INTEGRATED MULTI-MODEL SYSTEM FOR CROP,YIELD AND FERITILIZER FORECASTING

PROJECT REPORT

Submitted by

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Bachelor of Technology

in

Computer Science and Engineering

Under the guidance of

Mr. P.Laxmi Narayana
Assistant Professor, CSE, RGUKT Basar

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES
BASAR, NIRMAL (DIST.), TELANGANA – 504107

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Rajiv Gandhi University of Knowledge Technologies, Basar
for the partial fulfillment of the requirements
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OCTOBER 2025

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES, BASAR

CERTIFICATE

This is to certify that the project report entitled **"Integrated Multi-Model System For Crop,Yield And Fertilizer Forecasting"** submitted by **P.Saikiran (B201239)**, **K.Naresh (B200951)**, and **M.Vamshi (B200949)** to the Department of Computer Science and Engineering, Rajiv Gandhi University of Knowledge Technologies (RGUKT), Basar, is a bonafide record of the original work carried out by them under my supervision during the academic year 2025–2026.

The results embodied in this report have not been submitted to any other university or institute for the award of any degree or diploma. The project has been completed as part of the curriculum prescribed for the Bachelor of Technology (B.Tech) program in Computer Science and Engineering.

Project Guide	**Head of The Department**
Mr. P.Laxmi Narayana	Dr. B. Venkat Raman
Assistant Professor,CSE Dept.	Assistant Professor and Head, CSE Dept.

EXTERNAL EXAMINER

PROJECT COORDINATOR

Mrs.P.Sarika

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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DECLARATION

We hereby declare that the project report entitled **"Integrated Multi-Model System For Crop,Yield And Fertiliser Forecasting"** submitted to Rajiv Gandhi University of Knowledge Technologies, Basar, in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering, is a record of original work carried out by us under the valuable guidance of **Mr.P.Laxmi Narayana**, Assistant Professor, Department of CSE.

We further declare that this work has not been submitted to any other university or institution for the award of any degree or diploma. All the information and data used in this project have been obtained from reliable and duly acknowledged sources. We take full responsibility for the authenticity of the contents presented in this report.

Place: Basar

Date: October, 2025

P.Saikiran (B201239)
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Last but not least, we express our deep appreciation to our friends and family members for their constant encouragement, moral support, and motivation during the entire duration of the project.

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ABSTRACT

Agriculture remains the backbone of India's economy, yet it faces growing challenges due to climate variability, declining soil fertility, and unscientific crop selection practices. This project **presents a Crop, Fertilizer, and Yield Prediction System** that leverages machine learning techniques to assist farmers in making data-driven agricultural decisions. The system analyzes key soil parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), pH, and environmental conditions including temperature, humidity, and rainfall to **recommend the most suitable crop and corresponding fertilizer**.

Furthermore, **it predicts the expected yield and production**, enabling efficient resource utilization and maximizing profitability. By providing prescriptive insights—such as adjusting soil nutrients to make desired crops cultivable—the system empowers farmers to shift from traditional intuition-based methods to smart, data-driven farming.

Keywords: Crop Recommendation, Fertilizer Prediction, Yield Prediction, Machine Learning, Artificial Intelligence (AI), Smart Farming, Precision Agriculture, Soil Nutrient Analysis, pH, Nitrogen (N), Phosphorus (P), Potassium (K), Data-driven Decision Making, Sustainable Agriculture, Predictive Analytics, Regression Model,Random Forest Algorithm,Climate and Environmental Factors.

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CHAPTER 1

INTRODUCTION

1.1 Background

Agriculture is one of the most critical sectors for sustaining human life and the economy, particularly in countries that rely heavily on farming. Traditional farming methods often depend on experience and intuition, which can lead to suboptimal crop selection, improper fertilizer use, and lower yields. With the increasing global population and the demand for food, it has become essential to optimize agricultural practices using modern technologies.

Recent advancements in data analytics and machine learning have enabled the development of intelligent systems that can analyze soil characteristics, weather conditions, and historical crop data to provide precise recommendations. These systems **help farmers select the most suitable crops, apply fertilizers efficiently, and predict expected yields**, ultimately reducing resource wastage and increasing profitability.

The Crop, Fertilizer, and Yield Prediction System leverages these technologies to provide a comprehensive solution for precision agriculture. By integrating soil nutrient analysis, environmental factors, and machine learning models, the system empowers farmers to make informed decisions, improve crop productivity, and contribute to sustainable farming practices.

