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Predictive Analysis of Crop Suitability Using Machine Learning

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Abstract: *Agriculture plays a vital role in the Indian economy, but farmers often face challenges such as improper crop selection, inefficient fertilizer usage, plant diseases, and limited market access. To address these issues, this project proposes AgriSmart, a web-based agricultural advisory system that integrates Machine Learning (ML) and Deep Learning (DL) techniques to support farmers in making informed decisions.The system is developed using the Django web framework and provides four major services: Crop Prediction, Fertilizer Recommendation, Leaf Disease Detection, and an Agricultural E-Marketplace. Crop prediction is performed using a Gaussian Naive Bayes classifier, which recommends suitable crops based on soil nutrients (N, P, K), temperature, humidity, pH, and rainfall. Fertilizer recommendation is also implemented using a Naive Bayes model to suggest the most appropriate fertilizer for soil conditions. For disease detection, a VGG19-based Convolutional Neural Network (CNN) is employed to identify diseases from leaf images across 38 disease classes..*

Keywords: Agriculture, Machine Learning, Deep Learning, Crop Prediction, Fertilizer Recommendation, Plant Disease Detection, VGG19, Naive Bayes, Django, E-Marketplace, Smart Farming

I. INTRODUCTION

Agriculture plays a vital role in the Indian economy, contributing significantly to the country's GDP and providing employment to a large portion of the population. However, farmers face several challenges such as improper crop selection, inefficient fertilizer usage, plant diseases, and limited access to profitable markets. These issuesoften result in low crop productivity and economic losses.

With the advancement of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL), it is possible to provide intelligent solutions to agricultural problems. Machine learning models can analyze soil and climate conditions to recommend suitable crops and fertilizers, while deep learning techniques can identify plant diseases from leaf images with high accuracy.

The proposed system, AgriSmart – A Web-Based Smart Crop Prediction and Agricultural Advisory System, integrates Crop Prediction, Fertilizer Recommendation, Leaf Disease Detection, and an Agricultural E-Marketplace into a single platform. Developed using the Django framework, the system is accessible through any web browser and does not require additional software installation.

The main objective of the project is to help farmers make informed decisions, reduce crop losses, improve productivity, and increase income by providing accurate agricultural recommendations and direct market access.

II. PROBLEMSTATEMENT

Farmers face challenges in crop selection, fertilizer usage, disease detection, and marketing their produce. These issues often lead to low crop yield and reduced income. The proposed system uses Machine Learning and Deep Learning to

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provide crop recommendations, fertilizer suggestions, disease detection, and direct market access through an E-Marketplace.

III. OBJECTIVES

- To recommend suitable crops based on soil and climate conditions.
- To provide accurate fertilizer recommendations for improving soil fertility and crop yield.
- To detect and identify plant diseases at an early stage using deep learning techniques.
- Create a digital marketplace that enables direct interaction between farmers and buyers.
- To integrate modern Machine Learning and Deep Learning models into a web-based agricultural advisory platform.

IV. SCOPE

The scope of this project extends across different stages of agriculture, from crop planning to crop marketing. The system helps farmers select the most suitable crop based on soil nutrients and environmental conditions, ensuring better productivity and resource utilization. It also provides fertilizer recommendations to improve soil health and optimize crop growth.

The project includes a disease detection module that uses deep learning techniques to identify plant diseases from leaf images and suggest preventive measures. An integrated E-Marketplace allows farmers to directly connect with buyers, reducing dependency on intermediaries and improving profit margins.

In addition, the system provides useful agricultural information such as government schemes, crop insurance details, agricultural loans, and the latest farming news. Being a web-based application, it can be accessed from any device with an internet connection, making advanced agricultural advisory services easily available to farmers.

V. LITERATURE SURVEY

SrNo.	Title	Author(s)	Year	Description
1	Crop Recommendation System Using Machine Learning	S. Patel, R. Mehta, A. Joshi, N. Verma	2024	Developed a crop recommendation system using multiple ML algorithms. Gaussian Naive Bayes achieved the highest accuracy (97.5%) using soil nutrients and climate parameters.
2	Plant Leaf Disease Detection Using Deep Convolutional Neural Networks	A. Mohanty, D. Hughes, M. Salathé	2024	Applied transfer learning models such as VGG16, VGG19, ResNet50, and DenseNet121 on the PlantVillage dataset for plant disease detection. VGG19 achieved 91.2% accuracy.
3	Fertilizer Recommendation System Using Machine Learning and Soil Analysis	R. Sharma, K. Gupta, P. Singh, V. Mishra	2023	Proposed a Random Forest-based fertilizer recommendation model using soil and environmental parameters. The model achieved 96.1% accuracy.
4	Transfer Learning with VGG19 for Agricultural Crop Disease Classification	T. Zhang, L. Chen, M. Wang, H. Liu	2023	Investigated VGG19 transfer learning for classifying 38 plant disease categories. Fine-tuned VGG19 achieved 93.8% classification accuracy.
5	Smart Agriculture: IoT and Machine Learning Integration for Crop Yield Prediction	M. Kumar, S. Yadav, N. Verma, P. Agarwal	2023	Combined IoT sensors with machine learning models for crop prediction. Real-time sensor data improved prediction accuracy to 96.3%.

