AGRI STATE MANAGEMENT SYSTEM

Higher National Diploma in Software Engineering

Final Project Documentation

2023.2F

School of Computing and Engineering

National Institute of Business Management

Kandy

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Program: Higher National Diploma in Software Engineering

Supervisor: Mrs. Anjula Weerasingha

Institution: School of Computing, National Institute in Business Management

Date:

Declaration

We, the undersigned, declare that this project report titled “Agri State Management System” is my original work and has not been submitted previously for any academic qualification. To the best of my knowledge, it does not contain any material published or written by another person except where due reference is made in the text. Any contribution from other sources has been properly acknowledged.

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Mrs. Anjula Weerasinghe		

Abstract

Agriculture plays a crucial role in sustaining economies and feeding populations. However, traditional soil testing methods used in agricultural laboratories are time-consuming, often requiring up to 21 days for analysis.

The Agri State Management System is designed to revolutionize soil testing by leveraging IoT-enabled sensors and Machine Learning (ML) models to provide real-time soil nutrient analysis and automated fertilizer recommendations. This system incorporates an ESP32-based portable device that measures nitrogen (N), phosphorus (P), potassium (K), soil moisture, and humidity. The collected data is transmitted to a cloud-based platform, where an ML model processes it to generate accurate fertilizer suggestions.

The web-based dashboard provides real-time monitoring, visual trend analysis, and data storage for future reference. By reducing the testing time from weeks to real-time insights, this system enhances efficiency, minimizes human error, and optimizes agricultural decision-making. The implementation of this smart solution significantly contributes to precision farming and sustainable agriculture.

Acknowledgement

We would like to express our sincere gratitude to everyone who contributed to the successful completion of this project.

First and foremost, we extend our heartfelt thanks to our supervisor, Mrs. Anjula Weerasinghe, for her continuous guidance, valuable feedback, and unwavering support throughout the project. Her expertise and insightful suggestions played a crucial role in refining our research and implementation.

We are also immensely grateful to the faculty and staff of the National Institute of Business Management (NIBM), School of Computing and Engineering, for providing us with the resources and knowledge necessary to undertake this project.

Special appreciation goes to the agricultural researchers, soil scientists, and lab technicians who provided us with valuable insights into the current soil testing processes and the challenges faced by industry. Their cooperation and input helped shape the functionalities of our system.

A special mention to our families and friends for their continuous encouragement and support during this journey.

Lastly, we extend our gratitude to each team member for their dedication, hard work, and collaborative efforts that made this project a reality.

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1. Chapter 1: Introduction

1.1 Introduction for the Organization

The Agri State Management System is an innovative technological solution designed to enhance efficiency in soil analysis and fertilizer recommendations for agricultural laboratories. The organization specializes in agricultural research, primarily focusing on soil testing and nutrient analysis. Traditional soil testing methods often take several weeks, leading to inefficiencies and delays in decision-making. This project aims to address these challenges by integrating IoT and Machine Learning (ML) to provide real-time analysis and recommendations.

1.2 Organization Structure

The organization comprises multiple key roles:

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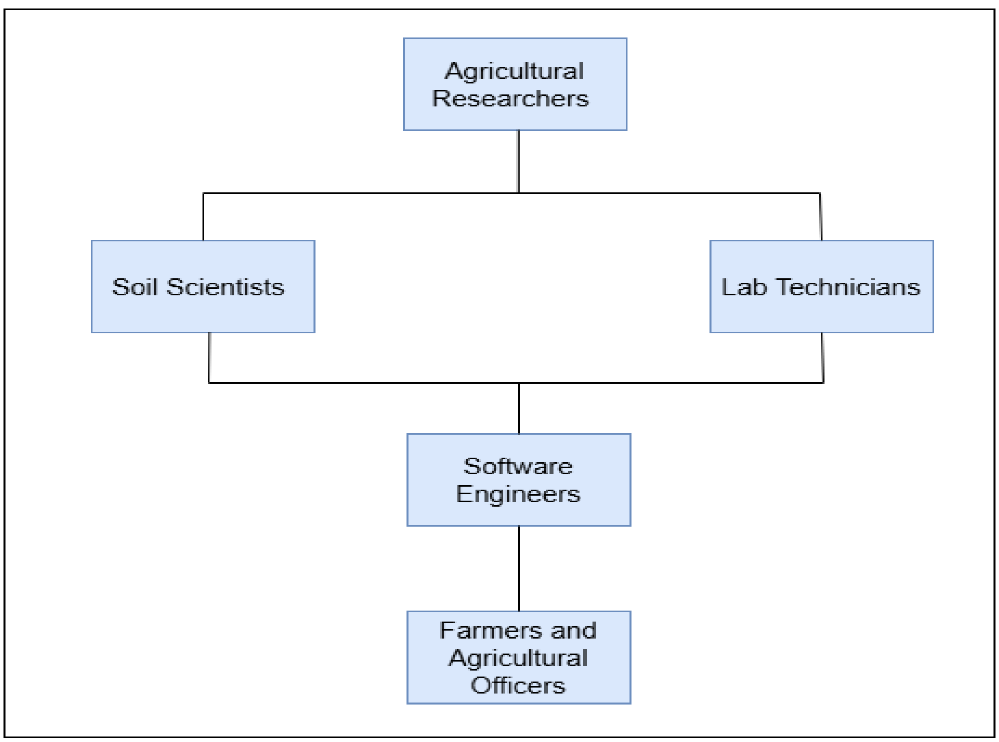


- **Agricultural Researchers**: Conduct research on soil health and analyze trends.
- **Soil Scientists**: Perform in-depth soil analysis and recommend fertilizers.
- **Lab Technicians**: Manage soil sample collection and data recording.
- **Software Engineers**: Develop and maintain the Agri State Management System.
- **Farmers and Agricultural Officers**: Utilize the system's data to optimize agricultural practices.

1.3 Current Operations in Organization

Soil Sample Collection

- Farmers or agricultural officers collect soil samples from different regions based on predefined sampling criteria.
- Samples are labeled with location, depth, and other relevant data.
- The samples are transported to the agricultural lab for further analysis.

Laboratory Testing

- Lab technicians process the soil samples using standard testing methods.
- Tests include pH levels, nitrogen (N), phosphorus (P), potassium (K), organic matter, moisture content, and micronutrient levels.
- Equipment used may include spectrophotometers, soil pH meters, and nutrient extraction systems.

Manual Data Analysis & Interpretation

- Soil scientists manually review the lab results to assess nutrient deficiencies.
- Data is compared against optimal soil nutrient levels for different crop types.
- Based on findings, appropriate fertilizers and soil treatment methods are recommended.

