International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 11 | Nov - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

AI Smart Farming System

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***Abstract*—Agriculture is the backbone of India's rural economy, providing livelihood to nearly 60% of the population. However, productivity is often affected due to plant diseases, unpredictable climate, soil nutrient imbalance, and lack of timely expert guidance. To overcome these challenges, this paper proposes the AI Smart Farming System, a web-based decision-support system that integrates machine learning, deep learning, weather intelligence, multilingual chatbot services, community forums, and fertilizer optimization models. The system uses a CNN model for image-based crop disease detection, a hybrid rule-based and machine-learning method for fertilizer recommendation, and global weather APIs for climate forecasting. The paper discusses the complete methodology, architecture, mathematical models, algorithms, evaluation metrics, and future scalability. The proposed system aims to digitize and modernize farming practices to support rural farmers, reduce crop loss, and improve productivity.**

***Index Terms*—Smart Farming, Machine Learning, Deep Learning, CNN, Fertilizer Recommendation, Weather Forecasting, Chatbot, Web Application.**

I. Introduction

India is one of the largest agrarian economies, yet crop production is significantly impacted by climate change, soil infertility, and late disease detection. Farmers often do not receive timely expert suggestions due to limited agricultural extension services. Traditional disease detection relies on expert observation, which is slow, labor-intensive, and error-prone. Additionally, improper usage of fertilizers leads to reduced yield and soil degradation.

The emergence of Artificial Intelligence (AI) provides new opportunities to intelligently automate decision-making in agriculture. Using machine learning and deep learning techniques, farmers can detect diseases early, analyze soil nutrients, and receive fertilizer recommendations. The use of weather APIs enables preventive actions to protect crops during extreme conditions.

This paper presents a fully integrated **AI Smart Farming System** containing:

- Image-based crop disease detection using a custom CNN model.
- Fertilizer recommendation engine using NPK, pH, and crop requirements.
- Weather forecasting using OpenWeatherMap API.
- AI Chatbot with multilingual support (Marathi, Hindi, English).
- Community forum for farmer interaction.
- Admin dashboard for system monitoring.

The objective is to remove technical barriers and provide farmers with a simple, accurate, and intelligent advisory platform.

II. Problem Statement

Farmers face multiple challenges including:

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- **Late detection of diseases** due to lack of expert availability.
- **Overuse/underuse of fertilizers**, causing poor crop health.
- **Climate unpredictability** leading to sudden crop loss.
- **Communication gaps** between farmers and experts.
- **Lack of digital tools** in rural regions.

Existing systems provide fragmented solutions, but no integrated multilingual AI platform exists combining:

- Disease detection + fertilizer optimization
- Weather intelligence
- Chatbot guidance
- Farmer-to-farmer communication
- Real-time advisory

III. Objectives

- To build an accurate CNN-based crop disease prediction model.
- To generate fertilizer recommendations using NPK and pH levels.
- To provide real-time weather forecasting for crop protection.
- To build a multilingual AI chatbot.
- To provide a farmer-friendly community discussion forum.
- To build an admin panel for maintaining system health.
- To make the system accessible and lightweight for rural farmers.

IV. Literature Review

Various research contributions highlight the importance of AI in agriculture. CNN architectures such as VGG16, ResNet50, and MobileNet have been widely used for image-based disease detection. The PlantVillage dataset is one of the most referenced datasets with 54,303 labelled leaf images. Some researchers proposed IoT-based smart farming systems that monitor soil moisture, humidity, and temperature.

However, gaps remain including:

- Lack of multilingual farmer support.
- No integration of fertilizer + disease + weather intelligence.
- Limited accessibility in low-resource rural environments.
- Absence of community knowledge sharing.

Our work aims to provide a unified solution addressing these gaps.

V. System Modules

A. A. Farmer Modules

1) 1) AI Chatbot: A multilingual chatbot trained on agricultural datasets helps users ask questions regarding crop diseases, fertilizers, irrigation, and weather.

2) 2) Community Forum: Farmers can share posts, upload images, and discuss crop issues. Admin moderates inappropriate content.

