AgriVision: AI Based Agriculture Market Advisor

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Abstract

The agricultural sector faces significant challenges due to farmers' reliance on intermediaries and limited access to timely, data-driven insights, leading to suboptimal crop yields and financial instability. This paper presents an AI-driven crop advisory system designed to empower farmers through real-time, actionable recommendations for crop selection, nutrient management, and market strategies. Leveraging machine learning (ML), IoT, and accessible platforms, the system integrates a Telegram bot and a web interface to deliver personalized advice based on environmental parameters such as soil nutrients (Nitrogen, Phosphorus, Potassium), temperature, humidity, pH, and rainfall. A Random Forest algorithm, trained on agricultural datasets, predicts optimal crops with high accuracy, while market trend analysis guides selling decisions. The system is deployed on a Raspberry Pi, ensuring cost-effective and energy-efficient operation in resource-constrained regions, with voice-based outputs via Google Text-to-Speech enhancing accessibility for non-literate users. Results demonstrate robust performance, with precise crop recommendations aligning with agronomic best practices and user-friendly interfaces facilitating widespread adoption. The solution reduces resource wastage, promotes sustainable practices, and mitigates dependency on middlemen by providing transparent, data-backed insights. Future enhancements include integrating real-time weather APIs, IoT sensors, and multi-language support to broaden scalability. By bridging technology and traditional farming, this system advances precision agriculture, fostering resilience, productivity, and equitable growth in global agricultural communities.

Keywords: AI-driven crop advisory, precision agriculture, random forest algorithm, sustainable farming, raspberry pi deployment.

I Introduction

Agriculture remains the backbone of many economies, particularly in developing regions, where small and medium-scale farmers constitute a significant portion of the workforce. These farmers often face challenges in making informed decisions due to limited access to reliable data regarding crop cultivation, soil health, weather conditions, and market dynamics. The lack of timely and accurate agricultural information results in suboptimal farming practices, financial losses, and dependency on intermediaries who exploit their market vulnerability. Traditional approaches to farming, characterized by manual decision-making and reliance on historical trends, are increasingly insufficient in addressing modern agricultural challenges such as climate variability, fluctuating market prices, and sustainable resource management. There is a pressing need for intelligent, data-driven solutions that empower farmers with real-time insights to enhance productivity, optimize resource utilization, and increase profitability [1][2].

With the advent of Artificial Intelligence (AI) and Machine Learning (ML), agriculture has witnessed a paradigm shift towards automation, precision farming, and predictive analytics. AI-driven systems have been successfully implemented in various agricultural domains, including crop yield prediction, smart irrigation, pest and disease detection, and automated farm management. Studies have demonstrated the effectiveness of AI-powered solutions in optimizing irrigation and pesticide application, enhancing crop yields and resource efficiency [3]. The development of AI-based decision support systems has provided farmers with real-time insights into soil health, pest control, and crop growth predictions, facilitating data-driven decision-making in farming practices [4]. The emergence of explainable AI in crop recommendation systems has improved agricultural decision-making by providing transparent and understandable insights to farmers [5].

The proposed system operates on a Raspberry Pi-based architecture, ensuring cost-effectiveness, portability, and accessibility even in rural settings. The integration of AI-powered analytics with a simple, intuitive interface allows farmers to access crucial information without requiring extensive technical expertise. The system includes a voice-based recommendation feature to cater to farmers with limited literacy levels, increasing its usability. Surveys on AI applications in agrifood systems have underscored the importance of data acquisition and processing techniques in enhancing agricultural outcomes [6]. This paper explores the development, implementation, and impact of the Crop Advisory System, detailing the methodologies used for data collection, model training, and system deployment. The system's performance is evaluated in terms of accuracy, usability, and effectiveness in optimizing agricultural decision-making. By bridging the gap between technology and traditional farming, this research aims to contribute to the advancement of intelligent agricultural practices, fostering sustainable farming and economic growth.

II Related Work

AI-driven agricultural solutions have significantly transformed farming practices by providing predictive analytics for crop selection and yield estimation. Keerthana et al. [7] proposed a machine learning-based system for smart farming that leverages environmental and soil parameters to determine optimal crop choices. Their approach integrated supervised learning techniques to improve prediction accuracy, leading to enhanced agricultural productivity. Zhang et al. [8] introduced an AI-driven decision support system designed to provide real-time recommendations on soil health, pest management, and irrigation. Their system, tested on various crops, demonstrated improvements in resource utilization and productivity. Research by Gupta et al. [9] examined AI-powered models for optimizing irrigation schedules, reducing water wastage while maintaining crop health.

