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Crop Care Tech: A Web Based Application for Crop, Fertilizer Recommendation, Disease Detection by Using ML, DL

B. Shireesha[1], M. Vinitha[2], K. Vamsi[3], Shaik Shabber Ali[4], Umadevi Sri Anuhya Nunna[5]
[1,2]Asst Professor, Department of CSE, RGUKT, Ongole, Andhra Pradesh, India.
[3,4,5]Student, Department of CSE, RGUKT, Ongole, Andhra Pradesh, India.
Emails: *shirishabheemaa@gmail.com[1], vinithamarlabeedu@gmail.com[2], vamsikopparthi84@gmail.com[3], shaikshabberali00@gmail.com[4], anuhyanunna@gmail.com[5]*

Abstract
Agriculture is the Backbone of the India's economy. Agriculture is the foundation of human civilization, embodying the art and science of cultivating crops and rearing livestock for sustenance and economic prosperity. Due to the poor weather, climate conditions, lack of proper care there are huge losses to the farmers in terms of their productivity. Because of not much knowledge, education in the rural area farmers tend to commit mistakes by not giving their crop proper treatment like good fertilizers to grow the crop, taking care of the disease which has been caught up by the crop. This study aims to develop a website utilizing machine learning models for crop recommendations, taking into account inputs such as pH values, temperature, and soil nutrients like nitrogen, potassium, phosphorus etc. Various machine learning algorithms including logistic regression, linear regression, support vector machines, random forests, naive bayes, xgboost, decision trees are used, with random forests and xgboost gives the higher prediction results. So basically, we are expecting that after taking valuable inputs from user like soil nutrients, images of the crop we will predict the desired output with highest efficiency. The main objective of this project is building a website which will help farmers to make the effective cultivation by providing good information like which crop is suitable for their soil, and which fertilizers are suitable to grow. Ultimately, these systems serve as a crucial tool in advancing modern agriculture, leveraging technology and data analysis to assist farmers in making decisions that contribute to food security and agricultural sustainability. Accessible through user-friendly platforms, crop recommendation systems empower farmers to harness the benefits of technology and data, thereby enhancing agricultural productivity, financial gains, and global food security through these modern agricultural advancements.

Keywords: *crop recommendation, disease detection, fertilizer recommendation, soil data, machine learning algorithms like logistic, random forest, decision trees, svm, Neural networks etc.*

1. Introduction

Modern agriculture is essential for sustaining global food security and meeting the demands of a growing population. In this context, leveraging advancements in technology is crucial to optimize agricultural practices and ensure efficient crop management. This project presents an integrated approach towards agricultural enhancement through a comprehensive system encompassing crop recommendation, fertilizer recommendation, and disease detection. The crop recommendation system utilizes machine learning algorithms and historical data to suggest the most suitable crops for a given geographical location based on various parameters such as soil type, climate, and water availability. This tailored advice empowers farmers to make informed decisions regarding crop selection, fostering improved yields and economic growth. In this project, we have implemented an intelligent system called Crop and fertilizer Recommendation, which intends to assist the farmers in making an informed decision about

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which crop to grow and which fertilizer used to depend on the sowing season, his farm's geographical location, soil characteristics as well as environmental factors such as temperature and rainfall. Furthermore, the fertilizer recommendation system offers guidance on appropriate fertilizers and their optimal usage, tailored to specific crop types and soil conditions. By considering factors like nutrient levels and soil composition, the system aids in promoting sustainable agricultural practices while maximizing crop productivity. In addition to crop and fertilizer recommendations, the project incorporates a disease detection component that employs computer vision techniques and deep learning models to identify diseases in plants. Timely disease detection allows for prompt intervention, preventing the spread of diseases and minimizing crop losses. The synergy of these interconnected components provides farmers with a holistic solution, enhancing their decision-making processes and overall farm productivity. This project contributes to the advancement of precision agriculture, promoting sustainability, efficiency, and ultimately aiding in the global effort to ensure food security. In this project, I present a website in which the following services are implemented; Crop recommendation, Fertilizer recommendation and Plant disease prediction, respectively. In the crop recommendation application, the user can provide the soil data from their side and the application will predict which crop should the user grow. For the fertilizer recommendation application, the user can input the soil data and the type of crop they are growing, and the application will predict what the soil lacks or has excess of and will recommend improvements. For the last application, that is the plant disease prediction application, the user can input an image of a diseased plant leaf, and the application will predict what disease it is and will also give a little background about the disease and suggestions to cure it. In essence, crop recommendation systems play a pivotal role in the modernization of agriculture, fostering sustainability, and improving the livelihoods of farmers worldwide. They serve as a beacon of hope in an industry crucial to our well-being and the future of our planet.

