AI-Based AgriTech Web Application for Smart and Sustainable Agriculture

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Abstract—Global agriculture faces increasing challenges from climate variability, crop diseases, soil degradation, and inefficient resource utilization, which significantly affect productivity and sustainability, particularly for small and marginal farmers. This paper presents AgriTech, an integrated AI-based web application designed to support smart and sustainable agricultural practices through data-driven decision-making.

The system integrates AI and machine learning techniques, including crop recommendation using soil and climatic parameters, convolutional neural network (CNN)-based plant disease detection, and crop yield prediction. Additional features, such as real-time weather advisory, digital marketplace integration, government scheme information, and a collaborative farmer community forum, enhance usability.

Experimental evaluation demonstrates robust performance, achieving crop recommendation accuracy of 99.55%, disease detection accuracy of 92.3%, and a yield prediction RMSE of 0.47 t/ha. These results indicate that AgriTech can effectively assist farmers in improving productivity, reducing risk, and adopting sustainable agricultural practices.

Keywords: *Smart Agriculture, Artificial Intelligence, Deep Learning, Crop Recommendation, Disease Detection, Yield Prediction, Precision Agriculture, AgriTech Platform*

1. INTRODUCTION

Agriculture is vital for food security and economic stability, especially in developing countries. Modern farming faces challenges such as unpredictable weather patterns, crop diseases, declining soil fertility, and limited access to expert guidance. Traditional practices, relying on experience and manual observation, are often insufficient to address these complexities.

Recent advancements in AI, ML, and web technologies provide solutions for transforming traditional agriculture. AI systems can analyze large volumes of soil, climate, and historical crop data to generate accurate recommendations. Web-based platforms enhance accessibility, enabling farmers to utilize these technologies through internet-enabled devices.

Most existing AI-based solutions focus on isolated functionalities like crop recommendation or disease detection, limiting real-world impact. This research addresses the gap by proposing a unified, farmer-centric AI platform integrating multiple intelligent services into a single web-based system.

Key contributions:

- Development of an integrated AI-based web platform for agricultural decision support.
- Implementation of optimized machine learning and deep learning models.
- Design of a user-friendly, mobile-first interface suitable for rural users.
- Evaluation using real-world agricultural datasets.
- Scalable and modular architecture supporting future enhancements.

2. PROBLEM DEFINITION

Farmers face challenges such as climate uncertainty, crop diseases, low productivity, insufficient expert guidance, and lack of real-time information. Existing digital solutions are fragmented and fail to provide comprehensive agricultural support. An **integrated AI-powered system** is needed to enable informed decision-making, improve yield, and enhance resource efficiency sustainably.

3. PROPOSED SOLUTION

Agri-Tech is a web-based AI-powered platform designed to provide comprehensive agricultural assistance through the following features:

i. AI-based crop recommendation using soil nutrients and climatic data
ii. Crop yield prediction and risk analysis
iii. CNN-based plant disease detection through image processing
iv. Real-time weather advisory and soil-related insights
v. Digital marketplace and price analytics
vi. Farmer community forum and AI chatbot support
vii. Farm dashboard for monitoring costs, profits, and crop cycles

The platform emphasizes accessibility, usability, and scalability, making it suitable for small and marginal farmers. It is designed to support future multilingual expansion and integration with emerging technologies.

4. LITERATURE REVIEW

Several studies have explored AI, ML, and IoT applications in agriculture, focusing on crop recommendation, disease detection, yield prediction, and digital advisory systems. Key works include:

1. Patel, R., Ghosh, S., & Mehta, K. (2018). "AI-Based Crop Recommendation Systems." This study explains how machine learning algorithms analyze soil nutrients, temperature, and rainfall to recommend suitable crops, highlighting how data-driven decisions improve productivity and reduce risk [1].
2. Sharma, L., Singh, V., & Rao, P. (2019). "Automated Plant Disease Detection Using Image Processing." This research focuses on detecting plant diseases using leaf images, demonstrating how CNN-based models enable early intervention [2].
3. Thomas, M., Lee, J., & Parker, C. (2020). "Smart Farming and IoT-Based Agricultural Platforms." This paper discusses IoT-enabled systems that collect real-time data, showing how smart tools enhance decision-making and farm efficiency [3].
4. Banerjee, A., Kumar, T., & Raj, H. (2020). "Predictive Analytics for Crop Yield Estimation." This study illustrates how machine learning models predict crop yield, supporting the use of predictive tools for resource planning [4].
5. Verma, S., Nair, K., & Deshmukh, P. (2021). "Digital Advisory Systems for Farmers." This review highlights the importance of digital platforms in providing guidance on crops, fertilizers, pest control, and government schemes [5].
6. Hoffman, J., Brown, L., & Wilson, D. (2021). "Role of Big Data in Modern Agriculture." This study shows how big data analytics supports large-scale farming decisions by identifying trends and performance patterns [6].
7. Singh, P., Mishra, A., & Gupta, Y. (2022). "AI-Driven Decision Support Systems in Agriculture." This research explores unified AI platforms that combine crop advice, soil testing, yield prediction, and disease alerts [7].

