

# An AI-Enabled Crop, Fertilizer, And Yield Recommendation System Using Machine Learning

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**Abstract:** Agriculture plays a vital role in global food security, and farmers constantly seek ways to optimize crop selection to maximize yield and profitability. However, identifying the most suitable crop for a specific region is challenging due to factors such as climate conditions, soil fertility, rainfall, temperature, and water availability. Traditional farming practices often rely on experience and assumptions, which may lead to reduced productivity and improper fertilizer usage. The proposed Crop and Fertilizer Recommendation System addresses these challenges by utilizing machine learning techniques to analyze environmental and soil-related parameters for intelligent decision-making. The system collects input data such as soil nutrients, temperature, humidity, rainfall, and pH values, and processes them using machine learning algorithms to recommend the most suitable crop and appropriate fertilizer. By providing accurate and data-driven recommendations, the system helps farmers improve crop yield, reduce resource wastage, and enhance sustainable agricultural practices. The developed model aims to support precision agriculture by assisting farmers in selecting crops that are best suited for their land conditions while also suggesting fertilizers to maintain soil health and productivity. Experimental results demonstrate that machine learning-based recommendations can significantly improve agricultural efficiency and contribute to smarter farming solutions.

## I. INTROUCTION

Agriculture plays a significant role in the economic development and food security of many countries. Farmers continuously face challenges in selecting suitable crops and fertilizers due to changing environmental conditions, soil characteristics, and climate variability. Choosing an inappropriate crop for a particular region can result in low productivity, poor soil health, and financial losses. Therefore, there is a growing need for intelligent systems that can assist farmers in making accurate and data-driven agricultural decisions.

The Crop and Fertilizer Recommendation System proposed in this project is designed to support farmers and agricultural planners in selecting suitable crops and fertilizers based on environmental and soil parameters. The system utilizes machine learning techniques, specifically the Random Forest algorithm, to analyze agricultural data and provide personalized recommendations. By considering factors such as rainfall, humidity, temperature, soil moisture, and soil pH, the system helps farmers identify crops that are most suitable for cultivation in a specific region. The model is trained using a dataset containing important agricultural attributes including district, rainfall, humidity, minimum temperature, maximum temperature, soil moisture, minimum pH, and maximum pH. These parameters have a direct impact on crop growth and productivity. Rainfall and humidity determine water availability, temperature influences plant development, and soil pH affects nutrient absorption by crops. By analyzing these variables together, the system can understand complex relationships between environmental conditions and agricultural productivity.

The Random Forest algorithm is selected because of its high prediction accuracy, robustness, and ability to handle large datasets with non-linear relationships. Random Forest is an ensemble machine learning technique that builds multiple decision trees and combines their outputs to improve classification performance and reduce overfitting. Using this approach, the system can generate reliable crop recommendations based on historical agricultural data and environmental conditions. In addition to crop recommendation, the system also includes a fertilizer recommendation module. Once a suitable crop is identified, the system evaluates the nutrient requirements of the selected crop and compares them with the soil conditions provided by the user. Based on this analysis, appropriate fertilizers are suggested to improve soil



fertility and support healthy crop growth. Proper fertilizer management is essential because insufficient or excessive fertilizer usage can negatively affect crop yield, soil quality, and the environment.

A key advantage of the proposed system is its integrated approach toward agricultural management. Instead of focusing only on crop prediction, the platform combines crop selection and fertilizer recommendation within a single intelligent framework. This enables farmers to make informed decisions throughout the cultivation process, optimize resource utilization, reduce unnecessary fertilizer consumption, and improve overall farming efficiency. Furthermore, the system can be implemented as a user-friendly web or mobile application where farmers can enter soil and environmental parameters to obtain recommendations in real time. Such a platform can be highly beneficial for farmers who lack access to expert agricultural advisory services. By providing accurate and data-driven guidance, the system can help increase agricultural productivity, reduce cultivation costs, and promote sustainable farming practices.

**Problem Statement:**

Farmers often face difficulties in selecting suitable crops for cultivation due to changing environmental conditions such as rainfall, temperature, humidity, soil moisture, and soil pH. Traditional farming methods mainly rely on experience and general guidelines, which may not accurately match current soil and climate conditions. This can lead to low crop yield, inefficient use of resources, and financial losses.

Additionally, climate change and limited access to agricultural advisory services make crop selection more challenging for farmers. Therefore, there is a need for an intelligent and data-driven system that can analyze environmental and soil parameters to recommend suitable crops and fertilizers. The proposed Crop and Fertilizer Recommendation System uses machine learning techniques to provide accurate recommendations, helping farmers improve productivity, reduce costs, and support sustainable agriculture.