Patel and Mehta [10] explored the application of AI-based decision support systems in agriculture, emphasizing machine learning algorithms such as Random Forest and Neural Networks for predicting crop suitability and early disease detection. Their study revealed that AI-driven predictive models could enhance decision-making accuracy, leading to higher efficiency in agricultural management. Singh and Rao [11] introduced explainable AI techniques in crop recommendation, ensuring that farmers could understand and trust AI-generated recommendations. Their research focused on transparency and interpretability, which are crucial for the widespread adoption of AI in farming. Elbasi et al. [12] reviewed AI applications in agrifood systems, highlighting the role of data acquisition and integration techniques in enhancing decision-making processes.

The reviewed studies collectively demonstrate the transformative potential of AI in agriculture, reinforcing the need for intelligent advisory systems to assist farmers in optimizing their farming strategies. The integration of machine learning models with real-time data acquisition has shown promise in addressing modern agricultural challenges such as climate unpredictability, soil degradation, and market fluctuations. By leveraging AI-based solutions, farmers can enhance productivity, reduce dependency on intermediaries, and adopt sustainable farming practices. Future research should focus on improving AI model generalization, incorporating region-specific datasets, and integrating real-time weather and market data for more precise recommendations.

III Methodology

The crop advisory system is designed to address key challenges faced by farmers by integrating technologies like artificial intelligence (AI), machine learning (ML), and the Internet of Things

(IoT). The system combines a Telegram bot and a web-based crop prediction platform to provide farmers with accurate, real-time insights that help them make informed decisions about crop cultivation and market strategies, while reducing their reliance on middlemen. It analyzes environmental parameters such as Nitrogen, Phosphorus, Potassium, temperature, pH, humidity, and rainfall to predict the most suitable crops for cultivation. The system also provides market advisory, guiding farmers on whether to sell or hold their produce based on market conditions. A Raspberry Pi acts as the central processing unit for the Telegram bot and web application, with an integrated speaker offering audio-based outputs for farmers with limited literacy. The system's design includes data collection, model development, and platform integration, resulting in a user-friendly and scalable solution. This system enhances resource efficiency, supports sustainable farming practices, and effectively addresses modern agricultural challenges.

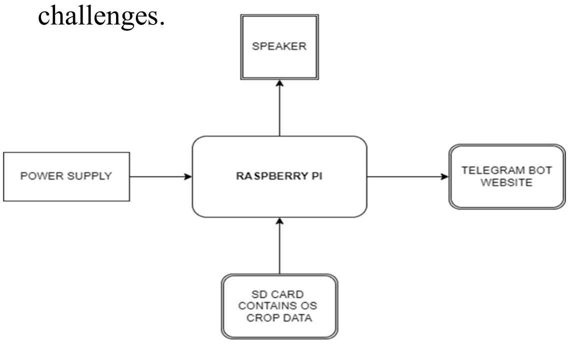


Fig 1. Block diagram of Agrivision

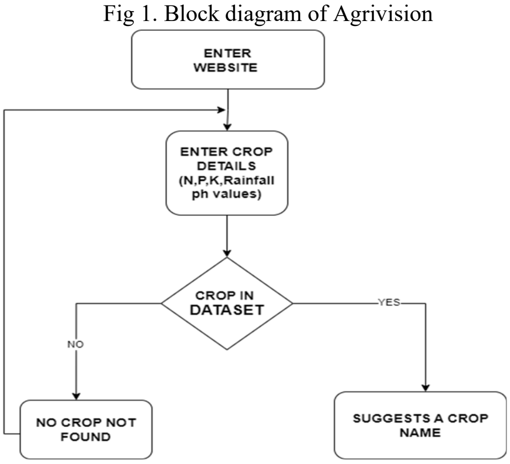


Fig. 2 Flowchart of Agrivision processing

1. **Data Collection**: The system gathers essential environmental parameters, including Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, rainfall, and soil pH. Market data such as crop prices and trends is collected from reliable sources. The data is then cleaned, normalized, and used for training the machine learning model.
2. **Machine Learning-Based Prediction**: A Random Forest algorithm processes the input data to predict the most suitable crop for the given environmental conditions. The model is trained on historical datasets of crop features and corresponding labels, enabling accurate crop recommendations. The system also analyzes historical price trends to provide insights on whether to sell or hold the produce.
3. **Telegram Bot Integration**: The Telegram bot acts as an interactive medium for farmers. Users input the crop name to receive details about its cultivation requirements and real-time market recommendations. The bot dynamically fetches data from the machine learning model and database to provide accurate, up-to-date responses.