Report Preparation & Communication

- Scientists compile their findings in detailed reports.

- Reports include soil health status, recommended fertilizers, and best practices for improvement.
- Reports are either printed or shared digitally with farmers, agricultural officers, or cooperative organizations.

Challenges in the Current Process

- **Time-Consuming:** The entire process takes up to 21 days, delaying decisions on soil treatment and crop planning.
- **Human Error:** Manual analysis and data entry increase the risk of errors in recommendations.
- **Limited Accessibility:** Farmers in remote areas may not receive timely information.
- **Inefficiency:** Lack of digital record-keeping makes historical trend analysis difficult.

1.4 Users and Responsibilities in the Organization

Researchers & Soil Scientists

Role:

- Conduct in-depth analysis of soil health trends over time.
- Interpret soil test data to determine deficiencies and imbalances.
- Develop improved fertilizer formulations based on research findings.
- Work on soil improvement techniques to enhance productivity.
- Publish research papers and provide recommendations to policymakers.

Responsibilities:

- Analyze soil samples for chemical, physical, and biological properties.
- Compare soil health data with historical trends.
- Recommend fertilizers and soil treatments tailored to different crops and regions.
- Collaborate with agricultural planners and policymakers to develop sustainable farming practices.

Lab Technicians

Role:

- Perform laboratory-based soil testing using scientific equipment.
- Ensure accuracy and consistency in test results.

- Maintain lab equipment and ensure compliance with testing protocols.
- Digitize test results for integration into the Agri State Management System.

Responsibilities:

- Collect, label, and store soil samples properly.
- Conduct tests such as pH measurement, nutrient analysis, and organic matter assessment.
- Upload test results into the system for review by researchers and agricultural planners.
- Maintain quality control standards to ensure reliable data.

IT Engineers

Role:

- Develop and maintain the Agri State Management System.
- Ensure seamless integration of soil test data into the system.
- Provide system security, backup, and troubleshooting support.
- Implement automation features to streamline processes.

Responsibilities:

- Design and optimize the user interface for researchers, farmers, and planners.
- Automate data collection and analysis for quicker recommendations.
- Ensure cyber security measures are in place to protect sensitive agricultural data.
- Continuously update and improve system functionalities based on user feedback.

Farmers & Agricultural Planners

Role:

- Utilize soil test results to make informed decisions on fertilization and crop selection.
- Implement soil improvement recommendations to enhance productivity.
- Work closely with researchers to adopt new agricultural techniques.
- Provide feedback on the effectiveness of fertilizer recommendations.

Responsibilities:

- Collect and submit soil samples to labs.
- Review and apply soil improvement recommendations.
- Optimize agricultural practices based on scientific data.
- Participate in training sessions on soil health management.

1.5 Problem Definition

Several challenges exist in the current system, which hinder efficiency and accuracy in soil testing and analysis:

- Time-consuming process: Traditional soil testing methods involve collecting samples, sending them to a laboratory, and waiting for results, which can take several weeks. This delay affects timely decision-making for farmers, agronomists, and land developers.
- Lack of real-time insights: The absence of an automated system means there is no immediate feedback on soil conditions, making it difficult to take prompt action regarding fertilization, irrigation, or crop selection.
- Human error: Manual calculations and interpretations introduce the risk of errors in analyzing soil properties, potentially leading to incorrect recommendations for soil improvement and crop management.
- Limited accessibility: Results are typically provided in printed reports, making it challenging to share, store, or retrieve historical data efficiently. The lack of a centralized digital platform further restricts access to valuable soil data for future reference and comparative analysis.
- Inefficiency in large-scale applications: For agricultural enterprises and researchers managing multiple sites, manual soil testing becomes impractical, leading to inconsistent data collection and slower implementation of corrective measures.

1.6 Project Objectives

- Develop an IoT-enabled portable device to provide real-time soil analysis.
- Use Machine Learning models to automate fertilizer recommendations.
- Improve efficiency in agricultural research by reducing manual workload.
- Provide graphical reports for visualizing soil conditions and trends.

1.7 Proposed Solution

To address the challenges in traditional soil testing, the proposed solution integrates **IoT sensors, cloud computing, and machine learning algorithms** to provide a **real-time, accurate, and accessible** soil analysis system. The key components include:

- ESP32-based IoT Device: A compact and cost-effective microcontroller that collects real-time data on nitrogen (N), phosphorus (P), potassium (K) levels, soil moisture, and humidity, ensuring continuous soil monitoring without manual intervention.
- Machine Learning Algorithms: Advanced ML models analyze soil data to detect patterns, predict soil health trends, and recommend optimal fertilizers based on soil conditions. This reduces human error and enhances precision in agricultural decision-making.

- Cloud-based Dashboard: A centralized platform where collected data is stored, processed, and visualized. Farmers and researchers can access real-time insights, historical data, and trend analysis through an intuitive dashboard.
- Mobile and Web Access: The system is designed to be accessible via smartphones, tablets, and web browsers, allowing users to check soil conditions anytime, from anywhere. This ensures timely intervention and enhances agricultural productivity.

1.8 Chapter Summary

This chapter provided an overview of the organization, the existing manual soil testing challenges, and the need for a more efficient solution. It outlined key problems such as delays, human error, and limited accessibility in current soil testing methods. To overcome these issues, a smart, automated system integrating IoT sensors, machine learning, and cloud computing was proposed. This solution enhances real-time soil monitoring, improves decision-making, and provides greater accessibility to farmers and researchers.

Chapter 2: Methodology

2.1 Introduction

The methodology of this project is crucial in ensuring the successful development and implementation of the Agri State Management System. This chapter provides a structured explanation of the approaches, techniques, and technologies used to achieve the project objectives. The development of the system follows an agile methodology, which promotes iterative development, continuous testing, and user feedback integration. This approach allows flexibility in making improvements based on real-world testing and stakeholder input.

To build a robust and accurate soil analysis system, various data collection methods were employed, including field research, expert interviews, and IoT-based sensor readings. The collected data was then processed using Machine Learning (ML) algorithms to generate accurate fertilizer recommendations. The software development process involved the use of modern technologies such as React.js for the frontend, Django for the backend, and Firebase/MySQL for database management. Hardware components, including ESP32 microcontrollers and soil nutrient sensors, were integrated to enable real-time data collection and transmission to the cloud.

Additionally, this chapter details the testing strategies implemented to ensure the reliability and efficiency of the system. Various testing methodologies, including unit testing, integration testing, performance testing, and user acceptance testing (UAT), were conducted to validate the system’s functionality. The implementation process was carried out in multiple phases, starting from the development of the IoT device, training the ML model, building the web-based dashboard, and finally integrating all components for real-world testing.

