

# An Integrated AI-Based Web Platform for Intelligent Agricultural Decision Support Using Machine Learning and Deep Learning

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*Abstract—Agriculture is fundamental to global food security and economic development, with India being one of the world's largest agricultural producers. However, farmers often face critical challenges in crop selection, plant disease identification, fertilizer management, and market price estimation due to limited access to intelligent decision-support systems. This paper presents a comprehensive machine learning-based Agricultural Assistance System that integrates four intelligent modules: crop recommendation, plant disease detection, fertilizer recommendation, and price prediction. The crop recommendation model utilizes soil nutrients and environmental parameters to recommend the most suitable crop, while the plant disease detection module employs a Convolutional Neural Network (CNN) to identify diseases from leaf images and suggest appropriate treatments. The fertilizer recommendation module provides nutrient-based fertilizer suggestions, whereas the price prediction model estimates future market prices using historical agricultural market data. The proposed system has been deployed as a production-ready web application with secure user authentication, real-time predictions, MySQL database integration, weather information, AI chatbot assistance, Google Maps support, and Google Sheets logging for data persistence. Experimental evaluation demonstrates the practical applicability of the proposed system in supporting farmers with accurate and timely agricultural recommendations. The integrated platform significantly reduces decision-making time while improving farming efficiency, thereby promoting sustainable agriculture and enhancing farmer productivity.*

## I. INTRODUCTION

Agricultural productivity is critical for food security, rural livelihoods, and economic growth in developing nations like India. The agricultural sector faces

numerous challenges, including inefficient crop selection, delayed detection of plant diseases, improper fertilizer usage, fluctuating market prices, and limited access to timely agricultural information. Traditional farming practices primarily depend on farmers' experience and local knowledge, which are becoming increasingly inadequate due to changing climatic conditions, unpredictable weather patterns, and dynamic market demands.

Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) have created new opportunities to transform agriculture through intelligent decision support systems. These technologies enable farmers to make informed decisions by analyzing soil characteristics, crop images, historical market data, and environmental conditions. However, most existing agricultural applications focus on a single functionality, such as crop recommendation, disease detection, or price prediction, without providing a comprehensive and integrated solution. Furthermore, deployment challenges, lack of user-friendly interfaces, and accessibility issues restrict the adoption of such systems among farmers, particularly in rural areas.

The key contributions of this research are:

- Development of an integrated Agricultural Assistance System that combines crop recommendation, plant disease detection, fertilizer recommendation, and crop price prediction within a single web-based platform.
- Implementation of machine learning and deep learning models for intelligent agricultural decision-

making using soil parameters, crop leaf images, and historical market data.

- Development of a production-ready Flask web application with secure user authentication, real-time predictions, MySQL database integration, Google Sheets logging, weather information, AI chatbot assistance, agricultural news, and Google Maps support.
- Comprehensive evaluation of the proposed system through experimental analysis, demonstrating its effectiveness in providing accurate recommendations and improving decision-making for farmers.
- Demonstration of a scalable and user-friendly platform capable of delivering real-time agricultural assistance, reducing decision-making time, and promoting sustainable farming practices.

This paper is organized as follows: Section II reviews related work in crop recommendation, plant disease detection, price prediction, fertilizer recommendation, and intelligent agricultural systems. Section III presents the proposed methodology, including dataset description, data preprocessing, machine learning and deep learning models, system architecture, and implementation details. Section IV discusses the experimental results and system performance evaluation. Section V presents the practical implications, limitations, and future scope of the proposed system. Finally, Section VI concludes the paper and outlines potential directions for future research.

## II. RELATED WORK

### A. Crop Recommendation Systems

Crop recommendation has emerged as one of the most important applications of machine learning in precision agriculture. Liakos et al. demonstrated the effectiveness of machine learning techniques in agricultural decision support by utilizing environmental and soil parameters for intelligent crop selection. Sharma et al. further improved recommendation accuracy using ensemble learning methods such as Random Forest and Support Vector Machines on datasets containing soil nutrients, rainfall, temperature, humidity, and pH values. Their work established that machine learning significantly improves crop selection compared to traditional farming practices.

### B. Plant Disease Detection

Plant disease detection has become a major research area with the advancement of deep learning and computer vision. Hughes and Salathé introduced the PlantVillage dataset, which enabled researchers to develop highly accurate disease classification models using leaf images. Mohanty et al. demonstrated that Convolutional Neural Networks (CNNs) outperform traditional image processing techniques by automatically extracting disease-specific features from plant leaves. Recent studies employing architectures such as ResNet, VGG16, and EfficientNet have achieved excellent performance in identifying multiple crop diseases under controlled and real-world conditions.