5. METHODOLOGY

A. System Architecture

AgriTech uses a modular microservices architecture separating frontend, backend, AI/ML models, and database layers for scalability and maintainability.

B. Data Collection and Preprocessing

- **Soil and Crop Data:** ICAR datasets
- **Plant Disease Images:** PlantVillage dataset
- **Yield Data:** Ministry of Agriculture, India
- **Market Data:** APMC commodity price datasets

Data preprocessing includes normalization, handling missing values, and image data augmentation to improve model generalization.

C. AI/ML Model Development

1. **Crop Recommendation:** An ensemble model combining Random Forest, XGBoost, and a Neural Network using soil nutrients (NPK), pH, temperature, humidity, and season.

2. **Plant Disease Detection:** A MobileNetV2- based CNN using transfer learning for efficient

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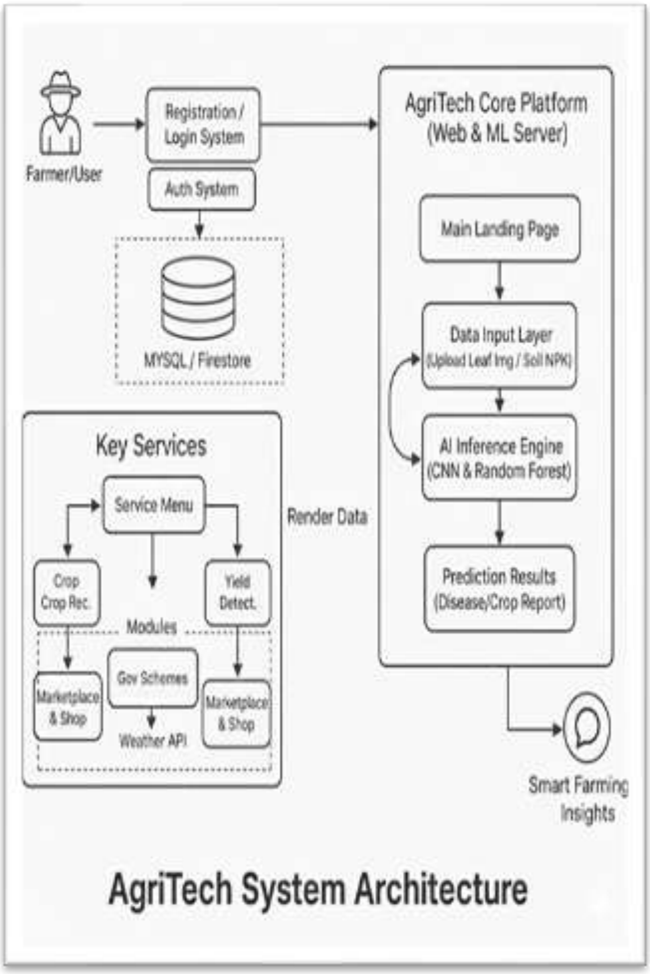
4. **Yield Prediction:** A hybrid model combining LSTM and Gradient Boosting regression for temporal yield forecasting.

D. Technology Stack

- **Frontend:** HTML5, CSS3 (Bootstrap), JavaScript
- **Backend:** Python (Flask)
- **Machine Learning:** TensorFlow/Keras, Scikit-learn, XGBoost
- **Database:** SQL-based relational database
- **Security:** Firebase authentication and input validation



Fig, 1. Architecture of AgriTech System

6. RESULTS

A. Plant Disease Detection Module

The Plant Disease Detection Module uses a **Convolutional Neural Network (CNN)** to detect diseases from leaf images. Farmers can upload photos of affected plants, and the system predicts the disease type along with confidence scores and recommended treatment plans. This early detection helps **prevent crop losses and improve disease management**.

The CNN model was trained on a dataset of 17,572 images across 38 classes. Validation results and sample predictions indicate **high accuracy and effective generalization**, ensuring reliable disease identification for various crops.

