iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IV **Month of publication:** April 2026

DOI: https://doi.org/10.22214/ijraset.2026.79251

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Crop Yield Prediction and Recommendation System using Machine Learning

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Abstract: ***Crop production plays a crucial role in ensuring food security and economic stability, especially in agriculture-dependent countries. However, farmers often face significant challenges due to unpredictable climatic conditions, soil variability, and lack of scientific guidance, which leads to reduced crop productivity and financial losses. To address these challenges, this project proposes an intelligent Crop Yield Prediction and Recommendation System using Machine Learning techniques. The system utilizes advanced algorithms such as Linear Regression and Random Forest to analyze agricultural data and predict crop yield based on key parameters including soil nutrients (Nitrogen, Phosphorus, Potassium), temperature, rainfall, humidity, and soil pH. Linear Regression is employed to identify relationships between environmental factors and yield, while Random Forest enhances prediction accuracy by handling non-linear patterns and complex interactions among features. The system incorporates data preprocessing techniques such as data cleaning, normalization, and feature selection to improve model performance and reliability. In addition to yield prediction, the proposed system provides crop recommendations by analyzing environmental suitability and predicts potential profit by considering market prices and production costs.***

Keywords: ***This crop yield prediction intelligent approach assists farmers in selecting the most suitable and profitable crops, enabling better planning and reducing risks associated with agriculture. The proposed system aims to improve agricultural productivity, promote sustainable farming practices, and enhance decision-making through the integration of artificial intelligence and data-driven insights***.

I. INTRODUCTION

Agriculture is a fundamental sector that supports the livelihood of a large population and contributes significantly to the economy. With increasing population and demand for food, improving agricultural productivity has become essential. However, traditional farming practices often rely on experience and intuition, which may not always yield optimal results due to changing environmental Factors such as soil fertility, climate variability, water availability, and market fluctuations greatly influence crop production. Farmers frequently lack access to accurate predictive tools that can guide them in selecting suitable crops and estimating yield outcomes. As a result, inefficient crop planning can lead to low productivity and economic instability.

Recent advancements in Machine Learning have opened new possibilities in agriculture by enabling data-driven decision-making. Machine learning models can analyze historical and real-time data to identify patterns and make accurate predictions. This project focuses on leveraging these technologies to build a smart system that predict

II. METHODOLOGY

The proposed system follows a structured workflow to ensure accurate prediction and recommendation Initially, agricultural data is collected from various sources, including soil datasets, weather reports, and historical crop yield records. The collected data undergoes preprocessing, where missing values are handled, irrelevant features are removed, and normalization techniques are applied to standardize the data After preprocessing, feature selection is performed to identify the most significant parameters influencing crop yield, such as NPK values, temperature, rainfall, humidity, and soil pH The system then applies two machine learning models Linear Regression Model: Used to establish relationships between input variables and crop yield. Random Forest Model: Used to improve prediction accuracy by handling complex and non-linear data patterns. Once the models are trained, they are used to predict crop yield for given input conditions. Based on these predictions, the system recommends suitable crops that can provide higher productivity under the given environmental conditions Additionally, a profit prediction module is included, which estimates potential earnings by analyzing predicted yield, market price, and cost of cultivation.

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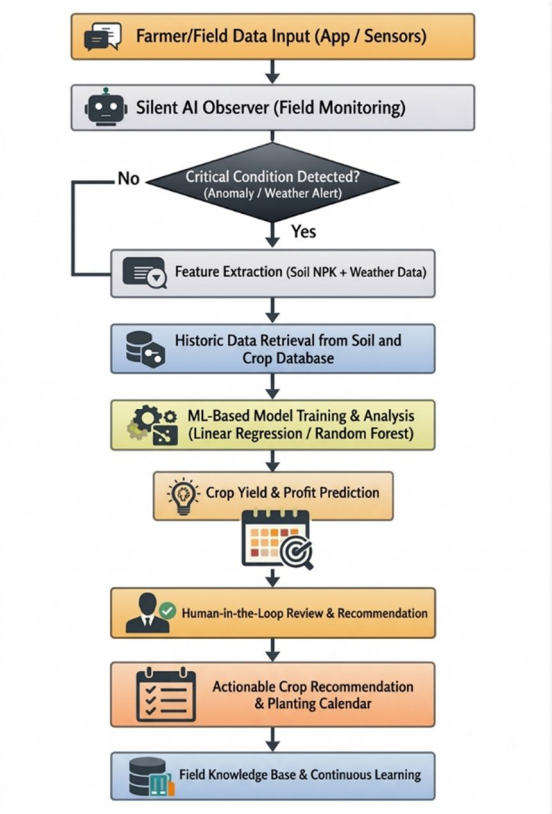


Fig. 1 Methodological Workflow

Once the models are trained and validated, they are deployed to predict crop yield based on new input conditions provided by the user. Based on the predicted yield and environmental suitability, the system recommends the most appropriate crops that are likely to produce higher productivity under given conditions. Additionally, a profit prediction module is integrated into the system, which estimates potential financial returns by analyzing predicted yield, current market prices, and the cost of cultivation, thereby enabling farmers to make economically beneficial decisions. The final output is presented through a user-friendly interface, providing clear insights into yield prediction improving overall productivity through intelligent and data-driven approaches.