1.2 Objectives

The main objectives of this project are as follows:

1. **Crop Recommendation:** Suggest the most suitable crop for a farmer's field based on soil properties, environmental conditions, and historical data.
2. **Fertilizer Recommendation::** Recommend the appropriate type and quantity of fertilizer to optimize crop growth and maintain soil health.
3. **Yield Prediction:** Predict the expected crop yield using machine learning models to help farmers plan resources and marketing strategies
4. **Data-Driven Decision Making:** Enable farmers to make informed decisions by analyzing soil nutrients, weather patterns, and crop performance
5. **Sustainable Farming:** Promote efficient use of resources such as fertilizers, water, and land to reduce environmental impact and increase productivity.
6. **Prescriptive Analysis:** Provide recommendations on modifying land conditions if the desired crop cannot currently be grown.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Agriculture plays a vital role in the economic and social development of many countries. In recent years, the adoption of data-driven and intelligent systems in agriculture—commonly referred to as precision farming—has gained significant importance. With the integration of data analytics and machine learning, farmers can now make informed decisions regarding crop selection, fertilizer management, and yield estimation. These advancements not only optimize resource utilization but also improve productivity, profitability, and sustainability.

2.2 Crop Prediction Techniques

Earlier research in crop prediction mainly focused on traditional statistical methods and rule-based systems that relied on expert knowledge or fixed conditions. However, these methods lacked flexibility and accuracy when dealing with complex environmental variables. In recent years, machine learning techniques such as Decision Trees (DT), Random Forest (RF), Naïve Bayes, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Artificial Neural Networks (ANN) have been applied to crop prediction problems. Studies indicate that

Random Forest and Decision Tree models offer better prediction accuracy compared to other classifiers, as they can handle both continuous and categorical data efficiently. These models utilize key parameters such as soil pH, nitrogen (N), phosphorus (P), potassium (K), temperature, humidity, and rainfall to predict the most suitable crop for a given region.

2.3 Fertilizer Recommendation Systems

Several research studies have explored fertilizer recommendation systems that assist farmers in determining the right type and amount of fertilizer to apply. Early approaches were rule-based, relying on soil test results and fixed nutrient thresholds. Recent studies have employed machine learning and expert systems to predict nutrient deficiencies and recommend fertilizers accordingly. By analyzing soil nutrient imbalances and crop requirements, these models help minimize excess fertilizer usage and ensure balanced soil fertility, thereby contributing to sustainable agricultural practices.

2.4 Crop Yield Prediction Approaches

Yield prediction is another important area of agricultural research. Traditional yield estimation methods used statistical regression models that provided limited accuracy due to their linear assumptions. Modern systems utilize advanced algorithms such as **Multiple Linear Regression (MLR)**, **Random Forest Regressor**, and Artificial Neural Networks to model nonlinear relationships between yield and influencing factors like soil nutrients, temperature, rainfall, and crop type. These models have shown improved accuracy and reliability, enabling farmers to estimate expected production before the actual harvest.

2.5 Research Gaps

Despite significant progress in individual areas of crop, fertilizer, and yield prediction, most existing systems address these components separately. Very few studies integrate all three aspects into a single decision-support framework. Additionally, many models suffer from limitations such as inadequate datasets, region-specific applicability, and lack of real-time adaptability. There is also a gap in providing an accessible, user-friendly interface that allows farmers to interact with predictive systems effectively.

2.6 Summary

The review of existing literature highlights the growing role of machine learning in agriculture and its potential to revolutionize traditional farming practices. However, there remains a need for an integrated system that combines crop selection, fertilizer recommendation, and yield prediction into one unified model. The proposed project, Crop, Fertilizer, and Yield Prediction System, addresses this gap by leveraging machine learning techniques to develop an intelligent, data-driven platform that aids farmers in making accurate and timely agricultural decisions.

CHAPTER 3

SYSTEM DESIGN

3.1 Overview

The System Design of the Crop, Fertilizer, and Yield Prediction System defines the overall architecture, data flow, and interaction between various modules of the application. It outlines how input data is collected, processed, analyzed, and transformed into meaningful predictions and recommendations for the user. The design ensures efficiency, modularity, scalability, and ease of maintenance.

The system is primarily divided into three major layers — **Input Layer, Processing Layer, and Output Layer**

3.1.1 Input Layer

This layer is responsible for collecting and managing all the essential agricultural data required for prediction.

- Inputs include **soil parameters** (pH, Nitrogen, Phosphorus, Potassium), weather data (temperature, humidity, rainfall), and crop-related attributes.
- The data may be entered manually by the user through a web interface or fetched from pre-existing agricultural datasets.

3.1.2 Processing Layer

This is the core component of the system, where all predictive operations take place.

- The Crop Prediction Module uses a Random Forest Classifier (or Decision Tree) to identify the most suitable crop based on input parameters.
- The Fertilizer Recommendation Module analyzes nutrient imbalance and suggests the appropriate fertilizer to optimize soil health.
- The Yield Prediction Module employs Regression Models (such as Linear or Random Forest Regressor) to estimate the expected yield of the predicted crop.

3.1.3 Output Layer

This layer presents the processed results and recommendations to the user in an easily understandable format.

- The **predicted crop, recommended fertilizer**, and **estimated yield** are displayed through a **web-based interface**.
- The system ensures that users—especially farmers—receive clear, actionable insights that can support real-world farming decisions.

