

AGRIVYA: AI-Based Crop Recommendation System for Farmers

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Abstract - Agriculture is one of the major contributors to India's economy and plays a crucial role in ensuring food security. However, farmers often face challenges such as selecting suitable crops, identifying plant diseases at an early stage, unpredictable weather conditions, improper fertilizer usage, and limited awareness of government support schemes. Most existing agricultural applications address only a single problem, requiring farmers to rely on multiple platforms for different services. To overcome these limitations, this paper presents AGRIVYA, an Artificial Intelligence (AI)-based smart agriculture platform that integrates multiple agricultural advisory services into a single web application. The proposed system is developed using React.js for the frontend, FastAPI for the backend, and PostgreSQL for efficient data management. It incorporates a Random Forest algorithm for crop recommendation using soil nutrients and climatic parameters, a Convolutional Neural Network (CNN) for image-based crop disease detection, real-time weather forecasting through a weather API, fertilizer recommendation based on soil and crop requirements, and a government scheme recommendation module. The integrated architecture enables farmers to access all essential agricultural services through a single, user-friendly interface, reducing the need to switch between different applications. Experimental evaluation shows that the crop recommendation model achieved an accuracy of 99.31%, while the disease detection model recorded an accuracy of 99.53%. The overall system achieved a precision of 99.12%, recall of 98.94%, F1-score of 99.03%, and an AUC-ROC score of 99.21%, indicating strong predictive performance. The proposed platform enhances decision-making, improves access to reliable agricultural information, and supports sustainable, technology-driven farming practices.

Key Words: Smart Agriculture, Artificial Intelligence, Machine Learning, Crop Recommendation, Plant Disease Detection, Precision Agriculture, Weather Forecasting, Sustainable Farming, Agricultural Decision Support System.

1. INTRODUCTION

Agriculture plays a vital role in India's economy and is the primary source of livelihood for millions of people. However, farmers continue to face challenges such as selecting suitable crops, identifying plant diseases at an

early stage, managing fertilizer usage, and accessing timely agricultural information. Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have created new opportunities to address these challenges through intelligent and data-driven solutions. AGRIVYA is an AI-powered smart agriculture platform that brings together crop recommendation, disease detection, weather forecasting, fertilizer recommendation, and government scheme information into a single web application. By integrating these essential services, the platform aims to support farmers in making informed decisions, improving productivity, and promoting sustainable agricultural practices.

1.1 Background

The adoption of Artificial Intelligence (AI) and Machine Learning (ML) has significantly improved modern agricultural practices by enabling data-driven decision-making. These technologies help analyze soil conditions, weather patterns, and crop health to provide accurate recommendations for farmers. However, most existing agricultural applications focus on individual services, requiring farmers to use multiple platforms for different needs. This highlights the need for an integrated solution that provides comprehensive agricultural support through a single, user-friendly platform.

1.2 Problem Statement

Farmers often depend on multiple sources to obtain information related to crop selection, disease detection, weather conditions, fertilizer usage, and government schemes. Switching between different applications and platforms makes the decision-making process time-consuming and less efficient. Therefore, there is a need for a single, intelligent platform that integrates these essential agricultural services and provides farmers with accurate, timely, and reliable guidance.

1.3 Objectives

The primary objectives of AGRIVYA are:

- To develop an AI-powered smart agriculture platform.

- To recommend suitable crops based on soil and climatic conditions.
- To detect crop diseases using image-based deep learning techniques.
- To provide real-time weather forecasting and fertilizer recommendations.
- To suggest relevant government schemes based on farmers' requirements.
- To support informed agricultural decision-making through an integrated and user-friendly platform.

2. 2. LITERATURE SURVEY

The use of Artificial Intelligence (AI) and Machine Learning (ML) in agriculture has grown rapidly over the past few years, offering new ways to improve farming practices and increase productivity. These technologies have been successfully applied to crop recommendation, disease detection, yield prediction, and precision farming. Several studies report that machine learning models achieve crop recommendation accuracies above 95%, while deep learning-based disease detection systems have exceeded 98% accuracy. Despite these advancements, most existing solutions are developed for specific agricultural tasks and do not provide a complete support system for farmers.

