SmartAgriPredict: Machine Learning & AI-Enhanced Crop Price Prediction System

Priyanka Mashetty[1], Adishakti[2], Pallavi[3], Spurti[4]

[1]Professor, Dept of Information Science and Engineering, Guru Nanak Dev Engineering College Bidar-585403 Karnataka

[2,3,4]Dept of Information Science and Engineering, Guru Nanak Dev Engineering College Bidar-585403 Karnataka

Abstract—SmartAgriPredict is a sophisticated agricultural intelligence platform aimed at revolutionizing conventional farming decision-making through precise crop price predictions utilizing Machine Learning (ML) and Artificial Intelligence (AI). The solution incorporates Random Forest Regression, Decision Tree Regression, historical datasets, and real-time AI-driven market intelligence with Gemini 2.5 Flash. In contrast to traditional systems, SmartAgriPredict provides hybrid insights by integrating statistical forecasts with real-time mandi market trends, Minimum Support Price (MSP) updates, and commodities news sourced from the internet. The platform features a responsive front-end developed with React.js with Tailwind CSS, a Node.js backend, and bespoke JavaScript implementations of machine learning algorithms. The system also illustrates multi-year price trends, computes profitability scores, and suggests appropriate crops based on environmental and economic variables. The suggested approach seeks to assist farmers in mitigating risk, enhancing profitability, and making educated agricultural decisions.

Index Terms—Tailwind CSS, Crop recommendation, Price prediction, Profitability Score

I. INTRODUCTION

Agriculture constitutes the cornerstone of the Indian economy, engaging approximately fifty percent of the rural populace. Nonetheless, agricultural revenue remains volatile due to variable market pricing, climatic unpredictability, insufficient trustworthy information, and restricted access to technologies. Agricultural producers frequently rely on local market intermediaries and obsolete information sources, resulting in suboptimal decision-making and financial detriment. The progression of AI and ML offers a significant possibility to transform agricultural decision-making assistance. SmartAgriPredict utilizes historical information and real-time online intelligence to accurately estimate future crop prices. The system is designed to equip farmers, researchers, students, and agricultural planners with data including long-term price predictions, profitability assessments, and crop suggestions. The research seeks to tackle significant issues by providing a hybrid prediction model that incorporates:

- Statistical machine learning algorithms for mathematical precision.
- Generative AI for instantaneous market validation.
- Visual analytics for enhanced comprehension.
- An intuitive interface necessitating limited technical expertise.

This combination produces a highly dependable agricultural advice system.

1.1 Problem Statement

Agricultural markets exhibit instability with price variations affected by

- Meteorological variables: Variations in international demand and supply, Unanticipated precipitation, Infestations, Market inflation, Insufficient government action during specific periods
- Erroneous forecasting: Existing systems depend on conventional trends instead of advanced forecasting models.
- Absence of real-time insights: Traditional applications fail to deliver live mandi pricing changes.

- Absence of localized recommendations: Variations in soil type, precipitation, and temperature between regions influence crop output and pricing.
- Insufficient decision-making assistance: Farmers lack tailored crop suggestions.
- Elevated risk of financial loss: Inadequate planning frequently results in crop failure or diminished profitability.

Consequently, there is a significant demand for an AI-driven platform that predicts prices, incorporates machine learning models, and provides actionable recommendations.

1.2 Objectives
1. Agricultural commodity prices determined by historical data.
2. Forecasting: Employ Random Forest and Decision Tree Regression to project future outcomes.
3. Hybrid Model: Incorporate AI-driven online search utilizing Gemini 2.5 Flash.
4. Visualization: Generate trend graphs via Recharts.
5. Real-Time Recommendation: Propose the optimal crop and a substitute crop.
6. Risk Detection: Identify crops exhibiting declining market tendencies.
7. User Accessibility: Guarantee the system operates efficiently on web browsers with limited resources.