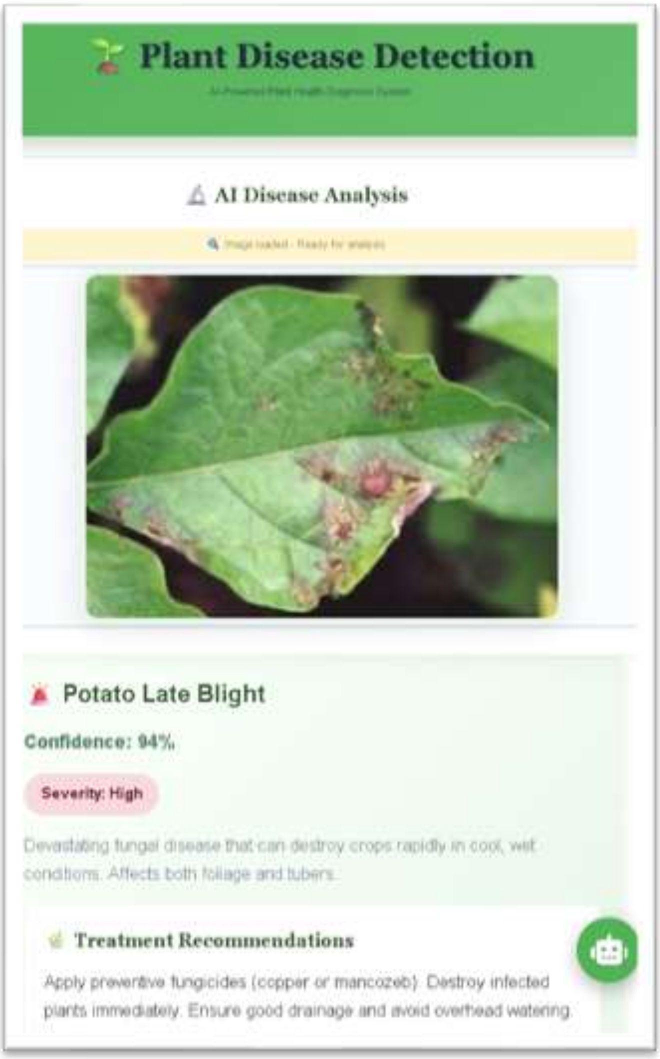


Fig. 2. Plant Disease Detection Module

B. Crop Recommendation Module

The Crop Recommendation Module provides **AI-driven suggestions** for suitable crops based on environmental and soil parameters (N, P, K, pH, temperature, humidity, and rainfall). Using machine learning algorithms such as Random Forest, the system delivers **confidence-based recommendations**. Visual aids like charts and progress bars make the output **easily interpretable**, helping farmers optimize yield and sustainability.

Among multiple algorithms tested, **Random Forest achieved the highest accuracy (99.55%)**, outperforming Decision Tree, SVM, Logistic Regression, XGBoost, and KNN, demonstrating its **stability and reliability for crop prediction**.

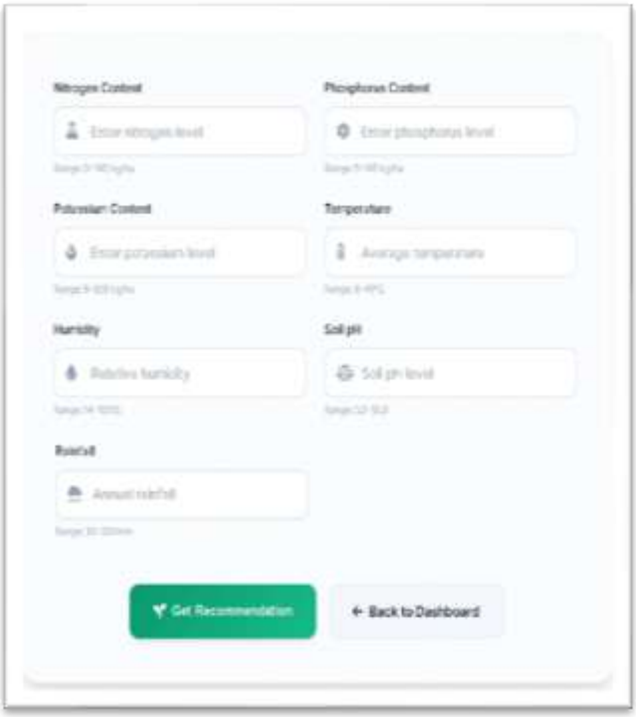


Fig. 3. Crop Recommendation Module

C. Crop Planner AI

The Crop Planner AI is an AI-powered tool that analyzes key farm parameters—including soil pH, temperature, rainfall, soil type, season, market demand, fertilizer type, pest issues, and irrigation method—to generate a comprehensive, customized farming plan. The system processes these inputs to recommend optimal crops, provide a planting calendar, and estimate resource requirements and expected profitability. By clicking "Get Full Farming Plan," users receive a complete roadmap for efficient and data-driven farm management, facilitating better decision-making and maximizing yield potential.