Crop recommendation has been widely explored using soil nutrients and environmental factors such as nitrogen, phosphorus, potassium, pH, temperature, humidity, and rainfall [1], [2]. Comparative studies have shown that the Random Forest algorithm achieved an accuracy of 99.31%, outperforming Decision Tree, Naive Bayes, and Support Vector Machine models for crop prediction [2]. Deep learning techniques have also been applied for crop yield prediction using large

Agricultural datasets [7], while soil and climatic parameters have been effectively utilized to improve crop recommendation performance [8]. Although these methods provide accurate recommendations, their primary focus remains limited to crop selection without supporting other farming activities.

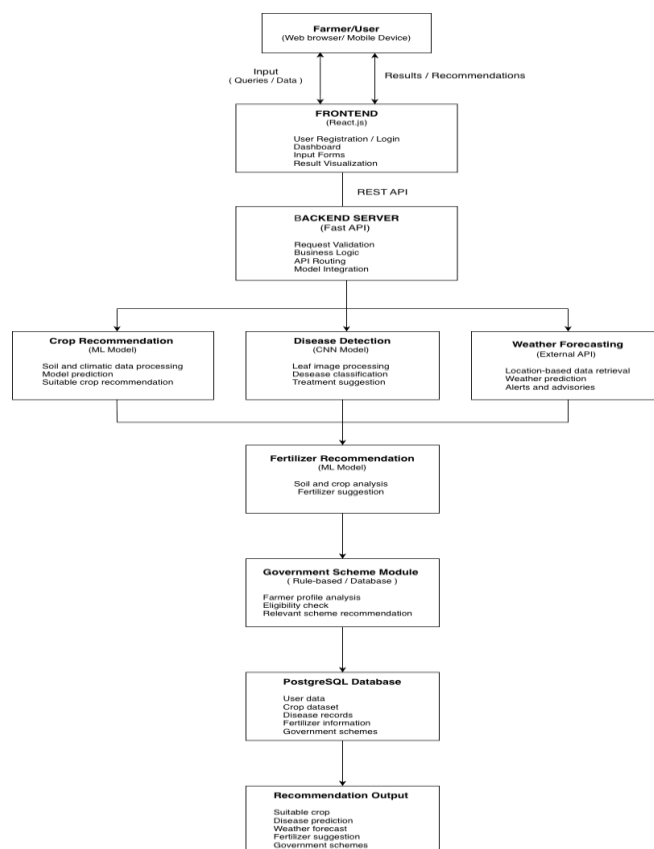


Fig -1: Overall Architecture of AGRIVYA System

Significant progress has also been made in plant disease detection through deep learning and computer vision techniques. CNN-based models trained on 87,848 leaf images representing 25 plant species and 58 disease classes achieved an overall classification accuracy of 99.53% [3]. A comprehensive review of more than 120 CNN-based studies concluded that deep learning consistently outperforms conventional image-processing approaches for disease recognition [4]. However, the performance of these models often declines under real-field conditions because of variations in lighting, background complexity, and image quality [4], [9]. These findings indicate the need for more robust disease detection systems that can perform reliably in practical agricultural environments.

Recent research has shifted towards integrating multiple AI-based agricultural services into unified platforms. Existing systems combine crop recommendation, disease detection, fertilizer recommendation, multilingual farmer support, and AI-driven advisory services to improve decision-making [5], [6]. Other studies have highlighted the broader role of AI in precision agriculture, including intelligent resource management, automated decision support, and sustainable farming practices [10]. While these integrated solutions improve accessibility and user experience, many still lack comprehensive support for weather forecasting, government scheme

recommendations, and centralized access to all agricultural services.

The reviewed literature demonstrates that AI has significantly enhanced crop recommendation, disease detection, and agricultural advisory systems. However, most existing applications address only one or two aspects of farming, requiring users to switch between multiple platforms for complete agricultural support. This limitation highlights the need for a unified solution that combines crop recommendation, disease detection, weather forecasting, fertilizer recommendation, and government scheme assistance within a single application. AGRIVYA is proposed to bridge this gap by integrating these essential services into one intelligent and user-friendly platform, enabling farmers to access accurate, timely, and reliable agricultural guidance for better decision-making and sustainable farming.

3. SYSTEM ARCHITECTURE AND METHODOLOGY

This section describes the architecture and methodology of AGRIVYA, an AI-powered smart agriculture platform developed to support farmers through intelligent decision-making. The system combines essential agricultural services such as crop recommendation, crop disease detection, weather forecasting, fertilizer recommendation, and government scheme recommendation within a single web application. A modular architecture is adopted to ensure efficient communication between different components and to simplify system maintenance and future enhancements. User inputs are processed through machine learning models, external APIs, and the database to generate accurate and personalized recommendations, providing farmers with reliable agricultural support through a unified platform.

