AgroConnect: A Farmer-Centric Platform for Data-Driven Agriculture

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Abstract- Agriculture remains the backbone of the Indian economy, employing over half of the population. Despite its significance, the sector faces several persistent and emerging challenges, including unpredictable weather conditions, diminishing soil fertility, improper fertilizer application, and a lack of timely expert guidance. These issues contribute to low yields, high input costs, and post-harvest losses. In response to these challenges, AgroConnect—a smart agriculture platform—has been developed using the Internet of Things (IoT) and Artificial Intelligence (AI). AgroConnect integrates real-time soil sensing devices with machine learning (ML) models to deliver intelligent, personalized recommendations and predictions related to crop selection, yield estimation, fertilizer usage, and market trends. It also features an AI-powered chatbot for 24/7 farming assistance and supports Telegram-based PDF report delivery for ease of access in rural areas. Unlike many existing systems, AgroConnect combines real-time and predictive analytics in a unified, user-friendly web platform. This paper outlines the technical architecture, methodologies, and results of implementing AgroConnect, demonstrating its value as a scalable and sustainable solution for modern agricultural practices.

Keywords- Smart Agriculture, Crop Recommendation, Yield Prediction, AI Chatbot, Sustainable Farming

INTRODUCTION

Agriculture has long played a foundational role in the development of civilizations and continues to be one of the most critical sectors for ensuring global food security and rural employment. In India, where over 50% of the population is directly or indirectly involved in agriculture, the sector is essential not just for food supply but also for economic stability. However, farmers face growing challenges such as erratic rainfall, changing climate patterns, poor soil health, rising input costs, market volatility, and limited access to timely, accurate agronomic advice. Traditional methods often rely on inherited knowledge and static recommendations that do not account for the variability of local conditions.

In this context, there is an urgent need for data-driven, scalable, and accessible technologies that empower farmers to make informed decisions. Smart agriculture—also known as precision farming—offers a compelling solution through the integration of data science, AI, IoT, cloud computing, and remote sensing. AgroConnect was conceived as a comprehensive, intelligent platform that addresses these challenges holistically. It serves as a digital assistant for farmers by combining multiple modules such as crop recommendation based on real-time soil data, yield prediction using ML regressors, AI-driven fertilizer advice, dynamic market price forecasting, and a 24/7 Agri-chatbot. The system ensures cross-module data reuse and automates delivery of results in PDF format through Telegram, making it suitable even for users with minimal digital literacy.

LITERATURE SURVEY

Over the past decade, several studies have explored the potential of smart farming through AI and IoT. M.S. Farooq et al. (2023) discussed the integration of IoT in conventional farming to improve productivity and resource efficiency. Chlingaryan et al. (2022) developed a real-time cloud-enabled crop monitoring platform, particularly useful for indoor plantations. Friha et al. (2021) conducted a survey highlighting how IoT, drones, and blockchain are revolutionizing agriculture through real-time data and precision analytics. A. Tripathy et al. (2021) emphasized the need for AI integration in IoT platforms for weather forecasting and pest detection.

However, most of the existing solutions address isolated agricultural problems—such as irrigation or disease detection—and lack an integrated decision-support system. Jagruti Sahoo and Kristin Barrett (2021) examined the global adoption of IoT, noting

that developing countries face barriers like infrastructure and affordability. Crop recommendation models, often using Random Forest and SVM classifiers, have shown promising results in suggesting optimal crops based on soil parameters. Yield prediction has also been explored using techniques like Gradient Boosting and CNNs, showing high accuracy when large historical datasets are available. AI chatbots, though still in early stages, offer promising applications in delivering expert advice round-the-clock, especially when trained on region-specific knowledge bases. AgroConnect builds upon these foundations by combining all such functionalities into a single, modular platform optimized for Indian conditions and smallholder farmers.