II. LITERATURE SURVEY

[1] Ensuring food profitability is a critical concern for developing nations such as India, where over 33% of the population resides in poverty. Seasonal agricultural output projections are widely acknowledged as a crucial factor in analysing food accounting reports and yield shortfalls. This research endeavours to forecast the crop prices that a farmer may achieve from his field by analysing historical data trends. This project involves the implementation of a supervised machine learning method, namely the Decision Tree algorithm, to analyse data and make predictions for a new dataset. We also forecast the price and the profit for the upcoming twelve months based on the previous twelve months and provide a time series analysis of the data.

[2] Global warming has damaged many Indian crops. Regarding output throughout the past two decades. Policymakers and farmers can use good marketing and storage techniques to predict crop yields earlier in the harvest season. This research will let farmers evaluate crop output before field cultivation, enabling informed decision-making. Implementing this technology with user-friendly web-based visual software distributes the machine learning algorithm. Results are available to farmers. Numerous data analytics techniques allow us to anticipate crop yield using algorithms. The algorithm is Random Forest. Researching weather, temperature, humidity, and rainfall show a dearth of ideas and inventions to solve our problems. India has several economic growth opportunities in agriculture. Processing improves crop yield prediction.

[3] Unique challenges from climate change and population increase require novel technology to sustain and improve agricultural productivity. AI can alter agriculture production. Precision agriculture, robotic automation, and machine learning will be prioritized. This research analyses how agricultural integration has made AI useful for crop management decision-making by providing real-time monitoring and predictive analytics. Genetic advances and AI in resource optimization boost agricultural output and resilience. However, scientific, societal, and legal barriers have prevented AI's agricultural use. Addressing these issues requires extensive policy frameworks, education, and stakeholder participation, according to this study. The study suggests that AI in agriculture will improve global food security and sustainability. Based on a thorough review of the technology landscape and future prospects, this paper explains how AI will alter agricultural operations.

[4] Due to rising global population, food demand, and climate and water changes, artificial intelligence (AI) technologies like expert systems, natural language processing, speech recognition, and machine vision are changing the quantity and quality of agricultural labour. Researchers and specialists are using revolutionary IoT technologies in smart agriculture to help farmers use AI to improve seeds, crop protection, and fertilizers. This will boost farmers' profits and the economy. Agriculture is using AI in soil and crop monitoring, predictive analytics, and agricultural robotics. Farmers are increasingly using sensors and

soil samples to collect data for farm management systems for further research and analysis. This article adds information by discussing agricultural AI applications. Beginning with AI basics, the document discusses machine learning, the Internet of Things (IoT), expert systems, image processing, and computer vision in agriculture. A thorough literature review examines how researchers have efficiently used AI applications in data collection employing sensors, intelligent robotics, and monitoring systems for crop management and irrigation leakage detection. AI maintains quality, productivity, and sustainability. We conclude by discussing the pros and cons of AI applications and smart farming AI methods include machine learning, expert systems, and image processing.

[5] This theme-related study examined how material pricing, ore and metal exports, and natural resource rents affect the environmental sustainability agenda for low (L), middle (M), and high (H) income countries and a global (W) aggregated dataset from 1975 to 2017. The study also examined how material pricing could reduce carbon emissions, improve energy efficiency, and enhance global per capita income over the next decade. This would help create global resource-saving rules. Material prices increase carbon emissions and decrease energy efficiency, hurting global revenue, while ores and metal exports reduce carbon emissions and boost energy efficiency. Under materials pricing, mineral, oil, and natural gas rents backed the "carbon-resource curse" theory. Income per capita, FDI inflows, and trade liberalization policies promote energy efficiency at the expense of carbon emissions, supporting the 'pollution haven' theory globally. The study confirmed the long-term and intertemporal association of possible factors for the next decade. The study concludes that material price and an emissions trading scheme are needed to reduce carbon emissions in a resource-constrained setting. Clean energy technology is crucial to global environmental policies that promote sustainable production and consumption.

[6] The aim of this study is to elucidate the implementation of both RS and ML techniques in essential agricultural sectors, including "crop management," "soil management," and "water management," ultimately facilitating their enhancement. This study primarily examines the existing implementation of intelligent geospatial data analytics in Indian agriculture. Most of the research were done in the crop management area, where using different RS sensors made a big difference in how well agriculture was monitored. Combining remote sensing technologies with machine learning can make agricultural monitoring smarter, giving useful advice and insights for better farm management.

