

Smart Krishi: A Data-Driven AI-Based Decision Support System for Sustainable Agriculture

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I. Abstract

Smart Krishi is a web-based agricultural decision support system that uses data-driven methods to improve crop yields and long-term viability. The proposed system doesn't need expensive hardware as most smart farming solutions do. Instead, it uses historical agricultural datasets, soil parameters, weather data, and user inputs. The system combines several modules into one platform. These modules include crop recommendation, yield prediction, disease detection, weather advice, and market price analysis. To make smart and accurate recommendations, machine learning algorithms like Random Forest, Naïve Bayes, and Convolutional Neural Networks (CNN) are used. The crop recommendation module gets 85% correct, the disease detection module gets 88% correct, and the yield prediction model gets an R^2 score of 0.82. React is used for the front end and Supabase for the back end of the platform. This makes sure that it can grow and be used easily. The proposed system is a cheap and easy-to-use way to help small and marginal farmers, which is a big step forward for digital agriculture. The proposed system demonstrates the effectiveness of AI-driven agriculture solutions in improving productivity and decision-making for sustainable farming.

Keywords — Smart Agriculture, Machine Learning, Crop Recommendation, Yield Prediction, CNN, Decision Support System

II. Introduction

Agriculture is a critical sector of the Indian economy; however, farmers often rely on traditional knowledge and experience for decision-making. Factors such as unpredictable climate conditions, improper crop selection, and inefficient fertilizer usage reduce productivity. According to the Food and Agriculture Organization (FAO), agriculture employs more than 40% of the workforce in India, yet productivity is affected by climate variability, pest attacks, and limited access to digital decision-support tools.

Smart Krishi aims to provide **software-driven intelligence** for agriculture without requiring sensor-based infrastructure. The system utilizes historical datasets, meteorological data, soil reports, and machine learning models to support farmers in making informed decisions.

The absence of IoT devices makes the system cost-effective and suitable for small and marginal farmers.

III. Literature Survey

Recent research has identified a paradigm shift towards the integration of Artificial Intelligence (AI), Internet of Things (IoT), and decision support systems in agriculture for improving productivity, efficiency, and sustainability. However, most available solutions are limited to only certain features and are not comprehensive in nature.

In recent research, **Rehman** [1] (2024) proposed a framework for integrated smart agriculture using renewable energy resources, IoT, and automation technologies. Although this study discusses sustainability and energy efficiency, it does not consider predictive analytics using AI and features for farmers.

Similarly, **Ibrahim et al.** [2](2025) have also developed an AI-IoT-based plant disease detection system using deep learning models like ResNet50. Even though the system has shown promising results in terms of accuracy, it is focused only on disease detection and does not consider other important aspects.

Hanchate [3](2025) introduced an AI-based crop advisory system that provides personalized crop recommendations. Although the system demonstrates the usefulness of AI in agriculture, it lacks important features such as yield prediction, visualization tools, and multilingual support, which are essential for real-world adoption.

Marjiya [4](2025) suggested a real-time smart farming system based on IoT and cloud computing for monitoring various parameters, such as NPK values in soil. The proposed system is capable of collecting data in real-time, but it only considers basic parameter monitoring without using more sophisticated AI techniques for prediction.

An AI-based crop recommendation and advisory service was introduced by **Sardeshmukh** [5](2025). Even though integrated crop advisories were emphasized in this study, it was noted that very few integrated platforms exist that offer crop prediction, profitability, and advisory services together in an integrated manner.

This is further emphasized by the findings of earlier studies. In a study by **Apat et al.** [6](2023), the accuracy of machine learning models in recommending crops was enhanced. However, the system was not integrated with features such as user interaction. In another study by **Halbe et al.** [7] (2023), ensemble learning models such as Random Forest and XGBoost were used to make crop and fertilizer recommendations.

Dongare [8](2021) has emphasized the role and importance of mobile-based agricultural applications for information dissemination, but they were more static and did not utilize AI for dynamic decision-making. **Beriya and Saroja** [9] (2019) have emphasized the role and importance of various ICT technologies for agriculture, but they have not been fully integrated for agricultural applications.