METHODOLOGY

AgroConnect's development followed a modular and iterative approach to integrate real-time IoT data with predictive ML models and an intuitive user interface. The first step involved requirement analysis through farmer interviews and a review of existing agri-tech platforms. A clear gap was identified: most available tools were fragmented and failed to offer integrated solutions. The goal, therefore, was to create a unified platform with modules for crop suggestion, yield estimation, fertilizer advice, price forecasting, and chatbot interaction.

Data was collected from reliable public sources such as Kaggle, Indian agri-portals, and FAO databases. Datasets included soil parameters (N, P, K, pH), environmental data (temperature, humidity), historical crop yields, and market price trends. The data underwent preprocessing involving normalization, outlier removal, and feature encoding. ML models were then developed: Random Forest for classification (crop recommendation), Gradient Boosting Regressor for yield estimation, Decision Tree for fertilizer suggestion, and LSTM for time-series price forecasting. Each model was trained using scikit-learn or TensorFlow libraries, evaluated on standard metrics like RMSE and R^2, and saved using pickle for real-time use.

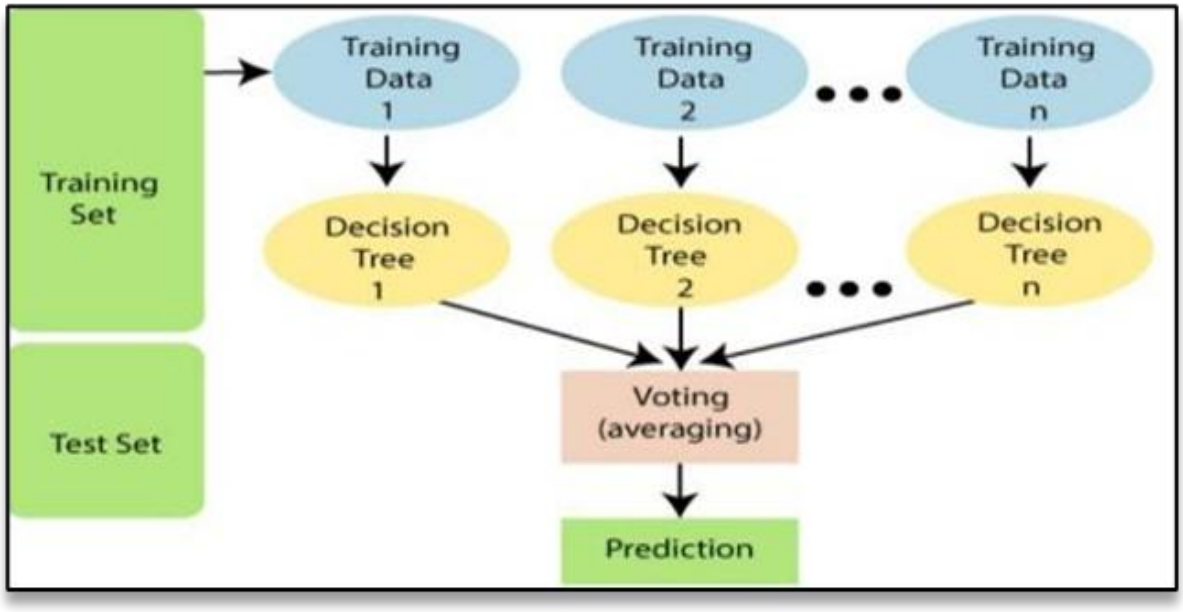


Figure 3.1. Random Forest

The platform's backend was developed in Flask (Python), while the frontend used HTML5, Bootstrap, and JavaScript. IoT integration was achieved using an ESP32 microcontroller connected to NPK and soil moisture sensors. These devices transmitted real-time data to cloud platforms like ThingSpeak. A 2x16 LCD displayed live readings, and the data could be auto-filled into the web platform for analysis. The AI-powered chatbot was developed using rule-based logic, with future enhancements planned using Dialog flow or OpenAI APIs. All predictions were compiled into professional PDF reports using pdf and sent to users through the Telegram Bot API.

