, nutrient uptake, and pest and disease pressure, a number of tools have been created to help farmers create efficient and optimized crop rotation plans. These methods have been demonstrated to considerably boost crop yields, decrease insect and disease pressure, and improve soil health.

2. RESEARCH GAP

Based on the literature review conducted above, a research gap can be identified for the development of a smart system for optimized organic crop rotation using precision agriculture data. While there is a growing interest in developing software solutions for crop rotation planning, existing systems do not appear to fully leverage the potential of precision agriculture data to optimize crop rotation plans.

Many of the existing crop rotation planning tools rely on traditional methods that may not take into account the full range of factors that can impact crop yields and soil health, such as pest and disease history, weather patterns, and nutrient requirements. While some systems do incorporate data on soil health and fertility, few appear to consider precision agriculture data, such as data on soil moisture, plant health, and yield variability.

As precision agriculture technologies continue to advance, there is a need to integrate these data sources into crop rotation planning tools to optimize crop yields, reduce input costs, and enhance sustainability. By developing a smart system for optimized organic crop rotation using precision agriculture data, farmers could benefit from more efficient and effective crop rotation plans that are tailored to the specific needs of their crops and soils.

Therefore, it can be concluded that the research gap in existing crop rotation systems is the lack of consideration of precision agriculture data in the crop rotation plan creation process.

3. RESEARCH PROBLEM

Despite the increasing interest in organic farming and the importance of crop rotation for sustainable agriculture, the lack of accessible and optimized crop rotation planning tools remains a challenge for farmers. Existing traditional methods of crop rotation planning rely on experience and intuition, and often do not consider key factors such as soil health, pest and disease history, crop nutrient requirements, climate and weather patterns, and market demand and profitability. Furthermore, while some crop rotation planning tools exist, they do not fully leverage precision agriculture data to create optimal crop rotation plans. Therefore, there is a need to develop a smart system for optimized organic crop rotation using precision agriculture data that considers all relevant factors and provides farmers with accessible and usable planning tools.

4. OBJECTIVES

4.1. Main Objectives

The objective of the proposed research is to develop and evaluate a smart system for optimized organic crop rotation using precision agriculture data. The system will aim to address the gap in existing crop rotation systems, where precision agriculture data input is not considered when creating crop rotation plans.

The overall goal of this research is to contribute to the advancement of sustainable agriculture practices, particularly in the context of organic farming. By developing a smart system for optimized organic crop rotation, this research aims to provide farmers with a tool that can enhance the sustainability and profitability of their operations while reducing negative impacts on the environment and human health.

4.2. Specific Objectives

4.2.1. Extract the knowledge of expert in organic crop rotation

The first sub-objective is to extract the knowledge of agricultural experts in organic crop rotation. This involves identifying and consulting with experts who have in-depth knowledge and experience in organic crop rotation. The experts will provide valuable insights on the different parameters to consider when creating a crop rotation plan, such as soil health, pests and diseases, weather and climate conditions, and plant nutrition. The team will conduct interviews, surveys, and focus group discussions to gather this knowledge and expertise.

4.2.2. Write the knowledge base respected to considered parameters

Based on the knowledge gathered from agricultural experts, the next sub-objective is to write the knowledge base for the crop rotation management system. The knowledge base will be created respecting the different parameters to be considered when generating a crop rotation plan, such as soil health, climate, pests and diseases, and plant nutrition. This involves developing a set of rules and algorithms that will be used to generate crop rotation plans based on the input data from IoT devices and farmer inputs.

4.2.3. Create the crop rotation plan according to the given output from the knowledge base system.

Once the knowledge base is developed, the next sub-objective is to create the crop rotation plan. The crop rotation plan will be generated by inputting data into the knowledge base system, which will then use the set of rules and algorithms to create a customized plan for each farm or land. The plan will take into account the specific soil health, climate, and pests and diseases of each farm or land, as well as the farmer's input and preferences. The team will also consider the sustainability of the crop rotation plan, ensuring that it promotes soil health and conservation.

