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AgroAdvisor: A Smart Agricultural Assistant for Crop Price Forecasting and Fertility-Based Crop Recommendation.

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Abstract - *An Agriculture in India remains highly vulnerable to unpredictable market prices and inconsistent soil fertility conditions. Farmers often rely on experience-based decisions rather than data-driven insights, resulting in economic losses and reduced productivity. AgroAdvisor is an intelligent web-based system designed to support farmers through two key capabilities: crop price forecasting and fertility-based crop recommendation. The system uses deep learning and machine learning techniques to analyze historical market data, soil nutrient levels (N, P, K), pH, and regional climatic conditions. Forecasting models predict future crop prices using time-series patterns, while classification models recommend suitable crops based on soil fertility and environmental factors. The platform also offers a simple and accessible user interface for farmers to input soil parameters, view insights, and make informed cultivation decisions. AgroAdvisor aims to bridge the technological gap in agriculture by providing personalized, intelligent, and actionable guidance, ultimately improving farmers' productivity and profitability.*

Key Words: **Machine Learning, Crop Recommendation, Price Forecasting, Soil Fertility, Agriculture, Deep Learning, Time-Series Analysis, Smart Farming.**

1.INTRODUCTION

Agriculture is one of the most critical sectors of the Indian economy, yet farmers continue to face challenges such as uncertain market prices, poor soil knowledge, and unpredictable climatic conditions. Traditional methods of crop selection often depend on experience or generalized advisory services, which fail to provide personalized guidance. With advancements in machine learning and data analytics, there is an increasing opportunity to support farmers through intelligent decision-support systems. AgroAdvisor is a smart agricultural assistant designed to enhance the decision-making process by combining soil fertility analysis with crop price forecasting. By taking soil nutrient parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH, along with climatic factors and historical price trends, the system provides actionable insights to farmers. It helps them choose suitable crops and plan their market strategy effectively.

1.1 Intelligent Crop Recommendation

The AgroAdvisor system uses a trained Decision Tree classifier to analyze soil nutrient values such as Nitrogen, Phosphorus, Potassium, and pH. By learning patterns from agricultural datasets, it identifies the crops that match specific soil profiles. This model not only evaluates raw values but also interprets nutrient balance, deficiency, and soil acidity before suggesting crops.

1.2 Soil Fertility–Based Decision Support

AgroAdvisor focuses heavily on soil fertility as the foundation for decision-making. The system evaluates the nutrient levels provided by the user and determines whether the soil conditions are optimal for particular crops. It reduces the chances of nutrient mismatch, which can negatively affect crop growth. By understanding soil fertility, the platform encourages farmers to grow crops best suited to their land rather than following traditional but unsuitable practices.

1.3 Data-Driven Price Forecasting

The price forecasting component is powered by Random Forest Regression, which analyzes historical mandi price data. It identifies seasonal trends, market fluctuations, and growth patterns over time. This helps predict future crop prices with considerable accuracy. Farmers can plan cultivation cycles, choose profitable crops, and decide the right time to sell their produce. The forecasting model reduces reliance on middlemen who often manipulate price. It empowers farmers with data-driven insights, helping them make informed financial decisions.

1.4 User-Friendly Web Interface

The platform features an intuitive and simple interface designed for farmers with minimal technical knowledge. It allows users to enter soil values easily and receive instant recommendations. The dashboard is visually appealing, with charts, graphs, and color-coded indicators for better

understanding. This ensures that farmers do not need specialized training to use the system. The mobile-friendly layout improves accessibility in rural areas where smartphones are common.

1.5 Integration of Soil, Weather, and Market Data

AgroAdvisor integrates multiple data sources to provide comprehensive recommendations. Soil nutrient values, climatic information, and historical price datasets are analyzed together to generate insights. This multi-dimensional approach increases accuracy and practicality. It ensures that the recommended crop is not only suitable for the soil but also profitable in the upcoming season. Integrating weather conditions helps farmers avoid climate-incompatible crop selections. Market price data ensures economic gain, while soil data ensures agronomic suitability. This holistic integration makes the system more reliable than solutions that consider only one type of data. It enables farmers to make decisions backed by science and economics simultaneously.