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VI. METHODOLOGY

The proposed system consists of a combination of Machine Learning (ML) and the Internet of Things (IoT) enabling data-driven decisions across the agricultural domain through predictive analytics. The investigation progresses through five key steps:

Data Acquisition:

The process of collecting multisource data: Soil Composition (NPK, pH, moisture), Weather (temperature, rain, humidity), and Crop Yield from IoT sensors, satellites, and other open agricultural data.

Data Preprocessing:

The collected data is curated, normalized, and transformed using a number of statistical and correlation methods to remove elements of noise and missing values from the raw data.

Model Development:

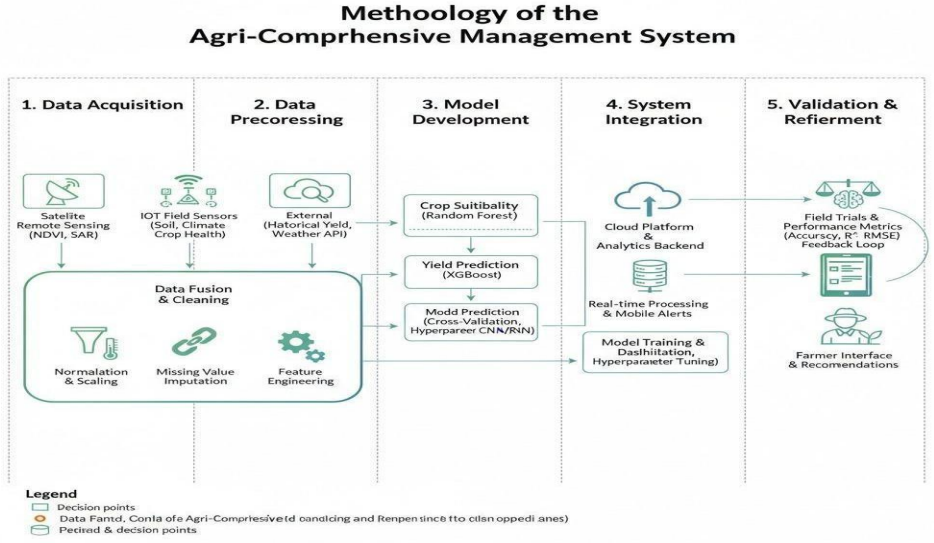
Trained algorithms of Machine Learning (ML) such as Random Forest, XGboost, and Artificial neural networks (ANN) create an intelligent prediction model predicting for crop suitability, irrigation, and yield from an agri management system. Hyperparameter tuning and cross validation evaluate model accuracy and generalize the model prediction.

System Integration:

After the models are trained, they are integrated to a cloud-based Agri Management System with IoT devices, allowing real-time monitoring, visualization, and automated decision support.

Validation and Testing:

The system predictions were validated with field trials and performance metrics (Accuracy, RMSE, R^2). engineering.



VII. MODELING AND ANALYSIS

1. Data Acquisition the first step involves collecting agricultural data from reliable sources. The dataset contains soil nutrients (Nitrogen, Phosphorous, Potassium), temperature, humidity, soil pH, and rainfall values along with the corresponding crop labels.

2. Data preparation - the collected data is cleaned to remove missing values, duplicate records, and inconsistencies. The dataset is then normalized and organized into a structured format. This preprocessing step ensures data quality and improves the performance of the machine learning model.