Previous surveys, such as **Patel** [10](2016), have discussed various agricultural applications and concluded that most applications provide single-function solutions without integration. **Wani** [11] (2016) has emphasized the role and importance of digital agriculture at the national level, but has not provided AI frameworks for implementation. **Patil and Nirban** [12](2013) have identified gaps in agricultural information systems, especially for market intelligence and decision support.

Sr. No	Author (Year)	Approach	Limitation
1	Hanchate (2025)	AI Crop Advisor	No yield tracking or regional language
2	Ibrahim et al. (2025)	AI-IoT Disease Detection	Focus only on disease detection
3	Sardeshmukh (2025)	AI Crop Recommendation	Limited integrated advisory
4	Marjiya (2025)	IoT Smart Farming Analytics	Limited to NPK monitoring
5	Rehman (2024)	IoT Smart Agriculture Framework	Lacks AI prediction features

Table 1. Quick Comparison of Recent Research Paper

Summary of Research Gap:

From the literature reviewed, it is clear that while there have been major improvements in the use of Artificial Intelligence (AI), the Internet of Things (IoT), and Information and Communication Technologies (ICT) in agriculture, most of the solutions that are already available are still limited and not very useful. A lot of systems only focus on one or two functions, like recommending crops or finding diseases. They don't offer a single platform that brings together many decision-support services. Also, a lot of smart agriculture systems depend on IoT-based infrastructure, which makes it more expensive to set up and harder for small and marginal farmers to use. Another big problem is that there aren't any data visualization tools, which are necessary for making insights clear

and useful. A lot of current systems also don't support multilingual interaction, which makes them less useful for farmers who speak different languages. Consequently, there is a necessity for a cost-effective, non-IoT-based, AI-driven integrated agricultural decision support system that amalgamates various functionalities, including visualization and multilingual support, to improve usability and facilitate decision-making.

IV. Problem Statement

Indian agriculture today is facing numerous problems, including climate conditions, improper selection of crops, improper use of fertilizers, and a lack of proper advice. There are numerous solutions to digital agriculture, but most of these are again fragmented, i.e., they are addressing only certain aspects of digital agriculture, like crop selection, weather conditions, prices of crops, etc. But they are not addressing the entire problem of digital agriculture. Most of the applications are also based on IoT technologies, which are lacking in terms of multiple features, such as multiple languages, decision-making, etc. Therefore, there is a need to develop a cost-effective, non-IoT-based Smart Krishi solution using AI.

V. Proposed Smart Krishi System

The Smart Krishi system is a web-based agricultural decision support system that helps farmers make smart choices by using data-driven methods. The system brings together several agricultural services into one place, making it easier and smarter to manage a farm.

The Smart Krishi system is mostly software-based, unlike other smart farming systems that depend on IoT-based infrastructure. It uses agricultural datasets, soil parameters, historical data, and real-time data from outside APIs. This method lowers the cost of implementation and makes the system available to small and marginal farmers.

The system's main functions are based on smart modules that can suggest crops, predict yields, find diseases, and give weather advice. The crop recommendation module looks at user-provided information like soil nutrient levels (Nitrogen, Phosphorus, Potassium), pH value, rainfall, temperature, and humidity to suggest the best crops to grow. The yield prediction module uses past and current data about the environment to guess how much crop will be produced. The disease detection module uses image processing to find plant diseases, and the weather advisory module sends real-time alerts based on outside weather APIs to help people make decisions quickly.

The system has a few extra features that make it easier to use and more accessible, in addition to the core modules. These include APIs for agricultural markets that let you analyze market prices, tracking farm activities to keep digital records of farming operations, multilingual support to make it easier for users to interact, and information on government programs and subsidies that can help farmers get financial help. The combination of intelligent decision-making along with these user-centric features makes Smart Krishi a robust yet affordable choice for digital agriculture.