Chart -1: AgroAdvisor System Overview.

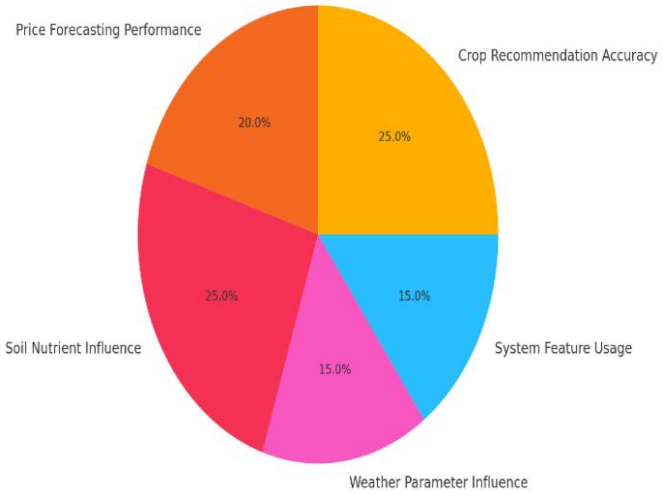

Table -1: Characteristics of AgroAdvisor

Characteristic	Explanation
Intelligent Decision making	Uses machine learning algorithms to analyse soil and market data for accurate recommendations.
Real-Time Recommendations	Provides instant crop suggestions and price predictions after user input.
Multi-Source data Integration	Combines soil, weather, and historical price datasets for holistic decision support.
High Accuracy Models	Utilizes Decision Tree and Random Forest algorithms for reliable outputs.
Scalable Architecture	Designed with modular components to allow future system expansion.
User-Friendly Interface	Simple dashboard designed to be easily used by farmers with minimal technical knowledge.
Data Security	Ensures secure login and protects user information from unauthorized access.

2. METHODOLOGIES

1. **Data Collection:**

AgroAdvisor begins with collecting data from multiple credible sources to build a strong foundation for prediction. Soil nutrient values such as Nitrogen (N), Phosphorus (P), Potassium (K), and pH are obtained from farmer inputs or sample soil reports. Historical mandi price datasets are collected from Agmarknet to train the price forecasting model. Weather data including temperature, rainfall, and humidity is fetched through API services. Additionally, agricultural crop datasets containing soil–crop mappings are used as references. This comprehensive data ensures accurate, real-time, and region-specific outputs.

2. **Data Preprocessing:**

Raw data often contains inconsistencies, missing values, and noise, so preprocessing is essential. Missing values are handled using imputation techniques to ensure model stability. Soil and weather attributes are normalized to maintain uniform scale across inputs. Duplicate records and outliers from price datasets are removed to avoid misleading predictions. Categorical entries are encoded numerically for ML compatibility. This step ensures clean, structured, and high-quality data for model training.

3. **Feature Engineering:**

Feature engineering enhances the predictive capability of the system by generating meaningful features. Nutrient ratios such as N:P:K are computed to better understand soil fertility patterns. Seasonal indicators are derived from date-wise price data to capture monthly or yearly trends. Weather-based crop growth factors are constructed to improve recommendation accuracy. Additional features like moving averages and price volatility strengthen time-series forecasting. These engineered features help the models learn deeper relationships within the data.

4. **Machine Learning Model Development:**

Two machine learning models are developed for AgroAdvisor: a Decision Tree classifier for crop recommendation and a Random Forest regressor for price forecasting. The Decision Tree analyzes soil nutrients and climate inputs to classify the most compatible crop. The Random Forest model learns from historical price patterns to predict future market prices. Hyperparameter tuning is performed to enhance accuracy and reduce errors. The models are trained, validated, and optimized through iterative testing. This stage builds the core intelligence of the system.

5. **System Integration:**

Once the models are trained, they are integrated into a web-based application for user access. Frontend technologies display input fields, charts, and prediction results in a clean interface. Backend logic connects the ML models through APIs, enabling real-time processing of user inputs. Soil and weather values entered by farmers are immediately passed to the models, and results are sent back to the UI. Data visualization tools such as graphs and tables present insights clearly. This integration ensures seamless communication between data, models, and user interaction.