By following a structured methodology, this project aims to bridge the gap between traditional and digital soil analysis techniques, making the process more efficient, accurate, and accessible to agricultural professionals.

2.1 Data Collection Methods

Field Research

Objective:

- To observe and analyze the current soil testing and agricultural practices in real-world settings.
- To identify inefficiencies in lab operations and recommend improvements.

Process:

- Researchers visit agricultural labs to examine the workflow and identify bottlenecks.
- Collect qualitative and quantitative data on soil testing procedures.
- Evaluate the accuracy and consistency of laboratory results.
- Identify challenges faced by lab technicians, scientists, and farmers.

Outcome:

- A deeper understanding of existing challenges and gaps in agricultural research.
- Documentation of best practices that can be scaled across different regions.
- Recommendations for improving soil testing efficiency and accuracy.

Interviews

Objective:

- To gain direct insights from soil scientists, lab technicians, and farmers regarding their needs, challenges, and expectations.

Process:

- **Soil Scientists:** Discuss soil health trends, testing challenges, and areas where automation can help.
- **Farmers:** Understand their difficulties in obtaining soil test results and applying recommendations.
- **Lab Technicians:** Identify workflow inefficiencies and challenges in handling large volumes of samples.
- **Agricultural Officers & Planners:** Gather insights on how soil data influences policymaking and large-scale agricultural strategies.

Outcome:

- Identification of pain points and areas for technological or procedural improvements.
- A clearer understanding of how data is currently used and where automation or AI could enhance decision-making.
- Insights into user experience challenges within the Agri State Management System.

Sensor Data Collection

Objective:

- To enhance soil testing efficiency by integrating IoT (Internet of Things) sensors for real-time data collection.

Process:

- Deploy IoT-based soil sensors in agricultural fields to monitor pH, moisture levels, temperature, and nutrient content.
- Connect sensors to a centralized data system for continuous real-time updates.
- Enable remote monitoring for researchers, farmers, and agricultural officers.
- Use machine learning algorithms to analyze sensor data for predictive soil health assessments.

Outcome:

- Faster, more accurate soil analysis compared to traditional methods.
- Reduction in manual testing workload for lab technicians.
- Real-time alerts for farmers on soil health changes, allowing for proactive action.
- A comprehensive digital database for tracking long-term soil health trends.

2.2 Software Process Model

Development Methodology: Agile Model

- **Incremental & Iterative Approach**: The system is built in small, functional parts with continuous feedback.
- **Frequent User Feedback**: Researchers, soil scientists, and farmers contribute insights at every stage.
- **Rapid Prototyping**: The IoT device, ML model, and web platform are tested in phases.

Software Development Phases

Phase 1: Requirement Analysis & Planning

- Identify system goals and user requirements.
- Conduct field research on soil testing processes.
- Define hardware and software components.

Phase 2: System Design

- **Hardware**: ESP32, sensors (NPK, moisture, humidity).
- **Software**:
  - **Frontend**: React.js (UI design).
  - **Backend**: Django (data processing).

  - **Database**: MySQL & Firebase (real-time storage).
  - **Machine Learning**: Python, TensorFlow (fertilizer recommendations).

Phase 3: Implementation & Development

- Develop IoT device and integrate with cloud services.
- Train ML models with real soil datasets.
- Develop a web-based dashboard for real-time monitoring.
- Implement a mobile-friendly version for farmers.

Phase 4: Testing

- **Unit Testing**: Validate individual components (sensor accuracy, ML predictions).
- **Integration Testing**: Ensure smooth communication between IoT, ML, and web services.
- **Performance Testing**: Optimize data processing speed.
- **User Acceptance Testing (UAT)**: Get feedback from agricultural experts.

Phase 5: Deployment & Maintenance

- Deploy the system in real-world agricultural labs.
- Provide user training for farmers and researchers.
- Implement periodic updates based on user feedback.

2.3 Software Development Tools

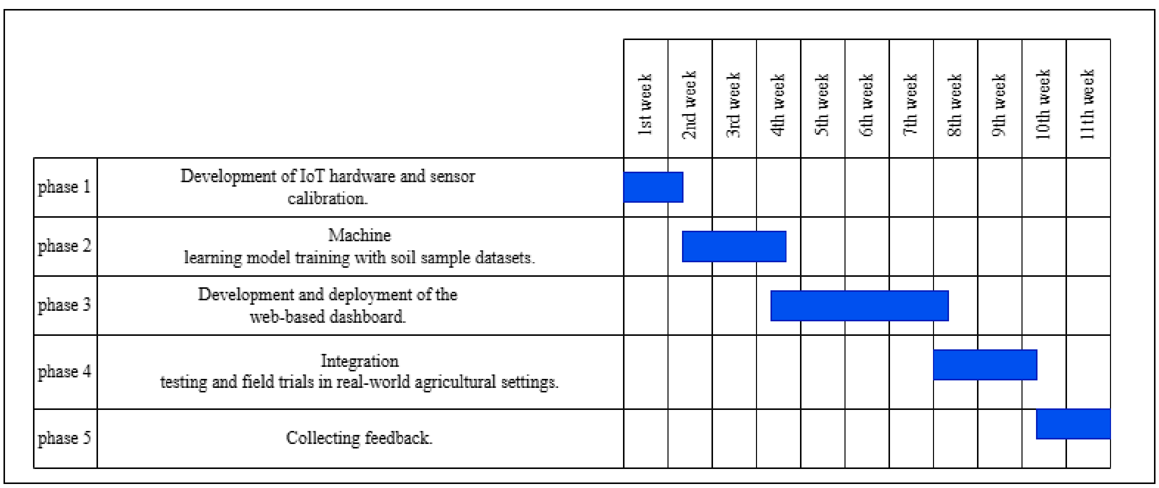
- **Frontend**: React.js for interactive user interfaces.
- **Backend**: Django for handling server-side logic.
- **Database**: MySQL and Firebase for real-time data storage.
- **Hardware & IoT**: ESP32, Arduino, and Blynk for data communication.

- **Machine Learning**: Python, TensorFlow, and Scikit-learn for prediction models.

2.4 Testing Strategies

- **Unit Testing**: Verifying individual components, such as sensor readings and ML algorithms.
- **Integration Testing**: Ensuring smooth interaction between hardware and software components.
- **Performance Testing**: Evaluating system responsiveness and data processing speed.
- **User Acceptance Testing (UAT)**: Collecting feedback from lab researchers and agricultural experts.