III. PROCESS FLOW

The proposed Crop Yield Prediction and Recommendation System follows a well-defined and sequential process workflow to ensure accurate analysis, prediction, and decision support for farmers. The process begins when the user accesses the system through a user-friendly interface and provides input parameters such as soil nutrient values including Nitrogen, Phosphorus, and Potassium, along with environmental factors like temperature, rainfall, humidity, and soil pH. Once the input is received, the system performs an initial preprocessing step where the input data is validated, cleaned if necessary, and transformed into a structured format suitable for model processing, including normalization and scaling to maintain consistency with the trained dataset.

After preprocessing, the refined input data is passed to the trained machine learning models, namely Linear Regression and Random Forest, which analyze the given parameters and generate crop yield predictions based on learned patterns from historical agricultural data. Simultaneously, the system evaluates environmental suitability by comparing the input conditions with optimal growth requirements of various crops stored in the system database, enabling the crop recommendation module to identify and suggest the most suitable crops that can achieve higher productivity under the given conditions. Following this, the predicted yield values are combined with external market data, including current crop prices and estimated cultivation costs, to compute the expected profit through the profit prediction module, thereby providing a comprehensive economic analysis. The system then integrates all outputs, including predicted yield, recommended crops, and estimated profit, and presents them to the user in a clear and organized format through the interface, allowing easy interpretation and decision-making

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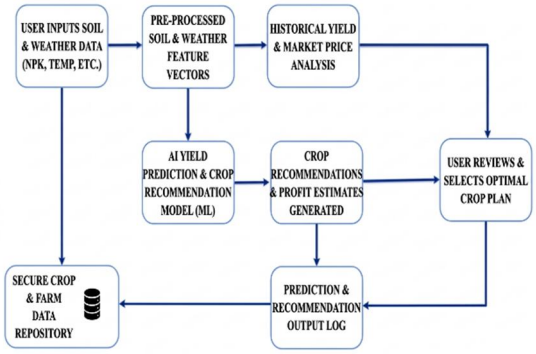


Fig. 2 Process flow

IV. IDENTITY AND ACCESS CONTROL

The proposed Crop Yield Prediction and Recommendation System incorporates a robust identity and access control mechanism to ensure secure, reliable, and authorized usage of the platform, particularly when handling sensitive agricultural data and user-specific information. The system provides a secure authentication process where users, such as farmers, administrators, and agricultural experts, access the platform through unique login credentials, including username and password, ensuring that only verified individuals can interact with the system. Role-based access control is implemented to define different levels of permissions, where farmers can input environmental parameters and view predictions, administrators can manage datasets, monitor system performance, and update models, and experts can analyze data and provide additional insights, thereby maintaining a structured and controlled environment. The system also employs secure session management techniques to prevent unauthorized access during active sessions and ensures that user interactions are protected against common security threats. n addition, data protection measures are implemented to safeguard sensitive information, including soil data, crop recommendations, and financial predictions, from unauthorized exposure or manipulation. Access logs are maintained to track user activities, providing accountability and enabling system monitoring for any suspicious behavior or misuse.

V. PREDICTIVE AGRO-PLANNING AND HUMAN-CENTRIC DECISION SUPPORT

Predictive analysis in the proposed Crop Yield Prediction and Recommendation System is achieved through the evaluation of environmental parameters, historical agricultural data, and weather patterns to generate accurate and reliable predictions. By analyzing key factors such as soil nutrients (Nitrogen, Phosphorus, Potassium), temperature, rainfall, humidity, and soil pH, the system estimates crop yield and identifies the most suitable crops for cultivation under specific conditions. The machine learning models, including Linear Regression and Random Forest, examine both linear and non-linear relationships among these variables to enhance prediction accuracy.

In addition to yield prediction, the system incorporates weather forecasting capabilities by utilizing historical and real-time weather data to predict future climatic conditions that may impact crop growth. This enables early identification of potential risks such as drought, excessive rainfall, or unfavorable temperature variations, allowing users to take preventive measures and plan agricultural activities effectively. The predictive insights assist farmers in optimizing resource utilization, including irrigation, fertilizer usage, and crop selection, thereby improving productivity and sustainability.