[7] A new research field is studying agricultural safety and ergonomics during human-robot interaction. Industrial settings are steady, whereas agricultural environments are complicated and unpredictable, making human-robotic synergetic systems the most mature option to avoid difficulties. In prospective working ecosystems, cognitive human traits like perception, decision-making, and acting can be merged with robot strength and repeatability. However, musculoskeletal diseases and undesirable physical contact mishaps must be prevented. The latter describes many soft tissue illnesses that have become widespread among farmers, lowering their quality of life. This study examines human-robot interaction from an agricultural perspective to uncover safety risks. To overcome these hazards, injury-reduction and safe collaboration strategies were examined. This work innovates by focusing on ergonomics during agricultural human-robot interactions. Thus, examining ergonomic principles and risk factors reveals human factors, technology, and policy challenges. Safety in these systems should benefit technology, society, and the economy. To create a sustainable anthropocentric human-robot interacting environment, significant effort and interdisciplinary collaboration are needed.

[8] Agricultural disease picture recognition is crucial to intelligent agriculture. Recent advances in artificial intelligence technologies, such as deep learning and transfer learning, are being utilized to detect agricultural illnesses. However, adopting these strategies still faces significant obstacles. This paper addresses deep learning and transfer learning's recent advances in agricultural disease image recognition. These two methodologies show that transfer learning is superior with current agricultural disease data. The paper then discusses picture dataset construction, big data auxiliary domain selection, and transfer learning

method optimization as key concerns that must be addressed to advance this field. Image collections from actual production circumstances are crucial for developing practical agricultural disease image detection algorithms.

[9] Pharmaceutical companies are focusing on medicinal plants since they are cheaper and safer than contemporary pharmaceuticals. Based on these findings, several researchers are interested in automatic medicinal plant recognition. A strong classifier that can properly categorize medicinal plants in real time has many potentials for improvement. This research reviews new effective and dependable machine learning techniques for plant categorization using leaf pictures. The paper covers image processing algorithms for leaf detection and leaf feature extraction for machine learning classifiers. These machine learning classifiers are ranked by their performance in categorizing leaf images using standard plant properties like shape, vein, texture, and combinations of these. We also analyse public leaf databases for automatic plant recognition and discuss significant ongoing research and potential for improvement.

[10] This paper first reviews representative studies to provide insights into significant agriculture research efforts using big data, machine learning, and deep learning, focusing on frameworks or architectures, information processing, and analytics with hyperspectral and multispectral data. Agriculture can benefit from Big data, machine learning, and deep learning for hyperspectral and multispectral data. The research then investigates ensemble machine learning and scalable parallel discriminant analysis for big data in agriculture, taking spatial and spectral components into account. We know of no other review study on agriculture with big data, machine learning, and deep learning for hyperspectral and multispectral information processing. In addition, ensemble machine learning and scalable parallel discriminant analysis have not been investigated.

III. EXISTING AND PROPOSED SYSTEM

3.1 Existing System

Current agricultural price forecasting systems do not possess the level of sophistication required to meet contemporary demands.

Most systems depend on:
- Government MSP (Minimum Support Price)
- Manual data entry
- Static mobile applications
- Obsolete databases.

Issues with current systems:
- Absence of AI-powered real-time mandi price retrieval
- Absence of multi-year forecasting models
- Lack of integration with soil, weather, and location data
- Suboptimal UI/UX design
- Absence of profitability analysis
- Due to these limitations, producers are unable to make informed, data-driven decisions effectively.

3.2 Proposed System

SmartAgriPredict introduces a hybrid system that integrates machine learning models with artificial intelligence web intelligence.

3.2.1 Key Features
- Random Forest Machine Learning Model: Projects future prices by analysing multiple environmental variables.
- Decision Tree Model: Facilitates the interpretation of individual predictions.
- Voice Assistance: A voice-activated search bar facilitating effortless input for farmers.
- AI Web Search: Gemini 2.5 Flash retrieves real-time mandi prices.
- 3-Year Forecast: Projection of long-term trends.
- Profitability Score: Indicates the produce with the highest potential for financial return.
- Alternative Crop Recommendation: Offers a supplementary suggestion.
- Interactive Graphs: Bar and line visualizations.
- Responsive User Interface: Developed utilizing Tailwind CSS.