2.5 Implementation Plan



2.6 Chapter Summary

This chapter outlined the **methodologies and software tools** used throughout the project, detailing the structured approach taken for data collection, system design, and implementation. It highlighted various **data collection techniques**, such as **sensor-based real-time monitoring, historical data analysis, and expert consultations**, to ensure accurate soil assessment.

Additionally, the chapter described the **implementation phases** based on the **Agile methodology**, which includes **planning, designing, development, testing, deploying, reviewing, and launching**. The **integration of IoT devices, cloud computing, and machine learning** was explained, showcasing how these technologies work together to provide real-time soil analysis. The chapter also covered the **software tools used**, including programming languages (**Python, JavaScript**), cloud services (**Firebase, AWS**), and machine learning frameworks (**TensorFlow, Scikit-learn**) for analyzing soil composition and predicting optimal fertilizer recommendations.

Overall, this chapter established the **technical foundation of the project**, ensuring a clear understanding of the methodologies and tools that contribute to a **reliable, automated, and user-friendly soil analysis system**.

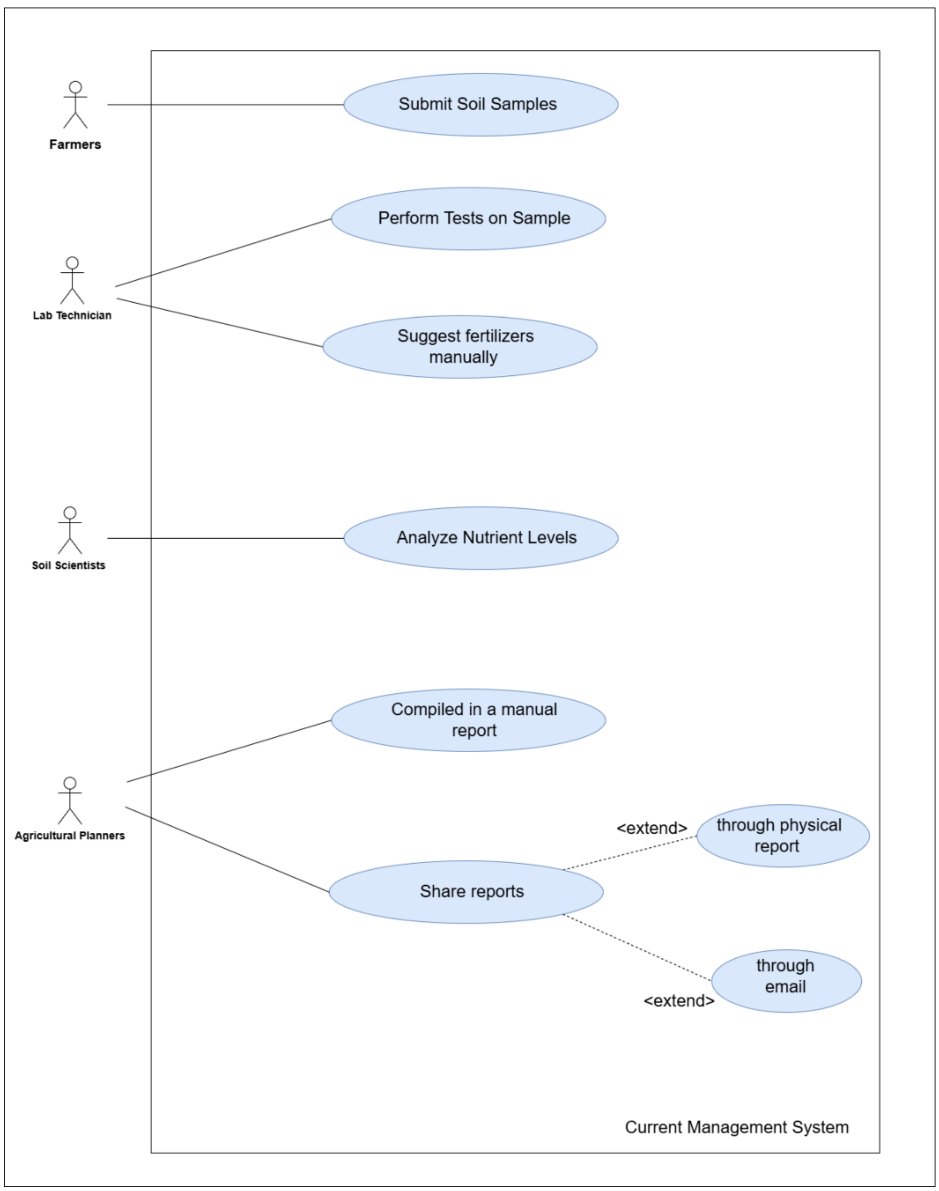
Chapter 3: Analysis

Introduction

This section analyzes the requirements, system architecture and functional design.

3.2 UML Diagram

Use Case Diagrams (Current System):



Use Case Diagrams (Proposed System):

Class Diagram:

Sequence Diagrams

ER Diagram of the Proposed System

Chapter Summary

Discussed the system analysis phase, including UML and ER diagrams.

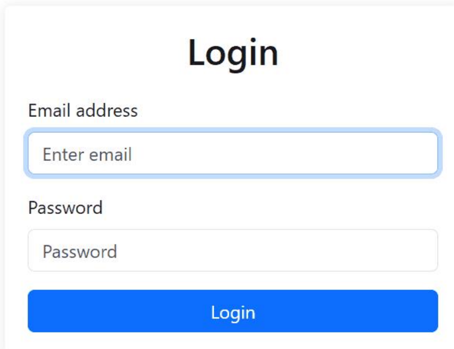
Chapter 4: Solution Design

Introduction

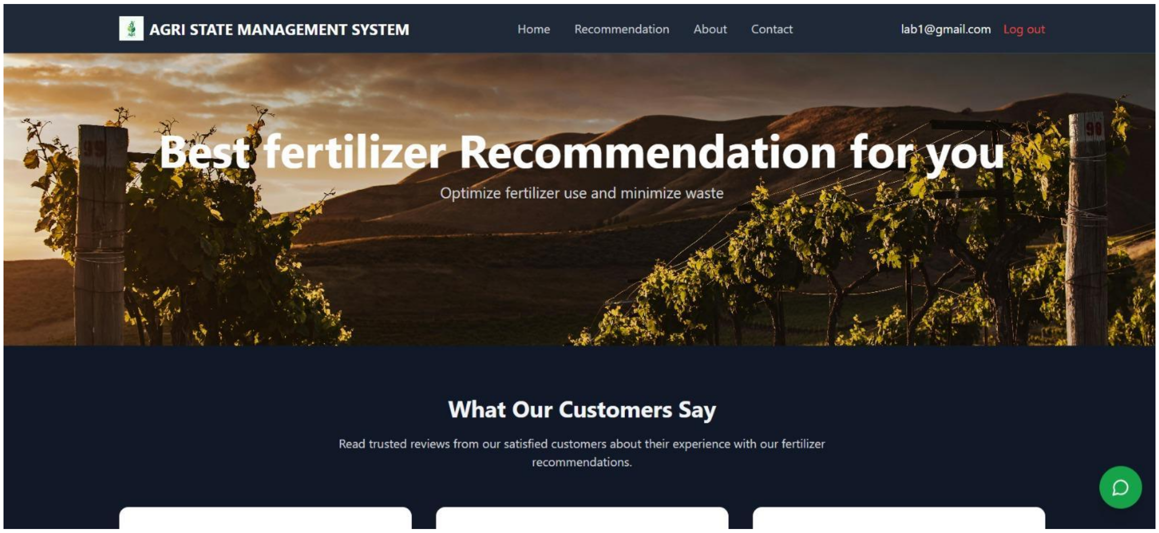
This section presents system design components, including hardware, software, and UI elements.

