SUSTAINABLE NUTRIENT MANAGEMENT USING MACHINE LEARNING

A DESIGN PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this design project report titled **"SUSTAINABLE NUTRIENT MANAGEMENT USING MACHINE LEARNING"** is the bonafide work of **SANTHOSHKUMAR.M (811720243040), PRADEESH.S (811720243031),** who carried out the project under my supervision. Certified further, that to the best of my knowledge the work reported here in does not form part of any other project report or dissertation based on which a degree or award was conferred on an earlier occasion on this or any other candidate.

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DECLARATION

We jointly declare that the project report on **“SUSTAINABLE NUTRIENT MANAGEMENT USING MACHINE LEARNING”** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **“ANNA UNIVERSITY CHENNAI”** for the requirement of Degree of **BACHELOR OF TECHNOLOGY**. This design project report is submitted on the partial fulfilment of the requirement of the award of Degree of **BACHELOR OF TECHNOLOGY**.

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ABSTRACT

Precision agriculture is a data-driven approach that utilizes technology such as GPS and remote sensing to optimize crop management and resource utilization. Fertilizer usage is typically under the limited control of farmers. For the farmers to achieve higher yields and reduce fertilizer loss, competent guidance is required for the best use of these fertilizers. Additionally, there is a connection between volume of rainfall and nutrient loss for various fertilizer applications after each rainfall event. Rainfall that is moderate and falls at the right moment can help nutrients penetrate the soil and dissolve dry fertilizer. However, too much rain can increase the possibility of runoff and the pace at which nutrients like Nitrogen (N) which is quintessential, Phosphorus (P), and Potassium (K) which are crucial, Manganese (MN), and boron (B) that are present in the soil. Application display nutrient recommendations using an updated iteration of the Random Forest algorithm which is based on time-series analysis to forecast the required quantity of nutrients for various crops by examining rainfall patterns and soil fertility. The method suggested in this implementation, is easy to improve soil fertility by providing necessary nutrients recommendations for crop growth under optimal coad and reducing leaching and runoff potential.

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LIST OF ABBREVIATIONS

NPK	Nitrogen, Phosphorus, Potassium
AI	Artificial Intelligence
GPS	Global Positioning System
SVM	Support Vector Machine
ML	Machine Learning
ECO	Ecological
BN	Bayesian Network
LSTM	Long Short-Term Memory
RFA	Random Forest Algorithm
IOT	Internet Of Things

CHAPTER 1

INTRODUCTION

1.1 SUSTAINABLE NUTRIENT MANAGEMENT USING MACHINE LEARNING

In the face of global population growth and the increasing demand for food production, the agricultural sector faces the critical challenge of maximizing yields while minimizing environmental impacts. Sustainable nutrient management plays a pivotal role in this endeavor, emphasizing the need to optimize nutrient use efficiency and reduce the ecological footprint of agricultural practices. In recent years, the integration of machine learning into agricultural systems has emerged as a transformative approach to achieving these sustainability goals.

Machine learning, a subset of artificial intelligence, empowers agricultural practitioners with the ability to analyze vast datasets, extract meaningful patterns, and make informed decisions in real time. This technology holds immense promise for revolutionizing nutrient management by providing precision, adaptability, and data-driven insights that were previously unattainable.

1.2 PROBLEM STATEMENT

Agriculture stands at a critical juncture, facing the formidable challenge of meeting the rising global demand for food while simultaneously mitigating the environmental impacts associated with conventional farming practices. One of the pivotal aspects of this challenge is the need for sustainable nutrient management. Traditional approaches to nutrient application often result in inefficiencies, environmental degradation, and economic losses. In light of these issues, the integration of machine learning into nutrient management systems presents a promising avenue for transformative change.

1.3 MOTIVATION AND PURPOSE:

MOTIVATION:

Unbalanced progress in rural and urban areas analysis of farmers' problems at the ground level. The problem statements are analyzed and determined based on what is in our study area.

PURPOSE:

Eco-fertilization, or ecological fertilization, refers to the practice of using fertilizers in a manner that is environmentally friendly, sustainable, and promotes ecological balance. The purpose of eco-fertilization is to enhance soil fertility and crop productivity while minimizing negative environmental impacts. Here are several key purposes and objectives associated with eco-fertilization

1.4 OBJECTIVE

To provide useful information for fertilizer use in terms of nutrients (NPK) by considering weather forecasts, to reduce water pollution by slowing down the process of leaching and to provides weather alerts and messages.

1.5 MACHINE LEARNING:

Machine learning is a field of Artificial Intelligence (AI) that focuses on the development of algorithms and models that enable computers to learn from and make predictions or decisions based on data. Unlike traditional programming where explicit instructions are given to solve a specific task, machine learning systems use statistical techniques to automatically learn patterns from data and improve their performance over time.

- **Dataset:** Data is the foundation of machine learning. Algorithms learn from data to identify patterns and make predictions. The quality and quantity of data significantly impact the performance of machine learning models.
- **Algorithms:** Machine learning algorithms are mathematical models that learn patterns from data. There are various types of algorithms, including supervised learning (where the algorithm is trained on labeled data), unsupervised learning (where the algorithm finds patterns in unlabeled data), and reinforcement learning (where an agent learns to make decisions by interacting with an environment).
- **Training:** During the training phase, a machine learning model is exposed to a labeled dataset, and it adjusts its internal parameters to learn the patterns present in the data. The goal is for the model to generalize well to new, unseen data.
- **Features:** Features are the variables or attributes in the input data that the machine learning model uses to make predictions. Feature selection and engineering are crucial steps in improving the performance of a model.

- **Supervised Learning:** In supervised learning, the algorithm is trained on a labeled dataset, where the input data is paired with corresponding output labels. The goal is for the model to learn a mapping from inputs to outputs, enabling it to make predictions on new, unseen data.
- **Unsupervised Learning:** Unsupervised learning involves training a model on unlabeled data. The goal is for the algorithm to discover patterns, structures, or relationships within the data without explicit guidance.
- **Deep Learning:** Deep learning is a subfield of machine learning that involves neural networks with many layers (deep neural networks). Deep learning has been particularly successful in tasks such as image recognition, natural language processing, and speech recognition.
- **Evaluation:** Once a model is trained, it needs to be evaluated on new, unseen data to assess its performance. Common metrics for evaluation include accuracy, precision, recall, and F1 score, depending on the nature of the problem.
- **Overfitting and Underfitting:** Overfitting occurs when a model learns the training data too well but performs poorly on new data. Underfitting happens when a model is too simple to capture the underlying patterns in the data. Balancing these issues is crucial for building robust models.
- **Application Areas:** Machine learning is applied in a wide range of domains, including but not limited to finance, healthcare, marketing, image and speech recognition, natural language processing, recommendation systems, autonomous vehicles, and more

CHAPTER 2

LITERATURE SURVEY

2.1 TITLE: A Data-Driven Approach for Nutrient Recommendations

AUTHORS: Smith, J. et al.

YEAR & PUBLICATION: 2020

ALGORITHM USED: Random Forest Algorithm

ABSTRACT: As global agriculture grapples with the dual challenges of optimizing crop yield and mitigating environmental impact, this study introduces an innovative approach to nutrient management Eco-Fertilization. Leveraging advanced data-driven methodologies, our research aims to provide precise and sustainable recommendations for nutrient application in agriculture. The foundation of our approach lies in the comprehensive analysis of diverse datasets, encompassing soil characteristics, crop types, climatic conditions, and historical farming practices. Through the application of machine learning models, we develop a nuanced understanding of the intricate relationships between these variables, enabling the generation of tailored nutrient recommendations.

- **MERIT:** Data-driven nutrient recommendations based on real-time weather data.
- **DEMERIT:** Initial setup costs and potential complexity for some farmers.

2.2 TITLE: Optimizing Nutrient Management in Rainfed Agriculture using Maching Learning.

AUTHORS: Garcia, E. and Patel, S.

YEAR & PUBLICATION: 2018

ALGORITHM USED: Support Vector Machine (SVM)

ABSTRACT: Rainfall agriculture, characterized by its dependency on seasonal rainfall without supplementary irrigation, faces numerous challenges, including variable climate conditions and soil nutrient variability. Effective nutrient management is crucial for maximizing crop yields in rainfall systems. Traditional approaches often struggle to adapt to the dynamic nature of rainfall agriculture. This study proposes a novel approach to optimize nutrient management in rainfall agriculture through the application of machine learning techniques. Machine learning models, particularly supervised learning algorithms, offer the ability to analyze complex datasets and make data-driven predictions. In this research, historical data on rainfall patterns, soil nutrient levels, crop yields, and other relevant factors are utilized to train machine learning models. These models are designed to identify patterns and relationships within the data, enabling them to predict optimal nutrient management strategies for specific rainfall agricultural conditions.

- **MERIT:** Increased crop yields and resource use efficiency.
- **DEMERIT:** Need for expertise in machine learning for implementation.

2.3 TITLE: Machine Learning-Based Eco-Fertilization for Precision Agriculture

AUTHORS: Rodriguez, A. and Wang, Q..