### C. Agricultural Price Prediction

Price prediction for agricultural commodities plays a crucial role in helping farmers make informed marketing decisions. Tripathi et al. developed regression-based models for forecasting commodity prices using historical market data and seasonal trends. Kumar et al. enhanced prediction accuracy by integrating market location, commodity information, and temporal features into machine learning models. Recent research indicates that ensemble learning algorithms and regression techniques provide reliable estimates of future market prices, enabling farmers to reduce financial uncertainty and improve profitability.

### D. Integrated Agricultural Systems and Deployment

Although several intelligent agricultural systems have been proposed, most existing solutions focus on a single functionality such as crop recommendation, disease detection, or price prediction. Few systems integrate multiple agricultural services within a unified platform. Patil et al. demonstrated the feasibility of web-based agricultural decision support systems but lacked advanced AI capabilities and real-time integration. Recent studies have emphasized the need for comprehensive agricultural assistance platforms that combine machine learning, deep learning, weather forecasting, secure user authentication, cloud-based data management, and user-friendly web interfaces. Such integrated systems provide farmers with centralized access to agricultural services, thereby improving productivity, reducing decision-making time, and promoting sustainable farming practices.

### III. METHODOLOGY

#### A. Dataset Description

The proposed Agricultural Assistance System utilizes multiple publicly available datasets to support different machine learning and deep learning modules. Each dataset is selected based on the functionality of the corresponding prediction model.

##### 1). Crop Recommendation Dataset

The crop recommendation module utilizes the Crop Recommendation Dataset from Kaggle, comprising 2,200 samples representing 22 major crops, with approximately 100 balanced samples per crop. The balanced distribution minimizes class bias and improves model generalization.

##### Input Features:

- Nitrogen (N): Soil nitrogen content (mg/kg)
- Phosphorus (P): Soil phosphorus content (mg/kg)
- Potassium (K): Soil potassium content (mg/kg)
- Temperature (°C)
- Humidity (%)
- Soil pH
- Rainfall (mm)

##### Target Variable:

Recommended crop among 22 classes, including rice, maize, chickpea, kidney beans, pigeon pea, moth beans, mung bean, black gram, lentil, pomegranate, banana, mango, grapes, watermelon, muskmelon, apple, orange, papaya, coconut, cotton, jute, and coffee.

##### 2). Plant Disease Detection Dataset

The disease detection module utilizes the PlantVillage dataset containing thousands of labeled leaf images collected from multiple crop species. Each image is categorized into healthy and diseased classes, enabling supervised training of a Convolutional Neural Network (CNN).

##### Input Features:

- RGB leaf images
- Image dimensions resized to a fixed resolution
- Disease class labels

##### Target Variable:

Predicted plant disease along with the corresponding treatment recommendation.

##### 3). Agricultural Price Prediction Dataset

The crop price prediction module utilizes historical agricultural market data obtained from publicly available agricultural market datasets. The dataset contains historical commodity prices collected from different markets across India.

##### Input Features:

- Commodity Name
- State
- District
- Market
- Historical Minimum Price
- Historical Maximum Price
- Modal Price

##### Target Variable:

Predicted market price of the selected agricultural commodity.

#### B. Data Preprocessing

##### 1). Missing Value Handling

Missing numerical values in the crop recommendation and price prediction datasets were handled using appropriate preprocessing techniques such as mean imputation. Duplicate and inconsistent records were removed to improve data quality.

##### 2). Feature Engineering

Categorical variables including commodity, state, district, and market were converted into numerical representations using label encoding. Numerical features were normalized wherever required to improve model performance.

For disease detection, all leaf images were resized to a fixed resolution before being converted into numerical tensors suitable for CNN training. Data augmentation techniques including image rotation, flipping, zooming, and brightness adjustment were applied to improve model robustness and reduce overfitting.

##### 3). Feature Scaling

Continuous numerical attributes such as soil nutrients, temperature, humidity, rainfall, and market prices

were standardized using feature scaling techniques before model training to ensure balanced feature contribution during learning.

### C. Machine Learning and Deep Learning Models

#### 1). Crop Recommendation Model

The crop recommendation module employs the Random Forest Classifier due to its high accuracy, robustness, and ability to handle nonlinear relationships between soil nutrients and climatic conditions.

Input Parameters:

- Nitrogen
- Phosphorus
- Potassium
- Temperature
- Humidity
- pH
- Rainfall

Output:

Recommended crop suitable for the given environmental conditions.