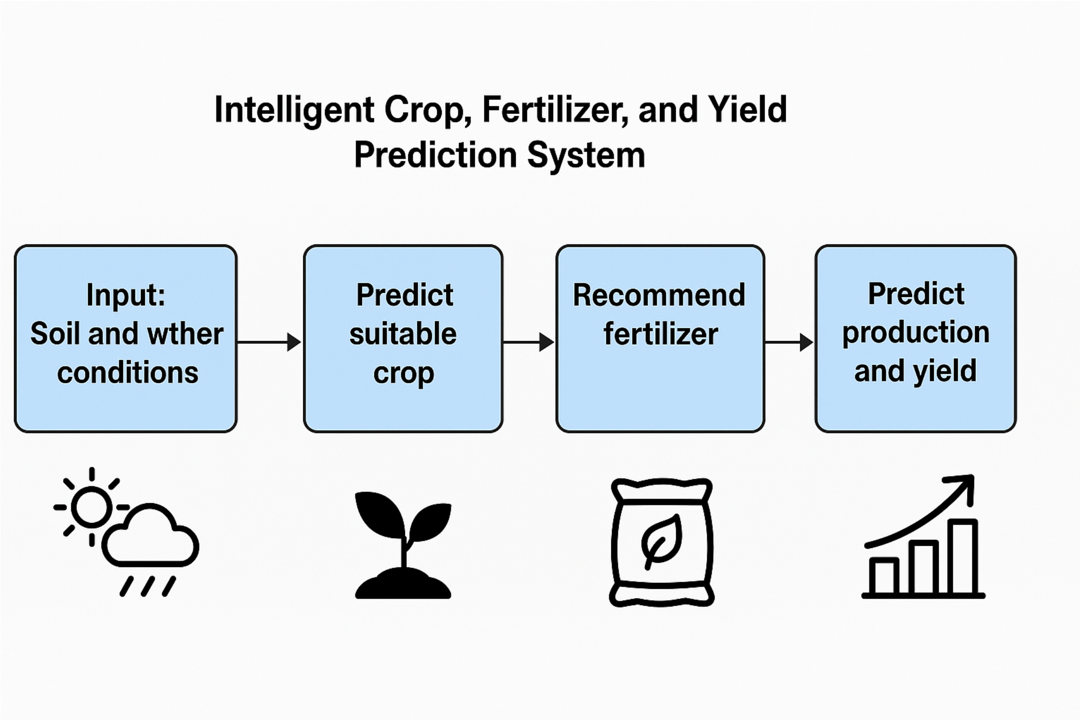

Figure 3.1: System Overview

3.2 System Architecture

The system follows a **modular architecture**, consisting of interconnected components such as:

- **Frontend Interface** - Developed using HTML, CSS, and Flask templates.
- **Backend Logic** – Implemented using Python for server-side operations and model integration.
- **Database Module** – Stores soil data, user inputs, and historical crop information using MySQL or similar databases.
- **Machine Learning Models** – Deployed and integrated into the backend to generate predictions dynamically.

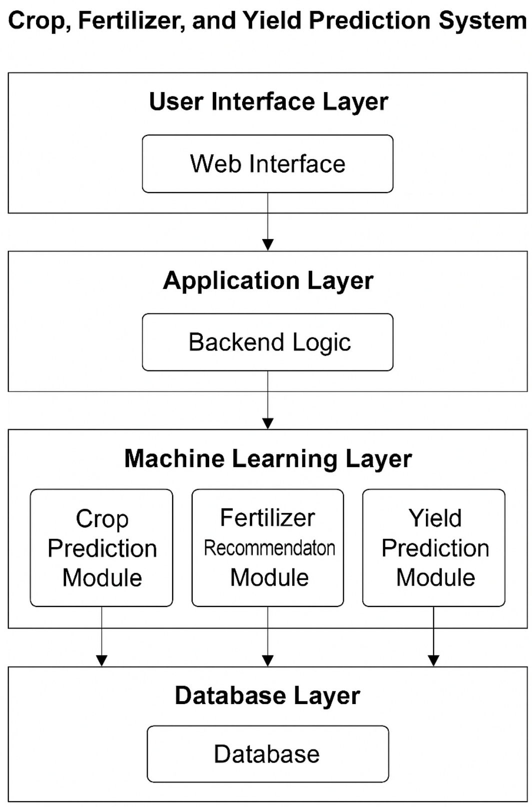

Figure 3.2: System Architecture

3.3 Data Flow

1. User enters soil and environmental data via the web interface.
2. The data is sent to the backend for preprocessing and model input
3. Machine learning models perform prediction and recommendation tasks.
4. The results are processed and displayed to the user through the interface.