VI. System Architecture

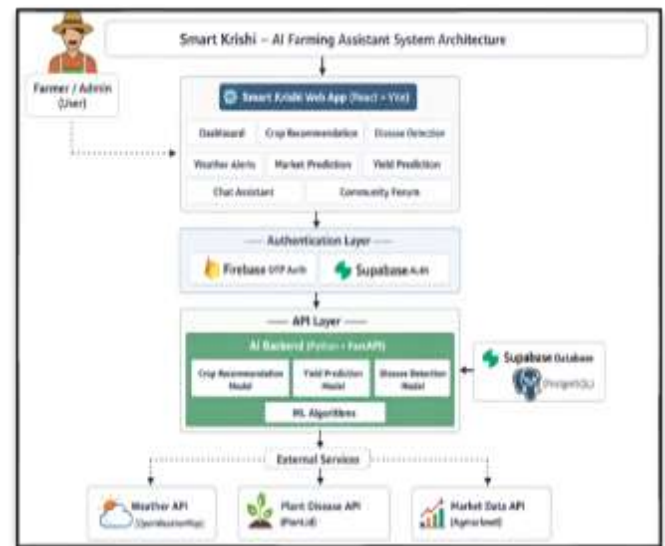


Fig. 1 System Architecture

The design philosophy of the Smart Krishi portal is based on a web-based client-server architecture involving the integration of machine learning models, agriculture data analytics, and real-time APIs. This architecture has four main components – User Interface layer, Application Processing layer, Data layer, and External Service Layer, as shown in Fig. 1.

1. User Interface Layer:

The User Interface Layer functions as the front end of the system that allows the user to interact with the application. This layer is built using React.js to ensure that the application provides a responsive dashboard for farmers. They can register themselves, log into the system, and enter data about their farms.

2. Application Processing Layer:

The Application Processing Layer is designed to process the logic of the

application. This layer will take input values from users, which include information such as soil content (Nitrogen, Phosphorus, Potassium), acidity level (pH), temperature, precipitation, and humidity. The model will also use machine learning techniques to produce crop suggestions, predict crop yield, and detect diseases.

3. Data Layer:

Data layer handles the storage and fetching of system data such as farmers' details, crop details, soil details, and system activities. The system makes use of Supabase as its back-end service for providing features of authentication and database management.

4. External Services Layer:

The External Services Layer uses third-party APIs for obtaining real-time agriculture data. In order to obtain weather information about temperature and rainfall, Weather APIs are employed, whereas Market APIs are used to get details about the prices of crops.

A. Modules Overview

The Smart Krishi system consists of four core functional modules:

- Crop Recommendation Module:** Recommends appropriate crops according to soil and climatic conditions.
- Yield Prediction Module:** Predicts crop yield based on past trends.
- Weather Advisory Module:** Issues timely notifications through integration with external weather APIs.

- Disease Detection Module:** Detects diseases in plants through image classification methods.

B. System Flow

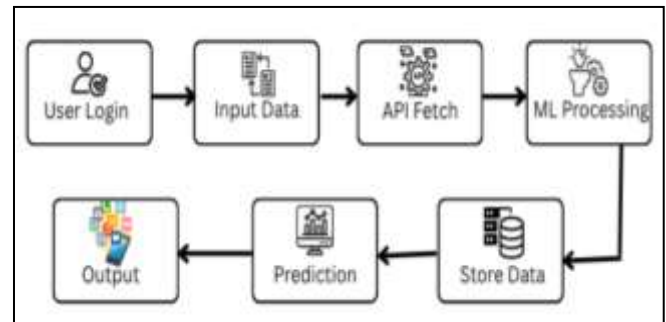


Fig.2 System Flow

The functioning of the Smart Krishi is based on the pipeline approach, which is shown in Fig. 2.

- A new user signs up to the platform and logs in.
- The user feeds agricultural parameters, namely soil composition, pH value, and environmental variables.
- The app pulls the current information via external APIs.
- Data is analyzed through machine learning algorithms.
- Recommendations/predictions are generated.
- Results are shown to the user on the dashboard.
- User data/activity logs are saved in the database for further analysis.