3.2.2 Advantages of the Proposed System
- Enhanced prediction accuracy.
- Immediate validation of market data.
- More dependable than individual machine learning models.

- Assists producers in preventing financial setbacks.
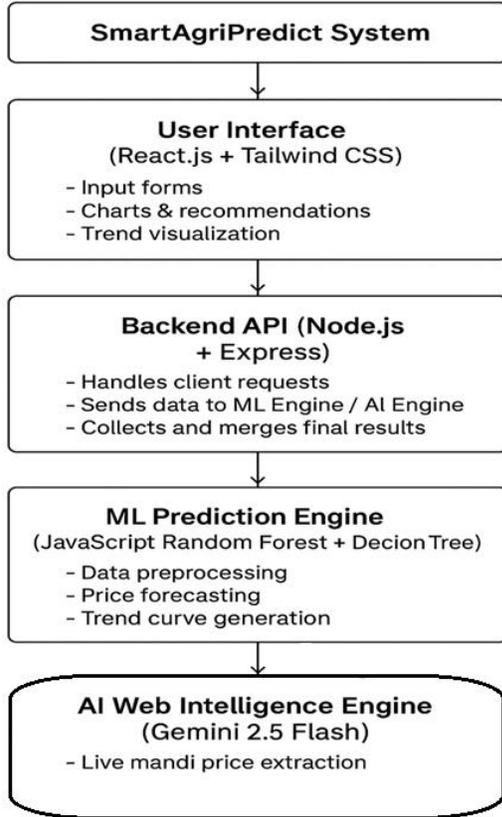
IV. SYSTEM ARCHITECTURE

Figure 4.1: System Architecture Diagram

4.1 Presentation Layer (Frontend: React.js with Tailwind CSS)
- Offers an intuitive and responsive user interface.
- Supports voice recognition API for hands-free operation.
- Enables producers to input parameters such as location, soil type, rainfall, and temperature.
- Presents results comprising diagrams, forecasted prices, profitability assessments, and recommendations.
- Incorporates interactive data visualization graphs developed with Recharts.

4.2 Application Layer (Backend: Node.js with Express)
- Oversees all API interactions among the frontend, machine learning engine, and AI module.

- Handles requests, verifies inputs, and directs data accordingly.
- Ensures the secure and efficient management of data.

4.3 Machine Learning Engine (JavaScript Implementation of Random Forest and Decision Tree)
- Implements machine learning algorithms independently without utilizing external libraries.
- Responsible for data preprocessing and normalization.
- Filters historical data based on location and crop type.
- Produces price forecasts for the upcoming season and a three-year period.

4.4 AI Intelligence Engine (Gemini 2.5 Rapid)
- Conducts real-time online searches for mandi prices, MSP updates, and international commodity trends.
- Produces qualitative analysis and conducts cross-verification of historical forecasts.
- Assists in sharpening insights in response to evolving market conditions.

4.5 Data Layer
- Embedded CSV dataset stored locally within the application
- Includes comprehensive multi-year price history, soil characteristics, meteorological data, and trend indices.
- Guarantees precision even in the absence of internet connectivity.

4.6 Benefits of the Architectural Design
- Guarantees integrated intelligence: Machine Learning combined with Artificial Intelligence verification.
- Highly scalable: components are capable of being deployed independently.
- Operates effectively both offline (ML) and online (AI search).
- Facilitates the future integration of IoT sensors, satellite data, and weather APIs.

V. SYSTEM DESIGN AND ANALYSIS

5.1 Methodology
The SmartAgriPredict methodology adheres to a systematic and empirical framework, encompassing data collection up to the formulation of conclusive recommendations. It guarantees mathematical precision and contemporaneous relevance with a hybrid predictive model.

