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CropRec: AI-Based Crop Recommendation System for Smarter Farming

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[1]***Abstract*—Farming today faces many challenges and often rely on traditional knowledge or personal experience. But this approach may not work well with changing weather, soil conditions, or market trends. Studies show that a 1 °C rise in temperature can reduce crop output value by up to 21%, while rainfall and temperature together account for over 30% of yield variation worldwide. However, many farmers — especially in developing regions — still depend on old, experience-based methods to choose crops. CropRec is an AI-powered crop recommendation system designed to solve this problem by providing data-driven guidance. It uses machine learning techniques such as decision trees, random forest models, and neural networks to study inputs such as soil type, previous crop performance, live weather data, and market trends. The platform offers a simple and user-friendly web interface where farmers can provide their soil and location details to instantly get smart crop suggestions. It connects with real-time APIs to ensure up-to-date suggestions. By removing guesswork, CropRec allows farmers to improve yield, save resources, and follow sustainable farming practices. The system shows how AI can bring smart, climate-ready, and profitable solutions to agriculture. Our proposed system believes in "Take the guesswork out of farming". CropRec helps farmers grow the right crops, at the correct time with intelligent AI support.**

***Index terms*— AI crop recommendation, machine learning, smart farming, sustainable agriculture, soil analysis, weather-based prediction, market trend analysis, tree-based models, ensemble learning methods, deep learning techniques, MERN technology stack.**

I. INTRODUCTION

Agriculture has consistently been a vital part of human survival and the global economy. But in recent years, farmers are facing new challenges due to unpredictable weather, degraded soil quality, reduced farmland, and changing market demand. These issues make it harder for them to make good farming decisions.

Research shows that even a small 1 °C rise in average temperature can reduce crop value by around 21%. Rainfall and temperature together are responsible for more than 30% of crop yield variations globally. These numbers clearly show how climate change is affecting farming productivity.

In developing countries, many farmers still depend on traditional knowledge and intuition. Although this experience helps in some cases, it is often not reliable when dealing with changing weather conditions or soil health. Because of this, farmers sometimes select crops that don't match the soil or season, leading to low yields and financial loss.

As digital technology and artificial intelligence (AI) continue to advance, modern agriculture is becoming more intelligent. AI is capable of analyzing huge volumes of data such as soil nutrients, rainfall, temperature, and market prices — and help farmers make better decisions. CropRec is one such AI-based system that provides farmers with customized crop suggestions using real-time data. The goal is to improve productivity and enhance farming to become more eco-friendly and economically beneficial.

II. Literature Review

This section discusses some earlier systems and research projects that inspired the idea behind CropRec.

A. Existing system

A study by R. Patel and S. Mehta in 2020 developed a crop selection model based on soil nutrients using a decision tree algorithm. It performed well in controlled datasets but failed to adapt to real-time weather changes.

In 2021, A. Kumar and P. Sharma designed a mobile application that recommended crops using basic machine learning classification techniques. The app was easy to use but did not include rainfall, soil moisture, or market data, which reduced its accuracy in real situations.

Another project in 2022 by V. Singh and his team used a random forest-based approach for estimating crop yield. Even though the outcomes were encouraging, the system struggled when it encountered incomplete or inconsistent weather data.

Later, in 2023, A. Das and S. Ghosh tested a neural network–based system to suggest crops according to soil composition. Their model achieved good accuracy but required powerful hardware and was not practical for rural farmers with limited access to technology.

B. Identified Gaps

The reviewed research shows that most existing systems share some common drawbacks. They often lack live weather updates and do not take market demand or economic factors into account. Many models are also trained using small or region-specific datasets, which limits their accuracy. In addition, most of these systems are too complicated for ordinary farmers to use easily.

C. Summary of Review

CropRec aims to overcome these issues by bringing all relevant data — soil, weather, and market — together into one system. It focuses equally on accuracy and simplicity so that even farmers with limited digital knowledge can benefit from it..

III. Proposed System: CropRec

CropRec is an intelligent, AI-based crop recommendation system that helps farmers choose crops based on soil, weather, and market conditions. The system uses machine learning models to process the input data and provide reliable suggestions.