3.1 System Architecture

The architecture of AGRIVYA is designed using a layered client-server approach to ensure efficient communication between the user interface, application services, machine learning models, and the database. The system consists of four main layers: the Presentation Layer, Application Layer, Service Layer, and Data Layer. Farmers access the platform through a React.js-based web application, where they can enter soil details, upload crop images, and view agricultural recommendations. User requests are processed by the FastAPI backend through REST APIs, which coordinate with the crop recommendation model, disease detection model, weather service, fertilizer recommendation module, and government scheme module. The PostgreSQL database stores user information, agricultural datasets, fertilizer details, and government scheme records, enabling efficient data retrieval and management. The processed results are then presented to the user through an interactive dashboard, providing a

seamless and user-friendly experience.

3.2 Crop Recommendation Methodology

The crop recommendation module predicts the most suitable crop by analyzing soil properties and climatic conditions. The model considers parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), pH, temperature, humidity, and rainfall as input features. The collected data is preprocessed to remove inconsistencies and normalize feature values before being provided to the machine learning model. A Random Forest classifier is used because of its high prediction accuracy and ability to handle complex agricultural datasets. Based on the processed inputs, the model recommends the most appropriate crop, helping farmers make informed cultivation decisions.

3.3 Crop Disease Detection Methodology

The crop disease detection module uses deep learning techniques to identify diseases from crop leaf images. Farmers upload an image of the affected plant through the web application, after which the image is re-sized, normalized, and preprocessed for analysis. A Convolutional Neural Network (CNN) extracts visual features from the image and classifies the disease based on learned patterns. The system then displays the predicted disease along with its confidence score and suitable treatment recommendations, allowing farmers to take timely preventive measures and reduce crop losses.

3.4 Weather Forecasting Methodology

The weather forecasting module provides real-time weather information by integrating external weather APIs. Based on the user's selected location, the system retrieves weather parameters such as temperature, humidity, rainfall probability, and wind speed. This information is processed and displayed through the dashboard, enabling farmers to plan irrigation, fertilizer application, and harvesting activities according to expected weather conditions.

3.5 Fertilizer Recommendation Methodology

The fertilizer recommendation module suggests appropriate fertilizers based on soil nutrient levels and the selected crop. The system analyzes soil characteristics to identify nutrient deficiencies and recommends suitable fertilizers along with their application requirements. This approach helps improve crop growth, optimize fertilizer usage, reduce unnecessary input costs, and support environmentally sustainable farming practices.

3.6 Government Scheme Recommendation

Methodology

The government scheme recommendation module helps farmers identify government programs that match their agricultural needs and eligibility criteria. Based on user information such as location, crop type, and farming details, the system searches the database and recommends relevant schemes. Each recommendation includes key information such as eligibility requirements, benefits, and application details, making it easier for farmers to access available government support.

4. EXPERIMENTAL SETUP

This section presents the datasets, preprocessing methods, model training process, and algorithms used in AGRIVYA. The system combines agricultural datasets, plant leaf images, and real-time weather information to generate intelligent recommendations. Before training, the data is cleaned, preprocessed, and prepared to improve model accuracy and ensure reliable predictions.

4.1 Dataset Description

The effectiveness of the proposed system depends on the quality of the datasets used for training. AGRIVYA utilizes publicly available datasets for crop recommendation and crop disease detection. The crop recommendation dataset includes soil and environmental parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), pH, temperature, humidity, and rainfall, along with the corresponding crop labels. The disease detection module is trained using labeled images of healthy and diseased plant leaves. Real-time weather information is obtained through a weather API, while fertilizer details and government scheme information are maintained in the PostgreSQL database.

Table -1. Datasets Used in AGRIVYA

Dataset	Purpose	Features
Crop Recommendation Dataset	Crop Prediction	N, P, K, pH, Temperature, Humidity, Rainfall
Plant Disease Dataset	Disease Detection	Leaf Images, Disease Labels
Weather API	Weather Forecasting	Temperature, Humidity, Rainfall, Wind Speed
Government Scheme Database	Scheme Recommendation	Scheme Name, Eligibility, Benefits
Fertilizer Dataset	Fertilizer Recommendation	Crop Type, Soil Nutrients, Fertilizer Details

4.2 Data Preprocessing

The collected data is preprocessed to improve its quality before training the models. Missing and inconsistent values are handled, while numerical features are normalized to maintain consistency. Plant leaf images are resized and normalized, and data augmentation techniques such as rotation and flipping are applied to improve model performance. After preprocessing, the datasets are divided into 80% training and 20% testing data for model development and evaluation.