Interface Design

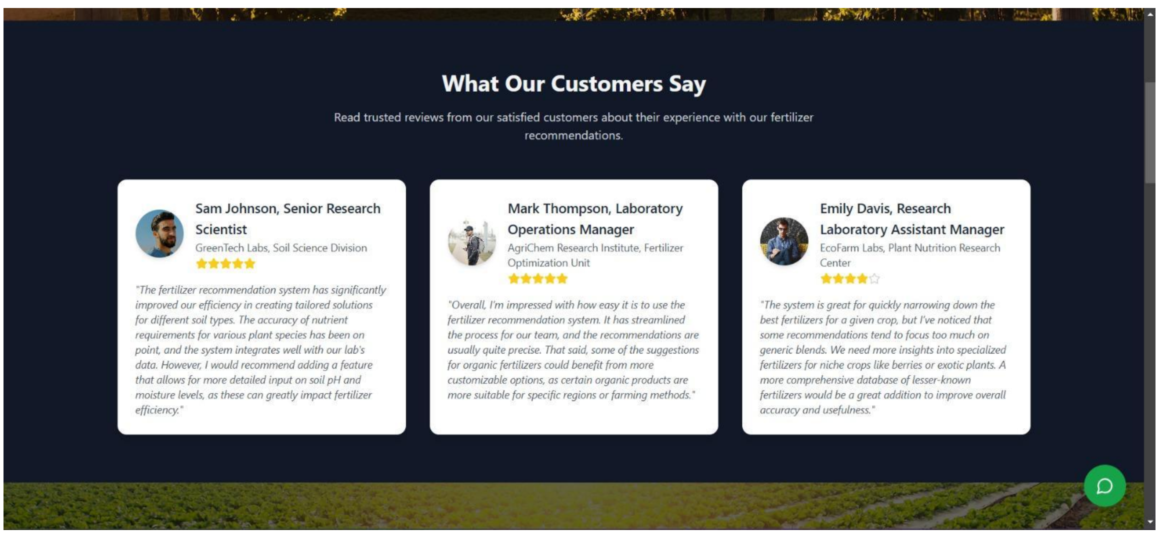
Login Page:



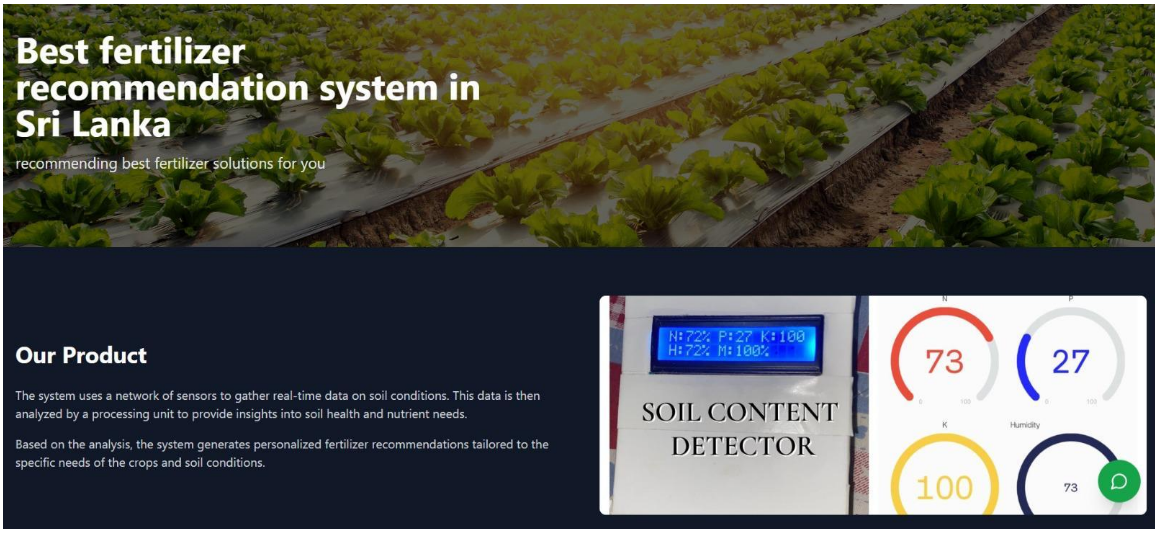
Home Page



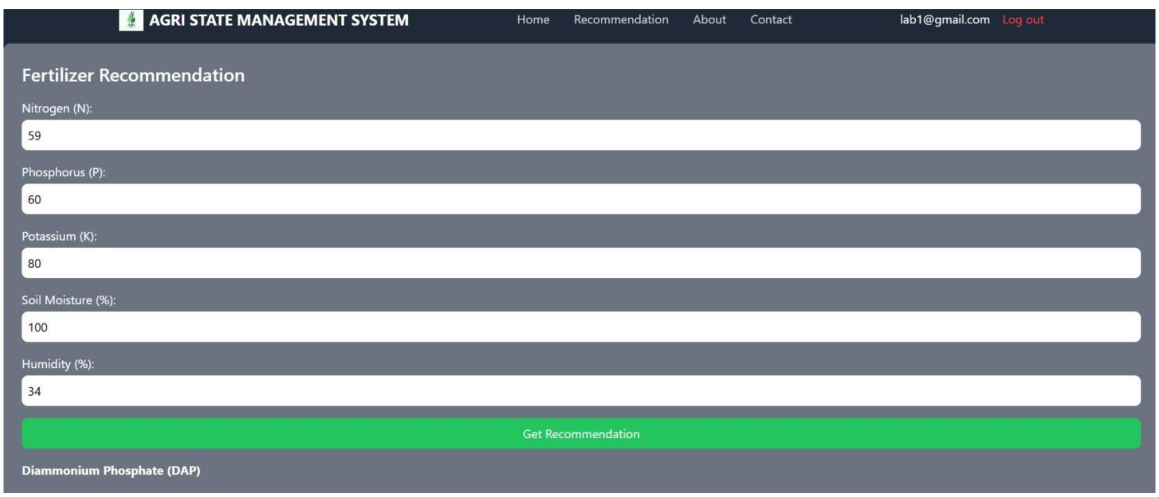
Customer Feedback



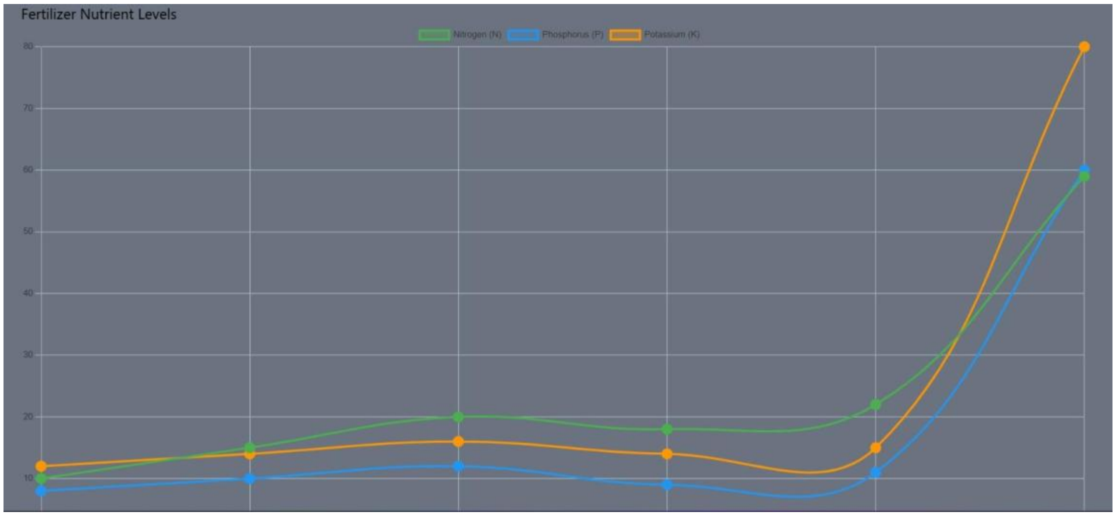
About Us

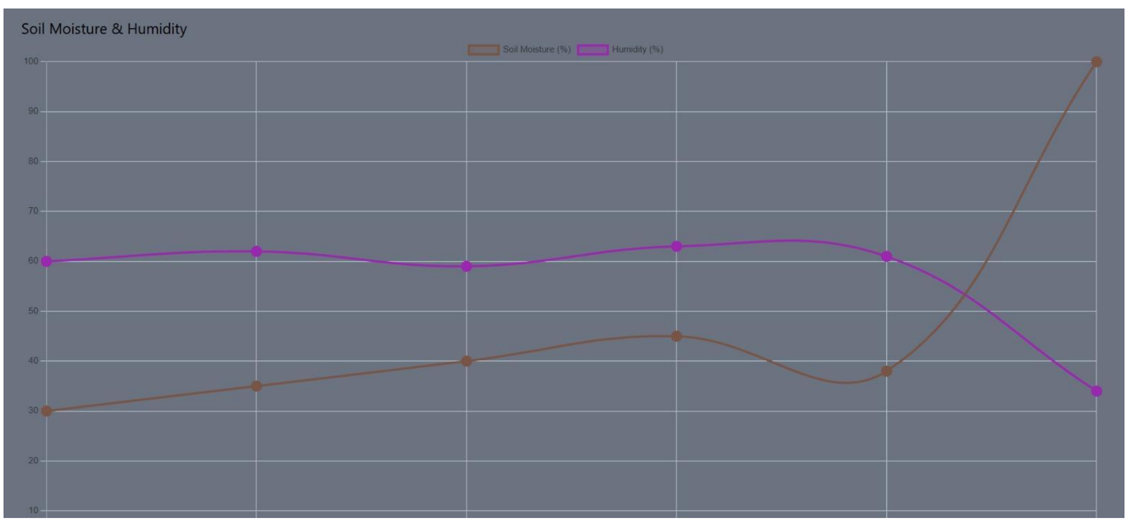


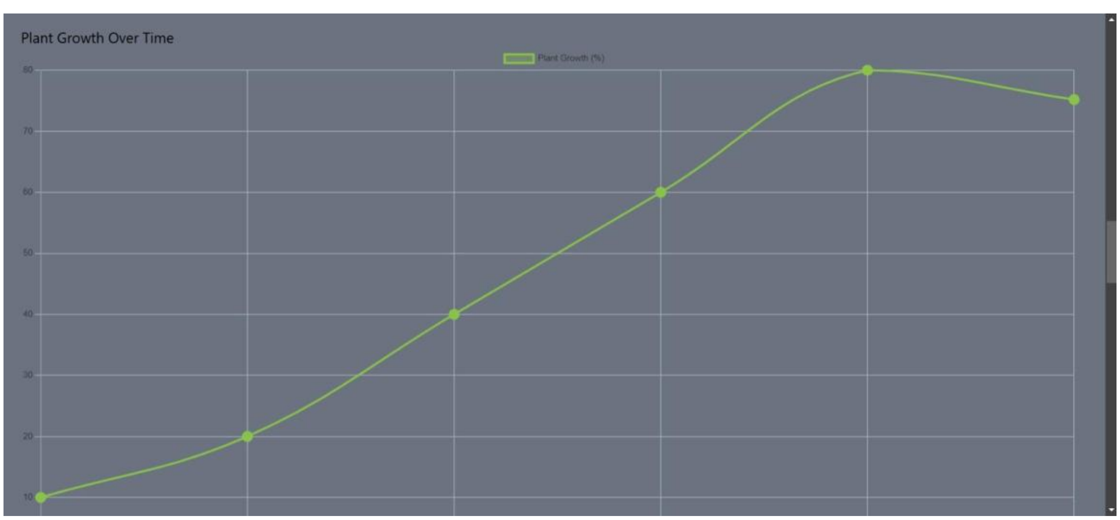
Fertilizer Recommendation Powered by ML



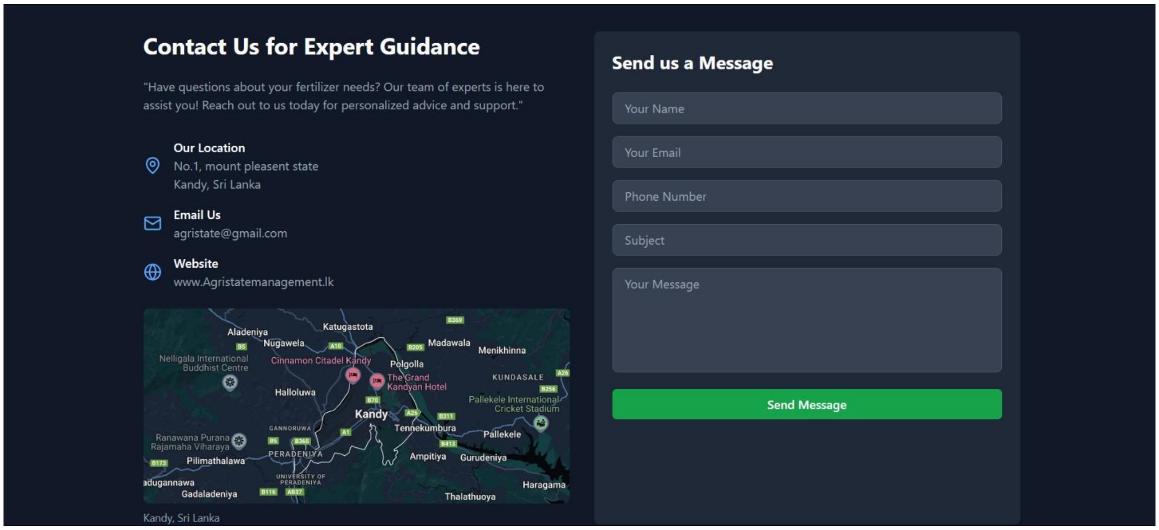
Analyzed Graphs



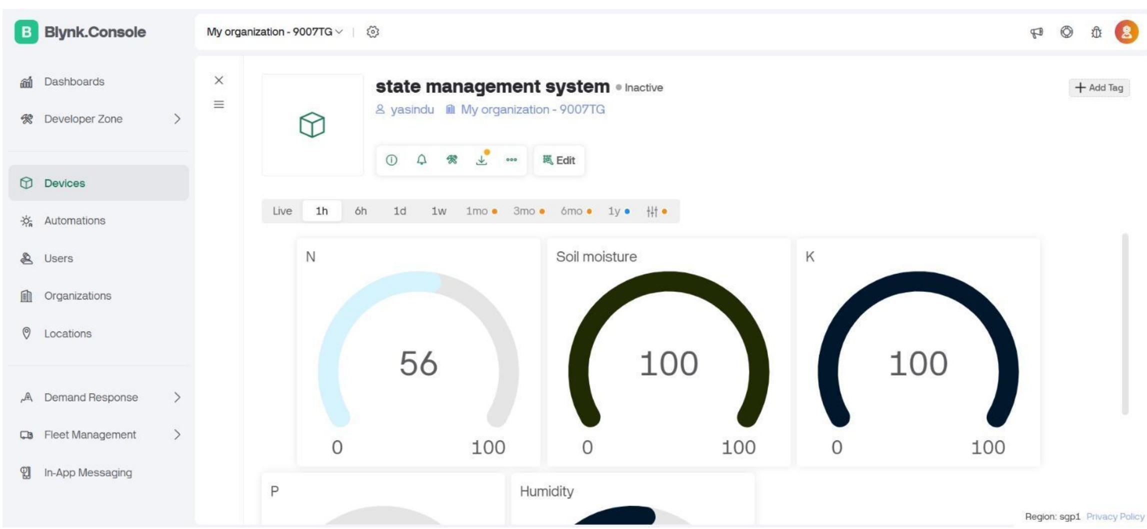




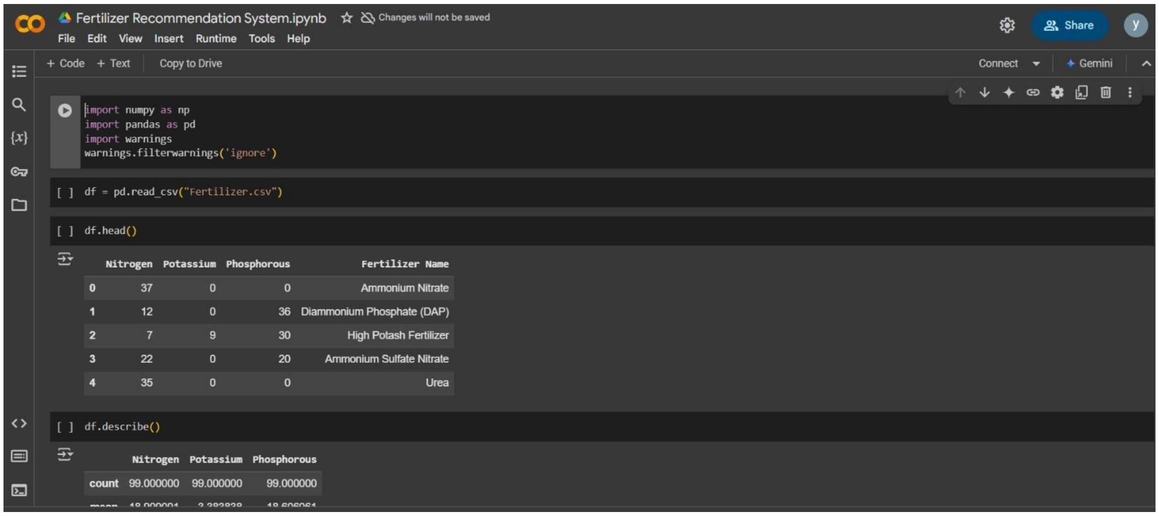
Contact Us



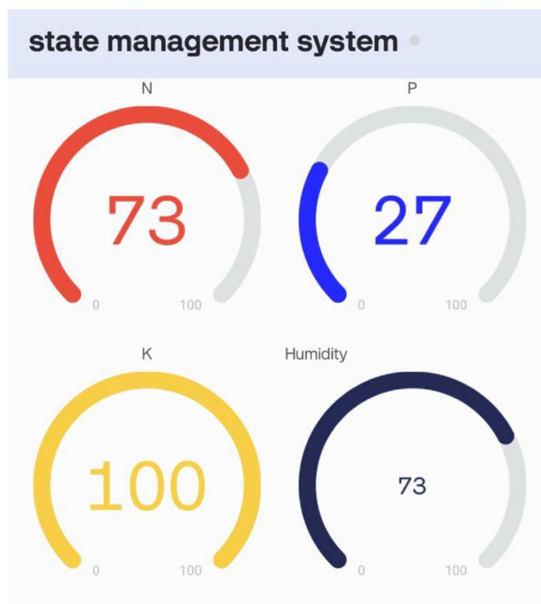
Blynk Console

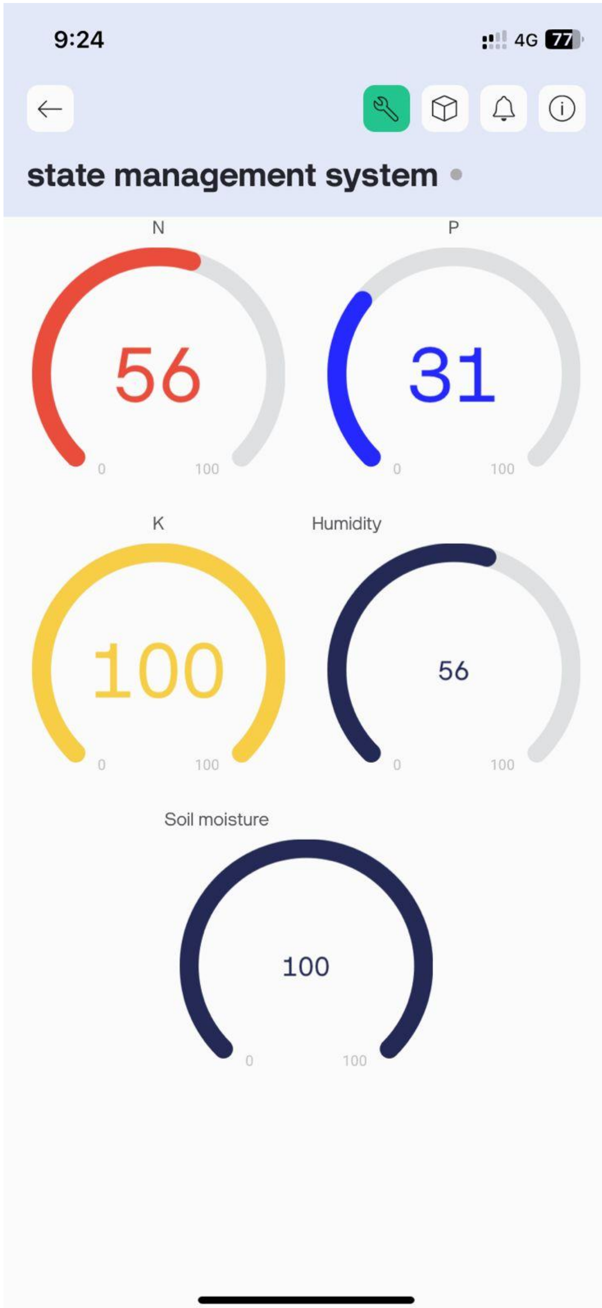


Testing and Training Model



Soil Content Detector Device

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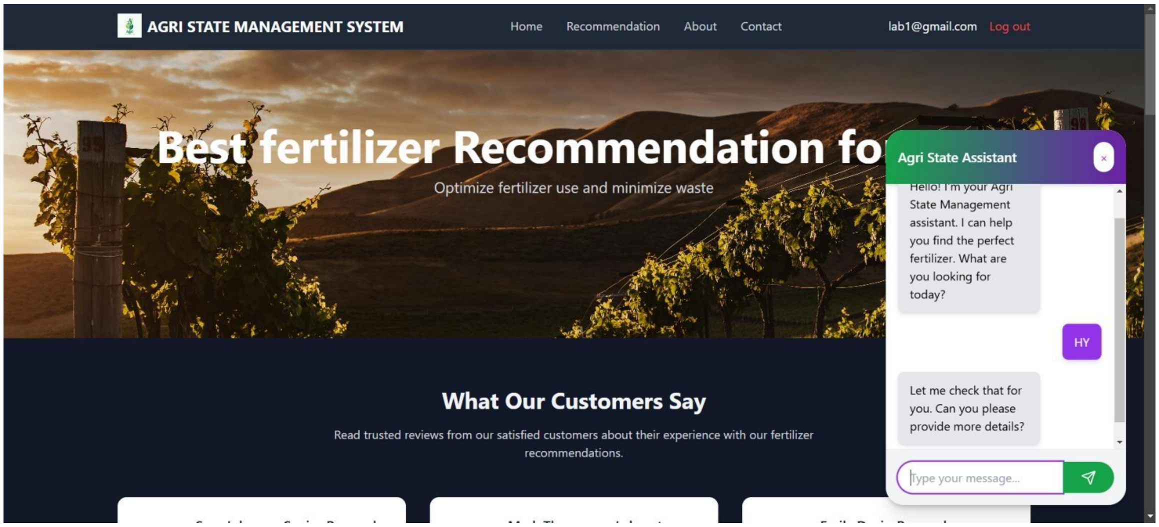
Chat Bot


AGRI STATE MANAGEMENT SYSTEM
Home
Recommendation
About
Contact
lab1@gmail.com
Log out
Best fertilizer Recommendation fo
Optimize fertilizer use and minimize waste
What Our Customers Say
Read trusted reviews from our satisfied customers about their experience with our fertilizer recommendations.
Agri State Assistant