4.2.4. Integrate the crop rotation plan component with other components.

The final sub-objective is to integrate the crop rotation plan component with other components of the system. This involves integrating the crop rotation plan with the soil health, climate, and pests and diseases data retrieved by other team members using IoT devices. The integration of these components will enable the system to generate accurate and customized crop rotation plans that consider the specific conditions and needs of each farm or land. The team will also develop a user-friendly interface for agricultural experts to update the knowledge base system, ensuring its accuracy and longevity.

5. METHODOLOGY

5.1. System Overview

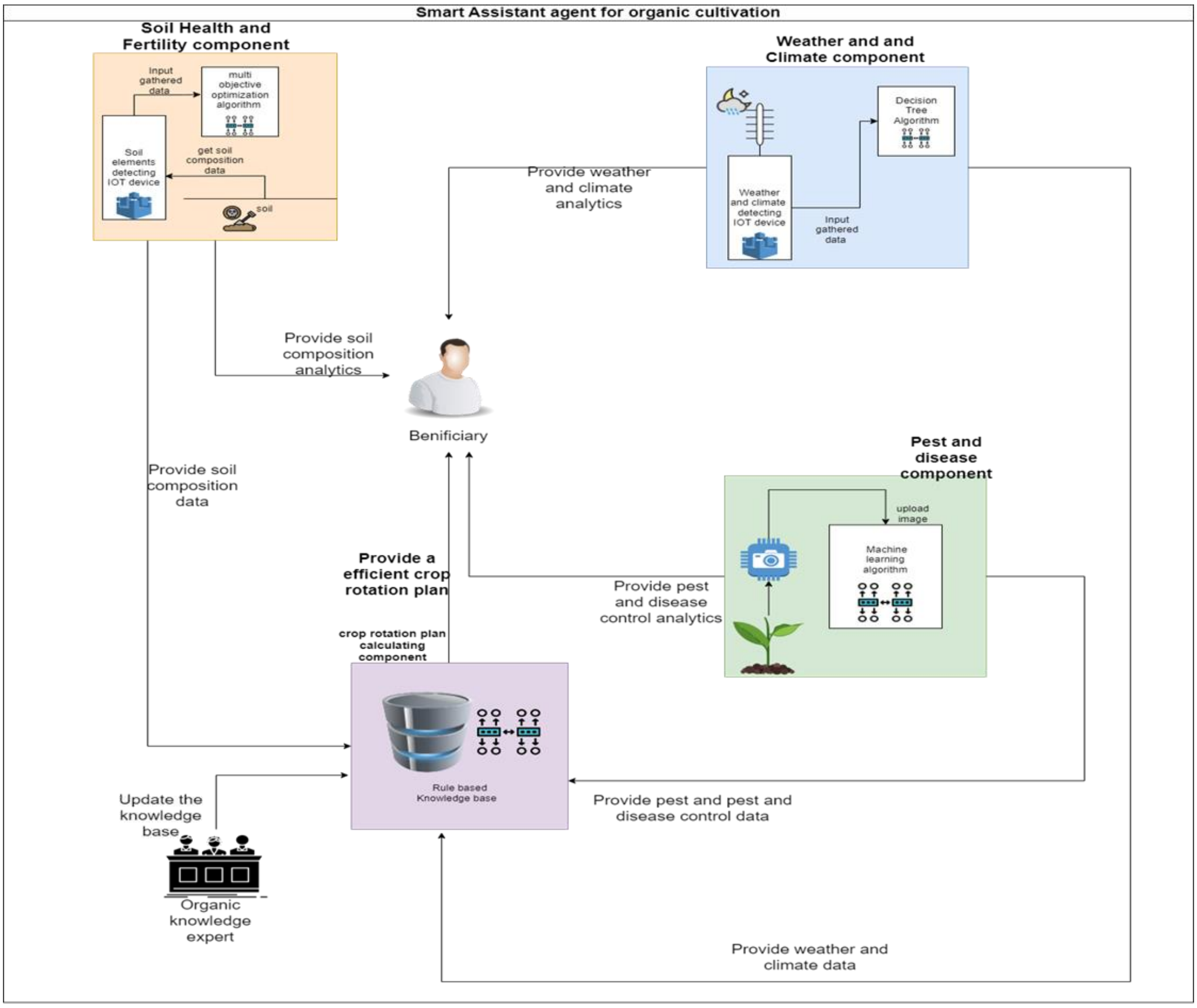


Figure 5.1 System overview

The proposed system is designed to provide farmers and other users with a comprehensive crop rotation plan that considers the specific soil health, climate, and pests and diseases of their farm or land. The system is composed of four main components, each responsible for a specific function, and will be implemented by a team of four members.

The first component of the system is soil composition analytics, which will retrieve data on the soil composition of the farm or land using IoT devices. The soil composition analytics component will be implemented by one member of the team, who will gather data on soil nutrients, pH levels, and other relevant parameters.

The second component of the system is the weather and climate analytics, which will retrieve data on the weather and climate conditions of the farm or land. The weather and climate analytics component will be implemented by another member of the team, who will gather data on temperature, rainfall, humidity, and other relevant parameters.

The third component of the system is the pest and disease control analytics, which will retrieve data on the pests and diseases that are prevalent in the area surrounding the farm or land. The pest and disease control analytics component will be implemented by a third member of the team, who will gather data on the type of pests and diseases, their life cycles, and other relevant parameters.

The fourth and main component of the system is the crop rotation plan creation component. This component will generate a customized crop rotation plan for the farm or land based on the data retrieved by the other three components. The crop rotation plan creation component will be implemented by the fourth member of the team, who will use the knowledge base created based on the insights from agricultural experts to develop a set of rules and algorithms for generating the crop rotation plan.

The system will be user-friendly, with a simple interface that allows farmers or other users to input their preferences and requirements. The system will then generate a customized crop rotation plan based on the input data, taking into account the specific soil health, climate, and pests and diseases of the farm or land.

Overall, the proposed system is designed to be a comprehensive crop rotation management solution that provides farmers with valuable insights into the specific conditions and needs of their farm or land, and promotes sustainable agriculture practices.