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VI. RESULT AND DISCUSSION

The developed system demonstrates an intelligent agricultural support environment that enhances decision-making, productivity, and resource management through machine learning-based predictions and recommendations. The platform provides a user-friendly interface integrated with secure authentication, ensuring that only authorized users can access system functionalities through a login module that implements role-based access control and secure credential verification. The login interface allows farmers and administrators to securely access personalized features, maintaining data privacy and system integrity.

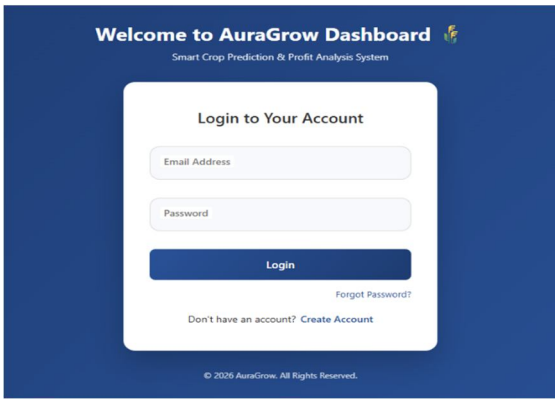


Fig. 3 Login Interface

The system includes a centralized dashboard that enables users to monitor agricultural insights efficiently. The dashboard presents key information such as predicted crop yield, recommended crops, weather forecasts, and profit estimation in a structured and visually organized manner.



Fig. 4 Dashboard

The crop recommendation module analyzes environmental conditions and suggests the most suitable crops that can achieve higher productivity under given inputs. It continuously updates based on user inputs and system analysis, ensuring that the displayed information remains relevant and accurate. Additionally, the dashboard highlights important alerts and suggestions generated by the system, such as unsuitable environmental conditions, better crop alternatives, or potential weather risks, helping users respond proactively. By integrating multiple functionalities into a single interface, the dashboard enhances usability, improves accessibility, and supports efficient agricultural planning while reducing the need for manual analysis and interpretation.



Fig. 5 Crop Recommendation

The weather prediction module provides insights into upcoming climatic conditions by analyzing weather data, enabling users to plan irrigation, harvesting, and other agricultural activities more effectively. This reduces the uncertainty associated with climate variability and supports better farm management.

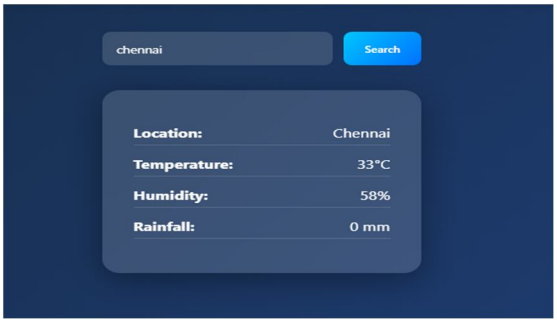


Fig. 6 Weather Prediction

The system also integrates yield prediction and profit analysis, where the predicted crop yield values are combined with real-time and historical market price data to estimate potential earnings for different crops. This integrated analysis enables farmers to not only understand how much yield they can expect under given environmental conditions but also evaluate the economic viability of cultivating a particular crop. By incorporating additional factors such as cost of cultivation, including expenses related to seeds, fertilizers, irrigation, labor, and transportation, the system provides a more realistic estimation of net profit rather than just gross income.

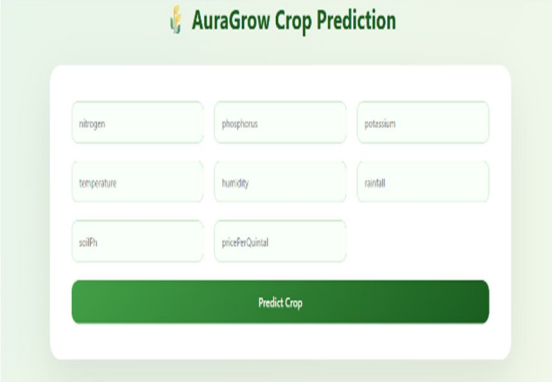


Fig .7 Yield and Profit Prediction.

The AI-generated suggestions integrated within the system provide intelligent recommendations based on user input parameters and analytical results, as illustrated in the system interface. These suggestions are generated when the system detects specific conditions such as unsuitable soil parameters, unfavorable weather predictions, or suboptimal crop selection.

