A Smart Farming: Intelligent Crop Management Through Machine Learning

[1]Chintalapudi Poorna Narasimha Rajesh, [2]G. Rajasekharam, [3]Dr. Surya Narayana Gorle
Student, , Associate Professor, Assistant Professor
Dept. Of Master of Computer Applications,
Miracle Educational Society Group of Institutions

ABSTRACT
Farmers still encounter many threats resulting from shifting crop prices, climate change, and lack of real-time data, however, agriculture is still considered the backbone of the economy. This projector implements a machine learning based approach to help farmers predict crop prices, recommend plants, and make general farming decisions. To provide aid in anticipating future markets, the system employs decision tree regression and other ML algorithms with historical data, rainfall, and economic quotes. Other additional features include weather predictions, fertilizer suggestions, and easy access features. The model's goal is to aid in reducing economic uncertainty for farmers, fostering good agricultural practices, and increasing return on investment. It combines AI-based information to help modernize agriculture making it more productive and robust.
Keywords: ML, Agriculture, Farmers

INTRODUCTION:

Agriculture contributes immensely to the global economy, and is a vital economic activity that sustains the lives of hundreds of millions of people. But price variability, limited information about the market, and outdated techniques of farming are a few of the hurdles that farmers have to always remember. The implementation and introduction of machine learning (ML) on agriculture has the potential to change the very basics of farming. This initiative aims to utilize machine learning to predict crop prices, optimize productivity, and assist farmers with actionable advice. The system analyzes historical data along with weather conditions, soil health, and economic activities to provide insights that facilitate effective decision-making. Unlike traditional approaches, solutions offered through ML granule precision farming have higher productivity and give farmers the opportunity to act rather than to react. The solution provided tackles basic agricultural problems with the use of various methods of machine learning with the intention of increasing efficiency, productivity, and economic development. This research seeks to introduce AI driven predictive models with the intention of closing the technology gap in agriculture, while encouraging smart sustainable farming practices.

GAP IDENTIFIED BASED ON LITERATURE SURVEY:

Even with new technologies, most systems for crop price prediction are still not accurate and lack multi-farming factor integration, along with real-time adaptiveness. A survey of the literature indicates the reliance of conventional statistical models that attempt to capture the complex mechanisms interlacing the price dynamics and are doomed to fail. Moreover, most of the studies are limited to focusing on one criteria of farming activity: forecasting crop yields or weather conditions or soils fertility assessment and do not integrate all the components into one

tool for a comprehensive decision-making process.

Key gaps identified include:

Limited Dataset Scope – A significant number of studies are based on localized or small scale datasets which do not easily transfer to other locations and climatic conditions.

Lack of Integrated Solutions – Current models specialize in weather forecasting and price prediction but do not comprehensively address crop recommendation with disease detection and fertilizer recommendation.

Farmer Accessibility – Most systems currently in use have poor usability and lack adaptation to local regions, which makes it impossible for farmers to use these systems effectively.

PROBLEM STATEMENT:

Farmers suffer due to fluctuations in agriculture prices and climate change, affecting their annual earnings and productivity. The lack of control over crop prices creates a revenue gap, while low understanding of the appropriate crop and fertilizer options leads to poor efficiency. The core issue focused on in this research is an absent smart system capable of delivering accurate real-time recommendations and predictions for the user interface, which is a farmer.

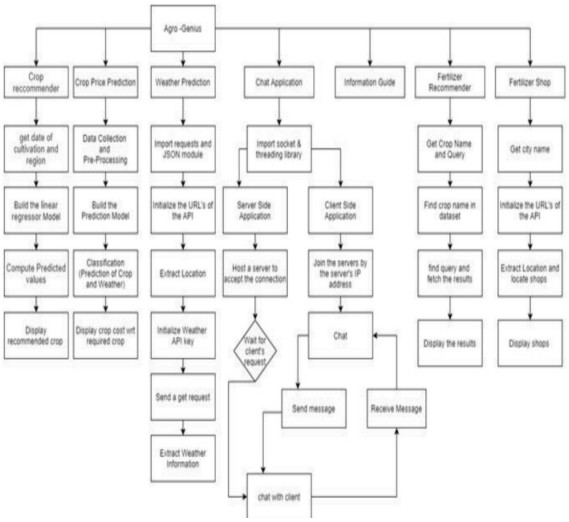
Key Challenges:

1. **Data Availability & Quality** – Relating to agricultural datasets, providing the most precise and newest data available.
2. **Integration of Multiple Factors** – Linking climate information, soil data, and existing market activity information.
3. **Real-time Adaptability** – Creating a system that continuously learns from new data.
4. **User Accessibility** – Designing a platform that is easy to use and available in regional languages.
5. **Model Accuracy & Performance** – Optimizing machine learning algorithms for precise forecasting.

PROPOSED METHOD:

The suggested solution focuses on the use of machine learning techniques with the aim of making better decisions in farming activities such as crop price forecasting, crop recommendation, and crop practice optimization. The model starts with collection of data from agricultural records, weather forecasts, and market trends. Data preprocessing takes care of missing data and normalization of datasets which is a prerequisite for accurate analysis. The system uses Decision Trees, Random Forest, and XGBoost machine learning models to make accurate estimates. A user-friendly interface that is responsive provides farmers the ability to see proposals and estimates as they are generated. The model is continuously evaluated and improved by using other measures like Mean Squared Error (MSE). This model helps farmers by providing an integrated approach with params and easy and intuitive interface enabling farmers to work and keep the business profitable and sustainable at the same time.

ARCHITECTURE:



DATASET:

The provided dataset contains several agricultural parameters needed for accurate prediction and recommendation of crop prices that are needed for this project. It contains historical prices of crops, taking into account, market movements of the last five years, weather parameters like temperature, rains and humidity, along with soil quality nutrients and pH level compositions.