2. Objective

Crop Recommendation: Develop a machine learning model that analyzes soil data to recommend the most suitable crops. The goal is to optimize agricultural yield by selecting crops that are well-matched to the soil's properties, including its nutrient content, pH level, and texture. This system will help farmers make informed decisions about which crops to plant, ensuring better growth and higher productivity. Fertilizer Recommendation: Create a model that provides precise fertilizer recommendations tailored to the specific needs of the selected crops. By considering the existing nutrient profile of the soil and the nutrient requirements of the crops, the system aims to suggest the optimal type and amount of fertilizer. This ensures efficient nutrient management, enhances crop growth, and minimizes environmental impact Plant Disease Detection: Implement a deep learning model using ResNet-9 to accurately detect plant diseases from images. The system will be trained to identify various plant diseases, allowing for early diagnosis and treatment. By providing timely and accurate disease detection, the model helps farmers take preventive measures, reducing crop losses and improving overall plant health. Develop a machine learning model to recommend suitable crops based on soil data. Provide accurate fertilizer recommendations for selected crops. Implement a deep learning model using Res Net-9 to detect plant diseases from images. Integrate language translation features for multilingual support. Evaluate the performance and effectiveness of the models and the overall system.

3. Literature Survey

3.1. Crop Recommendation Systems

3.1.1. Traditional Methods

Traditional crop recommendation methods rely on agronomic guidelines and expert advice. These methods typically consider factors such as soil type, climate conditions, and historical crop performance. However, they often lack precision and are not easily scalable to diverse agricultural settings.

3.1.2. Machine Learning Approaches

Recent advancements in machine learning have enabled more precise and data-driven crop recommendation systems. For example, studies by P.Priya, U.Muthaiah. Balamurugan have utilized supervised learning algorithms like Random Forest, Support Vector Machines (SVM), and Decision

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Trees to analyse soil data and recommend crops. These models have shown improved accuracy over traditional methods, demonstrating the potential of machine learning in agriculture. [1] Figure 1 shows the process of Recommendation.

3.1.3. Integrated Systems

Integrating crop recommendation with other agricultural decision-support tools is a growing trend. Systems like the one proposed by Patil et al. (2021) combine crop recommendation with irrigation scheduling and pest management, providing a comprehensive solution for farmers.[2]

3.2. Fertilizer Recommendation Systems

3.2.1. Conventional Techniques

Conventional fertilizer recommendation systems are based on soil testing and nutrient management guidelines. These methods, while effective, often require laboratory analysis and can be time-consuming and costly for farmers.

3.2.2. Data-Driven Models

Recent studies have explored data-driven approaches to optimize fertilizer use. For instance, Kanaga Suba Raja Subramanian[3] used machine learning algorithms to predict the optimal type and quantity of fertilizers needed based on soil and crop data. Their model incorporated factors such as soil nutrient levels, crop nutrient requirements, and environmental conditions, resulting in more efficient fertilizer usage.

3.2.3. Precision Agriculture

Precision agriculture technologies, including GPS and remote sensing, have been integrated with fertilizer recommendation systems. Research by R.G.Regalado and J. C. Dela Cruz highlights the use of precision agriculture to deliver site-specific fertilizer recommendations,[4] enhancing nutrient use efficiency and reducing environmental impact.