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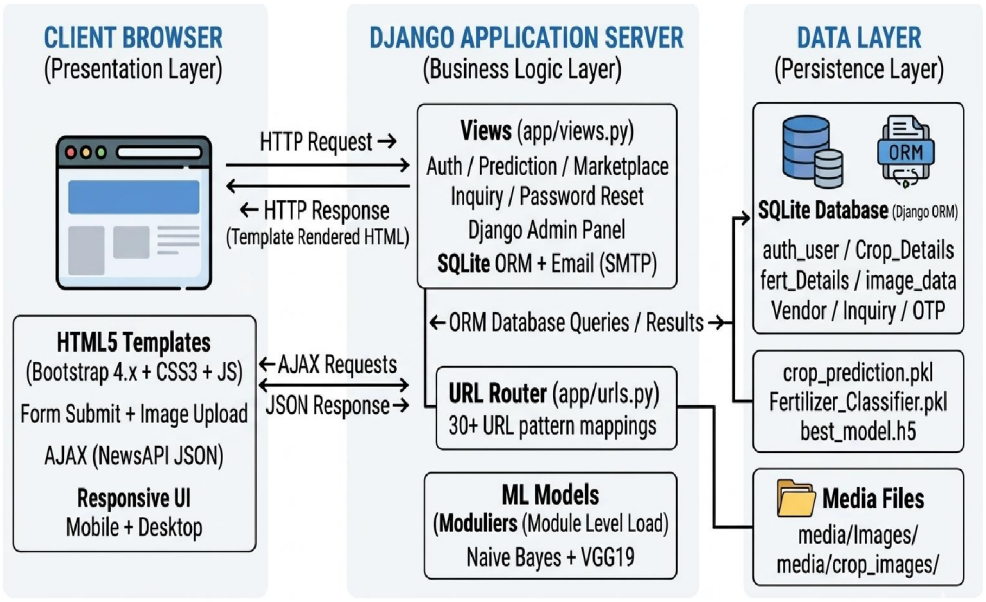
3. Data integration - all relevant soil and climatic parameters are combined into a single dataset. This integrated dataset provides a complete representation of environmental conditions required for accurate crop suitability prediction..
4. Machine learning model - the prepared dataset is fed into the Gaussian Naive Bayes (GNB) algorithm. The model learns the relationship between soil properties, climatic factors, and suitable crops. During training, it calculates the probability distribution of each crop category based on the input features.
5. Crop Suitability Prediction - when a farmer enters soil nutrient values, temperature, humidity, pH, and rainfall data, the trained model analyzes the inputs and predicts the most suitable crop. The crop with the highest probability score is selected as the final recommendation.
6. Decision Support System - The predicted crop recommendation is presented to the farmer through the web-based interface. This helps farmers make informed decisions regarding crop selection, leading to improved productivity and efficient resource utilization..

VIII. SYSTEM ARCHITECTURE



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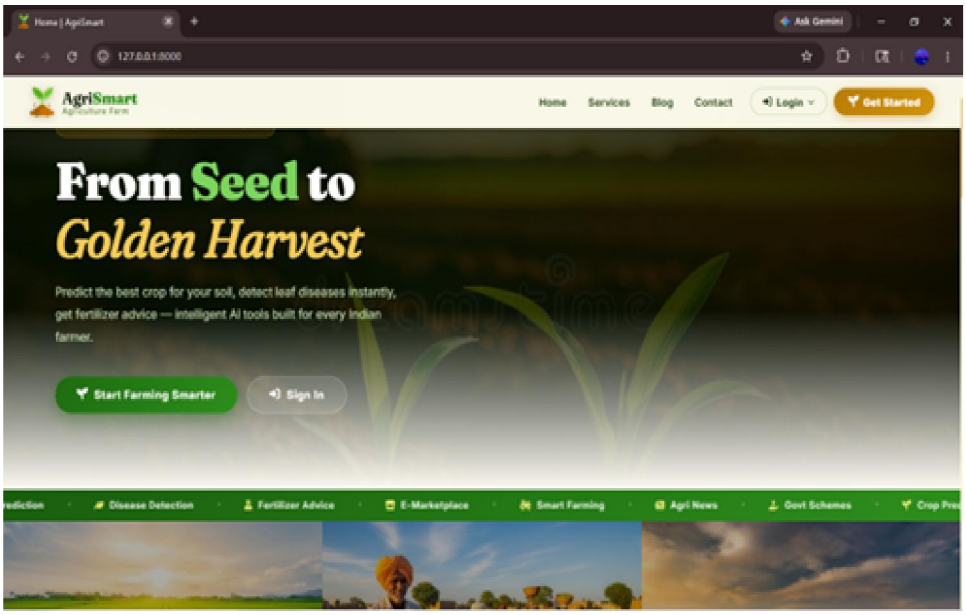
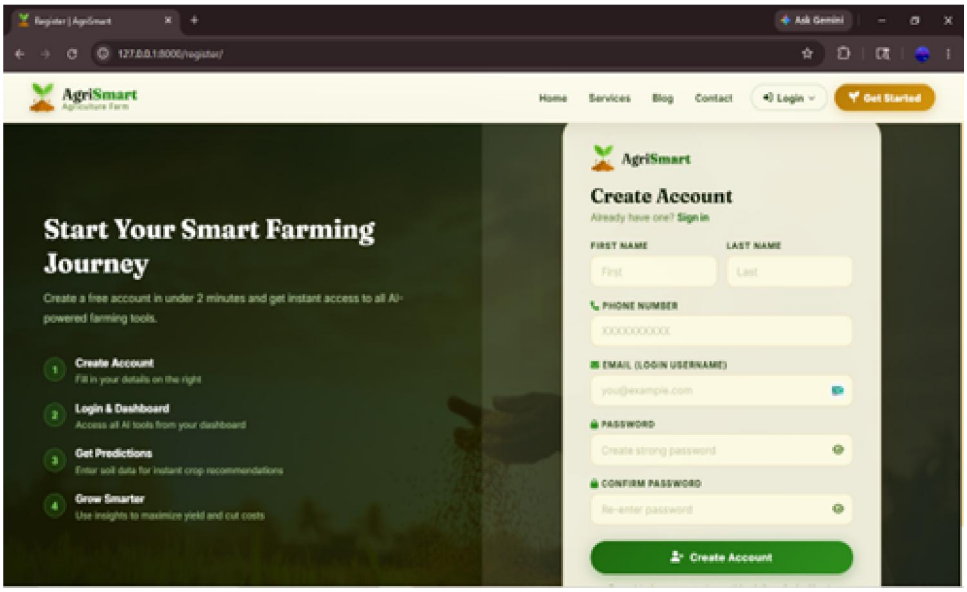
IX. RESULT AND DISCUSSION