5.2 Component Structure

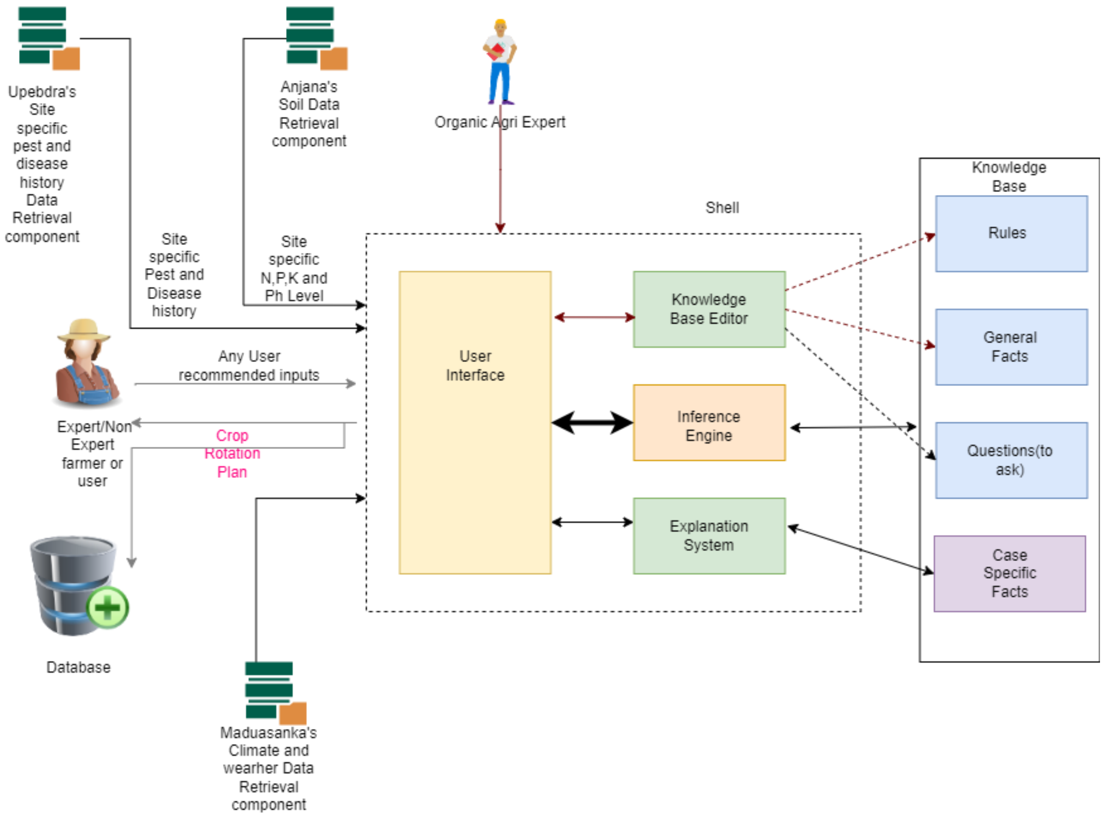


Figure 5.2 Component overview

5.2.1 Knowledge base Editor

Create a knowledge base that contains rules, general facts, questions to ask, and case-specific facts related to crop rotation management. The knowledge base editor will allow you to add, modify, and delete these rules and facts as necessary. You will gather information from agricultural experts and use this to create a comprehensive knowledge base that covers a wide range of scenarios.

5.2.2 Shell of Rule Base System

The inference engine will use the knowledge base to generate a customized crop rotation plan for each farm or land based on the data retrieved by the other three components. It will apply the rules and facts in the knowledge base to the specific input data, considering the soil health, climate, and pests and diseases of the farm or land. The inference engine will use a rule-based approach to generate the crop rotation plan, which will ensure that the plan is logical, consistent, and effective.

5.2.3 Explanation System

The explanation system will provide a detailed explanation of the reasoning behind the crop rotation plan generated by the inference engine. It will explain which rules and facts were applied, and how they were used to generate the final plan. This will help users understand the logic behind the plan and make any necessary adjustments. The explanation system will be an important tool for farmers and other users who may not have a deep understanding of crop rotation management.

Overall, my crop rotation plan creation component will be a critical part of the larger system, as it will use the knowledge base to generate customized crop rotation plans that take into account the unique characteristics of each farm or land. The component will be developed using a rule-based approach and will be designed to be user-friendly and easy to understand. The explanation system will help users understand the reasoning behind the plan and make any necessary adjustments, which will improve the effectiveness of the overall system.

5.3 Software Methodology

Figure 5.3 Component overview

Software methodology, also known as software development methodology or software process, is a framework or approach used to manage the software development lifecycle (SDLC) from planning to deployment and maintenance. It defines the process, tools, and techniques to be used to ensure efficient and effective software development. A comprehensive explanation of software methodology includes the following points.

- Planning: In this phase, the project objectives, scope, requirements, constraints, and risks are identified and analyzed. The planning phase also involves creating a project plan, setting milestones, and defining deliverables.
- Analysis: In this phase, the requirements are further analyzed and translated into functional specifications. This includes defining the system architecture, data model, and designing the user interface.
- Design: In this phase, the functional specifications are used to create a detailed design of the software system. This includes defining the software architecture, modules, algorithms, and data structures.