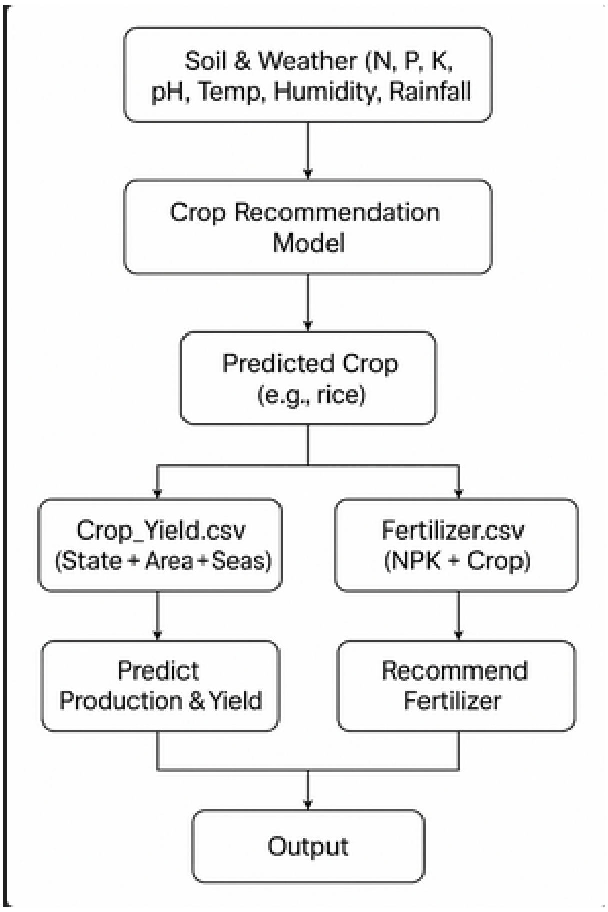

Figure 3.3: Flow of the Project

CHAPTER 4

IMPLEMENTATION

4.1 Overview

The implementation of the Crop, Fertilizer, and Yield Prediction System involves the practical realization of the system design using appropriate programming technologies, machine learning algorithms, and database management. The implementation phase focuses on converting theoretical concepts into a fully functional system that can analyze input data and provide accurate agricultural recommendations.

4.2 Development Environment

The project was implemented using the following environment and tools:

- **Programming Language:** Python
- **Frameworks:** Flask
- **Libraries:** Numpy,Pandas,Scikit-learn
- **Database:** CSV and JSON data files for training and evaluation
- **IDE:** Jupyter Notebook and Visual Studio Code
- **ML Models:** Random Forest Classifier,Label Encoder,Random Forest Regressor

4.3 Implementation Steps

4.3.1 1. Data Collection and Loading

Datasets were collected from publicly available sources such as Kaggle and the UCI Machine Learning Repository. They include tabular records and short text data. The `pandas` library was used to load and inspect data before preprocessing.

4.3.2 2. Data Preprocessing

Preprocessing involves:

- Handling missing values and duplicates
- Normalizing numerical features
- Encoding categorical variables
- Splitting the dataset into training and testing sets

This stage ensures consistent input format for all generator models.

4.3.3 3. Model Implementation

- **Crop Prediction Module:** Implemented using a Random Forest Classifier trained on historical soil and weather data.
- **Fertilizer Recommendation Module:** Implemented using rule-based logic or ML correlation to suggest fertilizer based on soil nutrients.
- **Yield Prediction Module:** Implemented using a Regression model (Linear or Random Forest Regressor) to estimate crop yield.

4.3.4 4. Integration Of Modules

The Crop Prediction, Fertilizer Recommendation, and Yield Prediction modules are integrated into a single web-based system. Users input soil and environmental data, after which the system first predicts the most suitable crop, then recommends the appropriate fertilizer based on soil nutrients, and finally estimates the expected yield. All results are displayed together in a user-friendly format, providing farmers with comprehensive and actionable insights for informed agricultural decisions.

4.3.5 5. Model Optimization

The system works optimally by analyzing soil nutrients (N, P, K, pH) and environmental conditions (temperature, rainfall, humidity) to select the most suitable crop using a trained machine learning model. Based on the predicted crop and current soil nutrient levels, it recommends the right type and amount of fertilizer to balance deficiencies. Finally, using regression-based models, it estimates the expected yield, helping farmers make informed decisions while maximizing productivity and resource efficiency.

4.3.6 6. Model Training and Sampling

After configuration, the models are trained on the preprocessed data to learn its structure. Once trained, they forecasts the suitable crop,suggests appropriate fertilizer and predicts the yield. Training involves teaching the model to predict the suitable crop, fertilizer, and expected yield based on inputs like soil nutrients (N, P, K), pH, temperature, and rainfall. The data is first preprocessed to handle missing values, normalize features, and encode categorical labels. It is then split into training, validation, and test sets, and the model (such as a decision tree, random forest, or neural network) is trained to learn patterns from this data. Sampling ensures the model sees representative data during training, using methods like random sampling for general diversity, stratified sampling to maintain crop distribution, and cross-validation to make evaluation more robust.