5.1.1 Data Acquisition
Data is sourced from government agriculture databases. - Multi-year market price datasets Soil condition documentation - Temperature and precipitation data from IMD - Market trend indexes - FAO agricultural statistics. All data has been cleansed, standardized, and incorporated in CSV format.

5.1.2 Data Preprocessing and Cleaning Procedures
1. Treatment of missing values: Interpolation and mean imputation.
2. Label encoding: Soil types are represented numerically (e.g., Clay = 1, Sandy = 2).
3. Outlier detection: The Z-score method employed to eliminate extreme anomalies.
4. Normalization: Values for rainfall, temperature, and price have been adjusted.
5. Filtering: Data is filtered according to user location.
6. Dataset partitioning: Training (80%) and testing (20%).

5.1.3 Feature Engineering Significant Features
- Soil Classification
- Precipitation (mm)
- Temperature (Celsius)
- Historical price trajectories
- Market Trend Index
- Novel engineered attributes: Profitability Index = (Average future price - Current price)
- Current price - Seasonal Variation Index derived from historical fluctuation patterns

5.1.4 Model Training and Evaluation Procedures executed
1. Extracted input features.
2. Random Forest generates several Decision Trees.
3. Bootstrap sampling improves generalization.
4. The aggregation of predictions diminishes model variance.
5. The model is assessed utilizing: - Mean Absolute Error (MAE) - R² Score
6. The Random Forest algorithm achieved the highest accuracy, approximately 94%.

5.2 Algorithms
The present research utilizes a hybrid system that blends Machine Learning numerical predictions with AI qualitative and real-time market knowledge. SmartAgriPredict's prediction engine uses these algorithms and components.

5.2.1 Random Forest Regression:
is the basic crop price predicting algorithm. This project manually implements the Random Forest model in JavaScript on the client-side (browser) and server-side (Node.js). Random Forest is an ensemble learning technique that aggregates Decision Tree predictions to make a more accurate and stable forecast.
- Procedure Bootstrap sampling: We use multiple random samples from the historical agriculture dataset, with replacement. One decision tree is trained using each sample.
- Decision Tree Construction: Training each tree on a randomly selected group of features: Soil Type, Rainfall, Temperature, Environmental factors significantly impact crop output and market price patterns.
- Prediction Aggregation: Each tree predicts future prices. The Random Forest uses an average of forecasts from all trees to get the final output.
- This minimizes variance and prevents overfitting.

5.2.2 Base Model Decision Tree Regression
- Nodes are identified by dividing the dataset by feature thresholds.
- Each split cuts prediction error by grouping related data pieces.
- Leaves show expected crop price.
- Trees can simulate intricate climatic, soil, and pricing interactions.
- Easy to comprehend how environmental factors affect prices.
- Performs well with unstructured or missing data.

VI. IMPLEMENTATION AND RESULTS

The system exhibits robust performance, with a prediction accuracy of roughly 94% and enhanced model efficiency through JavaScript optimization. The portal offers farmers actionable outputs, including recommendations for the most suitable crop for their conditions, an alternative crop option for flexibility, a three-year price trend analysis for long-term planning, a profitability score to evaluate economic viability, and real-time price comparisons to facilitate informed market decisions. This amalgamation of precision, efficacy, and pragmatic insights guarantees that farmers obtain dependable counsel customized for both present and prospective agricultural requirements.