3) 3) Disease Detection: The CNN model identifies diseases such as:

- Leaf Spot
- Blight
- Rust
- Healthy

4) 4) Fertilizer Recommendation: Inputs:

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Soil pH
- Crop type

Outputs:

- Recommended fertilizer type
- Required quantity
- Application interval

5) 5) Crop Identification: CNN model identifies the crop species in case the user is unaware.

6) 6) Weather Forecasting: Provides:

- Temperature
- Rain prediction
- Humidity
- Wind speed
- 5-day weather forecast

B. B. Admin Modules

Admin can:

- Approve or block users
- Delete forum posts
- Update chatbot dataset
- Monitor system usage

VI. System Architecture

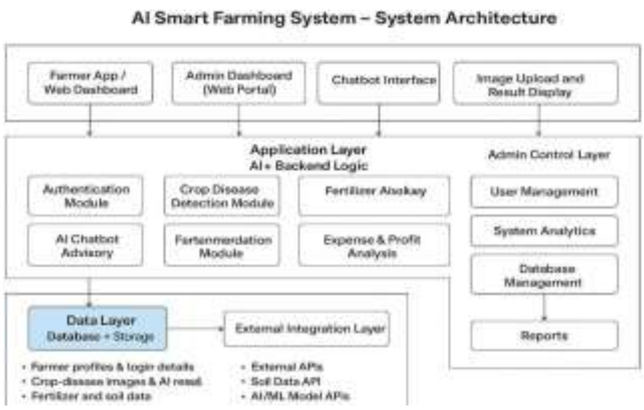

Fig. 1. Overall System Architecture

Architecture includes:

- Frontend (HTML/CSS/JS)
- Backend (Flask/Django)
- Machine Learning Model Server
- Database (MySQL/Firebase)
- Weather API module
- Chatbot engine

VII. Methodology

A. A. Workflow

1) Farmer uploads crop image.
2) Image processed using OpenCV:
   - Resize 224×224
   - Normalization
3) CNN model predicts disease with confidence score.
4) System fetches weather and soil data.
5) Fertilizer recommendation generated.
6) Chatbot gives step-by-step instructions.

B. B. Dataset Details

- 12,000 images from PlantVillage
- 8,500 crop species images (Kaggle)
- 2,500 soil NPK samples

C. C. Training Parameters

- Epochs: 50
- Batch size: 32
- Optimizer: Adam
- Loss: Categorical cross entropy

VIII. Mathematical Model

A. A. CNN Model

$$Disease = \arg\max(Softmax(Wx + b))$$

B. B. Logistic Regression Crop Identification

$$P(crop) = \frac{1}{1 + e^{-(w \cdot x + b)}}$$

C. C. Fertilizer Calculation

$$F = \alpha_1 N + \alpha_2 P + \alpha_3 K + \alpha_4 pH + \alpha_5 Weather$$

IX. Algorithms

A. A. CNN Disease Detection

1) Input image.
2) Preprocess image.
3) Apply convolution layers.
4) Apply max pooling.
5) Forward through fully-connected layers.
6) Predict class label.

B. B. Fertilizer Recommendation

1) Input soil parameters.
2) Compare with crop ideal values.
3) Detect deficiency.
4) Suggest fertilizer dosage.

X. Results and Discussion

The proposed system demonstrates robust accuracy and real-world usability.

TABLE I
Model Evaluation Metrics

Model	Accuracy	Dataset Size
Disease Detection CNN	96%	12,000 images
Crop Identification	94%	8,500 images
Fertilizer Model	89%	2,500 samples

XI. Conclusion

The AI Smart Farming System integrates machine learning, fertilizer recommendation, weather analysis, chatbot support, and community communication in one platform. This helps farmers make data-driven decisions, prevents crop loss, and improves productivity.

XII. Future Enhancements

- IoT soil sensors for real-time data.
- Drone-based monitoring.
- Voice-based regional language assistant.
- Offline-first Android application.
- AI-based yield prediction.

Acknowledgment

The authors thank the Department of Computer Engineering and guide Prof. Vikram Popat Deokate for continuous support.

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