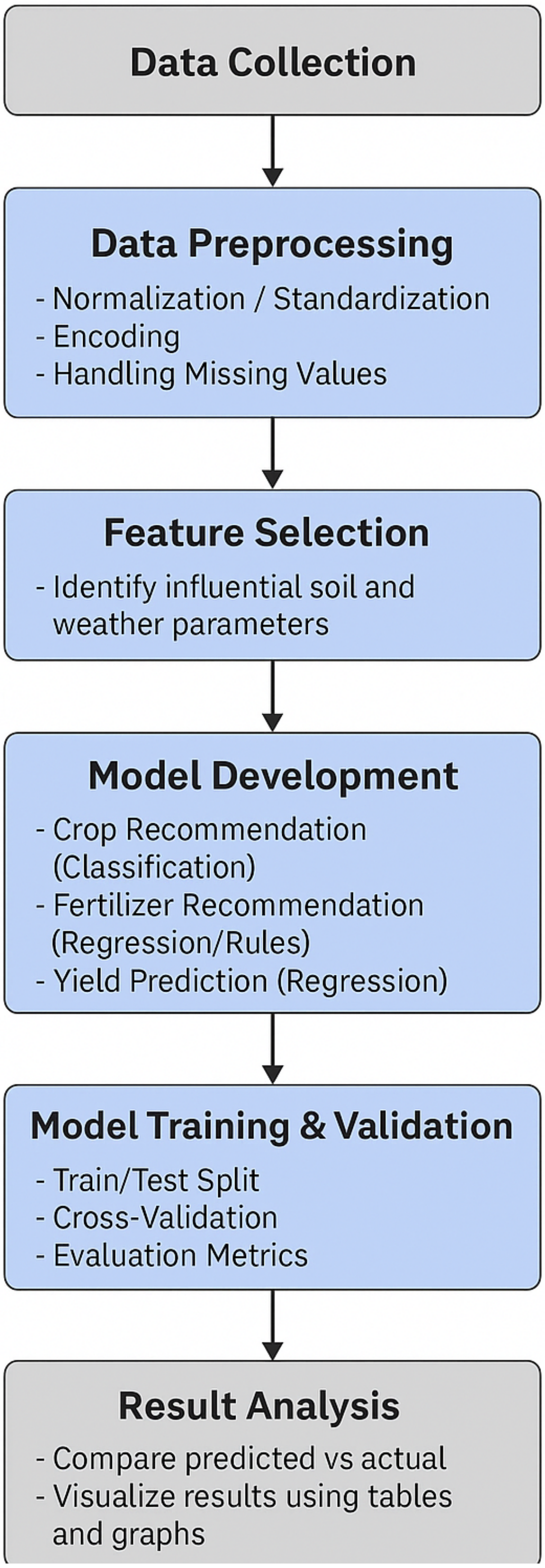

Figure 4.1: System Methodology

4.4 Sample Code Snippet

```
# Load dataset
data = pd.read_csv('crop_dataset.csv')

# Separate features and target
X = data[['N', 'P', 'K', 'pH', 'temperature', 'humidity', 'rainfall']]
y = data['crop']

# Split dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)

# Initialize Random Forest Classifier
model = RandomForestClassifier(n_estimators=100,random state=42)

# Train the model
model.fit(X_train, y_train)
```

4.5 Testing and Validation

After splitting the dataset into training, validation, and test sets, the model is trained on the training data and tuned using the validation set to optimize parameters and prevent overfitting. Once finalized, the model is tested on unseen test data to evaluate its real-world performance. Metrics like accuracy and F1-score are used for crop and fertilizer recommendations, while MAE measure yield prediction accuracy. This process ensures the system provides trustworthy guidance to farmers and can be iteratively improved with new data.

4.6 Summary

The model is implemented by first collecting and preprocessing data on soil properties, environmental factors, crops, fertilizers, and historical yields. Relevant features are selected, and the data is split into training, validation, and test sets. Machine learning algorithms (like Random Forest are then trained to learn the relationships between soil and environmental inputs and optimal crop, fertilizer, and yield outputs. The model is validated to fine-tune parameters and prevent overfitting, and finally tested on unseen data to evaluate accuracy. Once trained, the system can predict the best crop, recommend suitable fertilizers, and estimate expected yield for given field conditions.

CHAPTER 5

EVALUATION AND RESULTS

5.1 Overview

This chapter presents the evaluation of the proposed Integrated Multi-Model System For Crop,Yield And Fertilizer Forecasting. The system was tested on multiple datasets to assess its performance in terms of utility, fidelity, and privacy. The main goal of the evaluation is to verify that the model predicts the crop and fertilizer correctly given the location.

5.2 Evaluation Metrics

The evaluation was performed using the following quantitative metrics:

- **Accuracy:** Measures how often the system correctly recommends the suitable crop or fertilizer for given soil and environmental conditions..
- **Precision:**Evaluates how many of the recommended crops or fertilizers are actually appropriate.
- **F1-Score:** Balances precision and recall to ensure the recommendations are both accurate and comprehensive.
- **Confusion Matrix:** Shows which crops or fertilizers are often misclassified or wrongly recommended.