- Implementation: In this phase, the actual coding of the software system takes place. The implementation phase also includes testing and debugging the software to ensure it meets the functional specifications and is free of errors.
- Testing: In this phase, the software is tested to ensure it meets the requirements and functions as expected. This includes testing for functionality, performance, security, and user experience.
- Deployment: In this phase, the software is deployed to the production environment and made available to users. This includes installing the software, configuring the environment, and providing training and support to users.
- Maintenance: In this phase, the software is monitored, maintained, and updated as needed. This includes bug fixes, software updates, and enhancements to meet changing user needs.

5.4 Functional requirement

- Create a crop rotation plan according to given precision agriculture data:
  The system should be able to take in precision agriculture data, including soil health data, climate data, and pest and disease data, and generate a customized crop rotation plan based on that data. This functionality is critical to the success of the system, as it is the main goal of the project.
- Continuously update the knowledge-based system that creates the crop rotation plan:
  As new agricultural knowledge becomes available, the system should be able to continuously update the knowledge-based system used to generate the crop rotation plan. This will ensure that the system is always up-to-date with the latest information and can provide the best possible crop rotation plan to the user.
- Retrieve the previously suggested crop rotation plan:

The system should be able to retrieve previously suggested crop rotation plans in case the user wants to refer back to them. This functionality will help the user keep track of past crop rotation plans and evaluate their effectiveness over time.

5.5 Non-functional requirement

- Accuracy of crop rotation plan: The accuracy of the crop rotation plan is a critical non-functional requirement for the system. The system should be able to generate accurate crop rotation plans based on the input data and the knowledge base. The accuracy of the plan can be evaluated based on the yield of the crops and the overall health of the farm. The system should be able to provide the most suitable crop rotation plan for the specific farm or land, considering the soil health, climate, and pests and diseases.
- User-friendly interface for farmers: The system should have a user-friendly interface for the farmers or users who will be using the system. The interface should be simple and easy to use, with clear instructions on how to input the data and retrieve the crop rotation plan. The system should be designed with the user in mind, with intuitive navigation and clear feedback.
- User-friendly interface and knowledge base editor interface for Agri experts: The system should also have a user-friendly interface for Agri experts who will be updating the knowledge base. The knowledge base editor interface should be easy to use, allowing the experts to add, modify or delete rules and facts from the knowledge base. The system should also provide clear feedback on the changes made to the knowledge base and allow for easy retrieval of the previously suggested crop rotation plans.

5.6 Project Technology Stack

Table 5.6 Technologies and Tools

Technology	Rule based Expert System
Frontend	ReactJS
Backend	NodeJS/ Flask
Knowledge Base Framework	PyKE/CLIP's(Tentative)(In depth research going on)
Database	MongoDB
Editor	Visual Studio code

6. DESCRIPTIONS OF PERSONAL AND FACILITIES

6.1 Commercialization

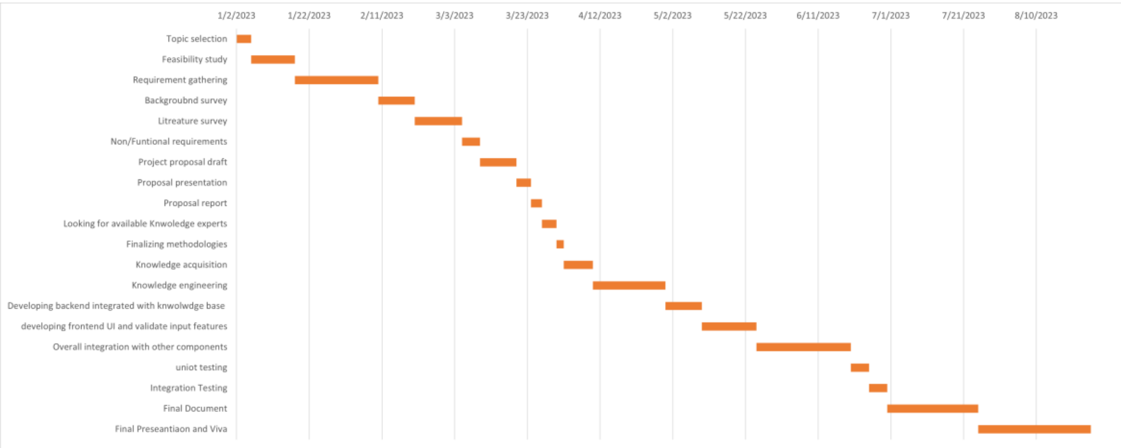
Software The proposed crop rotation management system has high commercial potential due to the growing trend towards sustainable agriculture. The system can be licensed to farming tech companies for integration into their existing software solutions, which can be offered as a premium feature to their customers.