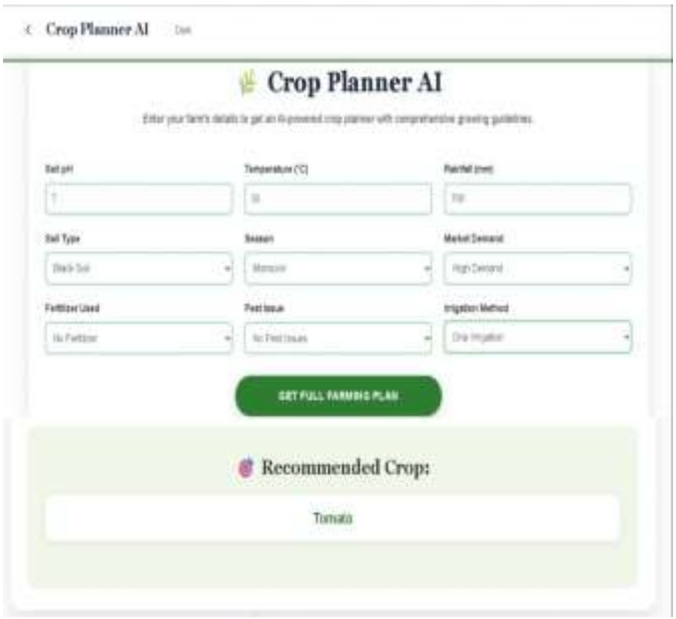


Figure 4. Crop Planner AI Interface

D. Marketplace Platform

The Marketplace Platform connects farmers directly with buyers, retailers, and shopkeepers, enabling **transparent and fair transactions**. Features include inventory management, order placement, search filters, and secure messaging.

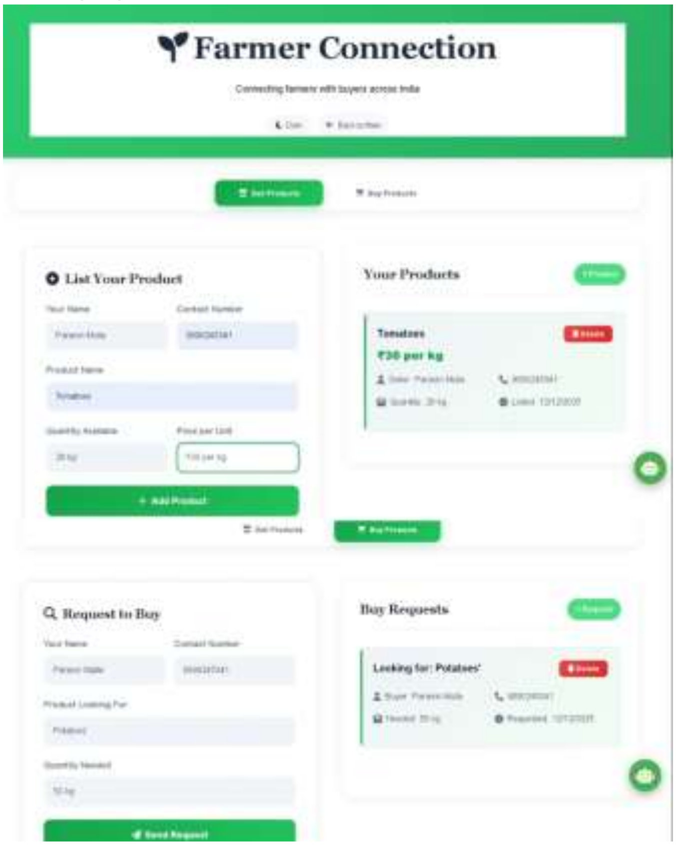


Figure 5.Marketplace Platform Interface

E. Community Forum

The Community Forum enables farmers, agronomists, and experts to **share knowledge and resolve challenges collaboratively**. Users can post questions, upload images, discuss market trends, and exchange best practices, fostering **peer-to-peer learning and networking**

Fig. 6. Community Forum Interface

F. Labour Scheduling and Alerts

The Labour Scheduling module modernizes the **hiring and management of agricultural labor**. Farmers can post requirements specifying work type, dates, location, and wages. The system connects labor supply with demand efficiently, **reducing operational delays and improving productivity**.