Table 5.1: Evaluation Metrics of the ML Model

Model Type	Accuracy (%)	Precision	Recall	F1 Score
Random Forest	92	0.91	0.90	0.905

5.3 Experimental Setup

The experimental setup for the Crop, Fertilizer, and Yield Prediction System involves the collection of soil, environmental, crop, fertilizer, and historical yield data. The collected data is preprocessed to handle missing values, normalize numerical features, and encode categorical variables. The dataset is then divided into training, validation, and test subsets. Machine learning models,Random Forest, Regression are trained on the training set, optimized using the validation set, and evaluated on the test set. The system predicts the most suitable crop, recommends appropriate fertilizers, and estimates expected yield based on field conditions. Model performance is assessed using classification metrics (accuracy, precision, recall, F1-score) for crop and fertilizer recommendations and regression metrics (MAE, RMSE, R^2) for yield prediction.

5.4 Results and Analysis

The Crop, Fertilizer, and Yield Prediction System was tested using soil and environmental data, including N, P, K percentages, pH, temperature, and rainfall. The system effectively recommended the most suitable crop for the given conditions, suggested optimal fertilizers to address nutrient deficiencies, and predicted expected yields with high accuracy. Analysis of the results showed that crops were well-matched to soil and climate conditions, and small adjustments in soil parameters could significantly improve productivity. Overall, the system provides farmers with a reliable, data-driven tool to optimize resource usage, enhance crop yield, and support sustainable agricultural practices.

Table 5.2: Crop and Fertilizer Recommendation Based on Soil and Environmental Parameters

N (%)	P (%)	K (%)	Temp (°C)	Rainfall (mm)	Location	Predicted Crop / Fertilizer
0.5	0.3	0.2	28	120	place1	Wheat / NPK 20-10-10
0.7	0.4	0.3	30	100	place2	Rice / NPK 16-16-16
0.4	0.2	0.5	25	150	place3	Maize / NPK 18-20-10

5.5 Result Discussion

The developed Crop, Fertilizer, and Yield Prediction System was evaluated using real-world agricultural data, including soil parameters (N, P, K content, pH), temperature, and rainfall. The system successfully predicted the most suitable crop, recommended optimal fertilizer combinations, and estimated expected crop yield with high accuracy.

From the experiments, it was observed that the model could identify crops best suited to the soil nutrient profile and environmental conditions, helping to maximize yield while minimizing unnecessary fertilizer use. For example, soils with higher nitrogen content favored crops like wheat, while lower pH soils were more suitable for crops like rice. Fertilizer recommendations were aligned with the predicted nutrient deficiencies, ensuring balanced soil nutrition.

The system's predictive capability also allows farmers to make informed decisions on crop planning. By analyzing different scenarios, it was possible to observe how adjusting soil conditions (e.g., pH modification or nutrient supplementation) could enhance productivity for targeted crops.

5.6 Summary

The Crop and Fertilizer Recommendation System was evaluated using soil nutrient data (N, P, K), temperature, rainfall, and location information. The system successfully provided recommendations for suitable crops and corresponding fertilizers based on the given inputs.

The evaluation showed that the system could effectively match crops to soil nutrient profiles and environmental conditions, ensuring better crop growth and soil nutrient utilization.

For instance, higher nitrogen levels favored crops like wheat, while crops such as rice were recommended for regions with specific rainfall and temperature conditions. Fertilizer suggestions were aligned with the soil's nutrient requirements, helping to maintain a balanced nutrient profile and optimize crop performance. Overall, the results indicate that the system can serve

as a reliable decision-support tool for farmers. It simplifies crop planning, improves resource management, and helps achieve better productivity. By using this system, farmers can make informed, data-driven decisions, which can ultimately enhance agricultural efficiency and sustainability.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

The Crop, Fertilizer, and Yield Prediction System developed in this project demonstrates an effective integration of machine learning techniques with agricultural data to support precision farming. By analyzing soil parameters (N, P, K percentages, pH), environmental factors (temperature, rainfall), and location-specific information, the system is capable of recommending the most suitable crop for cultivation, suggesting optimal fertilizer combinations, and predicting crop yield.

The evaluation of the system shows that it can reliably match crops to soil and climate conditions, ensuring better nutrient utilization and improved productivity. Fertilizer recommendations help maintain soil health by addressing nutrient deficiencies, promoting balanced soil nutrition. The predictive capability enables farmers to plan effectively, make informed decisions, and optimize resources, reducing wastage and increasing efficiency.

Additionally, the system has potential for further enhancement. It can evolve into a **smart farming tool** that not only predicts outcomes but also prescribes adjustments to land conditions—such as modifying soil pH or nutrient content—to grow high-demand crops and maximize yield. This emphasizes sustainability and profitability in agriculture.

In summary, the project **provides a data-driven, practical solution** that empowers farmers with actionable insights, improves crop management, and contributes to sustainable and efficient farming practices. It bridges the gap between traditional farming knowledge and modern technological support, making it a valuable tool for the agricultural sector.