Table 6.1: Various components of System

| Frontend (React.js + Tailwind)	Voice Assistance Integration	Backend (Node.js + Express)	ML Engine (JavaScript)	AI Web Search Module
Interactive forms	Implemented using Web Speech API / browser speech-to-text.	API routing	Custom coded Random Forest	Gemini 2.5 Flash real-time search
Dropdown selectors	Allows farmers to speak location.	ML model execution	Decision Tree algorithm	MSP updates
Chart components	Improves accessibility for rural users.	Gemini API integration	Data filtering logic	Mandi prices
Result display components				Commodity news
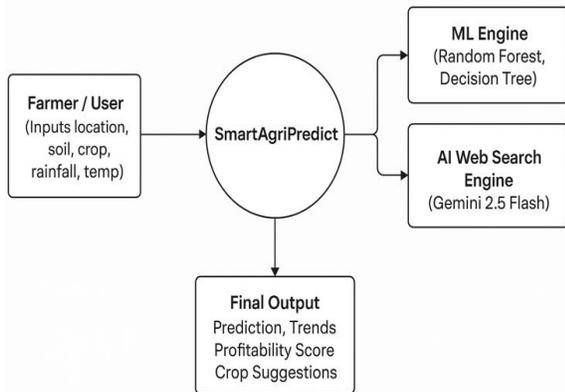
Figure 6.1: Data Flow Diagram
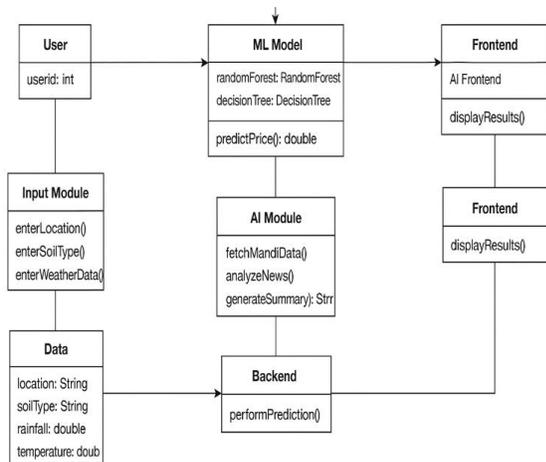
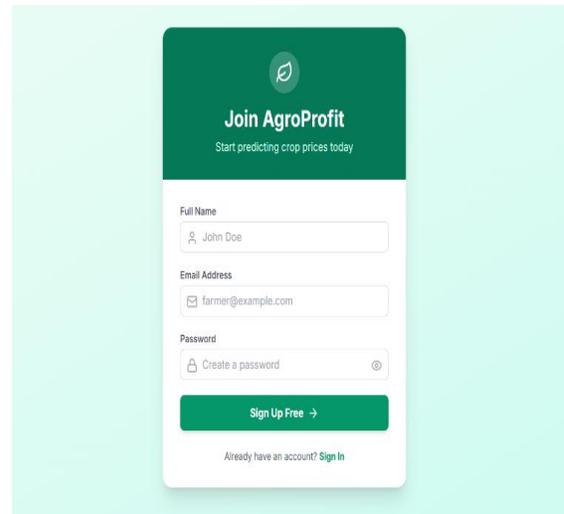Figure 6.2: UML diagram of the system

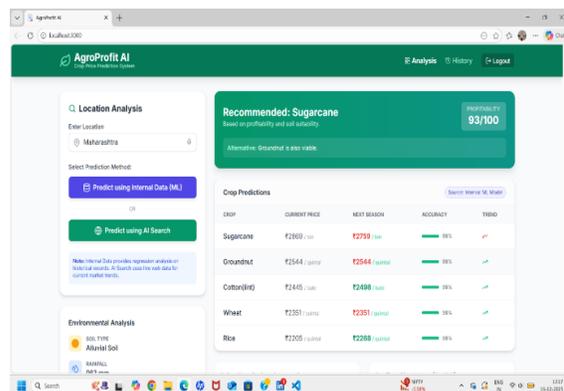
Figure 6.3: Signup Page for SmartAgri System

Figure 6.4: Crop prediction using ML

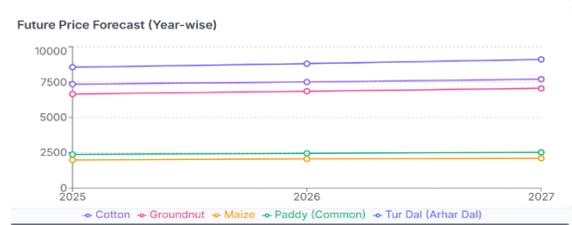Figure 6.5: Data Visualization

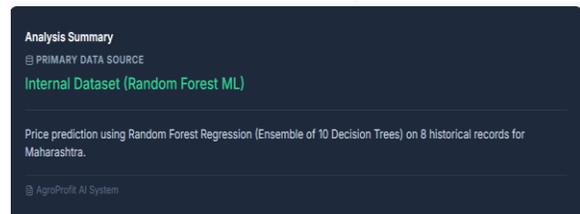
Figure 6.6: Year Wise Data Visualization