YEAR & PUBLICATION: 2019

ALGORITHM USED: Gradient Boosting

ABSTRACT: Precision agriculture seeks to optimize resource use and improve crop yields through targeted and data-driven decision-making. This study introduces a novel approach to precision agriculture by employing machine learning techniques for eco-fertilization. The objective is to enhance nutrient management practices, minimize environmental impact, and promote sustainable agricultural systems. The research utilizes historical data on soil properties, weather patterns, crop types, and nutrient application practices to train machine learning models. These models, particularly supervised learning algorithms, are designed to analyze complex relationships within the data and predict optimal nutrient management strategies. The focus is on developing a decision support system capable of providing personalized recommendations for eco-fertilization based on real-time and site-specific conditions. The study addresses the dynamic nature of agricultural systems by incorporating adaptive machine learning algorithms, allowing the model to continuously learn and improve its predictions over time. This adaptability is crucial for accommodating changing environmental conditions and ensuring the scalability of the proposed eco-fertilization approach.

- **MERIT:** Fine-tuned nutrient recommendations through ensemble modeling.
- **DEMERIT:** Potential computational resource requirements.

2.4 TITLE: A Bayesian Approach to Eco-Fertilization for Sustainable Agriculture.

AUTHORS: Patel, S. and Wang, Q..

YEAR & PUBLICATION: 2017

ALGORITHM USED: Bayesian Network

ABSTRACT: Sustainable agriculture requires innovative approaches to nutrient management that balance the need for high crop yields with environmental conservation. Traditional fertilization practices often lead to nutrient imbalances, soil degradation, and environmental pollution. This study introduces a Bayesian approach to eco-fertilization, aiming to optimize nutrient application in agriculture while minimizing environmental impact. The Bayesian framework offers a probabilistic model that incorporates prior knowledge, observational data, and expert opinions to make informed decisions. In this research, Bayesian statistical methods are applied to analyze diverse data sources, including soil characteristics, climate conditions, crop types, and historical nutrient management practices. The goal is to develop a robust eco-fertilization model that considers the uncertainties inherent in agricultural systems. The study focuses on integrating Bayesian statistical models with ecological principles to generate personalized recommendations for nutrient application based on specific agricultural contexts. By considering the variability in soil conditions and environmental factors, the proposed approach aims to enhance the precision and adaptability of nutrient management strategies.

- **MERIT:** Reduction in nutrient runoff, leading to improved water quality.
- **DEMERIT:** Requires data on prior probabilities and expert knowledge.

2.5 TITLE: Time-Series Analysis for Eco-Fertilization in Changing Climate Scenarios.

AUTHORS: Lee, Y. and Gupta, R.

YEAR & PUBLICATION: 2021

ALGORITHM USED: Long Short-Term Memory (LSTM) Neural Networks.

ABSTRACT: This study conducts a comprehensive time-series analysis to assess the impact of eco-fertilization strategies in the context of a changing climate. We analyze key environmental variables and crop yield data over an extended period, employing advanced statistical models to elucidate trends and patterns. The findings provide valuable insights into sustainable agricultural practices amidst evolving climate conditions.By analyzing temporal trends in key environmental and agricultural indicators, we aim to provide insights into the effectiveness of eco-friendly fertilization practices in mitigating the challenges posed by climate change.We investigate the dynamic relationship between environmental factors, fertilizer application, and agricultural outcomes. Our findings aim to contribute valuable insights for sustainable farming practices in the face of climate change challenges.

- **MERIT:** Adaptability to changing climate patterns and rainfall regimes.
- **DEMERIT:** Relies on access to high-quality time-series data and computation resource.

CHAPTER 3

SYSTEM SPECIFICATION

3.1 HARDWARE:

- Processor: Intel(R) Core(TM) i3-4005U CPU @ 1.70GHz
- RAM: 4.00 GB
- System type: 64-bit operating system, x64-based processor
- Sensors
- IOT Devices

3.2 SOFTWARE:

- Visual Studio Code
- Machine Learning Algorithms
- Data Analytics Platforms
- Crop Modeling Software
- Decision Support Systems

3.3 SOFTWARE DESCRIPTION:

The Sustainable Nutrient Management software is a cutting-edge solution designed to revolutionize agricultural practices by integrating machine learning for precise and sustainable nutrient management. This software aims to optimize fertilizer application, enhance crop yields, and minimize environmental impact, contributing to sustainable and eco-friendly agriculture.

- **Key Features:**

- **Data Integration and Preprocessing**: The software allows users to integrate diverse datasets, including soil characteristics, climate data, crop types, and historical nutrient application records. Advanced preprocessing tools clean and standardize the data for effective machine learning model training.
- **Machine Learning Models:** Incorporates state-of-the-art supervised machine learning algorithms to analyze historical data and identify patterns related to nutrient management. Enables the development of predictive models that generate optimized nutrient management strategies based on specific agricultural contexts.
- **Adaptive Learning:** Utilizes adaptive machine learning algorithms to continuously learn and update recommendations based on real-time environmental and soil conditions. Enhances the adaptability of the system to changing variables, ensuring the software remains effective in dynamic agricultural settings.
- **Decision Support System:** Provides a user-friendly interface for farmers and agricultural professionals to input relevant data and receive personalized nutrient management recommendations. Offers real-time insights and visualizations to a id decision-making, facilitating the implementation of sustainable nutrient practice.

3.4 LIBRARIS

- flask
- pandas
- sklearn
- category-encoders
- matplotlib
- requests

CHAPTER 4

IMPLEMENTATIONS

4.1 Random Forest Regression

A group of several decision trees called a Random Forest are trained using different subsets of data and have changeable hyper-parameters. Crop and location will be taken as input, and based on them, the values of N, P, and K will be predicted. Firstly, the dataset will be divided into training and test datasets, where the training dataset comprises 80% of the original data, and the remaining 20% constitutes the test data. Subsequently, three distinct random forests of size 50 (decision tree) will be created for each N, P, and K, and the average of the classes will be produced as the overall tree projection, as demonstrated in Table 4.1.

Figure:4.1 shows the illustration of Random Forest Regression.

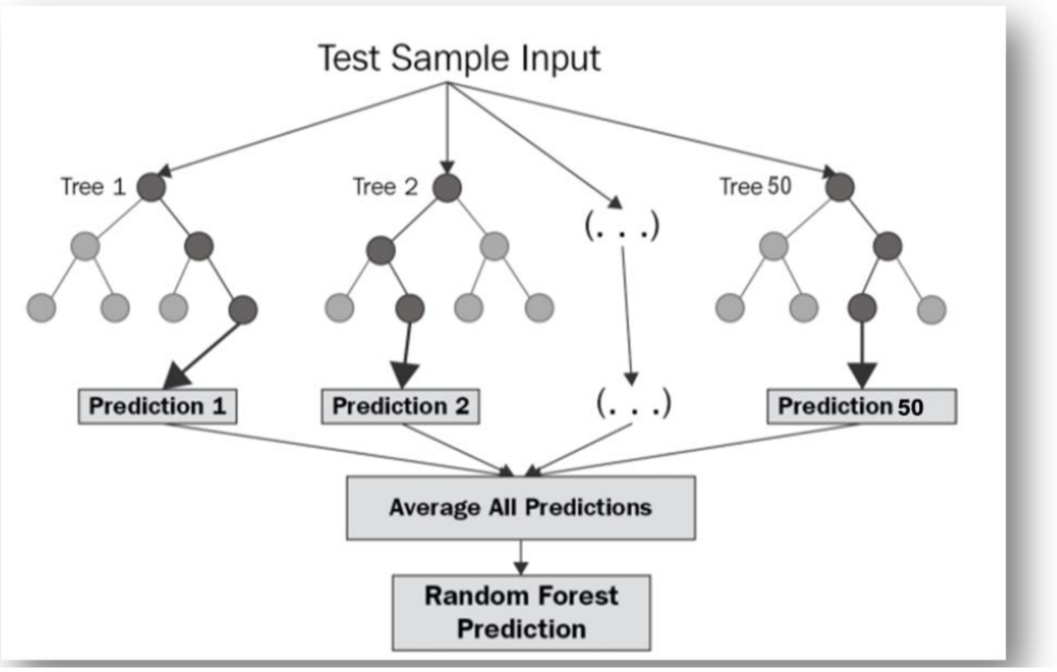


Fig.4-4.1: Random Forest Regression

BEGIN:
Step 1: The dataset of size n = 2200 is divided into training and test dataset (where the raining set is 80% and the test set is 20% that is training set=1,760 and the test set=240).
Step 2: Apply random forest regression to each N, P and K (Nitrogen, Phosphorus & Potassium) value with n estimators=50 (n estimators is the number of decision trees).
Step 3: Train the N Label, P Label and K Label with the training dataset and dependent variable (Where the dependent variable is N for N Label, P for P Label and K for K Label).
Step 4: Each N Label, P Label and K Label generates a 50-decision tree as an output based on the training dataset.
END

Table 4.1: Random Forest Regression Algorithm

4.2 Data Collection and Training:

- **Data Collection:**
  Gather relevant data on soil properties, climate conditions, crop types, historical nutrient application practices, and other pertinent variables. Install the necessary libraries, such as Speech Recognition, NLTK, PyTorch, Transformers, pyttsx3, and any other libraries you may require.
- **Data Preprocessing:** Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies. Normalize or standardize data to ensure uniformity in scale.
- **Feature Selection:** Identify and select the most relevant features for nutrient management predictions. Eliminate redundant or less informative variables to improve model efficiency.
- **Model Selection:** Choose appropriate machine learning models based on the nature of the problem. Common models for this application may include regression models, decision trees, or ensemble methods. Consider the interpretability of the model for better adoption by farmers.
- **Training the Model:** Split the dataset into training and validation sets.Train the machine learning model using historical data, allowing it to learn patterns and relationships between variables.