3.3. Plant Disease Detection

3.3.1. Traditional Identification Methods

Traditional plant disease identification relies on visual inspection by experts or laboratory testing. These methods can be slow, subjective, and often inaccessible to small-scale farmers.

3.3.2.Machine Learning and Image Processing

Machine learning and image processing techniques have significantly advanced plant disease detection. Studies by Cortes, Emanuel (2017) employed Convolutional Neural Networks (CNNs) to classify plant diseases from leaf images. These models achieved high accuracy and demonstrated the feasibility of automated disease detection. [6] Figure 2 shows the Website Interface

3.3.3.Deep Learning with ResNet Architectures

ResNet (Residual Networks) has been particularly effective for image classification tasks due to its ability to handle deep architectures without the vanishing gradient problem. Research by Chen et al. (2018) [5] used ResNet-50 to detect multiple plant diseases, achieving state-of-the-art performance. Their work illustrates the potential of deep learning models like ResNet-9 in accurately identifying plant diseases.

3.4. Multilingual Support in Agricultural Systems

3.4.1. Importance of Multilingual Systems

Multilingual support in agricultural advisory systems is crucial for reaching a broader audience, especially in regions with diverse linguistic backgrounds. Research by Steigerwald, Emma (2019) [7] highlights the importance of language accessibility in ensuring that agricultural recommendations are understood and implemented by farmers.

3.4.2. Language Translation Technologies

Recent advancements in natural language processing (NLP) have facilitated the development of multilingual systems. Tools like Google Translate and open-source libraries such as Hugging Face's Transformers have been integrated into agricultural advisory platforms to provide real-time language translation.

4. Proposed Method

The proposed system is an integrated platform designed to enhance agricultural productivity and sustainability through crop recommendation, fertilizer recommendation, and plant disease detection. It consists of several interconnected modules ensuring seamless data flow and integration of functionalities: data collection, data preprocessing, exploratory data analysis (EDA), model creation, and recommendation generation. The phases are as per the following:

1) Collection of Datasets
2) Pre-processing (Noise Removal)
3) Feature Extraction
4) Applied Machine Learning Algorithm
5) Recommendation System
6) Recommended Crop

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7) Recommend Fertilizer

8) Plant Disease Detection

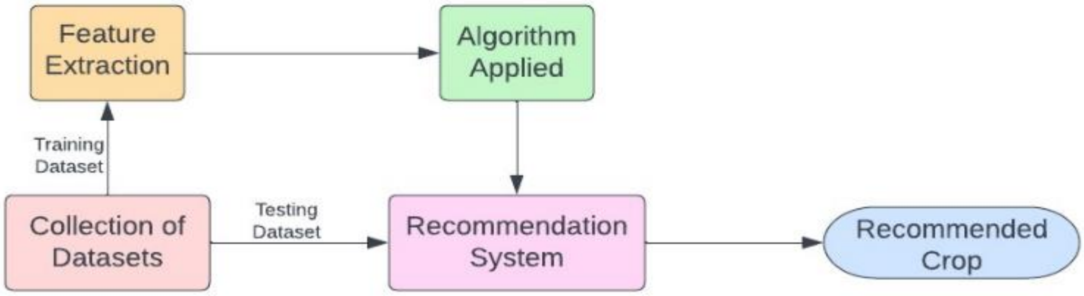

Figure 1 Process of Recommendation

4.1. Data Collection and Preprocessing

The system collects data from multiple sources, including soil properties (pH, moisture, nutrient levels, and texture), historical crop performance, climatic requirements, plant leaf images for disease detection, and real-time weather information. Data preprocessing is essential to clean and transform this data into a usable format. Soil data is cleaned to handle missing values and normalized, while image data undergoes augmentation, resizing, and normalization. EDA helps visualize data distributions, correlations, and identify key patterns.