**II. LITERATURE SURVEY****1. Crop Recommendation System Using Machine Learning**

Authors: R. Sujatha and P. Isakki

Year: 2020

This paper proposed a machine learning-based crop recommendation system that analyzes soil and climate conditions to suggest suitable crops. The study used algorithms such as Decision Tree and Random Forest to improve prediction accuracy. The system helped farmers make better cultivation decisions and increase productivity.

**2. Smart Agriculture Using Data Mining Techniques**

Authors: S. Ramesh and D. Vishnu Vardhan

Year: 2018

The authors developed a smart agriculture system using data mining techniques to analyze agricultural data. Parameters such as rainfall, soil type, and temperature were considered for crop prediction. The research demonstrated that data-driven farming methods can improve agricultural efficiency and reduce losses.

**3. Fertilizer Recommendation System for Precision Agriculture**

Authors: K. Meghana and S. Harish

Year: 2021

This study focused on recommending suitable fertilizers based on soil nutrient levels and crop requirements. Machine learning algorithms were used to identify nutrient deficiencies and suggest appropriate fertilizers. The system aimed to reduce excessive fertilizer usage and improve soil health.

**4. Machine Learning Approach for Crop Yield Prediction**

Authors: A. Kumar and N. Singh

Year: 2019

The paper presented a crop yield prediction model using machine learning algorithms such as Random Forest and Support Vector Machine (SVM). Environmental factors including temperature, rainfall, and humidity were analyzed to estimate crop performance. The research showed improved prediction accuracy compared to traditional methods.

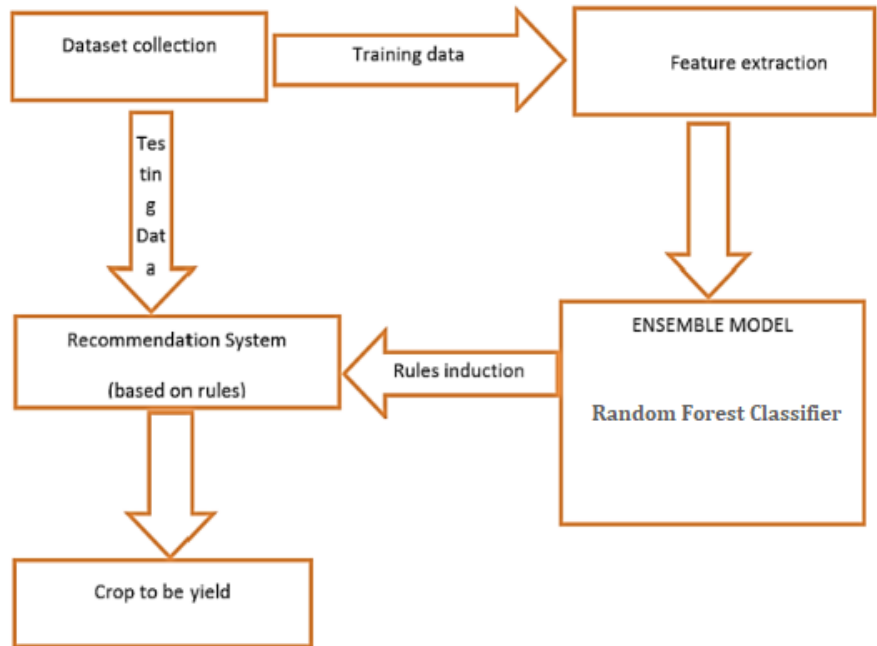
**5. IoT and Machine Learning Based Smart Farming System**

Authors: M. Prakash and R. Karthik

Year: 2022

This research introduced a smart farming system integrating IoT sensors and machine learning techniques. Real-time environmental data such as soil moisture and temperature were collected and analyzed to provide crop and fertilizer recommendations. The system supported precision agriculture and efficient resource management.

### III. METHODOLOGY



The proposed Crop and Fertilizer Recommendation System uses the Random Forest algorithm to provide accurate crop recommendations based on environmental and soil conditions. Random Forest is a Machine Learning ensemble technique that combines multiple decision trees to improve prediction accuracy and reliability. It is highly effective for agricultural datasets because it can handle large amounts of data and identify complex relationships between multiple variables.

The system considers important agricultural parameters such as district, rainfall, humidity, minimum temperature, maximum temperature, soil moisture, and soil pH. These factors directly influence crop growth and productivity. By analyzing all parameters together, the model can determine the most suitable crop for a specific region and environmental condition.

The Random Forest algorithm works by creating multiple decision trees using different subsets of training data and features. Each tree generates its own prediction, and the final result is obtained through majority voting. This approach reduces overfitting and increases the overall accuracy of the system. The algorithm can also capture non-linear relationships between environmental conditions and crop suitability, making it more effective than traditional rule-based systems.