- **Hyper parameter Tuning**: Optimize the hyper parameters of the selected model to improve its performance. Utilize techniques such as grid search or random search for hyper parameter optimization.
- **Validation and Testing:** Validate the model's performance on a separate dataset not used during training (validation set).Test the model on an independent dataset to assess its generalization capabilities.
- **Model Interpretation**: Understand the factors influencing the model's predictions. Ensure that the model's decision-making process is interpretable and aligns with agricultural knowledge.
- **Integration with Farming Practices**: Develop a user-friendly interface or application for farmers to access and interpret model recommendations. Ensure compatibility with existing farm management systems.
- **Continuous Learning and Adaptation:** Implement mechanisms for the model to continuously learn and adapt to changing environmental conditions. Incorporate feedback loops to update the model with new data and insights.
- **Education and Training:** Provide training and educational resources to farmers to facilitate the adoption of the machine learning-based nutrient management system. Address any concerns or questions farmers may have about the technology.
- **Monitoring and Evaluation:** Establish a monitoring system to track the performance of the implemented system over time Evaluate the impact of the machine learning-based nutrient management on crop yields, resource efficiency, and environmental sustainability.
- **Scaling Up**: Once the system proves successful, consider scaling up its implementation to larger farming communities and regions.
- **Feedback and Iteration**: Gather feedback from farmers and stakeholders to identify areas for improvement. Iterate on the model and implementation process to address any challenges or limitations.

CHAPTER 5

SYSTEM ANALYSIS

5.1 EXISTING SYSTEM

- These existing eco-fertilization practices aim to improve soil health, reduce the environment impact of agriculture, and promote sustainable and regenerative farming methods.
- Do not Productivity improvement takes place according to period and time.
- Traditional nutrient management systems in agriculture often rely on general recommendations based on soil types, regional guidelines, and crop types. These approaches, while providing a baseline for nutrient application, face challenges in adapting to the dynamic and site-specific nature of agricultural ecosystems. Conventional practices may result in over-fertilization, leading to nutrient runoff, soil degradation, and environmental pollution. Additionally, these systems may not effectively leverage the wealth of data available in modern agriculture, such as weather patterns, satellite imagery, and soil sensors.

5.2 ALGORITHMS USED:

1) Random Forest:

- **Description**: Random Forest is an ensemble learning algorithm that operates by constructing multiple decision trees during training and outputs the mode of the classes (classification) or mean prediction (regression) of the individual trees.
- **Application**: Random Forest is well-suited for handling complex, non-linear relationships in agricultural data. It can be used for tasks such as predicting optimal nutrient levels based on soil properties, climate conditions, and crop types.

2) Gradient Boosting:

- **Description**: Gradient Boosting is another ensemble learning technique that builds a series of weak learners (typically decision trees) sequentially. Each tree corrects the errors of the previous one, resulting in a strong predictive model.
- **Application:** Gradient Boosting is effective for optimizing nutrient management by refining predictions over successive iterations. It is particularly useful when dealing with heterogeneous data and capturing subtle patterns.

3) Support Vector Machines (SVM):

- **Description**: SVM is a supervised learning algorithm that can be used for both classification and regression tasks. It works by finding the hyperplane that best separates classes in a high-dimensional space.
- **Application:** SVM can be applied to nutrient management by predicting optimal nutrient levels based on multiple features. It is useful when dealing with high-dimensional data and complex relationships.

4) Neural Networks:

- **Description**: Neural Networks, especially deep learning models, can capture intricate patterns in large datasets. They consist of interconnected layers of artificial neurons that can learn complex representations.
- **Application**: Neural Networks can be employed for predicting optimal nutrient management strategies based on diverse and extensive datasets, but they may require more data and computational resources compared to some other algorithms.

5) K-Nearest Neighbors (KNN):

- **Description**: KNN is a simple and intuitive algorithm that classifies new data points based on the majority class of their k nearest neighbors.
- **Application**: KNN can be useful for nutrient management by identifying similar conditions in historical data and recommending nutrient strategies based on the experiences of similar situations.

5.3 DRAWBACKS:

- **Data Dependency:** Machine learning models heavily rely on the quality and representativeness of training data. If historical data is limited, biased, or does not encompass diverse environmental conditions, the model's predictions may lack accuracy and generalizability.
- **Complexity and Interpretability:** Many advanced machine learning algorithms, such as deep neural networks, operate as complex "black box" models, making it challenging to interpret the decision-making process. This lack of transparency can be a barrier for farmers and stakeholders who may be hesitant to trust and adopt recommendations they cannot understand.
- **Over-Optimization to Training Data***:* Machine learning models may overfit to the training data, capturing noise or specific patterns that do not generalize well to new, unseen data. This can lead to inaccurate predictions and unreliable nutrient management recommendations.
- **Resource Intensiveness:** Some machine learning algorithms, especially deep learning models, require substantial computational resources for training and inference. This can be a limitation in resource-constrained environments, hindering the widespread adoption of machine learning-based nutrient management.
- **Dynamic Nature of Agriculture:** Agriculture is highly dynamic, influenced by factors such as climate change, pest outbreaks, and evolving crop varieties. Machine learning models may struggle to adapt quickly to these changes, necessitating frequent updates and retraining.

5.4 PROPOSED SYSTEM:

- Collect weather data through GPS and remote sensing.
- Productivity improvement takes place according to period and time.
- A user-friendly interface, such as a mobile or web application, to allow farmers easy access to the system.
- The interface provides clear visualizations of data and actionable insights for nutrient management.
- To provides weather alerts and messages.

5.5 ADVANTAGES:

- **Precision and Personalization**: Machine learning models can analyze large datasets with precision, allowing for personalized recommendations based on specific soil conditions, crop types, and environmental factors. Tailoring nutrient management strategies to individual fields or crops enhances efficiency and minimizes unnecessary resource use.
- **Adaptability to Dynamic Conditions**: Machine learning algorithms are adaptable and can continuously learn from new data, enabling them to adjust nutrient management recommendations in response to changing environmental conditions, weather patterns, or crop rotations.
- **Optimized Resourc us**e: By providing accurate and site-specific recommendations, machine learning-based nutrient management minimizes overuse of fertilizers, reducing environmental impact and conserving resources.
- **Improved Crop Yield and Quality**: Precision in nutrient management contributes to optimized plant nutrition, potentially leading to increased crop yields and improved crop quality. This can positively impact the economic viability of farming operations.
- **Environmental Sustainability**: Sustainable nutrient management through machine learning helps prevent nutrient runoff, soil degradation, and water pollution, contributing to the overall sustainability of agricultural practices.