EXISTING SYSTEM

The current agricultural systems and platforms are largely fragmented and offer limited functionalities,

focusing only on specific tasks such as weather updates, basic crop calendars, or static fertilizer guidelines. These tools often lack integration and fail to provide personalized recommendations based on real-time data. Users are required to switch between multiple platforms to access insights on soil health, crop suitability, fertilizer needs, and market prices, leading to inefficient workflows and repeated data entry. Moreover, most existing systems do not utilize machine learning or IoT for dynamic and predictive analytics, nor do they offer AI-powered chatbot support or seamless communication via platforms like Telegram. The absence of automated documentation and real-time sensor input restricts their effectiveness, especially in rural regions where accessibility and usability are critical. These limitations highlight the pressing need for a unified and intelligent agricultural advisory system.

PROPOSED SYSTEM

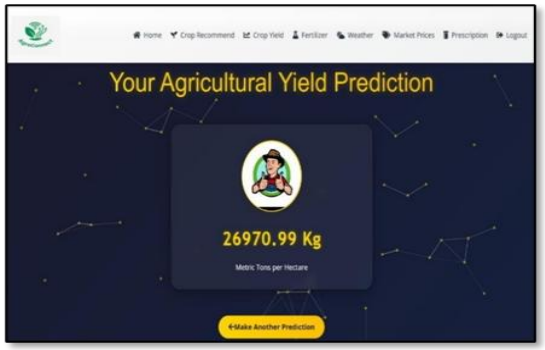
The proposed system, AgroConnect, is a comprehensive smart farming platform that addresses the shortcomings of existing systems by integrating multiple AI-powered modules into a single, user-friendly web interface. It offers functionalities such as crop recommendation, yield prediction, fertilizer suggestions, market price forecasting, and a 24/7 AI chatbot, all driven by machine learning and real-time IoT data. Unlike traditional tools, AgroConnect enables cross-functional data sharing, where soil data entered once can be reused across different modules. The backend, built using Flask and Python, interfaces with trained models for real-time predictions, and results are delivered as downloadable PDF reports through Telegram for convenient access. The platform supports real-time soil monitoring via an ESP32 microcontroller integrated with NPK and moisture sensors, and displays this data both locally and on the web. Its modular design ensures scalability, allowing future enhancements like multilingual support, voice input, and mobile app deployment. AgroConnect stands out for its intelligent integration, predictive capabilities, accessibility, and potential to transform farming into a more efficient and sustainable practice.

RESULTS AND DISCUSSION

AgroConnect underwent comprehensive testing to validate the accuracy, performance, and usability of its integrated modules. The system was tested using real datasets and simulated soil/environmental conditions. The

Crop Recommendation Module, powered by a Random Forest classifier, achieved over 90% prediction accuracy. It provided farmers with reliable crop suggestions based on soil NPK values, pH, temperature, and humidity. For instance, entering values such as N=90, P=42, K=43, pH=6.5, temperature=26°C, and humidity=60% resulted in a recommended crop of “grapes” as shown in Figure 6.1. The Crop Yield Prediction Module utilized a Gradient Boosting Regressor model and produced accurate yield estimates. For a selected crop and season, the system predicted expected production in tons per hectare. Users found the interface intuitive, with visual indicators showing projected yield. An example prediction output is shown in Figure 6.2.

Figure 6.1: Crop Recommendation Output – Frontend interface displaying predicted crop. Figure 6.2: Yield



Prediction Page showing input fields and prediction results

he Fertilizer Suggestion Module applied a decision tree logic to determine optimal fertilizer dosages. Based on the entered soil nutrient values and selected crop, it recommended precise quantities of essential fertilizers. The output was structured clearly to guide farmers in minimizing fertilizer

wastage. A sample result is displayed in Figure 6.3. One of the most impactful features is the Market Price Forecasting Module, which employs LSTM for time-series analysis. It visualized predicted prices using interactive graphs, enabling farmers to plan their selling strategies. A forecast example for tomato prices is shown in Figure 6.4, where upcoming months with expected high prices are highlighted.