A. System Architecture

The architecture of CropRec consists of several connected components that work together from data input to result display. It starts by collecting inputs such as soil data (pH and NPK levels), location, temperature, rainfall, humidity, and past yield records. This information is then processed using machine learning models like Decision Tree, Random Forest, and Neural Network. Finally, the system provides a ranked list of the most suitable crops along with their predicted yield and best growing period.

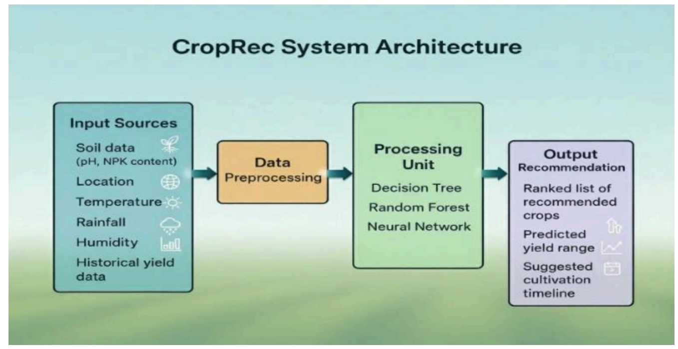

Fig. 1. CropRec System Architecture

B. Components

1) **Input Layer:** Collects soil and weather data from users and online APIs.
2) **Preprocessing Layer:** Cleans and standardizes the data.
3) **Model Layer:** Applies trained machine learning models to predict best crops.
4) **API Layer:** Fetches live updates from weather and market APIs.
5) **User Interface:** A simple web app (MERN stack) where farmers enter details and get recommendation

C. Advantages

The modular structure allows CropRec to update easily with new data. It adjusts to regional differences, provides accurate results, and supports both small and large-scale farmers

IV. Methodology

CropRec follows a step-by-step process to collect, clean process data before providing crop suggestions.

A. Dataset Collection

The system uses datasets collected from government sources, research institutions, and open platforms such as Kaggle. These datasets include information on soil nutrients (N, P, K, and pH), weather details like temperature, humidity, and rainfall, as well as past crop yield and market price data. By combining both static and real-time information, the model can provide more accurate and reliable recommendations across various conditions.

B. Dataset Preprocessing

Before training, the data goes through a cleaning and formatting process. Missing values are filled with average values, and all numerical data is scaled to a common range. Soil types and crop names are converted into a machine-readable format, and only the most relevant features are kept for model training. The processed data is then stored in MongoDB to ensure fast access and easy management

C. Machine Learning Algorithms

The system uses three main machine learning models. The **Decision Tree** model is simple and quick, making it suitable for smaller datasets, though it may overfit at times. The **Random Forest** model combines multiple trees to improve accuracy and reliability. The **Neural Network** model is used to identify complex relationships between soil, weather, and yield data, providing deeper insights for better crop prediction.

D. Model Training and Evaluation

The data is divided — 80% for training, 20% for testing. Every model is independently trained and evaluated. Performance is measured using metrics such as accuracy, precision, and recallCross-validation helps ensure fair results.

E. Performance Metrics

Accuracy shows how often the system's predictions are correct. **Precision** measures how many of the crops suggested by the system are truly suitable. **Recall** indicates how many of the actually suitable crops were correctly identified by the system.

V. Implementation

A. Technology Stack

The frontend, developed with React.js, offers a fast, responsive, and interactive user experience that works perfectly on both mobile and desktop devices. The backend, built with Node.js and Express.js, manages all API requests and provides a secure bridge between the user interface and the machine learning models.

The system uses MongoDB as its database, which allows easy storage and retrieval of information such as user profiles, soil records, and crop recommendations in a flexible NoSQL format. The machine learning layer is developed using Python, making use of libraries like scikit-learn, TensorFlow, and Pandas for building, training, and testing predictive models that analyze various agricultural parameters.

