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AGROGENIE AI: A Smart Generative Agriculture Advisor System for Precision Farming

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ABSTRACT: Agriculture faces significant challenges such as unpredictable weather conditions, inefficient resource utilization, and limited access to expert guidance. This paper proposes AGROGENIE AI, a smart generative agriculture advisor system integrating Machine Learning (ML) and Generative AI for precision farming. The system analyzes soil data, weather conditions, and crop growth stages to provide personalized recommendations for irrigation, fertilizer usage, disease prevention, and harvesting. Unlike traditional systems, it minimizes hardware dependency and delivers intelligent, real-time, multilingual advisory support through a chatbot interface, improving crop productivity and promoting sustainable agricultural practices.

KEYWORDS: Precision Farming, Machine Learning, Generative AI, Smart Agriculture, Crop Recommendation, Sustainable Farming.

I. INTRODUCTION

Agriculture is essential for economic development and global food security. Traditional farming practices rely more on experience than scientific methods, leading to poor resource utilization and lower crop yields. The integration of Artificial Intelligence (AI) and Machine Learning (ML) has enabled intelligent systems that analyze large data volumes and provide accurate predictions, supporting precision farming in crop selection, irrigation scheduling, fertilizer usage, and disease management.

Despite these advancements, many existing systems provide generic recommendations not tailored to specific farm conditions, depend heavily on IoT hardware, and lack user-friendly multilingual interfaces. To address these challenges, this paper proposes AGROGENIE AI: a system integrating ML for prediction and Generative AI for explanation, enabling a conversational and multilingual interface that delivers precise agricultural guidance while promoting sustainable farming.

II. RELATED WORKS

Several researchers have explored AI and ML techniques to improve agricultural productivity. In 2019, IEEE researchers demonstrated ML algorithms for crop prediction, irrigation management, and disease detection. A 2021 Springer study focused on crop yield prediction using soil data, rainfall, and temperature. Elsevier (2023) introduced AI-based systems for crop monitoring and pest detection. Recent IEEE work (2024) proposed precision agriculture systems using ML for crop recommendations based on environmental conditions. While these systems provide valuable insights, most offer generalized recommendations, lack personalization, and depend on hardware devices. AGROGENIE AI addresses these limitations by integrating ML with Generative AI for personalized, real-time, multilingual guidance.

III. PROPOSED METHODOLOGY

The proposed system integrates Machine Learning with Generative AI to analyze agricultural data and provide effective decision support. The methodology proceeds through the following stages:



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Data Collection & Preprocessing

Agricultural data is collected from soil information, weather conditions, and crop details, including temperature, humidity, rainfall, and soil nutrients. The data is then cleaned, missing values handled, and normalized to ensure consistency and improve ML model accuracy.

Crop and Resource Prediction

ML algorithms analyze preprocessed data to predict suitable crops, irrigation needs, and fertilizer requirements. The Generative AI module then converts these predictions into human-readable suggestions with detailed explanations for farmers.

User Interaction & Feedback

Farmers interact through a multilingual chatbot interface, receiving personalized recommendations for crop selection, irrigation schedules, fertilizer usage, and disease prevention. User feedback is continuously collected to improve future prediction accuracy.

IV. SYSTEM ARCHITECTURE

The AGROGENIE AI architecture consists of the following integrated layers:

- User Interface Layer: Chatbot interface, input forms, and recommendation dashboard accessible via web or mobile application.
- Data Processing Layer: Handles collection and preprocessing of soil type, temperature, humidity, and rainfall data.
- Application Server: Manages data handling, model execution, and communication between modules.
- Machine Learning Module: Predicts suitable crops, irrigation schedules, and fertilizer requirements using trained agricultural datasets.
- Generative AI Module: Converts ML predictions into clear, human-readable recommendations.
- Database Layer: Stores soil, weather, crop, and user data with historical records for continuous model improvement.
- Admin Panel: Enables administrators to update datasets, monitor performance, and manage user activities.