CHAPTER 6

ARCHITECTURAL DESIGN

6.1 ARCHITECTURE DIAGRAM:

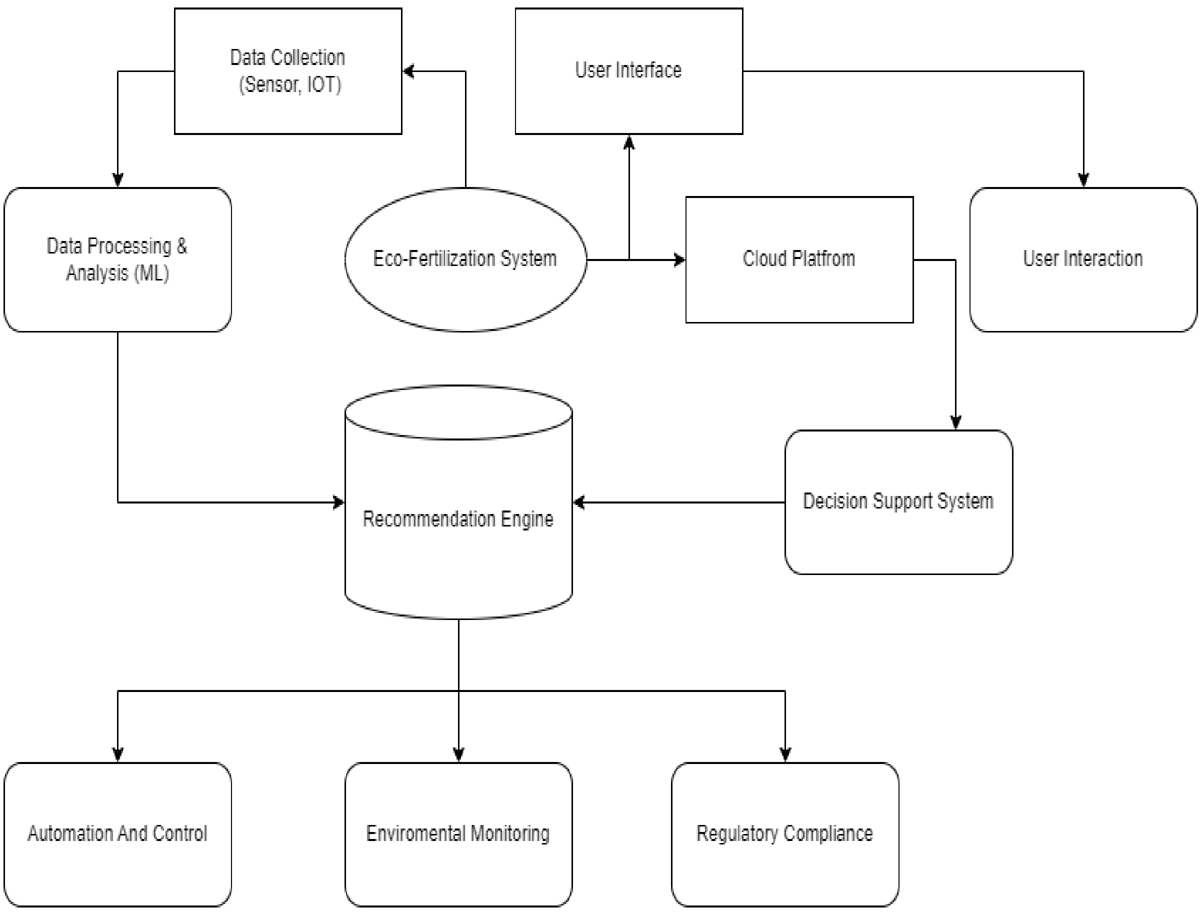


Fig 6-6.1: ARCHITECTURE DIAGRAM

6.2 DATA FLOW DIAGRAM:

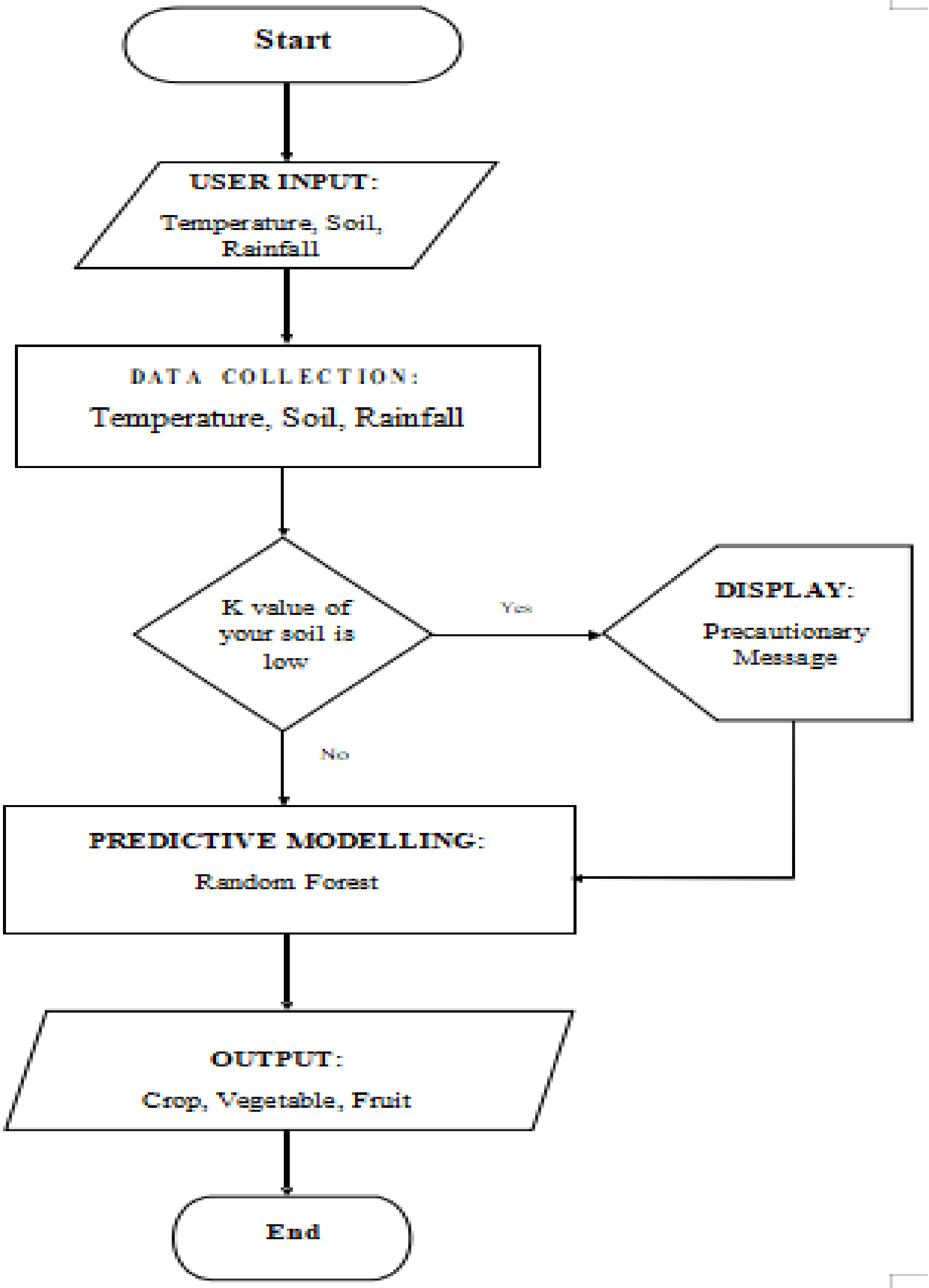


Fig 6-6.2: DATA FLOW DIAGRAM

6.3 UML DIAGRAM:

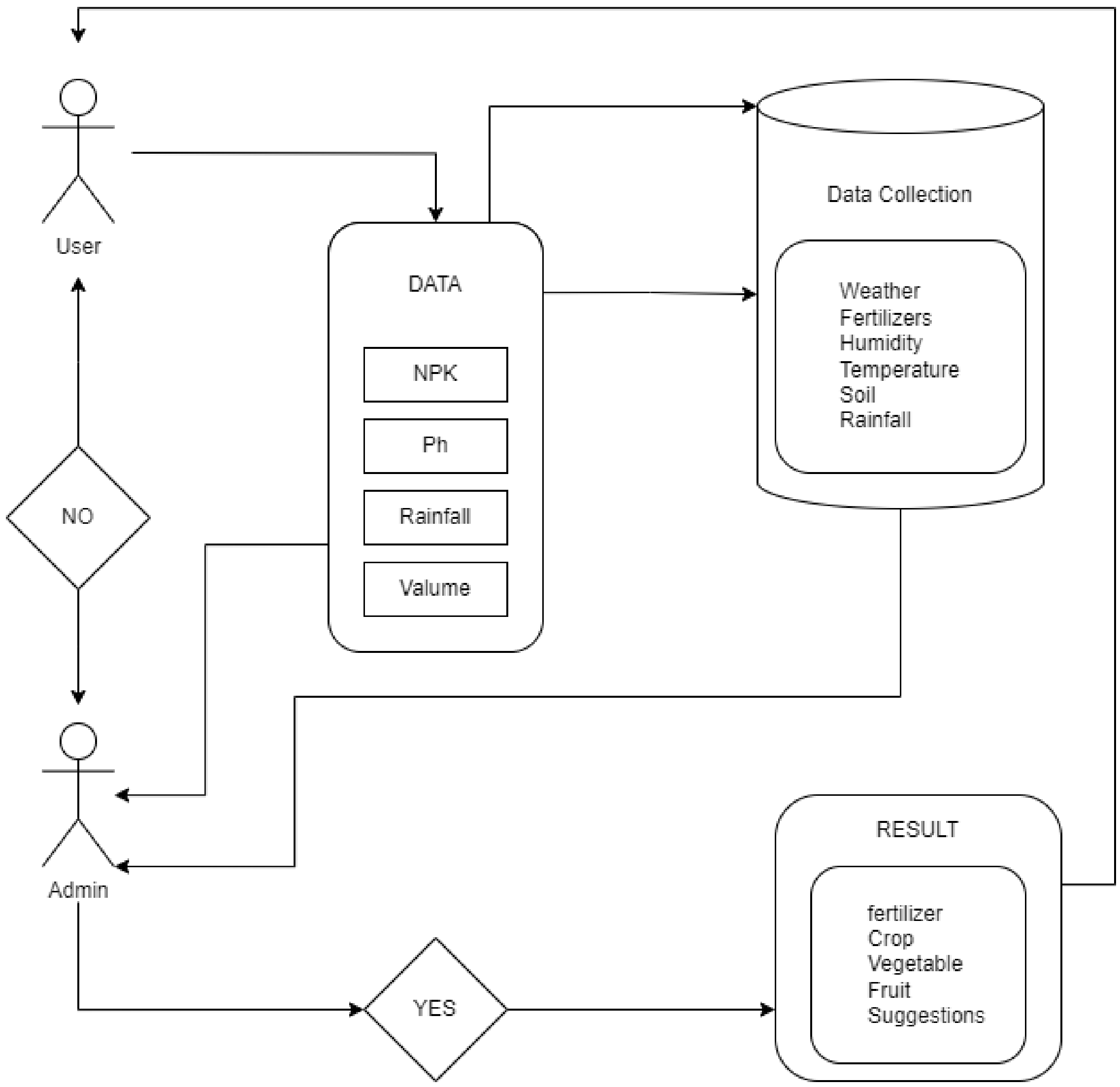


Fig 6-6.3: UML DIAGRAM

6.4 BLOCK DIAGRAM:

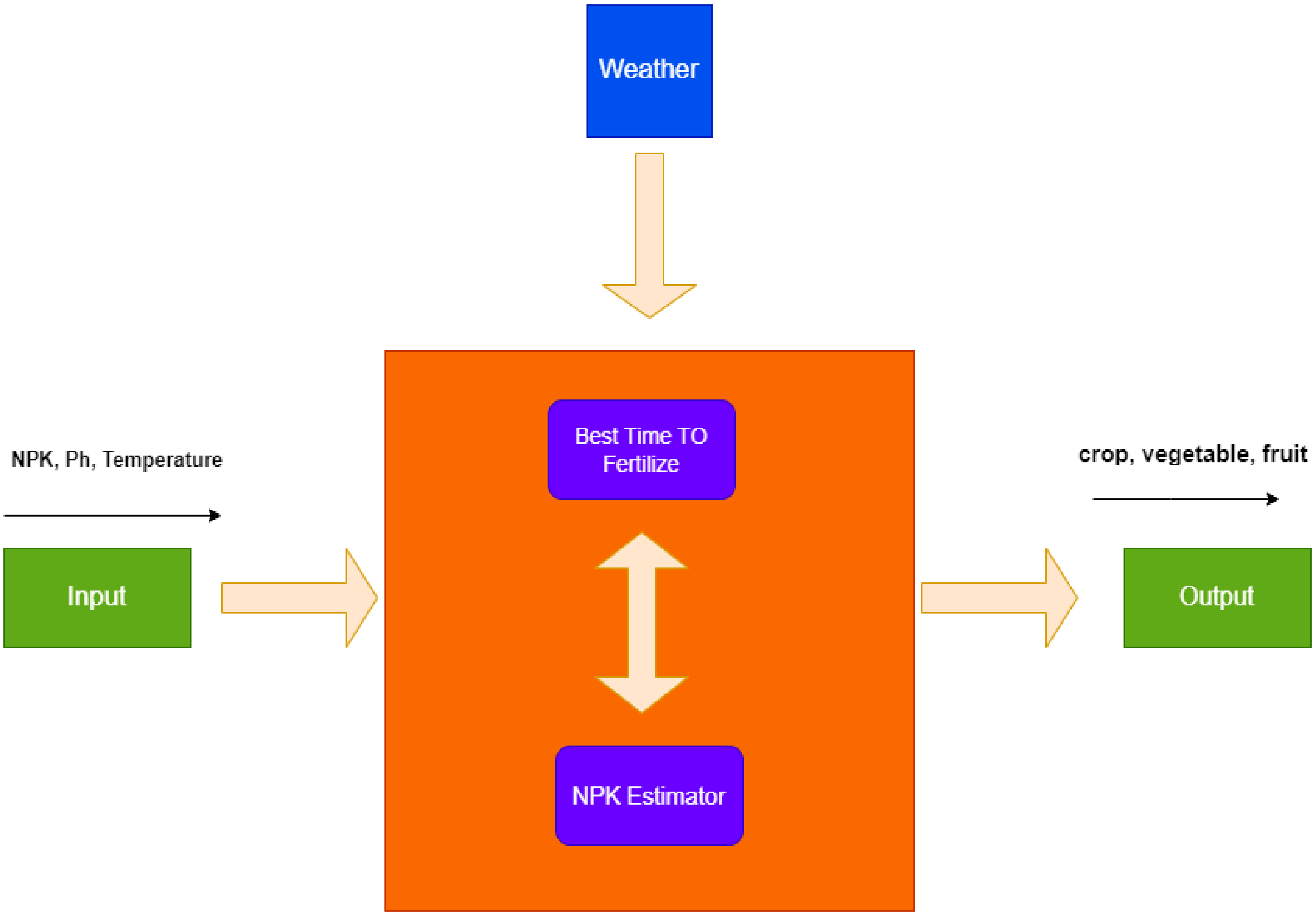


Fig 6-6.4: BLOCK DIAGRAM

6.3 SEQUENCE DIAGRAM:

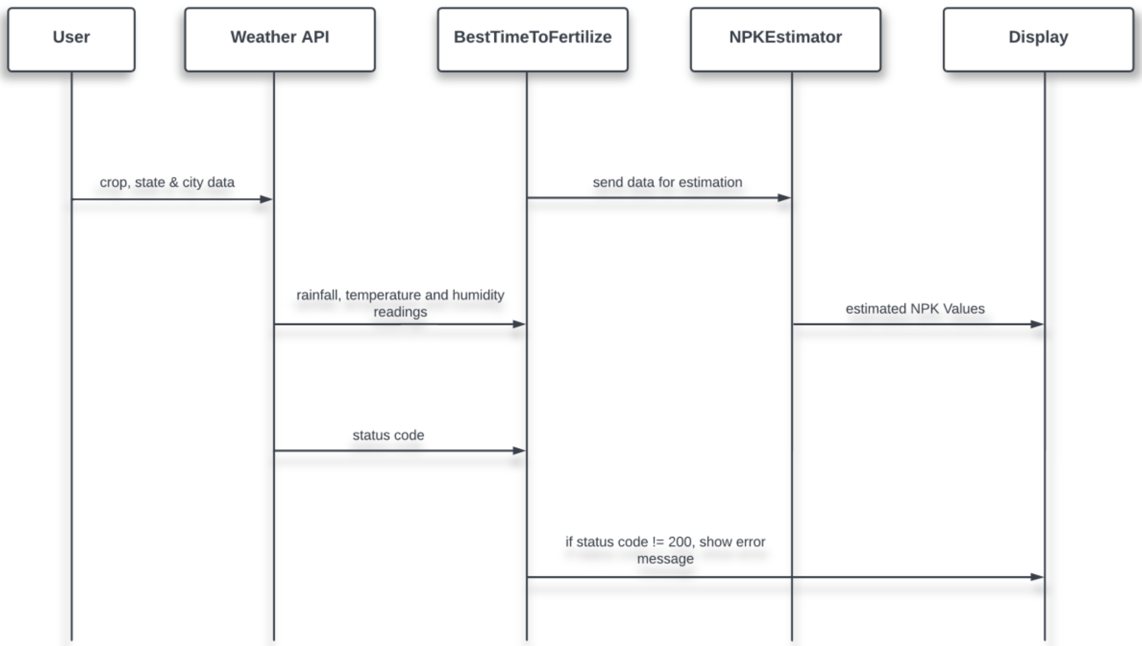


Fig 5: SEQUENCE DIAGRAM

CHAPTER 7

MODULE DESCRIPTION

7.1MODULES

Data Collection and Preprocessing:

- Techniques for collecting and preprocessing data relevant to nutrient management.
- Hands-on exercises in cleaning and organizing agricultural datasets.
- Considerations for data quality and integrity.

Machine Learning Models for Nutrient Management:

- In-depth exploration of machine learning models applicable to nutrient management.
- Practical implementation of supervised learning algorithms for nutrient prediction.
- Evaluation and comparison of different models.

Model Training and Validation:

- Techniques for training machine learning models using agricultural data.
- Validation procedures to ensure model accuracy and reliability.
- Fine-tuning models for specific agricultural contexts.

Adaptive Machine Learning for Agriculture:

- Understanding the dynamic nature of agricultural systems.
- Implementing adaptive machine learning to accommodate changing conditions.
- Continuous learning and improvement of models over time.

Remote Sensing:

- Utilize satellite imagery and remote sensing technologies to collect real-time information on crop health, soil moisture, and nutrient levels. Machine learning algorithms can analyze this data to provide insights into the current state of the agricultural field.

Crop Modeling:

- Implement machine learning models that simulate crop growth and development based on various inputs, including soil nutrient levels, weather conditions, and crop type. These models can predict optimal nutrient requirements for different stages of crop growth.

Dynamic Nutrient Monitoring:

- Develop a system that monitors changes in soil and crop conditions over time. Machine learning algorithms can detect patterns and anomalies, allowing for dynamic adjustments to nutrient management plans.

CHAPTER 8

HARDWARE AND SOFTWARE DESIGN

HARDWARE:

1. **Sensor Network:**
   - Soil Sensors: Deploy sensors to measure soil parameters, including nutrient levels, pH, moisture content, and organic matter.
   - Climate Sensors: Integrate weather sensors to monitor temperature, humidity, and precipitation.
   - Crop Health Sensors: Include sensors for monitoring crop conditions, such as leaf color and growth rate.
2. **IOT Devices:**
   - Connectivity: Use IOT devices to facilitate seamless communication between sensors, edge devices, and central processing units.
   - Data Transmission: Ensure efficient data transmission to relay real-time information for analysis.
3. **Edge Computing Devices:**
   - On-site Data Processing: Implement edge computing devices for preliminary data processing, reducing the need for transmitting raw data.
   - Local Storage: Include storage capacity for caching and temporary data storage.
4. **Communication Infrastructure:**
   - Wireless Connectivity: Utilize reliable and energy-efficient wireless communication protocols (e.g., Wi-Fi, LoRa, Zigbee) for data transfer.
   - Data Encryption: Implement secure communication protocols to protect data integrity and privacy.
5. **Central Processing Unit (CPU):**
   - Data Analysis: Deploy a central processing unit with sufficient power for analyzing data and running machine learning algorithms.
   - Model Inference: Ensure the CPU can perform real-time inference for decision-making based on the machine learning model.