4.2. Model Creation

The system uses machine learning algorithms for crop and fertilizer recommendations and a deep learning model (ResNet-9) for plant disease detection. The crop recommendation model analyses soil data using supervised learning algorithms like Random Forest, SVM, and Decision Trees. It undergoes training and validation using historical crop data and feature engineering to improve accuracy. The fertilizer recommendation model uses regression algorithms and optimization techniques to predict nutrient requirements, ensuring recommendations maximize crop yield while minimizing environmental impact. The plant disease detection model employs ResNet-9 to classify diseases from plant leaf images, training on a labelled dataset to ensure robust detection through accuracy, precision, recall, and F1-score evaluations.

4.3. Language Translation and System Workflow

To support farmers from diverse linguistic backgrounds, the system integrates multilingual translation capabilities using tools like Google Translate API or open-source NLP libraries (e.g.,Hugging Face Transformers). The user-friendly interface allows farmers to interact with the system in their preferred language. The overall workflow involves farmers inputting soil data, uploading plant leaf images, and providing location information for weather data. The system preprocesses this input data, performs EDA, and feeds it into respective models for generating recommendations and detecting diseases. Finally, the system translates the recommendations and results into the farmer's preferred language, ensuring accessibility and usability.

4.4. Designing of Models

The models we developed for crop recommendation, fertilizer recommendation, and plant disease detection are deployed using the pickle module in Python. These pickle files are then utilized in the website to provide real-time recommendations and diagnostics. For designing the user interface of the project, we employed HTML, CSS, and JavaScript to ensure a responsive and user-friendly experience. The website is deployed using Python Flask and runs on the local host of the system, facilitating easy access and interaction for users. This integrated approach allows farmers to receive accurate agricultural advice through a seamless online platform.

The Machine learning algorithms used for model design:

SVM (Support Vector Machine): A supervised learning algorithm used for classification and regression tasks, which finds the hyperplane that best separates different classes in the feature space.

Random Forest: An ensemble learning method that constructs multiple decision trees during training and outputs the mode of the classes for classification or mean prediction for regression.
Logistic Regression: A statistical model used for binary classification that predicts the probability of an outcome based on one or more predictor variables using a logistic function.
XGBoost (Extreme Gradient Boosting): An efficient and scalable implementation of gradient boosting framework by adding more accurate approximations to the model and focusing on speed and performance.
Decision Trees: A non-parametric supervised learning method used for classification and regression that splits data into subsets based on the value of input features, creating a tree structure of decisions.