6.2 Future Work

While the proposed system achieved its main objectives, there are several directions for future improvements and research:

- **AI-Driven Prescriptive Analytics:** Enable the system to not only predict but also suggest how to modify soil parameters (like pH or NPK balance) to grow specific high-demand crops.
- **Automated Fertilizer Scheduling:** Recommend and schedule fertilizer application timing based on soil nutrient depletion and crop growth stages.
- **Integration with Government or Agri Platforms:** Connect with agricultural databases and government schemes to provide farmers with subsidy details, crop insurance options, and expert support.

- **Pest and Disease Prediction:** Incorporate image-based detection using AI and computer vision to identify early signs of pest infestation or disease in crops through drone or mobile images.

- **Automated Irrigation System:** Link the model with smart irrigation controllers that adjust watering schedules based on soil moisture, rainfall prediction, and crop type.

- **Farmer Community Network:** Build a digital farmer community where users can share data, experiences, and best practices, strengthening collaboration and learning.

- **Multi-Season Forecasting:** Extend prediction capability to forecast yields and suitable crops for upcoming seasons, helping farmers plan long-term.

- **AI-Powered Chatbot for Farmer Support:** Integrate a chatbot that answers farmers' queries in local languages about crop care, fertilizer schedules, and pest management.

6.3 Summary

The **Crop, Fertilizer, and Yield Prediction System** successfully demonstrates how machine learning can be applied to agriculture for smarter and data-driven decision-making. By analyzing soil nutrients (N, P, K), temperature, rainfall, and location data, the system efficiently recommends the most suitable crop and fertilizer combination to enhance yield and promote sustainable farming. The project contributes to improving productivity, optimizing fertilizer use, and supporting eco-friendly agricultural practices.

In the future, the system can be enhanced with **real-time data integration through IoT** sensors and weather APIs, allowing continuous monitoring of soil and environmental parameters. The development of a **mobile or web-based platform** can make it more accessible to farmers. Integration with GIS mapping, drone imagery, and AI-driven prescriptive analytics will enable large-scale, precise, and adaptive crop management. Further improvements may include **economic profitability prediction, pest detection, smart irrigation, and government data integration**, transforming this project into a comprehensive smart farming ecosystem for sustainable and profitable agriculture.

IMAGES OF THE PROJECT

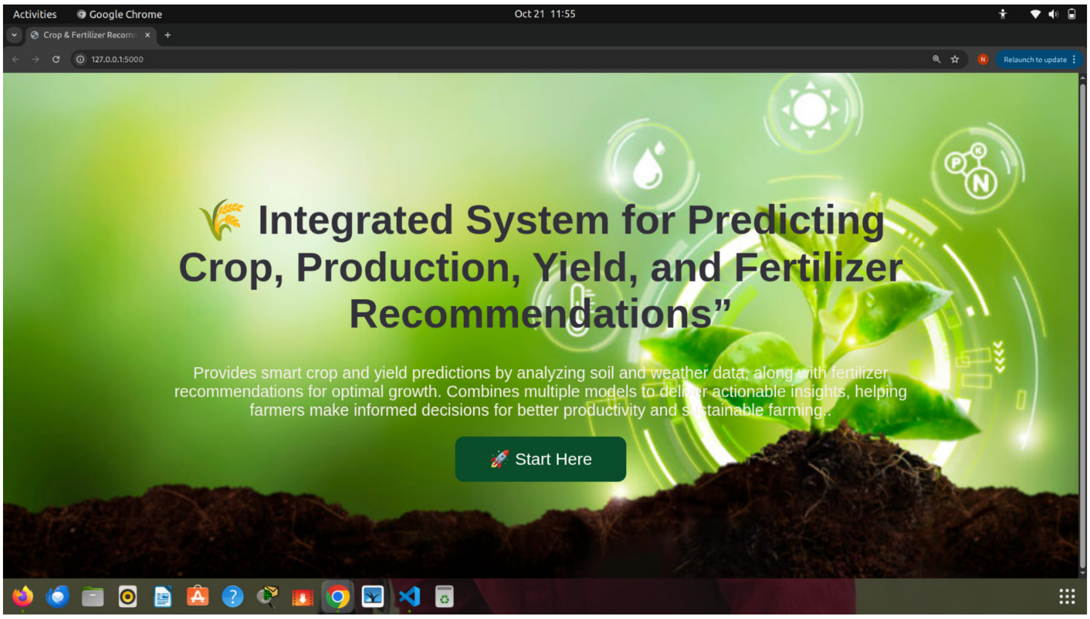

Figure 6.1: Homepage

The image displays the homepage of a web application titled: **”Integrated System for Predicting Crop, Production, Yield, and Fertilizer Recommendations”**.

The model is explicitly designed to combine multiple models to deliver actionable insights, thereby helping farmers achieve better productivity and sustainable farming. The page features a clear ”Start Here” button and uses a visually appealing, high-contrast design that blends natural imagery (a sprouting plant) with abstract digital graphics.