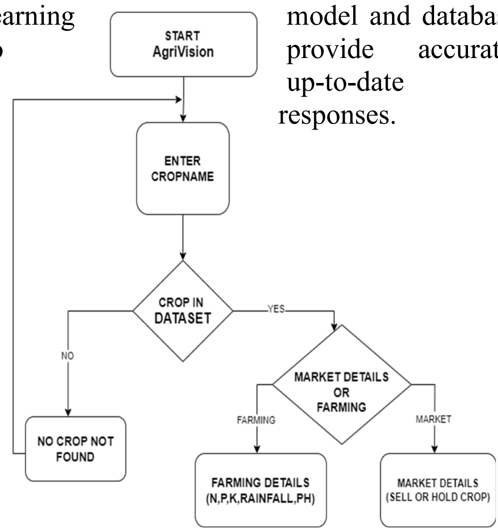
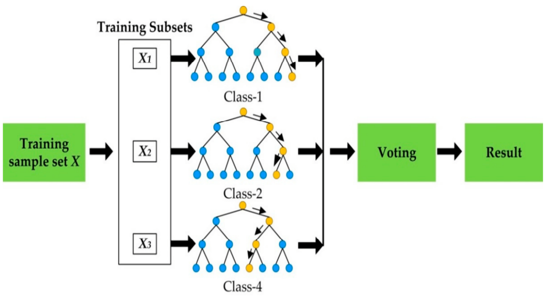


Fig. 3 Website flowchart

4. **Web-Based Crop Prediction**: The web application allows farmers to input environmental data through a user-friendly

interface. The application processes the inputs, runs them through the trained model, and displays the recommended crop along with



required chemical combinations and cultivation guidelines.

Fig. 4 Random forest processor

5. **Raspberry Pi and Speaker Integration**: A Raspberry Pi serves as the central processing unit for running the Telegram bot and the web platform. It is connected to a speaker, which outputs audio recommendations, ensuring accessibility for farmers with limited literacy or technical knowledge. Text-to-speech technology, using Gtts, converts the predictions and recommendations into audio messages in the farmer's local language.

The crop advisory system combines machine learning, artificial intelligence, and IoT technologies to deliver actionable insights for crop selection, cultivation, and market strategies. It consists of two primary components: a Telegram bot and a web-based crop prediction platform, both designed to streamline decision-making and enhance agricultural outcomes.

The software implementation of the crop advisory system relies on several major libraries to enhance its functionality. Numpy and Pandas provide robust support for numerical computing and data manipulation, respectively, ensuring effective data preprocessing for machine learning models. Scikit-learn is crucial for building and evaluating machine learning algorithms like decision trees and random forests, along with tools for data preprocessing and performance evaluation. Flask is used to create the web interface, enabling user interaction with the system. Pickle facilitates model serialization, while GTTS enhances accessibility by converting crop recommendations into audio. The Telegram Bot API integrates the system with Telegram for seamless user communication.

These libraries together create a powerful and user-friendly platform for farmers to access crop recommendations and market insights. With data analysis, model training, and an intuitive interface, the system provides valuable guidance for farmers. By leveraging machine learning and IoT, the system predicts suitable crops based on environmental conditions and offers real-time market advice. The integration of audio output through GTTS and chatbot functionality via Telegram makes the system accessible to a wider audience, ensuring that even farmers with limited literacy or visual impairments can benefit from the advisory system.

IV Results and discussion

This section presents an analysis of the performance and effectiveness of the crop advisory system. It evaluates the system's accuracy in predicting suitable crops and its impact on decision-making in agriculture. The findings highlight the system's ability to enhance resource efficiency, optimize crop selection, and provide actionable market insights. This section also addresses the challenges faced during implementation and offers insights into potential improvements for future iterations.

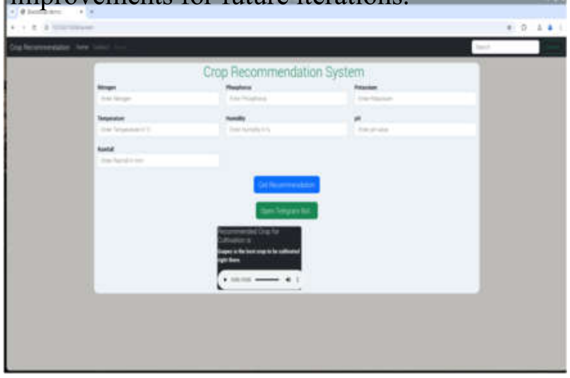


Fig. 5a Webpage interfaces

The results of the Crop Recommendation System demonstrate its effectiveness in supporting agricultural decision-making. Soil nutrients (N, P, K), temperature, humidity, pH, and rainfall are key factors influencing crop recommendations. Nitrogen-rich soils are associated with crops like maize, while potassium-rich soils are linked to crops such as banana. By optimizing crop selection based on these environmental parameters, the system enhances productivity and resource efficiency, reducing the wastage of water and fertilizers. This has significant economic and environmental benefits, particularly for both small-scale and large-scale farmers.