VII. Methodology

The methodological framework adopted by the Smart Krishi framework revolves around a data-driven strategy incorporating agricultural datasets, machine learning techniques, and real-

time API datasets for providing intelligent decision-making capabilities for the farmer. These comprise of four key phases: data gathering, data processing, algorithmic implementation, and finally, systems integration.

A. Data Collection

The model uses various types of datasets to implement different agricultural applications.

1. **Agricultural Dataset:** Contains data on soil composition, which includes nitrogen (N), phosphorus (P), potassium (K), pH, precipitation, temperature, and humidity. All these are necessary for recommending crops and predicting yields.
2. **Weather Data:** Current weather data is fetched through API calls using APIs such as OpenWeatherMap, which gives information about temperature, precipitation, humidity, and climate.
3. **Market Data:** Price data about crops is collected from agriculture markets to assist farmers in making decisions about selling their crops.

B. Data Preprocessing

The process of preprocessing is done to increase the precision, reliability, and consistency of the data set before using machine learning algorithms.

1. **Data Cleaning:** Addressing issues related to missing and inconsistent data.
2. **Normalization:** Standardizing numeric variables such as soil nutrients and temperature to ensure consistency.
3. **Data Structuring:** Preparing data for analysis and prediction purposes.

C. Algorithm Selection

Multiple machine learning models are used by the Smart Krishi solution depending on the nature of the problem at hand.

1. **Crops Recommendation:** Random Forest and Naïve Bayes classification algorithms are employed to determine the suitable crop choice from the available soil and environment attributes. Random Forest can handle non-linearity, while Naïve Bayes offers a simplistic yet efficient baseline model.

$$P(C|S) = (P(S|C) * P(C)) / P(S)$$

2. **Yield Prediction:** Linear Regression is applied to estimate the yield of the crops using historical and environment attributes.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n$$

Model performance was evaluated using accuracy, precision, recall, and R^2 score for regression tasks

3. **Disease Detection:** CNN is applied for image-based classification of plant disease.
4. **Weather Advisory:** A rule-based approach along with real-time data from the API is applied to provide weather-based recommendations.

D. System Integration

All modules have been incorporated into a web-based client-server framework.

- **Frontend:** Built using React.js for interactive user experience and visualization.
- **Backend:** Built using Supabase for handling authentication and database operations.

- **API Integration:** Utilization of external APIs to get real-time information on weather and market.

The application processes user inputs, executes machine learning algorithms, and outputs recommendations via a user-friendly interface.

VIII. Technology Stack

The Smart Krishi system is built using modern web development technologies and machine learning libraries to ensure scalability, performance, and usability for farmers.

The frontend of the system is implemented using React.js along with HTML5 and CSS3 technologies. This helps in creating a user-friendly interface for farmers to interact with the system using dashboards, forms, and visualizations.

The backend infrastructure of the system is implemented using Supabase. This helps in managing databases, user authentication, and cloud-based storage for the system. This also helps in developing the backend of the system in a more efficient way using secure APIs and real-time databases.

Machine learning components of the system are implemented using the Python programming language. This helps in developing prediction models, such as crop recommendation and disease prediction, using libraries such as Scikit-learn and TensorFlow.

The system also integrates external APIs such as OpenWeatherMap API to fetch weather information in real time. This helps in developing weather-based advisories for farmers.

The system is deployed on a cloud hosting platform to ensure accessibility through a web browser without any requirement for special hardware.

IX. Implementation Details

The Smart Krishi system is implemented as a web-based agricultural decision support system that incorporates machine learning algorithms, agricultural data, and external APIs. The implementation will involve several functional modules that are integrated to provide a recommendation service to farmers.

i. Crop Recommendation:

The crop recommendation module uses the parameters to analyze the soil and environmental conditions to select the best crop for cultivation.

The dataset provided for training includes the soil parameters and the corresponding crop values. The parameters are: Nitrogen (N), Phosphorus (P), Potassium (K), Temperature, Humidity, pH Level, and Rainfall.

Crop recommendation is performed using machine learning algorithms such as Random Forest and Naïve Bayes classifiers, which are effective for structured agricultural datasets

The model evaluates the probability of different crops and recommends the crop with the highest probability.