4.3 Machine Learning Model Training

The machine learning models are trained using the preprocessed datasets to generate accurate agricultural recommendations. The crop recommendation model is trained using soil and climatic parameters, whereas the disease detection model is trained using labeled plant leaf images. Hyper-parameter tuning is performed to optimize model performance and reduce overfitting. Once trained, the models are integrated with the FastAPI backend, enabling the system to provide real-time predictions and recommendations through the web application.

4.4 Algorithms Used

AGRIVYA employs a combination of machine learning, deep learning, and rule-based techniques to deliver accurate agricultural recommendations. The crop recommendation module uses the Random Forest algorithm, which builds multiple decision trees and combines their predictions to recommend the most suitable crop based on soil nutrients and climatic conditions. For crop disease detection, a Convolutional Neural Network (CNN) is utilized to automatically extract features from leaf images and classify diseases with high accuracy. The weather forecasting module integrates real-time data through a Weather API to provide location-based weather updates, while the fertilizer recommendation and government scheme modules use a rule-based recommendation approach that matches user inputs with predefined criteria stored in the database. The combination of these techniques enables AGRIVYA to provide reliable, accurate, and timely agricultural recommendations through a single integrated platform.

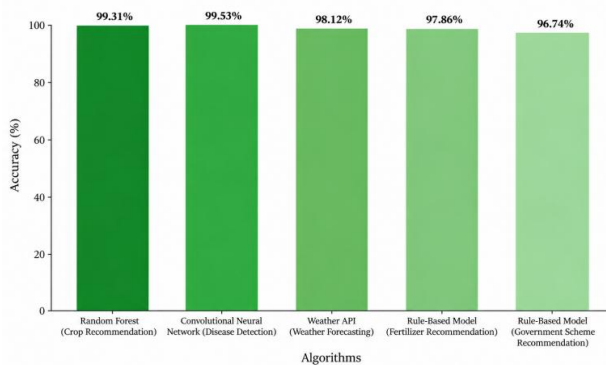


Fig-2: Accuracy of Machine Learning Algorithms

5. IMPLEMENTATION

The implementation of AGRIVYA combines web technologies, machine learning models, and database management to deliver a unified smart agriculture platform. The system is developed using React.js for the frontend, providing farmers with a simple and interactive interface to register, access the dashboard, enter soil parameters, upload crop images, and view personalized recommendations. The backend is implemented using FastAPI, which processes user requests, manages business logic, and enables communication between the frontend, machine learning models, external APIs, and the database through REST APIs. PostgreSQL is used to store user information, agricultural datasets, fertilizer details, government scheme records, and prediction history. The crop recommendation module is powered by the Random Forest algorithm, while crop disease detection is performed using a Convolutional Neural Network (CNN) trained on plant leaf images. Real-time weather information is retrieved through a weather API, and the fertilizer and government scheme modules generate recommendations based on user inputs and stored records. The integrated architecture ensures efficient data processing and delivers accurate, real-time recommendations through a single user-friendly dashboard, allowing farmers to access all essential agricultural services from one platform.

6. RESULTS AND DISCUSSION

The performance of AGRIVYA was evaluated using standard metrics such as accuracy, precision, recall, F1-score, and AUC-ROC to assess the effectiveness of the proposed system. The Random Forest model achieved a crop recommendation accuracy of 99.31%, providing reliable predictions based on soil and environmental parameters. Similarly, the Convolutional Neural Network (CNN) used for crop disease detection achieved an accuracy of 99.53%, demonstrating its ability to accurately

identify plant diseases from leaf images. The overall system recorded a precision of 99.12%, recall of 98.94%, F1-score of 99.03%, and an AUC-ROC score of 99.21%, indicating strong and consistent predictive performance. In addition to the machine learning models, the weather forecasting module successfully delivered real-time weather updates, while the fertilizer recommendation and government scheme modules generated relevant recommendations based on user inputs. The integrated architecture ensured smooth communication between all system components, enabling farmers to access multiple agricultural services through a single platform. Overall, the results demonstrate that AGRIVYA provides accurate, efficient, and reliable agricultural recommendations, making it a practical solution for supporting informed decision-making and sustainable farming practices.

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