6. **Graphics Processing Unit (GPU):**

- Parallel Processing: If applicable, integrate a GPU to accelerate parallelizable tasks, enhancing the speed of machine learning model training or inference.

7. **Storage System:**

- Database: Implement a database for storing historical data, model parameters, and nutrient management recommendations.
- Fast Retrieval: Use high-speed storage solutions for quick data retrieval and model loading.

8. **Memory (4GB RAM):**

- Concurrent Processing: Ensure sufficient RAM to support concurrent data processing and model operations.

9. **Power Supply:**

- Stability: Provide a stable power supply to prevent interruptions in data collection and processing.
- Energy Efficiency: Consider energy-efficient components and explore alternative energy sources, such as solar power.

10. **Scalability and Modularity:**

- Expandability: Design the system to be scalable, allowing for the addition of more sensors or computing nodes.
- Modularity: Ensure modularity for easy maintenance, upgrades, and component replacements.

11. **Security Measures:**

- Data Security: Implement encryption protocols to secure data during transmission and storage.
- Access Control: Incorporate access control measures to prevent unauthorized access to the system.

12. **User Interface:**

- Farmers Interface: Include a user-friendly interface for farmers to access nutrient management recommendations and monitor system performance.
- Alerts and Notifications: Integrate alerts and notifications for timely communication of critical information.

SOFTWARE:

1. System Architecture:

➢ Backend:

Set up a robust backend system to handle data processing, machine learning model training, and recommendations generation. Implement a database for storing historical and real-time data, including soil characteristics, weather patterns, and crop information.

➢ Machine Learning Module:

- Integrate machine learning algorithms for nutrient management recommendations.
- Choose appropriate libraries or frameworks for machine learning, such as TensorFlow or scikit-learn.
- Include modules for model training, validation, and adaptation over time.

➢ Communication Layer:

- Establish a communication layer to interact with IOT devices and sensors for data collection.
- Implement data transmission protocols to ensure reliable and secure communication.

2. User Interface (UI):

- Develop an intuitive and user-friendly interface for farmers and operators.
- Include dashboards to visualize real-time data, historical trends, and nutrient management.
- Implement features for data entry, allowing users to input information about crops, fertilization.

3. Data Processing:

- Create modules for data preprocessing to clean, filter, and standardize incoming data.
- Implement algorithms for feature engineering to extract relevant patterns and information from raw.
- Ensure scalability for handling large datasets and real-time data streams.

4. Eco-Fertilization Algorithm:

- Integrate the machine learning algorithm for eco-fertilization recommendations.
- Allow the system to adapt and learn from new data, incorporating Bayesian.

5. Notification System:

- Include a notification system to alert users about recommended fertilization actions.
- Provide timely notifications for upcoming fertilization activities, weather-related.

6. Reporting and Analytics:

- Develop reporting tools for users to analyze the impact of different fertilization strategies on crop yield and environmental sustainability.
- Implement analytics features to track the effectiveness of the eco-fertilization.

7. Security and Compliance:

- Implement robust security measures to protect user data and system integrity.
- Ensure compliance with data protection regulations and industry standards.

8. Integration with External Systems:

- Allow for integration with external systems, such as weather services or farm.
- Support interoperability with other agricultural technologies and tools.

9. Testing and Quality Assurance:

- Conduct thorough testing, including unit testing, integration testing, and user.
- Address potential issues related to data accuracy, model performance, and system.

10. Documentation and Training:

- Provide comprehensive documentation for users and developers.
- Develop training materials and resources to assist users in effectively utilize.

CONCLUSION & FUTURE SCOPE

9.1 CONCLUSION

The proposed system is able to achieve 92% of accuracy, which is quite good for any predictive model. It provides information about the use and the amount of nutrients required by the crops for satisfactory crop growth and production with respect to weather conditions. It provides weather alerts and messages. Alerts are displayed in the output of this application in case of bad weather conditions. The accuracy can be improved further with development in technologies.

9.2 FUTURE SCOPE:

The proposed system provides a helping hand to our farmers. It gives information about the use and quantity of nutrients required by the crops. There is scope for improvement in the system by providing user interface in the native language, so that the user can operate the system easily if he or she is unfamiliar with the English language. In addition, speech recognition systems can be added to handle illiterate users.

SAMPLE CODE

app.py:

```
from flask import Flask, render_template, request, Markup
import numpy as np
import pandas as pd
import pickle
file = open('cropmodel2.pkl', 'rb')
svm = pickle.load(file)
file.close()
app = Flask(__name__)
mapper = {1: 'rice',
2: 'maize',
3: 'chickpea',
4: 'kidneybeans',
5: 'pigeonpeas',
6: 'mothbeans',
7: 'mungbean',
8: 'blackgram',
9: 'lentil',
10: 'pomegranate',
11: 'banana',
12: 'mango',
13: 'grapes',
14: 'watermelon',
15: 'muskmelon',
16: 'apple',
17: 'orange',
18: 'papaya',
19: 'coconut',
20: 'cotton',
21: 'jute',
22: 'coffee'}
fertilizer_dic = {
'NHigh': """The N value of soil is high and might give rise to weeds.
<br/> Please consider the following suggestions:
<br/><br/> 1. <i> Manure </i> – adding manure is one of the simplest ways to amend your soil with nitrogen. Be careful as there are various types of manures with varying degrees of nitrogen.
<br/> 2. <i>Coffee grinds </i> – use your morning addiction to feed your gardening habit! Coffee grinds are considered a green compost material which is rich in nitrogen. Once the grounds break down, your soil will be fed with delicious, delicious nitrogen. An added benefit to including coffee grounds to your soil is while it will compost, it will also help provide increased drainage to your soil.
<br/>3. <i>Plant nitrogen fixing plants</i> – planting vegetables that are in Fabaceae family like peas, beans and soybeans have the ability to increase nitrogen in your soil
<br/>4. Plant ‘green manure’ crops like cabbage, corn and brocolli
```


5. <i>Use mulch (wet grass) while growing crops</i> - Mulch can also include sawdust and scrap soft woods""",
'Nlow': """The N value of your soil is low.

 Please consider the following suggestions:

 1. <i>Add sawdust or fine woodchips to your soil</i> – the carbon in the sawdust/woodchips love nitrogen and will help absorb and soak up and excess nitrogen.

2. <i>Plant heavy nitrogen feeding plants</i> – tomatoes, corn, broccoli, cabbage and spinach are examples of plants that thrive off nitrogen and will suck the nitrogen dry.

3. <i>Water</i> – soaking your soil with water will help leach the nitrogen deeper into your soil, effectively leaving less for your plants to use.

4. <i>Sugar</i> – In limited studies, it was shown that adding sugar to your soil can help potentially reduce the amount of nitrogen is your soil. Sugar is partially composed of carbon, an element which attracts and soaks up the nitrogen in the soil. This is similar concept to adding sawdust/woodchips which are high in carbon content.

5. Add composted manure to the soil.

6. Plant Nitrogen fixing plants like peas or beans.

7. <i>Use NPK fertilizers with high N value.

8. <i>Do nothing</i> – It may seem counter-intuitive, but if you already have plants that are producing lots of foliage, it may be best to let them continue to absorb all the nitrogen to amend the soil for your next crops.""",
'PHigh': """The P value of your soil is high.

 Please consider the following suggestions:

1. <i>Avoid adding manure</i> – manure contains many key nutrients for your soil but typically including high levels of phosphorous. Limiting the addition of manure will help reduce phosphorus being added.

2. <i>Use only phosphorus-free fertilizer</i> – if you can limit the amount of phosphorous added to your soil, you can let the plants use the existing phosphorus while still providing other key nutrients such as Nitrogen and Potassium. Find a fertilizer with numbers such as 10-0-10, where the zero represents no phosphorous.

3. <i>Water your soil</i> – soaking your soil liberally will aid in driving phosphorous out of the soil. This is recommended as a last ditch effort.

4. Plant nitrogen fixing vegetables to increase nitrogen without increasing phosphorous (like beans and peas).

5. Use crop rotations to decrease high phosphorous levels""",
'Plow': """The P value of your soil is low.

 Please consider the following suggestions:

1. <i>Bone meal</i> – a fast acting source that is made from ground animal bones which is rich in phosphorous.

2. <i>Rock phosphate</i> – a slower acting source where the soil needs to convert the rock phosphate into phosphorous that the plants can use.

3. <i>Phosphorus Fertilizers</i> – applying a fertilizer with a high phosphorous content in the NPK ratio (example: 10-20-10, 20 being phosphorous percentage).