In addition to crop recommendation, the system also includes a fertilizer recommendation module. After predicting the suitable crop, the system analyzes soil conditions and nutrient requirements to suggest appropriate fertilizers. This helps farmers maintain soil fertility, improve crop yield, and reduce excessive fertilizer usage.

Another advantage of the proposed system is its scalability and adaptability. The model can be trained using large agricultural datasets from different regions and updated regularly with new environmental data. The system can also identify the most influential factors affecting crop selection through feature importance analysis, helping farmers make informed decisions.

Overall, the proposed methodology provides a data-driven, efficient, and intelligent solution for modern agriculture. By integrating crop and fertilizer recommendations into a single platform, the system supports precision farming, improves productivity, and promotes sustainable agricultural practices.

#### IV. RESULT

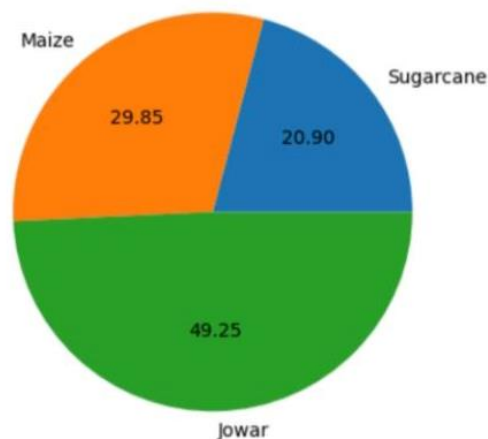
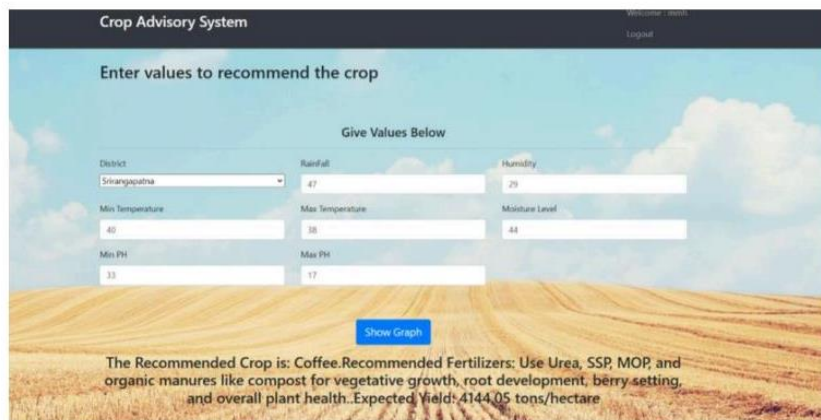
The Crop and Fertilizer Recommendation System was successfully developed and tested using the Random Forest machine learning algorithm. The model was trained using agricultural datasets containing parameters such as district, rainfall, humidity, temperature, soil moisture, and soil pH. After training, the system was able to accurately recommend suitable crops based on the given environmental and soil conditions. The Random Forest algorithm produced high prediction accuracy compared to traditional crop selection methods. The system effectively analyzed multiple environmental factors simultaneously and identified suitable crops for different regions. The ensemble nature of Random Forest helped reduce overfitting and improved the reliability of predictions.

The fertilizer recommendation module also generated appropriate fertilizer suggestions based on soil conditions and crop nutrient requirements. This helped in reducing unnecessary fertilizer usage and supported better soil management practices. By providing both crop and fertilizer recommendations within a single system, the platform improved decision-making efficiency for farmers.

The developed system demonstrated several advantages, including:

- Accurate crop prediction based on environmental conditions.
- Efficient fertilizer recommendations for improved soil fertility.
- Reduced dependency on traditional guess-based farming methods.
- Better resource utilization and reduced agricultural losses.
- Support for sustainable and precision farming practices.

Experimental analysis showed that machine learning techniques can significantly improve agricultural productivity and provide reliable support for farmers. The system can further be enhanced by integrating real-time weather data, IoT sensors, and mobile application support for wider usability and better performance in practical farming environments.



**V. CONCLUSION**

In conclusion, the Crop Recommendation System developed using the Random Forest algorithm provides an effective and intelligent solution for supporting farmers in crop selection. By analyzing agricultural parameters such as rainfall, humidity, temperature, soil moisture, soil pH, and district information, the system generates accurate and personalized crop recommendations based on environmental conditions. The use of the Random Forest algorithm improves prediction accuracy, reliability, and robustness by handling large agricultural datasets and identifying important relationships between different factors. The system also supports efficient resource utilization and promotes sustainable farming practices by helping farmers select suitable crops and manage soil nutrients effectively. The developed system has the potential to improve agricultural productivity, reduce farming risks, and assist farmers in making data-driven decisions. In the future, the system can be further enhanced by integrating real-time weather data, IoT sensors, and mobile or web-based applications to provide more accessible and practical solutions for modern agriculture.

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