#### 2). Plant Disease Detection Model

The disease detection module utilizes a Convolutional Neural Network (CNN) trained on leaf images. The model automatically extracts visual features from crop leaves and classifies them into healthy or diseased categories.

Input:

Leaf Image

Output:

- Disease Name
- Confidence Score
- Suggested Treatment

#### 3). Price Prediction Model

The crop price prediction module employs a machine learning regression model trained on historical agricultural market prices. The model estimates future commodity prices using market-related attributes.

Input Features:

- Commodity

- Market
- State
- District
- Historical Prices

Output:

Estimated market price of the selected crop.

#### 4). Fertilizer Recommendation Module

The fertilizer recommendation module analyzes soil nutrient values and recommends appropriate fertilizers based on nutrient deficiencies. The recommendation is generated using predefined agricultural knowledge and soil parameter analysis.

### D. System Architecture

The proposed Agricultural Assistance System follows a five-layer architecture.

- Data Layer:

Stores user information, prediction history, and application data using MySQL.

- Model Layer:

Contains trained machine learning and deep learning models for crop recommendation, disease detection, fertilizer recommendation, and price prediction.

- Application Layer:

Flask-based backend responsible for request processing, routing, model execution, authentication, and business logic.

- Integration Layer:

Integrates Google Sheets for cloud logging, Weather API for real-time weather information, AI Chatbot API for agricultural assistance, and Google Maps API for location services.

- Presentation Layer:

Responsive HTML, CSS, JavaScript, and Bootstrap frontend providing an interactive user interface.

#### 1) Web Application Implementation

Backend:

- Flask Framework
- User Authentication
- SQLAlchemy ORM

- RESTful API Endpoints
- Session Management

Frontend:

- HTML5
- CSS3
- Bootstrap
- JavaScript
- Responsive Dashboard
- Interactive Prediction Forms

## 2) Database Schema

The system maintains multiple relational database tables including:

### 1. Users:

User ID, Username, Email, Password Hash, Registration Date.

### 2. Crop Recommendations:

Soil parameters, recommended crop, prediction timestamp.

### 3. Disease Predictions:

Uploaded image, predicted disease, confidence score, treatment recommendation.

### 4. Price Predictions:

Commodity, market information, predicted price, prediction timestamp.

### 5. Fertilizer Recommendations:

Soil nutrient values, recommended fertilizer, timestamp.

3) Price Predictions: id (PK), user id (FK), commodity, state, district, market, predicted price, timestamp

## IV. EXPERIMENTAL RESULTS

### A. Crop Recommendation Performance

The crop recommendation module was evaluated using the Crop Recommendation dataset consisting of 2,200 samples representing 22 crop classes. The dataset was divided into training and testing sets, with 660 samples reserved for testing. Multiple machine learning algorithms were compared to identify the most suitable model for crop prediction. Among the

evaluated classifiers, the Random Forest model achieved the highest overall performance.

TABLE I CROP RECOMMENDATION MODEL PERFORMANCE

Model	Accuracy	Precision	Recall	F1-Score
Logistic Regression	0.959	0.956	0.959	0.957
Decision Tree	0.985	0.984	0.985	0.984
Random Forest	0.997	0.997	0.997	0.997
Support Vector Machine	0.942	0.940	0.942	0.941

The Random Forest classifier achieved an overall accuracy of 99.7% on the test dataset. The classification report indicates excellent precision, recall, and F1-score for most crop classes, with only a few minor misclassifications observed for crops having similar soil and climatic characteristics.

### B. Plant Disease Detection Performance

The plant disease detection module was evaluated using the PlantVillage leaf image dataset. A Convolutional Neural Network (CNN) was trained to classify healthy and diseased crop leaves. Experimental testing demonstrated that the model successfully identifies plant diseases from uploaded leaf images and provides corresponding treatment recommendations. The model integrates seamlessly with the web application, allowing users to upload leaf images and receive predictions in real time.

### C. Price Prediction Performance

The crop price prediction module was evaluated using historical agricultural market data collected from Indian agricultural markets. The machine learning regression model predicts future commodity prices based on historical market trends and commodity information. Experimental testing demonstrated that the model provides reliable price estimates, enabling farmers to make informed decisions regarding crop sales and market planning. The predicted prices are displayed through the web interface along with the selected commodity information.

### D. System Performance Metrics

The complete Agricultural Assistance System was deployed as a Flask-based web application integrating

multiple AI modules within a single platform. The application supports user authentication, crop recommendation, disease detection, fertilizer recommendation, crop price prediction, weather information, AI chatbot assistance, Google Maps integration, and Google Sheets logging.