Additionally, a subscription service can be offered directly to farmers through partnerships with farming associations, cooperatives, and individual farmers. This would provide farmers with a customized crop rotation plan based on their specific requirements, improving the overall health of their crops and increasing their yields.

To promote the system, it can be showcased at conferences and industry events to attract potential customers and investors. Social media can also be used to create awareness and generate interest in the product. Case studies can be developed to demonstrate the value and effectiveness of the system in different farming scenarios.

The key to the success of the commercialization strategy is to establish a strong network of partners, including farming associations, cooperatives, and individual farmers, and to consistently deliver a high-quality product that meets their needs and expectations.

6.2 Gantt Chart



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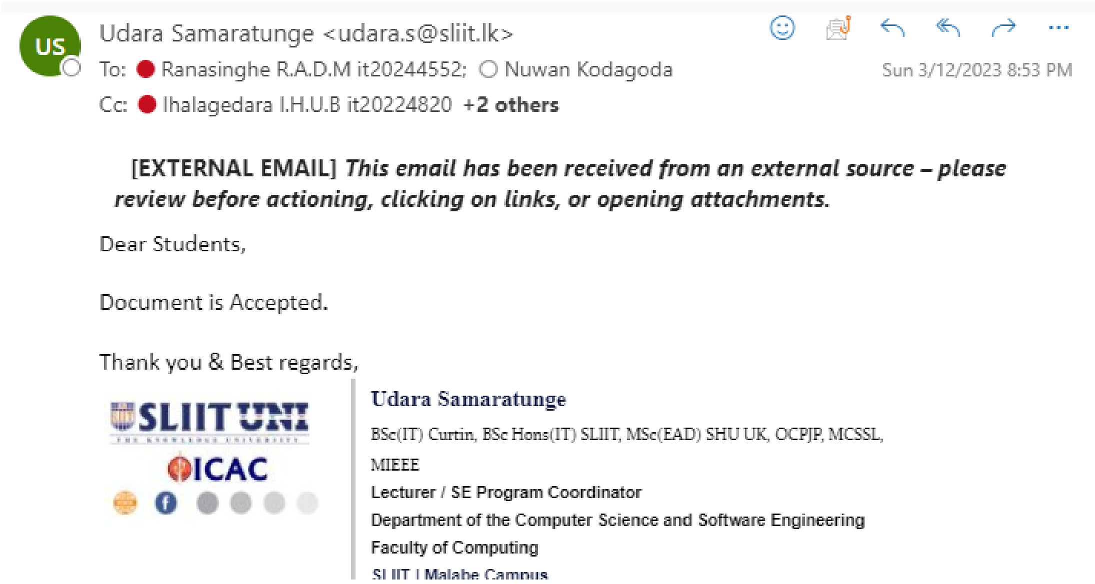
APPENDIX


Udara Samaratunge <udara.s@sliit.lk>
To: Ranasinghe R.A.D.M it20244552; Nuwan Kodagoda
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Dear Students,

Document is Accepted.

Thank you & Best regards,

Udara Samaratunge
BSc(IT) Curtin, BSc Hons(IT) SLIIT, MSc(EAD) SHU UK, OCPJP, MCSSL, MIEEE
Lecturer / SE Program Coordinator
Department of the Computer Science and Software Engineering
Faculty of Computing
SLIIT | Malabe Campus