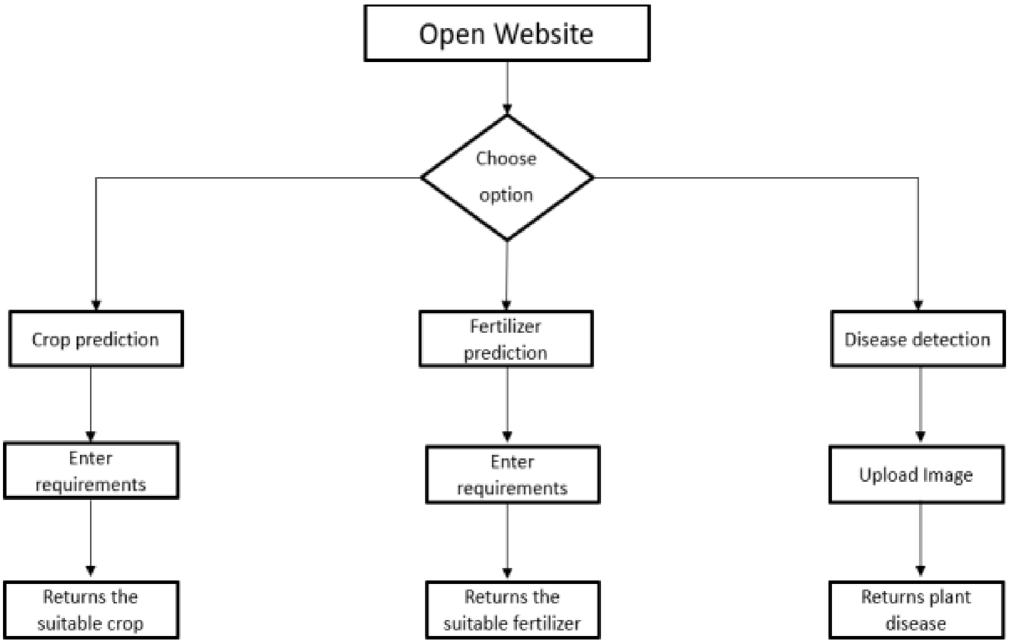

Figure 2 Website Interface

4.5. Implementation Process

Dataset Description: The dataset comprises 2200 instances with attributes like Nitrogen (N), Phosphorus (P), Potassium (K), pH, Rainfall, Humidity, Temperature, and Crop Name. This comprehensive dataset forms the basis of our model.

4.5.1.Data Preprocessing

Cleaning the Data:nStandardized the crop names to lowercase. Removed any redundant entries to ensure data integrity.
Splitting the Data: The dataset was split into training (80%) and testing (20%) sets using the train_test_split function from the sklearn library.
Model Training: We utilized multiple machine learning algorithms to build robust prediction models:
Model Deployment: Models were serialized using the pickle module in Python. This allows the trained models to be saved and loaded for use in the web application.

4.5.2.Website Development

User Interface: Designed using HTML, CSS, and JavaScript to provide an intuitive and user-friendly experience.
Backend Deployment: Deployed using the Flask framework in Python, running on the local host. Flask handles the routing, model loading, and serving of predictions based on user inputs.
Advanced Model Insights: Neural Networks and CNNs: While traditional machine learning methods were used for initial predictions, convolutional neural networks (CNNs) with deep layers were considered

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for future improvements, particularly in feature extraction and learning.

Plant Disease Detection: Integrated plant disease prediction using deep learning with CNN architectures like ResNet, which addresses issues like vanishing gradients and improves model accuracy.

This comprehensive implementation ensures accurate crop and fertilizer predictions, aiding farmers in optimizing their agricultural practices. By leveraging data science and machine learning, we aim to enhance agricultural productivity and sustainability.

5. Results

The implementation of our crop and fertilizer prediction system yielded promising results, with each machine learning model demonstrating high accuracy in its respective tasks. The XGBoost and Random Forest models particularly excelled in crop prediction, providing precise recommendations based on soil attributes. Logistic Regression and Decision Trees also performed well, confirming their suitability for such classification tasks. For plant disease detection, the ResNet-9 CNN model achieved remarkable accuracy, effectively identifying various plant diseases from leaf images. The integration of these models into a user-friendly web interface, deployed via Flask, facilitated real-time predictions and recommendations for farmers. This comprehensive system enhances agricultural decision-making, promoting better crop management and sustainable farming practices. The results are shown in figure (3-7)