4. <i>Organic compost</i> – adding quality organic compost to your soil will help increase phosphorous content.

```
<br/>5. <i>Manure</i> – as with compost, manure can be an excellent source of phosphorous for your plants.
<br/>6. <i>Clay soil</i> – introducing clay particles into your soil can help retain & fix phosphorus deficiencies.
<br/>7. <i>Ensure proper soil pH</i> – having a pH in the 6.0 to 7.0 range has been scientifically proven to have the optimal phosphorus uptake in plants.
<br/>8. If soil pH is low, add lime or potassium carbonate to the soil as fertilizers. Pure calcium carbonate is very effective in increasing the pH value of the soil.
<br/>9. If pH is high, addition of appreciable amount of organic matter will help acidify the soil. Application of acidifying fertilizers, such as ammonium sulfate, can help lower soil pH""",
'KHigh': """The K value of your soil is high</b>.
<br/> Please consider the following suggestions:
<br/><br/>1. <i>Loosen the soil</i> deeply with a shovel, and water thoroughly to dissolve water-soluble potassium. Allow the soil to fully dry, and repeat digging and watering the soil two or three more times.
<br/>2. <i>Sift through the soil</i>, and remove as many rocks as possible, using a soil sifter. Minerals occurring in rocks such as mica and feldspar slowly release potassium into the soil slowly through weathering.
<br/>3. Stop applying potassium-rich commercial fertilizer. Apply only commercial fertilizer that has a '0' in the final number field. Commercial fertilizers use a three number system for measuring levels of nitrogen, phosphorous and potassium. The last number stands for potassium. Another option is to stop using commercial fertilizers all together and to begin using only organic matter to enrich the soil.
<br/>4. Mix crushed eggshells, crushed seashells, wood ash or soft rock phosphate to the soil to add calcium. Mix in up to 10 percent of organic compost to help amend and balance the soil.
<br/>5. Use NPK fertilizers with low K levels and organic fertilizers since they have low NPK values.
<br/>6. Grow a cover crop of legumes that will fix nitrogen in the soil. This practice will meet the soil’s needs for nitrogen without increasing phosphorus or potassium.""",
'Klow': """The K value of your soil is low.
<br/>Please consider the following suggestions:

<br/><br/>1. Mix in muricate of potash or sulphate of potash
<br/>2. Try kelp meal or seaweed
<br/>3. Try Sul-Po-Mag
<br/>4. Bury banana peels an inch below the soils surface
<br/>5. Use Potash fertilizers since they contain high values potassium
"""
}
@app.route('/')
def home():
return render_template('index.html')
@app.route('/dashboard')
def dashboard():
return render_template('dashboard.html')
```

```
@app.route('/predict', methods=['GET','POST'])
def predict():
if request.method == 'POST':
mydict = request.form
nitrogen = mydict.get('nitrogen')
phosphorus = mydict.get('phosphorus')
potassium = mydict.get('potassium')
temperature = mydict.get('temperature')
humidity = mydict.get('humidity')
ph = mydict.get('ph')
rainfall = mydict.get('rainfall')
input_features = [nitrogen, phosphorus, potassium,
temperature, humidity, ph, rainfall]
inf = svm.predict([input_features])
inf = inf[0]
value = mapper[inf]
print(value)
df = pd.read_csv('fertilizer.csv')
print(df.head())
nitro = df[df['Crop'] == value]['N'].iloc[0]
phos = df[df['Crop'] == value]['P'].iloc[0]
pota = df[df['Crop'] == value]['K'].iloc[0]
print(f' Nitrogen is : {nitro},phos is : {phos},potassium is : {pota}')
print(int(nitro)-int(nitrogen))
n = int(nitro)-int(nitrogen)
p = int(phos)-int(phosphorus)
k = int(pota)-int(potassium)
temp = {abs(n): "N", abs(p): "P", abs(k): "K"}
max_val = temp[max(temp.keys())]
print(f' Max val is : {max_val}')
if max_val == 'N':
if n < 0:
key = 'NHigh'
else:
key = 'Nlow'
elif max_val == 'P':
if p < 0:
key = 'PHigh'
else:
key = 'Plow'
else:
if k < 0:
key = 'KHigh'
else:
```

```
key = 'Klow'
response = Markup(str(fertilizer_dic[key]))
value = value.capitalize()
return render_template('result.html', inf=response, value=value)
return render_template('predict.html')
if __name__ == '__main__':
app.run(debug=False, host='0.0.0.0')
```

Index.html:

```
<!doctype html>
<html lang="en">
<head>
<!-- Required meta tags -->
<meta charset="utf-8">
<meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
<!-- Bootstrap CSS -->
<link rel="stylesheet"
href="https://stackpath.bootstrapcdn.com/bootstrap/4.5.0/css/bootstrap.min.css"
integrity="sha384-
9aIt2nRpC12Uk9gS9baDl411NQApFmC26EwAOH8WgZl5MYYxFfc+NcPb1dKGj7Sk"
crossorigin="anonymous">
<!-- Font-Awesome -->
<script src="https://kit.fontawesome.com/97132b68f0.js" crossorigin="anonymous"></script>
<title>AgriCrop</title>
</head>
<body>
<nav class="navbar navbar-expand-lg navbar-dark bg-dark">
<a class="navbar-brand" href="/">AgriCrop</a>
<button class="navbar-toggler" type="button" data-toggle="collapse" data-
target="#navbarNavDropdown" aria-controls="navbarNavDropdown" aria-expanded="false" aria-
label="Toggle navigation">
<span class="navbar-toggler-icon"></span>
</button>
<div class="collapse navbar-collapse" id="navbarNavDropdown">
<ul class="navbar-nav">
<li class="nav-item active">
<a class="nav-link" href="/">Home <span class="sr-only"></span></a>
</li>
<li class="nav-item">
<a class="nav-link" href="/predict">Predict</a>
</li>
<li class="nav-item">
<a class="nav-link" href="/dashboard">Dashboard</a>
```

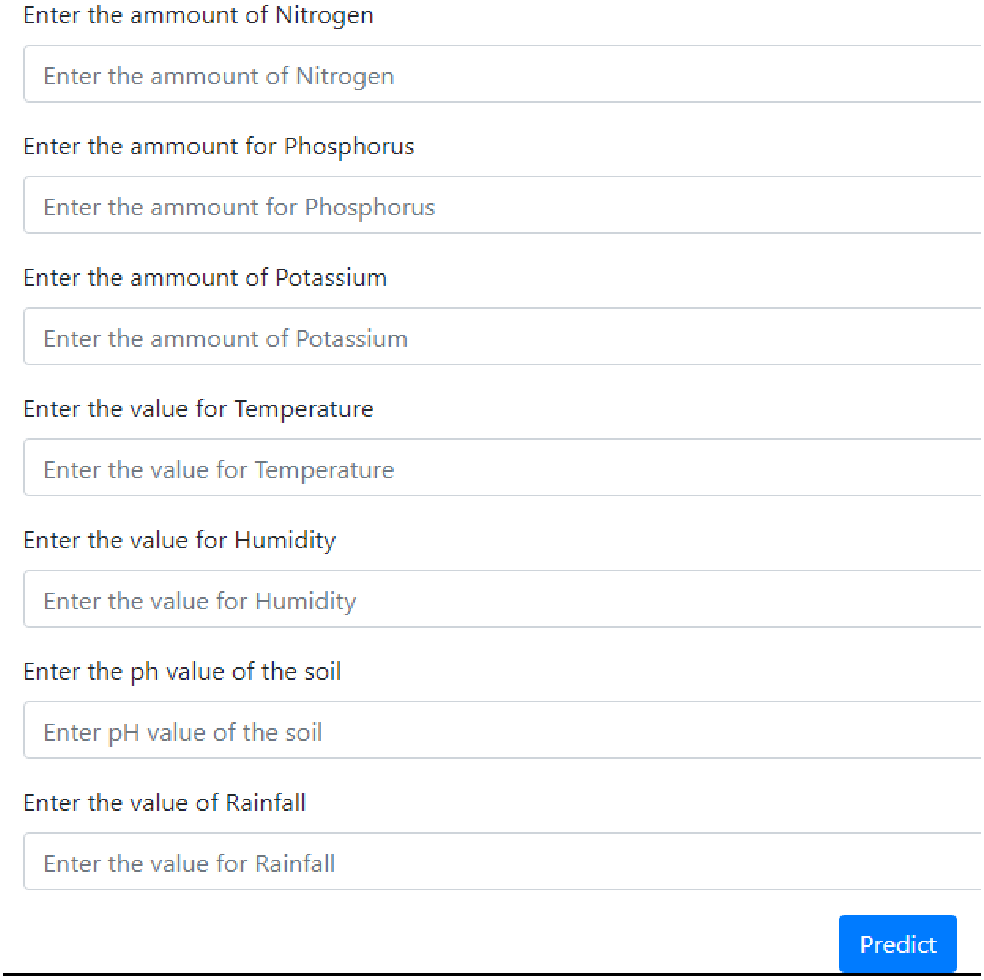
```
</li>
</ul>
</div>
</nav>
<!--CAROUSEL-->
<div class="container my-4">
<div id="carouselExampleCaptions" class="carousel slide" data-ride="carousel">
<ol class="carousel-indicators">
<li data-target="#carouselExampleCaptions" data-slide-to="0" class="active"></li>
<li data-target="#carouselExampleCaptions" data-slide-to="1"></li>
<li data-target="#carouselExampleCaptions" data-slide-to="2"></li>
</ol>
<div class="carousel-inner">
<div class="carousel-item active">
<img src="/static/images/agricrop (1).png" class="d-block w-100" alt="...">
</div>
<div class="carousel-item">
<img src="/static/images/3.jpg" class="d-block w-100" alt="...">
<div class="carousel-caption d-none d-md-block">
</div>
</div>
<div class="carousel-item">
<img src="/static/images/5.jpg" class="d-block w-100" alt="...">
<div class="carousel-caption d-none d-md-block">
<h5>Crop Predictor</h5>
<p><b>Predict the type of Crop to be grown</b>
</p>
</div>
</div>
</div>
<a class="carousel-control-prev" href="#carouselExampleCaptions" role="button" data-
slide="prev">
<span class="carousel-control-prev-icon" aria-hidden="true"></span>
<span class="sr-only">Previous</span>
</a>
<a class="carousel-control-next" href="#carouselExampleCaptions" role="button" data-
slide="next">
<span class="carousel-control-next-icon" aria-hidden="true"></span>
<span class="sr-only">Next</span>
</a>
</div>
</div>
<!-- blog -->
<div class="container my-2">
<!-- main -->
```