6. **Model Evaluation & Testing:**

The system undergoes extensive testing to ensure accuracy, reliability, and robustness. Crop recommendation accuracy is measured using classification metrics such as Accuracy Score and Confusion Matrix. Price forecasting is evaluated using R^2 Score and Mean Squared Error (MSE) to validate prediction quality. Cross-validation ensures that models perform well across different data samples. Unit testing verifies individual components, while integration testing ensures smooth interaction between modules. The final evaluation confirms the readiness of AgroAdvisor for real-world deployment.

3. PROS and CONS:

3.1 PROS

1. Data-Driven Crop Recommendations

AgroAdvisor eliminates guesswork by using machine learning techniques to recommend crops based on soil nutrients, weather conditions, and regional patterns. This ensures scientifically accurate and personalized crop selection.

2. Accurate Price Forecasting

The system predicts future crop prices using historical mandi datasets, enabling farmers to plan cultivation and selling strategies more profitably. This helps reduce financial risks and enhances income stability.

3. Improved Resource Utilization

By aligning crop choices with soil fertility, AgroAdvisor supports efficient use of fertilizers, water, and land. Farmers avoid growing crops unsuitable for their soil, improving overall soil health and sustainability.

4. User-Friendly Interface

The platform provides a simple and interactive dashboard, making it easy for farmers—including those with limited technical knowledge—to input soil data and interpret results quickly.

5. Multi-Source Data Integration

The system intelligently merges soil, weather, and market price data, allowing farmers to make decisions that consider both biological and economic factors simultaneously.

6. Supports Sustainable Agriculture

By recommending crops that match the soil's natural fertility, AgroAdvisor reduces excessive fertilizer use and promotes eco-friendly farming practices.

7. Reduces Dependency on Middlemen

Farmers gain direct access to market price trends and future price predictions, reducing their reliance on external agents who may manipulate information.

3.2 CONS

1. Dependence on Internet Connectivity

Since AgroAdvisor is an online platform, farmers in remote or low-network areas may face

difficulties accessing the system, affecting real-time data retrieval and predictions.

2. Data Quality Sensitivity

The accuracy of recommendations heavily depends on correct soil inputs and reliable dataset sources. Incorrect nutrient values or inconsistent market data can reduce prediction performance.

3. Limited to Trained Crops

The system can only recommend crops included in its training dataset. Uncommon or regionally specific crops may not appear in suggestions, limiting flexibility for certain farmers.

4. Requires Basic Technical Literacy

Although designed to be simple, farmers unfamiliar with smartphones or web applications may still find it challenging to use the system without initial guidance.

5. Weather Variability Impact

Sudden climate changes or unpredicted rainfall patterns can affect the practicality of recommendations, as no model can fully capture real-time environmental unpredictability.

6. Computational Requirements

Running ML models and updating datasets requires backend computational resources, making the system dependent on server availability and maintenance.

7. No Real-Time Soil Sensor Integration

Since Agroadvisor relies on manually entered soil values, inconsistent sampling or human error can affect results. Integration with IoT soil sensors would increase precision but is not yet implemented.

4. CONCLUSION

AgroAdvisor provides a comprehensive, intelligent, and user-friendly decision-support system aimed at improving agricultural planning and profitability for farmers. By integrating soil nutrient analysis, climatic data, and historical market trends, the platform offers accurate crop recommendations and reliable price forecasting. The use of machine learning techniques such as Decision Tree Classification and Random Forest Regression significantly enhances prediction accuracy and reduces dependency on traditional guesswork-based decisions. The system also helps farmers make informed choices that optimize soil fertility, reduce cultivation risks, and promote sustainable farming practices. With its simple interface and data-driven insights, AgroAdvisor demonstrates strong potential for large-scale adoption among rural farming communities. Future enhancements, including IoT soil sensors, multilingual support, and expanded crop datasets, can further improve the system's accuracy and usability, making Agro Advisor a valuable contribution to modern precision agriculture.

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