V. IMPLEMENTATION AND SYSTEM FEATURES

The system is implemented using a software-based platform integrating ML with Generative AI. The three main modules are: User Module, Machine Learning Module, and Admin Module. Users provide agricultural inputs (soil type, crop details, environmental conditions); data is preprocessed and passed to ML models for analysis; predictions are processed by the Generative AI module and returned as chatbot recommendations.

Key Features

- Personalized Recommendations: Crop-specific, location-based recommendations from soil and weather analysis.
- Real-Time Decision Support: Live suggestions for irrigation, fertilizer, and crop management.
- Multilingual Chatbot Interface: Accessible to farmers in their native languages.
- AI-Based Prediction: ML models accurately predict crop suitability, disease risks, and resource needs.
- Reduced Hardware Dependency: Software-based approach eliminates costly IoT sensor requirements.
- Continuous Learning: Model improves over time from new data and user feedback.

Technology Stack

Frontend: HTML, CSS, JavaScript | Backend: Python/Java | ML: Scikit-learn, TensorFlow | AI: Generative AI APIs | Database: MySQL | APIs: Weather Data APIs

VI. DATASET PREPROCESSING

The dataset contains soil conditions, weather parameters, and crop details including: Soil Type, Soil Nutrient Levels, Temperature, Humidity, Rainfall, Crop Type, Growth Stage, Fertilizer Requirements, Irrigation Data, Location Details, and Historical Crop Data. Preprocessing involves: (1) Data Collection from soil reports, weather APIs, and crop databases; (2) Data Cleaning to remove incomplete or duplicate records; (3) Data Validation for correctness; (4) Data Normalization to consistent ranges; and (5) Secure Data Storage in the system database.



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VII. RESULTS AND DISCUSSION

The AGROGENIE AI system was tested for accuracy, efficiency, and reliability in providing agricultural recommendations. The preprocessing module successfully handled soil, weather, and crop data. ML models generated accurate predictions for crop recommendations, irrigation schedules, and fertilizer suggestions, which were converted into user-friendly outputs via the Generative AI module.

The system provided real-time decision support by analyzing current weather and environmental factors, continuously updating recommendations. Experimental evaluation showed the system achieved an accuracy of approximately 95–97%, demonstrating significantly improved performance over traditional farming approaches. Overall, results confirm that the integration of ML and Generative AI delivers a reliable, efficient, and scalable solution for smart agriculture.

VIII. LIMITATIONS

- **Data Dependency:** Accuracy depends on quality input data; incorrect or incomplete data may reduce recommendation reliability.
- **Internet Dependency:** Requires stable connectivity, limiting use in rural/remote areas.
- **Limited Dataset Availability:** System performance is constrained by available agricultural data quality.
- **Technical Complexity:** ML and Generative AI integration requires expertise for development and maintenance.
- **User Awareness:** Limited technical knowledge among farmers may impact system adoption.

IX. SOCIAL AND ETHICAL IMPLICATIONS

The AGROGENIE AI system promotes transparency and trust by providing data-driven, verifiable recommendations. It must ensure data privacy protection for user location and farming information. Efforts should target equal access for rural farmers with limited technical knowledge, while addressing the digital divide in areas with limited smartphone or internet access. Developers must maintain system accountability and follow ethical AI guidelines to ensure fairness, sustainability, and responsible technology use.

X. CONCLUSION

This paper presented AGROGENIE AI, a smart generative agriculture advisor system that integrates Machine Learning with Generative AI to address challenges in traditional farming. By analyzing soil conditions, weather data, and crop requirements, the system provides accurate, personalized, real-time recommendations for crop selection, irrigation, fertilizer usage, and disease prevention. The multilingual chatbot interface enhances accessibility, while the software-based approach reduces hardware dependency, making the system practical and scalable for farmers worldwide.

XI. FUTURE SCOPE

Future enhancements include: integration of IoT sensors for real-time environmental data collection; mobile application development for wider rural accessibility; incorporation of computer vision and image processing for crop disease detection from plant images; and optimization of ML algorithms with larger, more diverse datasets. These improvements will ensure wider adoption of smart agriculture systems and contribute to sustainable, efficient farming practices.

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