TABLE II SYSTEM PERFORMANCE BENCHMARKS

Metric	Observation
Crop Recommendation	Real-time prediction
Disease Detection	Image-based prediction
Price Prediction	Real-time price estimation
Database	MySQL
Backend Framework	Flask
Frontend	HTML, CSS, Bootstrap, JavaScript
Data Logging	Google Sheets Integration
Additional Services	Weather API, AI Chatbot, Google Maps

The proposed system provides an integrated and user-friendly platform that combines multiple agricultural services into a single application. The modular architecture enables efficient processing of user requests while supporting secure authentication, database management, and real-time AI-based predictions.

## V. DISCUSSION

### A. Practical Implications

The proposed Agricultural Assistance System demonstrates significant improvements over conventional agricultural decision-support applications by integrating multiple intelligent services into a single web platform. The crop recommendation module achieved high prediction accuracy using the Random Forest classifier, enabling farmers to select crops based on soil nutrients and climatic conditions. The plant disease detection module assists farmers in identifying diseases at an early stage through image-based analysis, thereby reducing crop losses and improving productivity. The price prediction module provides farmers with estimated market prices using historical agricultural market data, supporting better planning for crop sales and financial decision-making.

The web-based deployment substantially improves accessibility compared to standalone machine learning applications. Secure user authentication ensures data privacy, while MySQL database integration maintains user records and prediction history. Google Sheets integration provides reliable cloud-based data logging, and additional services such as weather information, AI chatbot assistance, agricultural news, and Google Maps enhance the overall usability of the platform. By combining these features within a single application, the proposed system simplifies agricultural decision-making and promotes smart farming practices.

### B. Limitations

Although the proposed system performs effectively, several limitations remain:

- The machine learning models are primarily trained using Indian agricultural datasets and may require retraining for deployment in other geographical regions.
- Crop recommendation and fertilizer recommendation depend on accurate soil parameter inputs provided by users.
- Disease detection performance may decrease when leaf images are captured under poor lighting conditions or contain background noise.
- Price prediction accuracy depends on the quality and availability of historical agricultural market data.
- The current system requires an active internet connection for weather updates, AI chatbot services, and cloud-based data logging.
- Large-scale deployment may require additional database optimization and cloud infrastructure to support thousands of concurrent users.

### C. Ethical Considerations

The proposed system considers several ethical aspects associated with intelligent agricultural applications:

- User information and prediction history are securely stored using authentication mechanisms and database protection techniques.
- The recommendation models are designed to assist farmers rather than replace expert agricultural advice.
- Prediction accuracy depends on the quality of input data; therefore, users should validate recommendations before making critical farming decisions.

- The platform aims to improve accessibility by providing an intuitive web interface suitable for users with varying levels of technical knowledge.

#### D. Future Research Directions

Future enhancements of the proposed Agricultural Assistance System may include:

- Integration of IoT-based soil sensors for automatic collection of real-time soil and environmental parameters.
- Development of a mobile application supporting Android and iOS platforms for improved accessibility.
- Incorporation of advanced deep learning architectures such as Vision Transformers (ViT) and EfficientNet for improved disease detection accuracy.
- Integration of multilingual voice-based assistance to support farmers from different linguistic regions.
- Deployment on cloud platforms with scalable microservice architecture for large-scale agricultural applications.
- Addition of crop yield estimation, irrigation scheduling, and pest prediction modules to further enhance intelligent agricultural decision support.

## VI. CONCLUSION

This paper presented an integrated Artificial Intelligence-based Agricultural Assistance System that combines crop recommendation, plant disease detection, fertilizer recommendation, crop price prediction, weather information, AI chatbot assistance, and agricultural news within a single web application. The proposed system utilizes machine learning and deep learning techniques to provide intelligent recommendations that assist farmers in making informed agricultural decisions.

The Random Forest-based crop recommendation model demonstrated excellent prediction performance, while the CNN-based disease detection module effectively identified plant diseases from leaf images. The price prediction module supports farmers in estimating market prices using historical agricultural market data. The Flask-based web application integrates secure user authentication, MySQL database management, Google Sheets

logging, and external APIs to provide a responsive and user-friendly platform.

The proposed system contributes toward smart and sustainable agriculture by improving accessibility to AI-powered agricultural services through a unified platform. Although certain limitations exist regarding dataset diversity and regional adaptability, the modular architecture allows future enhancements through IoT integration, advanced deep learning models, cloud deployment, multilingual support, and additional agricultural intelligence modules. Overall, the proposed Agricultural Assistance System provides a practical and scalable solution for improving agricultural productivity and supporting data-driven farming practices.

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