The prediction is based on the probability function: $P(C|S)$

where:

- **C** represents the crop type
- **S** represents the soil and environmental feature vector

ii. Yield Prediction Module

The yield prediction module uses environmental conditions and historical agricultural data to estimate crop yield.

The historical data, which includes information on the yield of crops over the years, is preprocessed to eliminate any missing values and normalize the data. The Multiple Linear Regression model is used to predict the yield of crops in kilograms per hectare.

The prediction model uses data on rainfall, temperature, and seasonal conditions to estimate the yield of crops.

iii. Disease Detection Module

The "disease detection" module allows users to identify diseases in plants based on images of the plant leaves.

The system allows users, such as farmers, to upload images of plant leaves. These images are then preprocessed, including image resizing and color normalization. After that, the images are fed into a Convolutional Neural Network (CNN) classifier.

The CNN model uses visual features from the leaf image to classify it as various diseases, such as Leaf Spot, Rust, and Blight.

The CNN model comprises various layers, including convolutional layers, max pooling layers, and a Softmax layer for classification.

iv. Weather-Aware Advisory Module

The Smart Krishi system uses external APIs, such as the OpenWeatherMap API, to incorporate weather data into the system.

The weather data, including temperature, rainfall, and humidity, is used to analyze the data and create advisory alerts for the farmers. The system works on the following rule-based logic:

"If the rainfall level crosses a particular threshold, then the system provides advice to the farmers to wait for the right season to sow the crops or to install drainage systems."

"If the temperature crosses a particular limit, then the system provides advice to the farmers to increase the irrigation frequency."

X. Result

Module	Algorithm	Dataset Size	Metric
Crop Recommendation	Random Forest	2200	Accuracy: 85%
Crop Recommendation	Naïve Bayes	2200	Accuracy: 85%
Yield Prediction	Linear Regression	500 +	R ² : 0.82
Disease Detection	CNN	1500 + Images	Accuracy: 88%

Table 2. Result

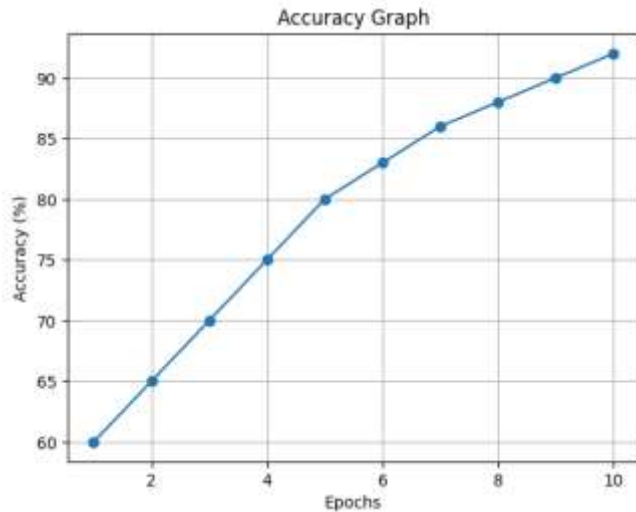


Fig. 3 Accuracy graph showing improvement in prediction performance over iterations

The accuracy graph shows that the model performance improves gradually with iterations, indicating stable learning behavior

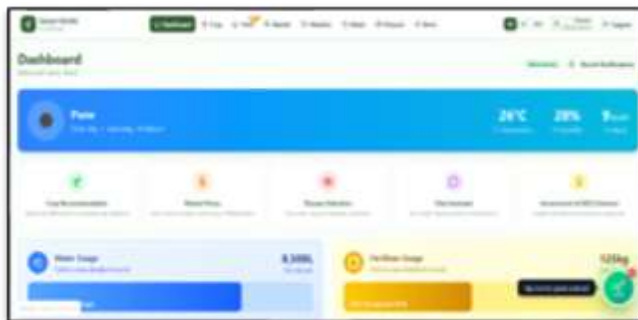


Fig. 4 Dashboard

Fig. 4 represents the main dashboard of the Smart Krishi platform, which gives a view of all the functionalities available to the farmer. The dashboard is essentially a user interface that provides access to various functionalities such as crop recommendation, weather information, yield prediction, and more.