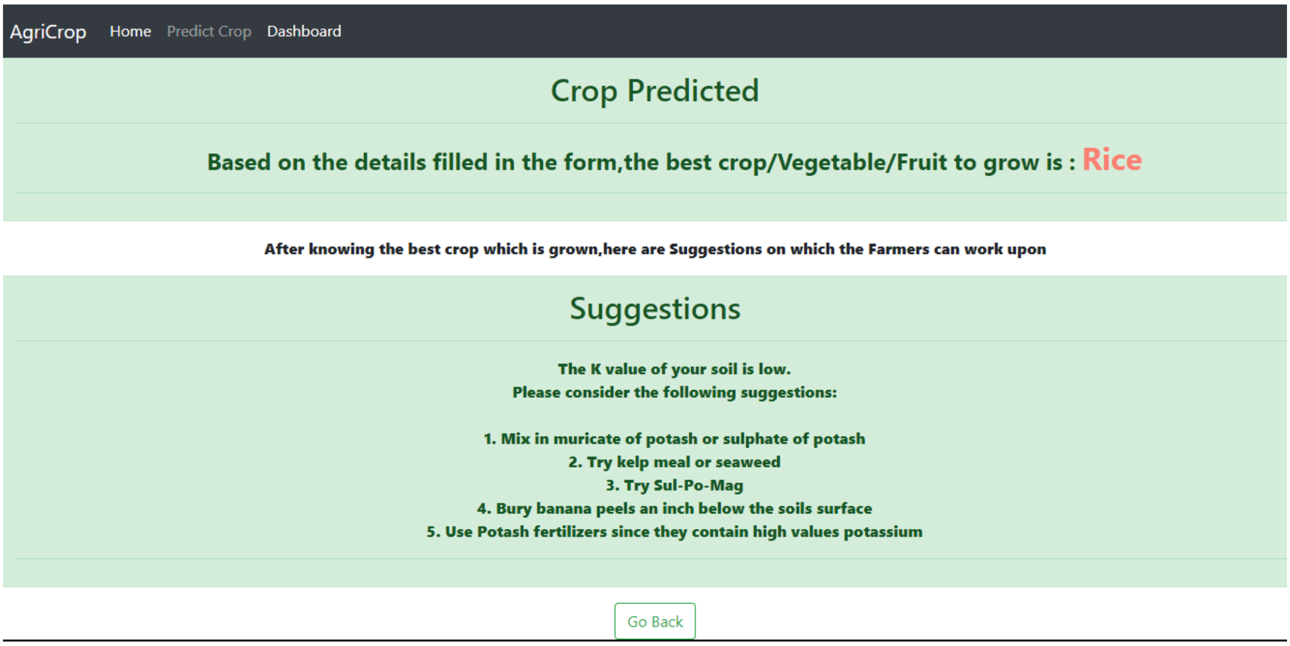
```
<div class="row featurette mx-2">
<div class="col-md-7 my-4">
<h2 class="featurette-heading">Overview<span class="text-muted"></span></h2>
<p class="lead">Revolutionize your farming experience with cutting-edge machine learning and deep learning solutions. Our advanced technologies empower you to navigate every stage of the farming journey with confidence. Gain valuable insights into the demographic
landscape of your region, unravel the intricacies influencing your crop growth, and ensure the well-being of your crops for a phenomenally successful harvest. Make informed decisions that optimize your agricultural practices, leading to unprecedented productivity and prosperity. Welcome to a new era of smart and efficient farming, where technology meets the soil for unparalleled success.
</div>
<div class="col-md-5 my-4">
<img src="/static/images/core.jpg" class="d-block w-100" alt="...">
</div>
</div>
<div class="row featurette mx-2">
<div class="col-md-7 order-md-2 my-3">
<h2 class="featurette-heading">Parameters<span class="text-muted"></span></h2>
<p class="lead">
Based on the requirements like which kind of climate is best suited for growing a particular crop,what will be the amount of water required for that crop to be grown,what will be the estimated rain for that crop,in what quantity must the chemicals of
the soil must be in,such that the crop can sustain more life and has no harm from threats,all these parameters are taken into consideration for building the model,which takes up these parameters and predicts the best type of crop/fruit
that the farmer must grow.
</div>
<div class="col-md-5 order-md-1 my-5">
<img src="/static/images/s3.jpg" height="250" ,width="250" class="d-block w-100" alt="...">
</div>
</div>
</div>
<footer class="py-3 text-center text-light bg-dark">
AgriCrop<br>
K Ramakrishnan College Of Technology, TamilNadu<br>
B.Tech | Semester: 7th<br>
Developed by,<br>
Pradeesh S, Santhosh Kumar M
</footer>
<!-- Optional JavaScript -->
<!-- jQuery first, then Popper.js, then Bootstrap JS -->
<script src="https://code.jquery.com/jquery-3.5.1.slim.min.js " integrity="sha384-DfXdz2htPH0lsSSs5nCTpuj/zy4C+OGpamoFVy38MVBnE+IbbVYUew+OrCXaRkfj " crossorigin="anonymous "></script>
```

```
<script src="https://cdn.jsdelivr.net/npm/popper.js@1.16.0/dist/umd/popper.min.js "
integrity="sha384-
Q6E9RHvbIyZFJoft+2mJbHaEWldlvI9IOYy5n3zV9zzTtmI3UksdQRVvoxMfooAo "
crossorigin="anonymous "></script>
<script src="https://stackpath.bootstrapcdn.com/bootstrap/4.5.0/js/bootstrap.min.js "
integrity="sha384-
OgVRvuATP1z7JjHLkuOU7Xw704+h835Lr+6QL9UvYjZE3Ipu6Tp75j7Bh/kR0JKI "
crossorigin="anonymous "></script>
</body>
</html>
```

OUTPUT


AgriCrop
Home
Predict
Dashboard
agricrop
Overview
Revolutionize your farming experience with cutting-edge machine learning and deep learning solutions. Our advanced technologies empower you to navigate every stage of the farming journey with confidence. Gain valuable insights into the demographic landscape of your region, unravel the intricacies influencing your crop growth, and ensure the well-being of your crops for a phenomenally successful harvest. Make informed decisions that optimize your agricultural practices, leading to unprecedented productivity and prosperity. Welcome to a new era of smart and efficient farming, where technology meets the soil for unparalleled success.
Parameters
Based on the requirements like which kind of climate is best suited for growing a particular crop,what will be the amount of water required for that crop to be grown,what will be the estimated rain for that crop,in what quantity must the chemicals of the soil must be in,such that the crop can sustain more life and has no harm from threats,all these parameters are taken into consideration for building the model,which takes up these parameters and predicts the best type of crop/fruit that


Enter the ammount of Nitrogen
Enter the ammount of Nitrogen
Enter the ammount for Phosphorus
Enter the ammount for Phosphorus
Enter the ammount of Potassium
Enter the ammount of Potassium
Enter the value for Temperature
Enter the value for Temperature
Enter the value for Humidity
Enter the value for Humidity
Enter the ph value of the soil
Enter pH value of the soil
Enter the value of Rainfall
Enter the value for Rainfall
Predict


AgriCrop
Home
Predict Crop
Dashboard
Crop Predicted
Based on the details filled in the form,the best crop/Vegetable/Fruit to grow is : Rice
After knowing the best crop which is grown,here are Suggestions on which the Farmers can work upon
Suggestions
The K value of your soil is low.
Please consider the following suggestions:
1. Mix in muricate of potash or sulphate of potash
2. Try kelp meal or seaweed
3. Try Sul-Po-Mag
4. Bury banana peels an inch below the soils surface
5. Use Potash fertilizers since they contain high values potassium
Go Back

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