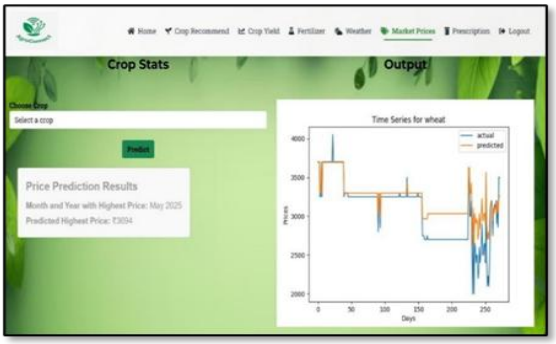


Figure 6.3: Fertilizer Suggestion Output – Decision tree-based recommendations. Figure 6.4: Market Price Forecasting – Price trend graph

The Agri Assistant Chatbot enhanced user engagement by answering queries related to crop cultivation, pest control, and fertilizer usage. This chatbot operated 24/7 and was especially beneficial for farmers in remote areas seeking instant guidance. A screenshot of the chatbot interface is provided in Figure 6.5.

The Weather Forecast Module added further utility by integrating live weather predictions, aiding in timely irrigation and pest management. The platform supported dynamic display and multi-day forecasts (see Figure 6.6).

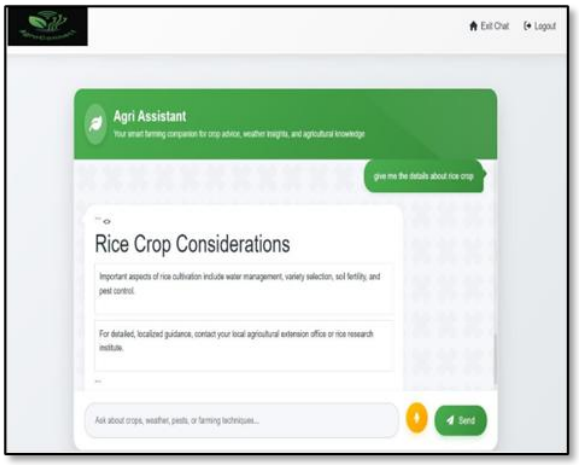


Figure 6.5: AI-powered Agri Assistant Chatbot Interface. Figure 6.6: Weather Forecast Page – Displaying 5-day forecast.

Additionally, each module generated a professional PDF report containing the user's inputs and model outputs. These were sent to the user's Telegram account automatically, enhancing accessibility and record-keeping. This PDF integration is especially useful in rural areas with limited web access. Overall, AgroConnect demonstrated strong performance, user-friendliness, and practical relevance. The seamless fusion of real-time IoT data and AI predictions makes it a robust tool for sustainable and profitable farming.

CONCLUSION AND FUTURE SCOPE

AgroConnect proves that integrating AI and IoT into agriculture can lead to meaningful improvements in productivity, sustainability, and farmer empowerment. It brings precision farming within reach for small and medium farmers through a responsive, low-cost, and intelligent platform. Unlike many existing tools, AgroConnect provides an end-to-

end solution, from real-time soil sensing to predictive analytics and chatbot-based advisory.

Future enhancements include multilingual and voice-enabled chatbot support, allowing interaction in local languages. Another planned feature is real-time pest and disease detection using CNNs and image processing. Mobile application development will extend access further, especially in low-connectivity rural areas. The system can also be integrated with government schemes and e-marketplaces for broader agricultural impact.

In conclusion, AgroConnect is not just a technical prototype but a viable framework for smart agriculture in developing regions. It aligns with the Digital India and Smart Village visions and has the potential to evolve into a national or even global agri-tech solution. With proper institutional support and iterative refinement, AgroConnect could help achieve sustainable farming, increased yield, and improved rural livelihoods.

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