METHODOLOGY:

1. Data Collection

- **Gathering Agricultural Data**: Crop prices, market trends, weather reports, soil quality, and government policies are sourced from reliable datasets.
- **Weather and Climate Data**: Includes temperature, rainfall, and humidity trends over previous years to analyze environmental factors affecting crop yield.
- **Market Price Records**: Past and present market prices for different crops are collected from government and private agricultural agencies.
- **Soil Health and Fertilizer Usage**: Nutrient levels and fertilizer recommendations are included to suggest optimal crop choices.

2. Data Preprocessing

- **Handling Missing Values**: Any missing or incomplete data is cleaned and replaced using statistical methods or interpolation techniques.
- **Data Normalization**: Ensures that data from different sources is standardized for accurate model processing.
- **Feature Selection**: Identifying key influencing parameters such as crop type, soil quality, climate, and economic indicators.
- **Encoding Categorical Data**: Converting text-based data (e.g., crop names, locations) into numerical format for machine learning models.

3. Feature Engineering

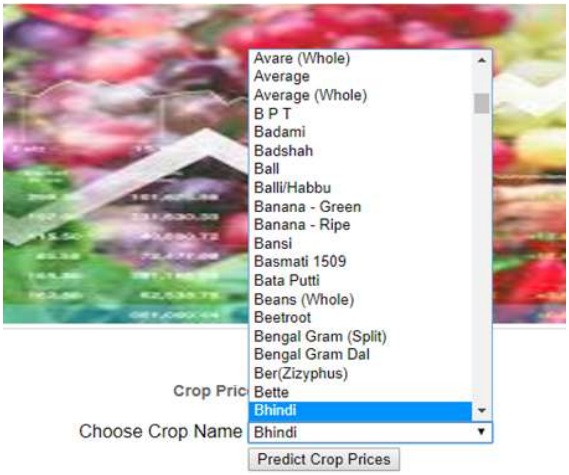
- **Data Transformation**: Creating new meaningful variables such as price trends, seasonal variations, and market demand.
- **Trend Analysis**: Identifying long-term price trends and variations based on historical patterns.

4. Model Selection & Training

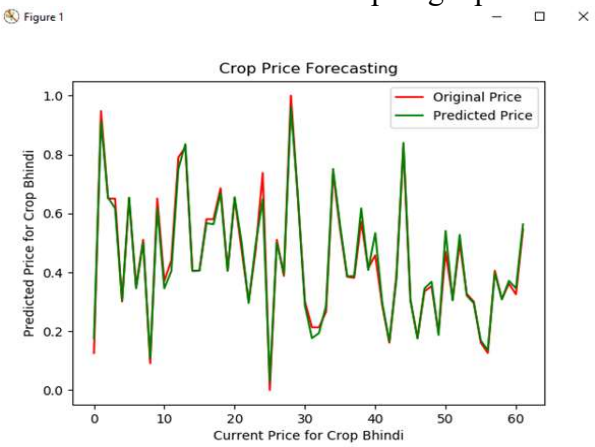
Machine Learning Algorithms Implemented:

- **Decision Tree Regression**: Helps in forecasting future crop prices based on historical data.
- **Random Forest**: Enhances accuracy by considering multiple decision trees for robust predictions.
- **XGBoost**: An advanced gradient boosting technique that improves overall predictive performance.

RESULTS:



Farmer can select desired crop to get price



Graph red line represents Original prices and green line represents predicted prices

Crop Price Prediction Screen

District Market	Crop Name	Original Price	Predicted Price
Rajnandgaon	Bhindi	1000.0	1289.5833333333348
Ambala	Bhindi	5700.0	5501.000000000007
Ambala	Bhindi	4000.0	4022.000000000008
Kurukshetra	Bhindi	4000.0	3810.7690476190496
Mahendragarh-Narnaul	Bhindi	2000.0	2021.4687770562768
Rohtak	Bhindi	4000.0	4022.000000000008
Bangalore	Bhindi	2300.0	2256.0720634920635
Bangalore	Bhindi	3200.0000000000005	3143.797619047621
Davangere	Bhindi	800.0000000000001	900.8333333333342
Ernakulam	Bhindi	4000.0	3810.7690476190496
Ernakulam	Bhindi	2400.0	2256.0720634920635
Ernakulam	Bhindi	2800.0	2592.619047619047
Ernakulam	Bhindi	4800.0	4576.450000000001
Kasargod	Bhindi	5000.0	5057.000000000006
Kollam	Bhindi	2600.0	2593.600000000003
Kottayam	Bhindi	2600.0	2600.3000000000025
Kottayam	Bhindi	3600.0	3522.6
Kottayam	Bhindi	3600.0	3501.5999999999995
Kottayam	Bhindi	4200.0	4116.000000000006
Kozhikode(Calicut)	Bhindi	2600.0	2593.600000000003
Palakad	Bhindi	4000.0	4028.000000000008

Predicted prices using Machine learning algorithms

Random Forest Accuracy	0.9993409853957524
Decision Tree Accuracy	0.9997952633406897
KNN Accuracy	0.9986281918756577

Random forest, KNN and decision tree prediction accuracy.

CONCLUSION

The adoption of machine learning in agriculture holds the potential to change farming practices for the better by offering predictive analyses and data-based decision making. This project proposes an AI-based system that predicts crop prices and assists farmers in making decisions related to crop type, market, and climatic conditions. To achieve maximum efficiency and accuracy, advanced ML models such as Decision Trees, Random Forest, and XGBoost are utilized. Deep learning models, along with real-time data from IoT sensors can be added to improve precision in future versions. With this research, the goal is to encourage farmers, boost sustainability in agriculture, and help the economic development of the farming sector.

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