In addition, the system integrates external APIs for real-time data access. The OpenWeatherMap API supplies up-to-date weather details like temperature, humidity, and rainfall, while the AgriMarket API provides live crop price data. These inputs help farmers make better and more informed decisions.

Overall, CropRec combines web development, data science, and AI to deliver a reliable and intelligent platform that supports sustainable and data-driven farming practices.

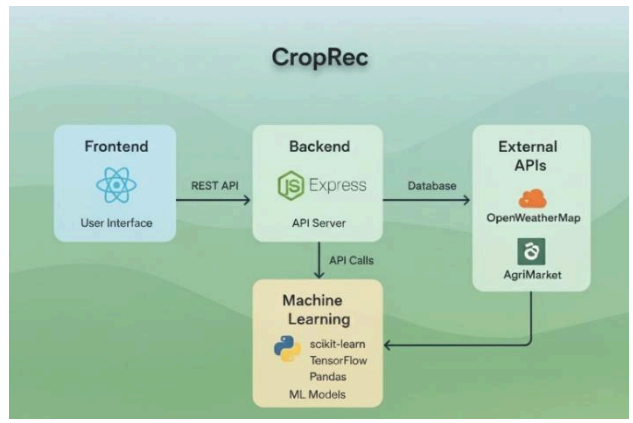

Fig.2. Technology Integration Diagram

B. Workflow

Farmers can use CropRec by entering either soil information, location details, or both through the web interface. The backend automatically fetches any missing data from connected APIs such as weather or market databases. The complete dataset is then processed by trained ML algorithms, after which the system generates recommendations for the best crops along with yield probability and reasoning.

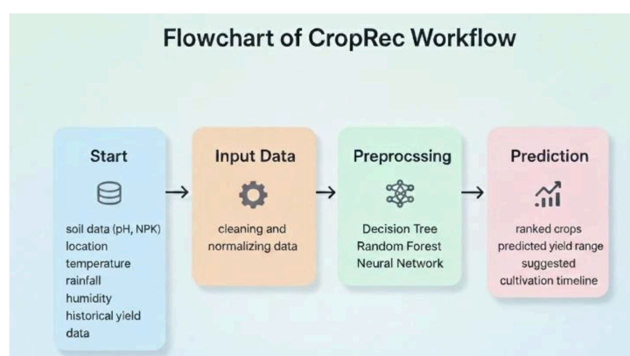

Fig. 3. Flowchart of CropRec Workflow

VI. Results and discussion

The testing phase showed that CropRec performs better than traditional or static models. Live data integration made predictions more accurate and context-aware.

A. Accuracy Analysis

Among the three models, the neural network performed the best with 93.6% accuracy. The random forest model was stable and consistent even when the input data varied. The decision tree gave quicker results but was less precise.

TABLE I: Model Accuracy

Algorithm	Accuracy (%)	Precision (%)	Recall (%)
Decision Tree	85.4	83.6	81.2
Random Forest	91.2	89.7	88.9
Neural Network	93.6	92.3	91.8

B. Impact on Farmers

CropRec allows farmers to choose crops confidently based on real-time soil and environmental parameters. It helps save resources like water and fertilizer. In simulation tests, CropRec improved yields by around 15–20% compared to traditional methods.

C. Sustainability Benefits

By using accurate recommendations, farmers can avoid overusing land and fertilizers. CropRec supports eco-friendly farming and helps maintain and improve soil condition for the coming seasons.

D. Economic Benefits

Since the system also considers market trends, farmers can plant crops with better profit potential. This helps reduce post-harvest waste and improves financial stability for rural communities

VII. Conclusion and future work

CropRec is an AI-powered system designed to make farming smarter and more efficient. By combining environmental, agricultural, and economic data, it gives farmers useful insights to increase yield and profit. The system highlights how machine learning and real-time analytics can transform modern agriculture.

In the future, CropRec can be improved by adding IoT sensors for automatic soil data collection, using satellite imagery for land and crop monitoring, developing a mobile app for easy access in the field, and applying reinforcement learning models for adaptive and smarter predictions. With these upgrades, CropRec could become a complete digital farming assistant that supports precision agriculture worldwide.

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