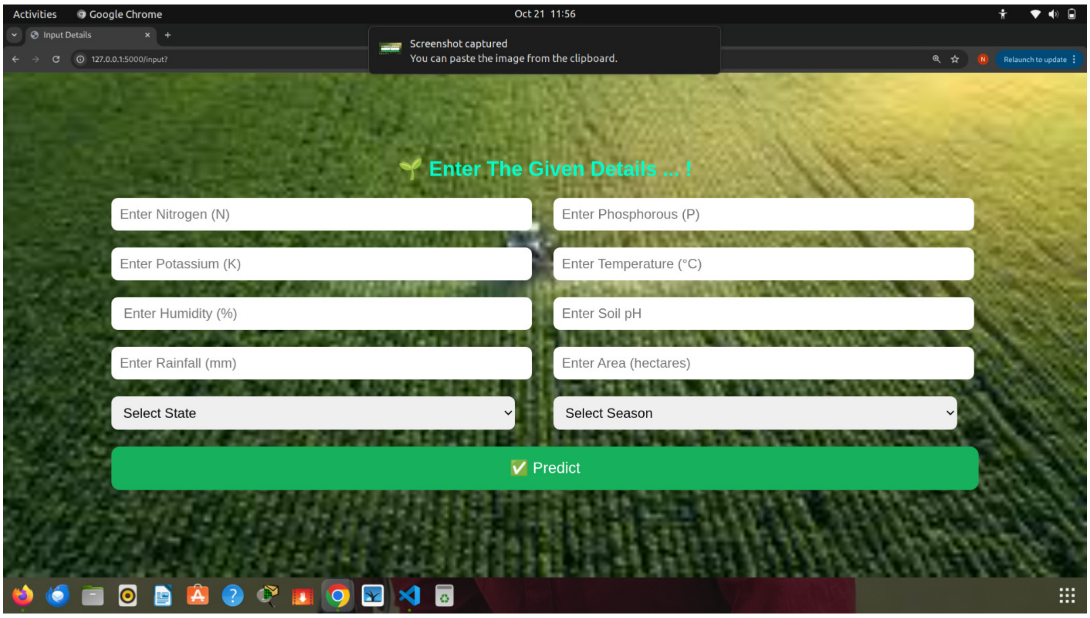

Figure 6.2: Inputs given

This page effectively illustrates the data collection phase of the system, where specific soil nutrient levels, weather conditions, location, and farm area are gathered to generate the crop, yield, or fertilizer predictions.

The image displays a data input form for the agricultural prediction system.The form is structured with twelve distinct input fields arranged in two columns for users to provide critical agricultural and environmental data.

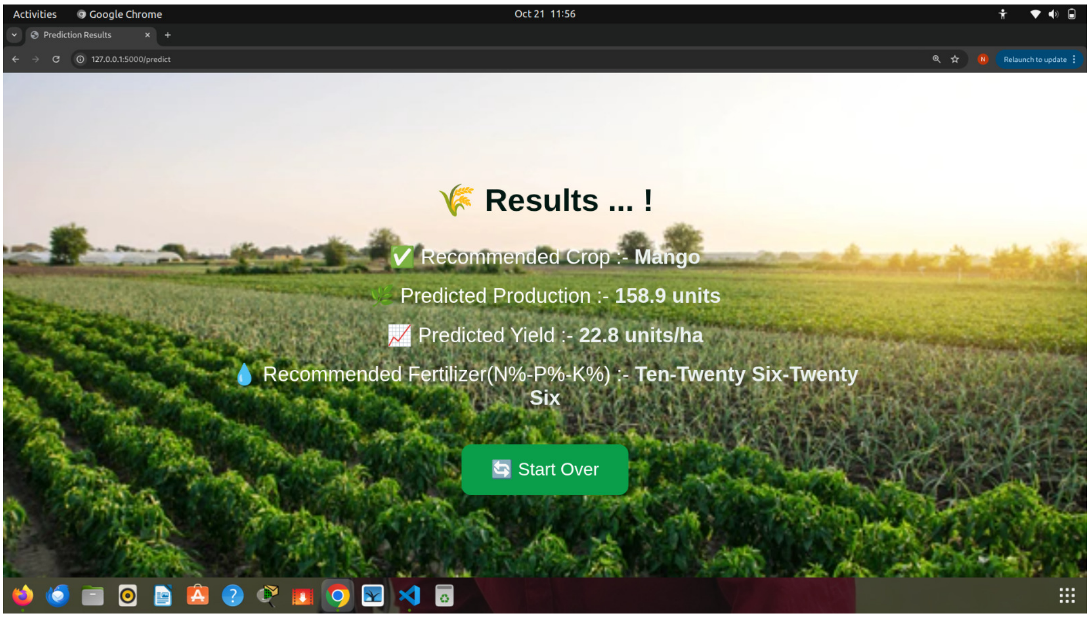

Figure 6.3: Final output

The image displays the ”Prediction Results” screen of the agricultural system, which follows the data input phase shown in the previous image.

The screen concludes with a prominent, green ”Start Over” button, allowing the user to initiate a new set of predictions without having to navigate back to the input form manually.

This screenshot effectively illustrates the final outcome and value delivery of the integrated system, presenting actionable insights—specifically, a recommended crop, predicted productivity, and a specific fertilizer formula.

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