Hello! I'm your Agri State Management assistant. I can help you find the perfect fertilizer. What are you looking for today?
HY
Let me check that for you. Can you please provide more details?
Type your message...

Chapter 5: Conclusion

The Agri State Management System successfully addresses the inefficiencies of traditional soil testing by integrating IoT-based sensors, cloud computing, and machine learning algorithms to provide real-time, accurate, and accessible soil analysis. By automating the process, this system significantly reduces the time required for soil testing from weeks to real-time insights, enabling faster and more informed decision-making for farmers, researchers, and agricultural planners.

The system's ESP32-based IoT sensors collect essential soil parameters such as NPK levels, moisture, pH, and temperature, which are processed by machine learning models to generate precise fertilizer recommendations. The cloud-based dashboard ensures that users can monitor soil health remotely, providing graphical reports and historical trend analysis for better farm management.

The Agile development methodology used in the project ensured continuous improvement through iterative phases, incorporating user feedback at each stage. The implementation of security measures, mobile accessibility, and automated data processing further enhances the system's efficiency, making it a scalable and sustainable solution for modern agriculture.

By bridging the gap between traditional soil analysis and digital precision farming, this project contributes to sustainable agriculture, resource optimization, and improved crop productivity. Future enhancements may include AI-driven predictive analytics, integration with smart irrigation systems, and mobile app-based real-time alerts to further empower farmers and agricultural professionals.

This project demonstrates a significant advancement in agricultural technology, paving the way for more data-driven, intelligent, and efficient farming solutions in the future.

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