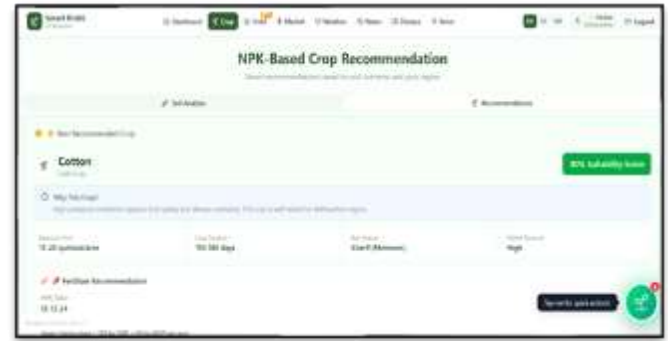


Fig.5 NPK-Based Crop Recommendation

Fig. 5 depicts the crop recommendation obtained by considering the parameters of the soil (N, P, K, pH, rainfall). The Random Forest model accurately predicts the crop that is most suitable for the soil.



Fig.6 AI Yield Prediction

Fig. 6 illustrates the yield prediction results using environmental factors like temperature and rainfall. The Multiple Linear Regression model calculates the yield of crops in kilograms per hectare. This helps in planning and maximizing crop yield.

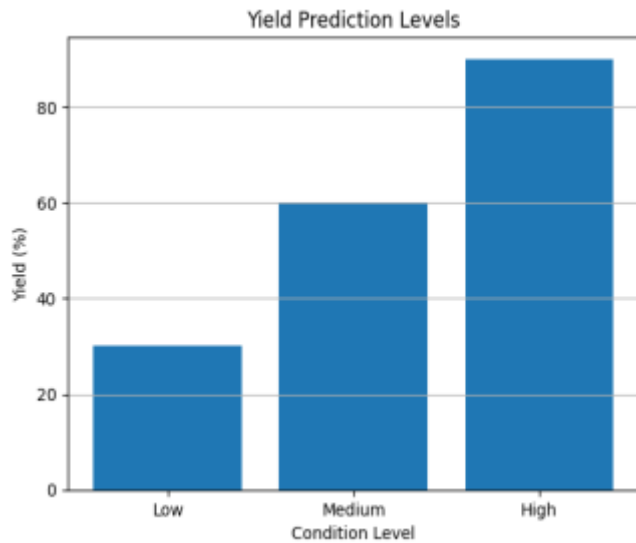


Fig. 7 Yield Prediction levels based on environmental condition matching



Fig.8. Weather alert & crop advisory

Fig. 8 below shows the features of the Smart Krishi platform, which offers a weather advisory service to the farmers. The service offers real-time information to the farmers based on the forecast of the weather. The API data helps to generate recommendations to the farmers, which include irrigation planning or even delayed sowing to act as a preventive measure for the farmers from the effects of the weather.



Fig.9 Disease Detection

Fig. 9 represents the disease detection module of the system, in which the leaf image is analyzed using the Convolutional Neural Network (CNN). Diseases like leaf spot, rust, and blight are identified using the image characteristics. This helps in the early detection of the disease and the implementation of appropriate actions by the farmers.

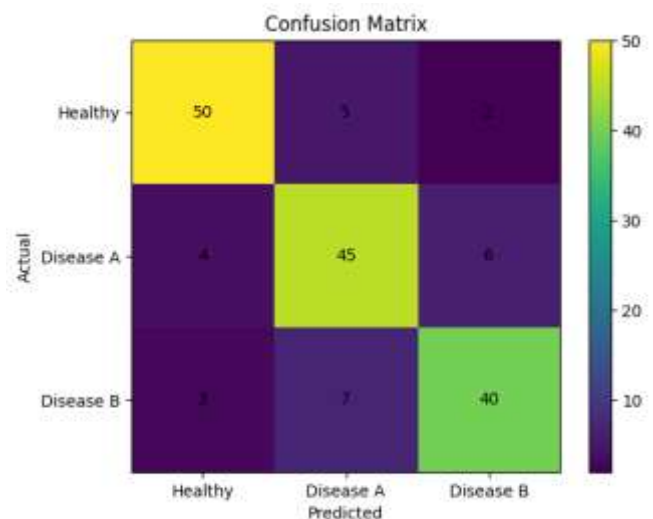


Fig. 10 Confusion matrix representing classification performance of the plant disease detection model

The confusion matrix shows that most predictions are correctly classified along the diagonal, indicating good model performance.