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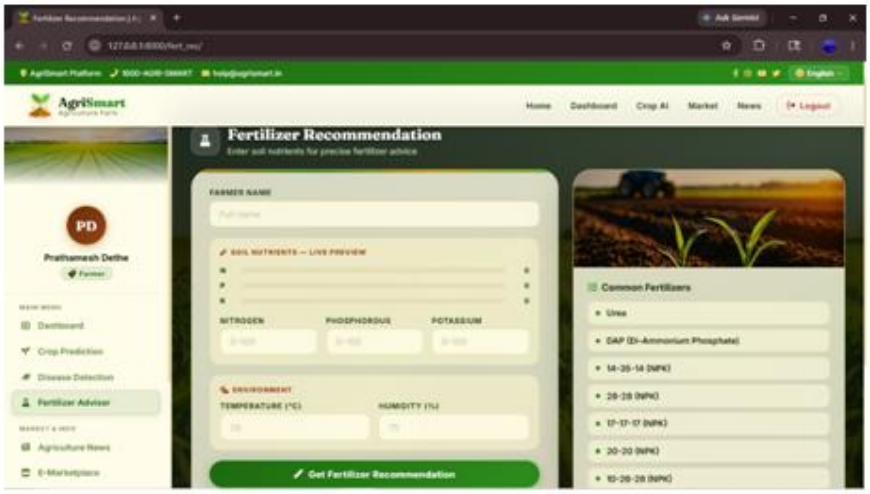

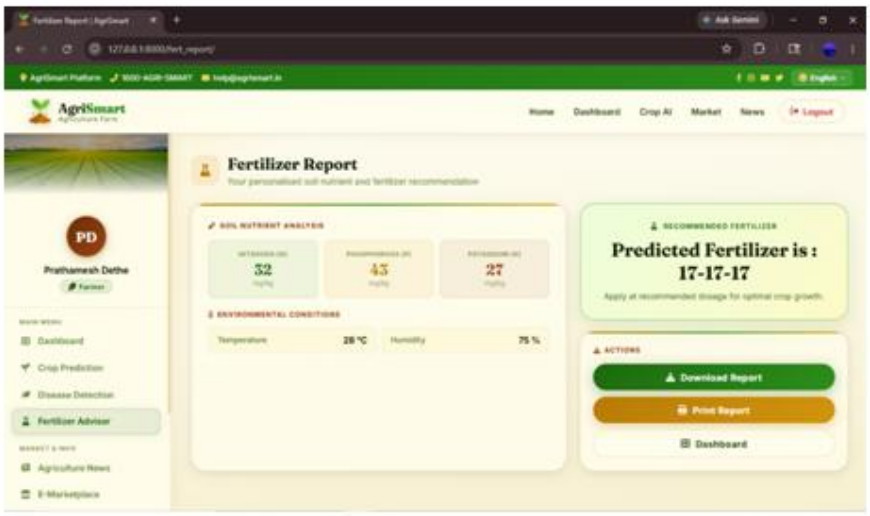

X. CONCLUSION

The systems integrates Machine Learning and Deep Learning technologies to support modern agriculture. The system provides accurate crop recommendations, fertilizer suggestions, and plant disease detection, helping farmers make informed decisions and improve crop productivity.

The integrated E-Marketplace enables direct interaction between farmers and buyers, reducing the role of intermediaries and increasing farmers' profits. Additional services such as agricultural news, government schemes, insurance guidance, and loan information make the platform a comprehensive agricultural support system.

Overall, the project demonstrates how advanced technologies can be effectively applied in agriculture to reduce crop losses, improve farming efficiency, and enhance farmers' income. The system serves as a practical and user-friendly solution for promoting smart and sustainable farming practices.

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