Figure 3 **Crop Recommendation Input Values**

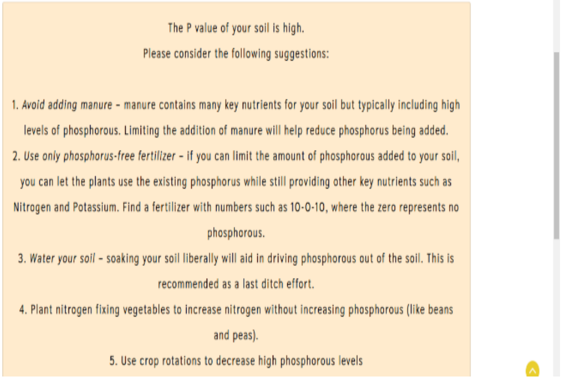

Figure 4 **Output of the Crop Recommendation**

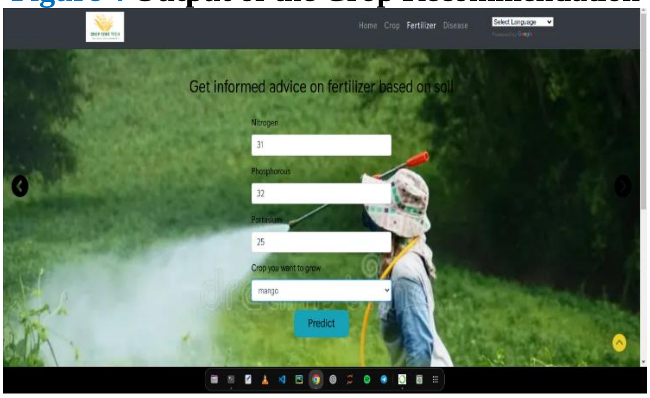

Figure 5 **Fertilizer Recommendation Input Data**

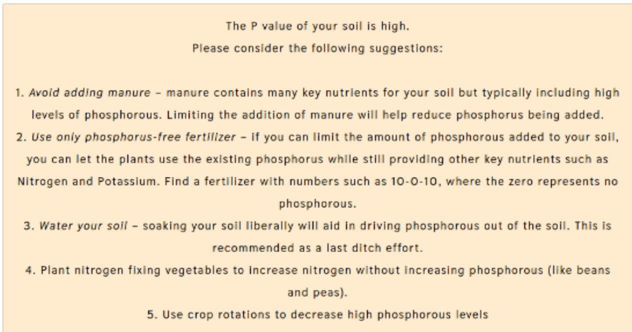

Figure 6 **Output Data of Fertilizer Recommendation**

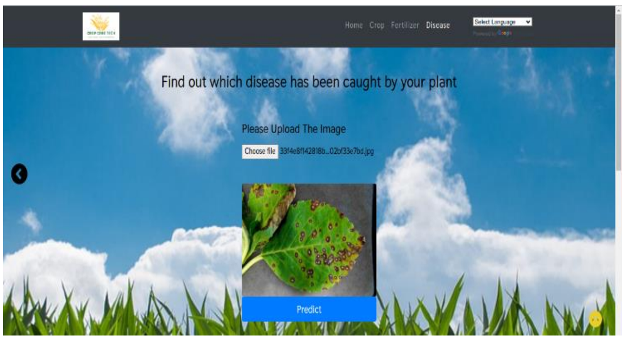

Figure 7 **Diseased Plant Image**

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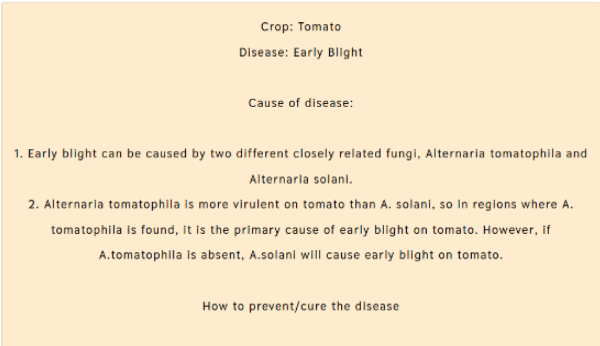

Figure 8 Output of Disease Detection

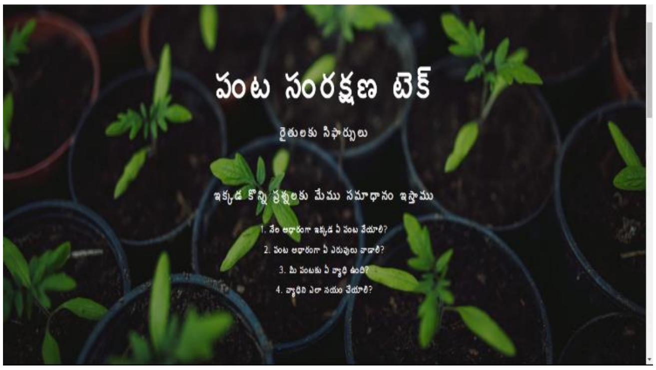

Figure 9 Language Translation of Website

Table 1 Performance of All models

S. No	Models	Performance	Accuracy
1	Decision Tree	93.6%	92.9%
2	GNB	99.5%	98.8%
3	SVM	98.8%	98.4%
4	Logistic regression	96.5%	95.5%
5	Random forest	99.5%	98.8%
6	Xg boost	99.3%	99.1%
7	CNN	98.2%	97.5%