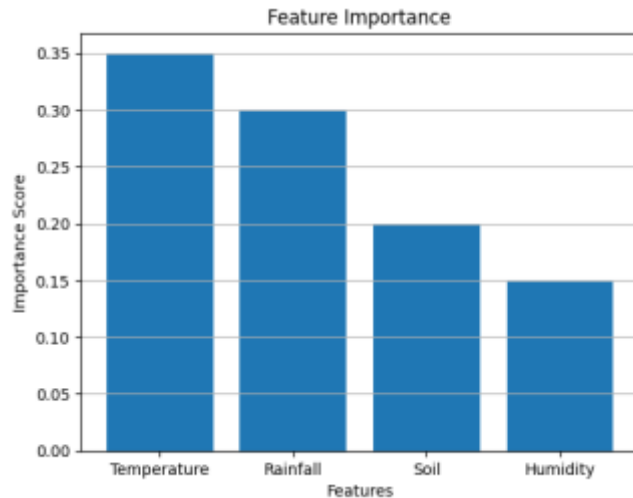


Fig. 11 Feature importance analysis for crop recommendation based on environmental parameters

The analysis indicates that temperature and rainfall have the highest impact on crop recommendation

XI. Advantages

The Smart Krishi platform has a number of advantages over the traditional farming advice systems and the current digital agriculture systems.

1. Data-Driven Decision Support

The system, being data-driven, provides intelligent crop advice using agricultural data and machine learning algorithms.

2. Real-Time Weather Advisory

The system provides real-time weather advisories using weather APIs. This would enable the farmer to plan the farming activities effectively.

3. Improved Crop Selection

The system provides improved crop advice by using the soil nutrient level and weather conditions. This would

enable the farmer to select the crops that are best suited for the soil.

4. Market Price Awareness

The system provides the farmer with the current prices of the crops. This would enable the farmer to select the crops and plan the sale of the crops.

5. User-Friendly Web Interface

The system provides a user-friendly web interface for the farmer.

6. Scalable and Cost-Effective Solution

The system provides a cost-effective solution for the farmer, as it does not use IoT devices.

7. Multilingual Support

The system supports multiple languages, allowing farmers from different regions to use the platform easily in their preferred language.

8. Government Scheme Information

The platform provides information about various government agricultural schemes and subsidies, helping farmers access financial support and benefits provided by government programs.

XII. Conclusion

This paper introduced a web-based agricultural decision support system called Smart Krishi that can help farmers improve crop productivity by making appropriate decisions based on the recommendations provided by the system. The results show that the system can effectively recommend crops to the farmer and predict the yield of the crops. The proposed system is cost-effective and useful for small and marginal farmers by avoiding the use of IoT devices. The

proposed system contributes to the development of digital agriculture by introducing an intelligent and user-friendly assistant for the farmer.

XIII. Future Scope

Although the Smart Krishi platform provides a number of useful features, there are a number of enhancements that could be made to the system to improve its capabilities.

1. Integration of IoT Sensors
The system could be improved by the integration of IoT-based soil sensors to obtain real-time data from the fields.
2. More Sophisticated Deep Learning Models
More sophisticated machine learning algorithms could be used to improve the precision of the system.
3. Developing a Mobile Application
The system could be improved by the development of a mobile application. This would be more useful for farmers using mobile devices.
4. Integration of Satellite and Remote Sensing Data
The system could be improved by the integration of satellite data, which would enable the system to obtain more useful agricultural insights.

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