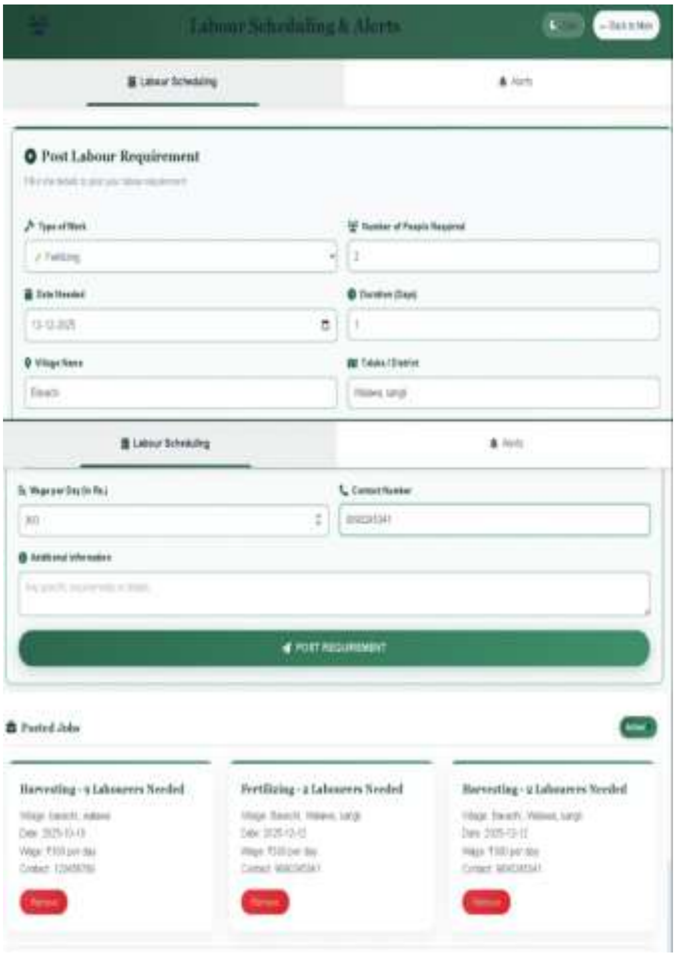


Fig. 7. Labour Scheduling and Alert

G. Model Performance Analysis

The system demonstrates **strong performance** across its key AI modules, as summarized in Table

Table -1: Performance Evaluation of AI Models

Module	Metric	Value
Crop Recommendation	Accuracy	99.55%
Disease Detection	Accuracy	92.3%
Yield Prediction	RMSE	0.47 t/ha

Crop Recommendation: Among the algorithms tested, **Random Forest** outperformed others with an accuracy of **99.55%** across diverse crop types (Fig. 3). Its robust and consistent performance ensures **reliable crop selection** for practical agricultural decision-making.

Plant Disease Detection: The **CNN-based model** achieved high training and validation accuracy while maintaining low loss values .The use of **transfer learning and data augmentation** enhanced generalization across varied plant images. Sample predictions confirmed the system's ability to **accurately classify plant diseases**, enabling early interventions and improved crop management.

Yield Prediction: The results indicate that **hybrid temporal models** are effective for agricultural forecasting, providing reliable estimates of expected crop yield.

Overall, the integrated performance of these modules demonstrates the **effectiveness and practicality of the AI-powered AgriTech platform**, supporting **sustainable farming, precision agriculture, and informed decision-making**.

7. CONCLUSIONS

Agri-Tech presents an integrated AI-powered web platform for smart and sustainable agriculture. By combining crop recommendation, disease detection, and yield prediction with marketplace and community features, the system provides comprehensive support for farmers. Experimental results demonstrate reliable performance and practical applicability. Future enhancements include IoT sensor integration, mobile application development, multilingual expansion, and blockchain-based supply chain transparency.

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BIOGRAPHIES

Shweta J. Patil is a Professor in the Department of Computer Science & Engineering at Nanasaheb Mahadik College of Engineering, Peth, Sangli. Her research interests include artificial intelligence, machine learning, and smart agricultural systems. She has guided multiple undergraduate projects and actively contributes to academic research and innovation activities.