6. Future scope

The future scope of this project is vast and holds the potential for significant advancements in agricultural technology. Here are some key areas for future development:

1. **Enhanced Deep Learning Models:** Integrate more advanced deep learning architectures such as Transformer networks or GANs (Generative Adversarial Networks) to improve the accuracy and robustness of plant disease detection and other image-based tasks.
2. **Integration with IoT Devices:** Incorporate Internet of Things (IoT) sensors for real-time monitoring of soil health, crop growth, and environmental conditions, providing dynamic and up-to-date data for more accurate recommendations.
3. **Expanded Dataset and Multi-Region Support:** Collect and integrate more extensive datasets from various geographical regions to increase the model's applicability and accuracy across different climates and soil types.
4. **Mobile Application Development:** Develop a mobile application to provide farmers with easy access to crop recommendations, fertilizer suggestions, and disease diagnostics, even in remote areas with limited internet connectivity.
5. **AI-Powered Decision Support Systems:** Build AI-powered decision support systems that not only recommend crops and fertilizers but also provide actionable insights and suggestions for pest control, irrigation management, and crop rotation strategies.
6. **Precision Agriculture:** Implement precision agriculture techniques by leveraging satellite imagery and drone technology for more accurate field-level data, enhancing the precision of recommendations and interventions.
7. **Integration with Blockchain:** Use blockchain technology to ensure data security, transparency, and traceability, enhancing the trustworthiness of the recommendations provided to farmers.
8. **Machine Learning Model Interpretability:** Focus on the interpretability of machine learning models to help farmers understand the reasoning behind specific recommendations, fostering greater trust and adoption of the technology.
9. **Collaborative Platforms:** Create collaborative platforms where farmers can share their experiences and feedback, enabling

the continuous improvement of the models and recommendations based on user inputs and real-world application. By pursuing these future developments, the project can significantly enhance its impact, supporting sustainable farming practices, improving crop yields, and ultimately contributing to food security on a global scale.

Conclusion

Farming recommendation systems play a vital role in modern agriculture by leveraging data-driven technology to assist farmers in making informed decisions. These systems utilize a combination of data sources, such as weather patterns, soil conditions, crop types, and historical data, to provide tailored advice on planting, fertilization, pest control, irrigation, and harvesting. The benefits of farming recommendation systems include increased efficiency, higher crop yields, reduced resource wastage, and improved sustainability. Our project exemplifies the effective integration of machine learning and deep learning techniques in developing a comprehensive agricultural support system. By employing algorithms such as XGBoost, Random Forest, and ResNet-9, we achieved high accuracy in crop recommendation, fertilizer suggestion, and plant disease detection. The deployment of these models through a user-friendly web interface, developed using Flask, HTML, CSS, and JavaScript, ensures accessibility and real-time support for farmers. As technology continues to advance, farming recommendation systems are becoming increasingly sophisticated, incorporating machine learning and artificial intelligence to enhance their recommendations. By adopting and integrating such systems into their practices, farmers can boost their productivity and contribute to the overall sustainability of agriculture. It is important to recognize that the effectiveness of these systems may vary based on regional and environmental factors, necessitating customization to local conditions. In the future, the development and adoption of farming recommendation systems will likely continue to evolve, playing a crucial role in addressing the global challenge of feeding a growing population while minimizing the environmental impact of agriculture. These systems will remain valuable tools for farmers, helping them navigate the complexities of modern agriculture and make decisions that are both economically viable and environmentally responsible. By leveraging advanced technology and data-driven insights, we can drive the transformation of agriculture towards greater sustainability and productivity. The performance of All Models are shown in Table 1.

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