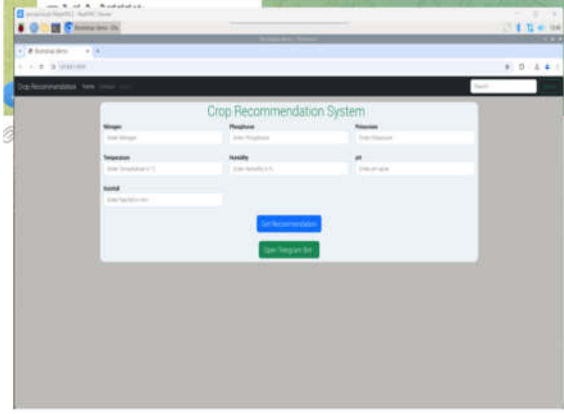


Fig. 5b Webpage interfaces

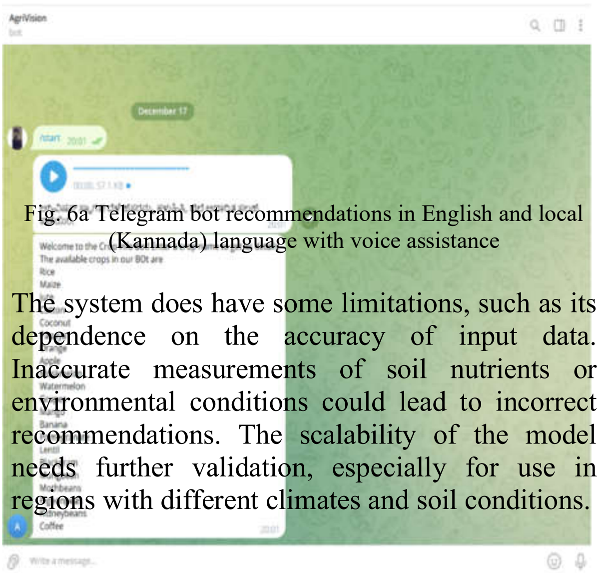


Fig. 6a Telegram bot recommendations in English and local (Kannada) language with voice assistance

The system does have some limitations, such as its dependence on the accuracy of input data. Inaccurate measurements of soil nutrients or environmental conditions could lead to incorrect recommendations. The scalability of the model needs further validation, especially for use in regions with different climates and soil conditions.

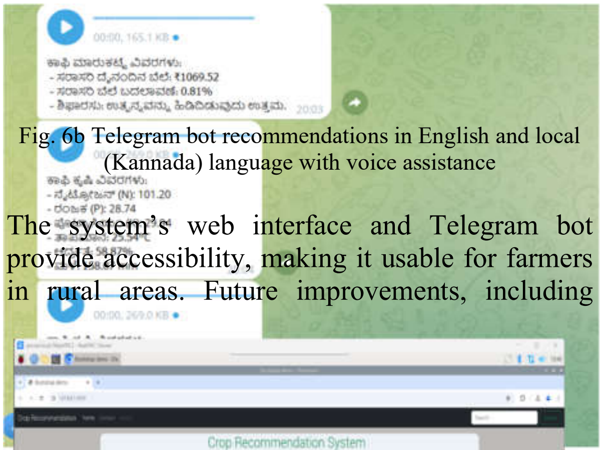


Fig. 6b Telegram bot recommendations in English and local (Kannada) language with voice assistance

The system's web interface and Telegram bot provide accessibility, making it usable for farmers in rural areas. Future improvements, including real-time weather data, localized models, and multi-language support, would enhance prediction accuracy and ensure inclusivity. The system promotes sustainable agriculture by recommending crops that are more resilient and require fewer resources, contributing to global goals of reducing agricultural emissions and enhancing food security.

V Conclusion

The Crop Recommendation System provides an effective solution for farmers to make informed decisions regarding crop selection and market strategies. By utilizing machine learning, artificial intelligence, and IoT technologies, the system analyzes environmental factors such as soil nutrients, temperature, humidity, pH, and rainfall to offer tailored crop recommendations. This approach helps optimize resource use, enhances productivity, and reduces environmental impact by minimizing water and fertilizer wastage. The integration of a web interface and Telegram bot ensures accessibility for farmers, particularly those in rural areas, making the system easy to interact with.

While the system has demonstrated promising results, there are limitations that need to be addressed. The accuracy of the input data is critical, and errors in environmental or soil measurements could affect the recommendations. The system's scalability must also be validated in different geographic and climatic conditions. Future improvements, such as incorporating real-time weather data, localized models, and multi-language support, will enhance the system's accuracy and broaden its application. The system holds significant potential in transforming farming practices by supporting sustainable agriculture, increasing resilience to climate change, and improving food security through better resource management.

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