VII. CONCLUSION

The proposed Crop Yield Prediction and Recommendation System presents an intelligent and comprehensive solution for modern agricultural challenges by integrating machine learning techniques with environmental and economic data analysis. The system effectively utilizes parameters such as soil nutrients, temperature, rainfall, humidity, and soil pH to generate accurate crop yield predictions and recommend the most suitable crops for specific conditions, thereby supporting data-driven decision-making in agriculture. In addition to yield prediction, the inclusion of weather forecasting enables users to anticipate climatic changes and take preventive actions, reducing risks associated with unpredictable environmental factors. The system also incorporates a profit prediction module that analyzes market prices and cultivation costs, allowing farmers to evaluate the economic feasibility of crop selection and improve financial planning. The implementation of a secure login mechanism ensures controlled access and data protection, while the interactive dashboard provides a clear and organized visualization of predictions, recommendations, and analytical insights, making the system accessible even to non-technical users. Furthermore, the integration of a human-in-the-loop approach ensures that users retain full control over decision-making by allowing them to review

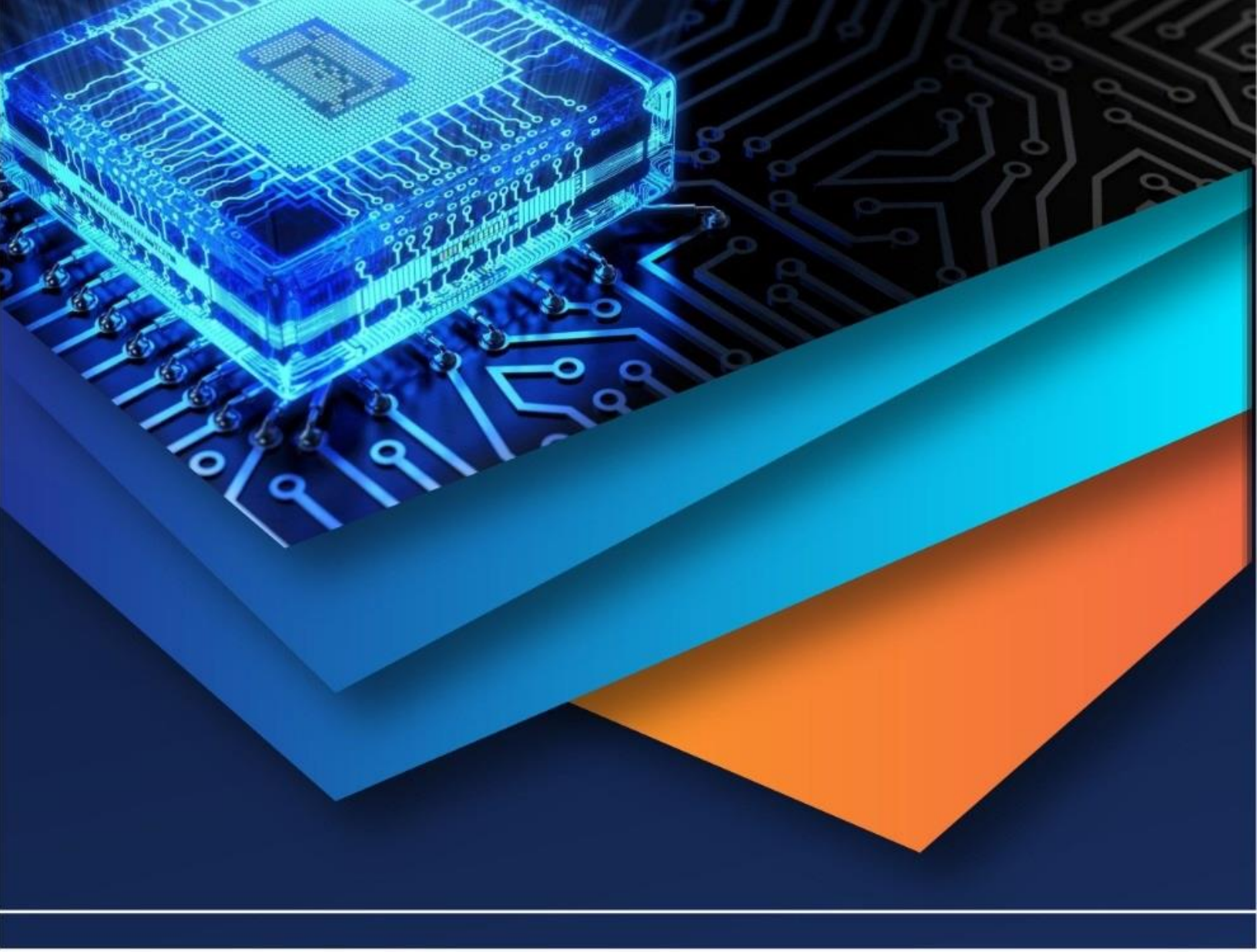
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