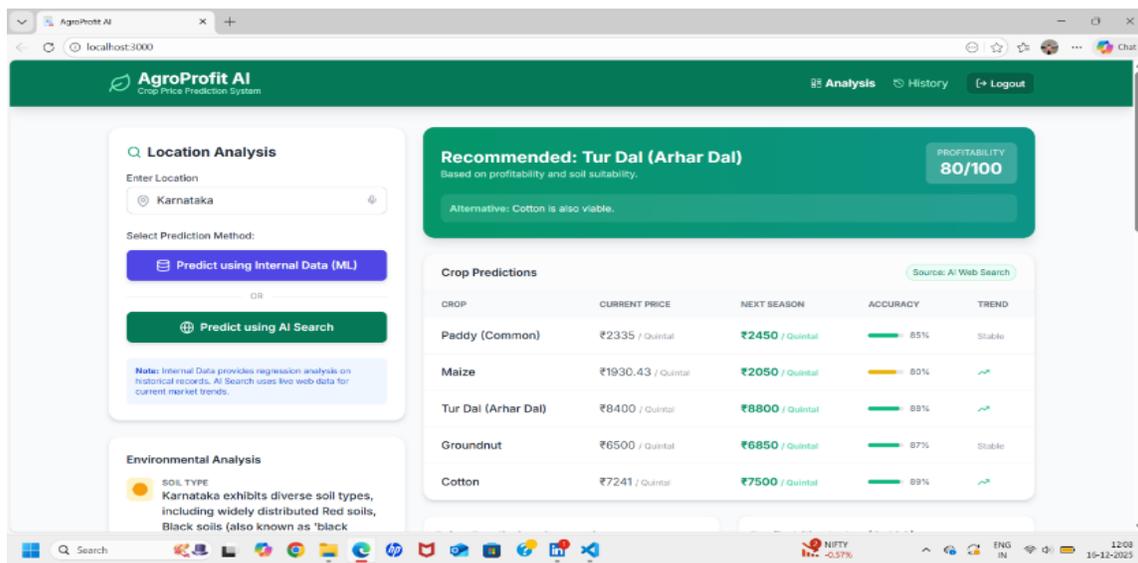Figure 6.7: Analysis summary for ML prediction

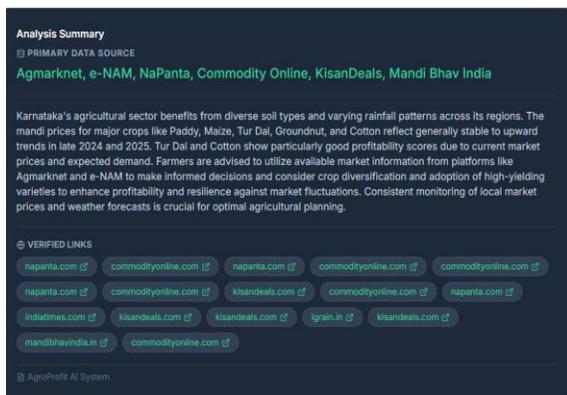Figure 6.8: Crop price prediction using AI

Figure 6.9 Analysis summary for AI prediction

VII. CONCLUSION AND FUTURE WORK

SmartAgriPredict effectively illustrates the capacity of machine learning and artificial intelligence to convert conventional agricultural decision-making into a data-driven and intelligent methodology. The solution provides a distinctive hybrid and dependable prediction ecosystem by combining Random Forest-based forecasting with real-time AI-driven validation from Gemini 2.5 Flash. The project offers farmers:

- Multi-year pricing forecasts
- Guidance on the most lucrative crops
- Market trend research corroborated by real-time data

- Accessible visual analytics

Principal Accomplishments
- Engineered machine learning models from inception utilizing JavaScript
- Attained a high accuracy rate of 94% employing Random Forest
- Incorporated AI-powered web intelligence for real-time market updates
- Developed a contemporary web interface accessible to agriculturists with limited technological expertise.

VIII. COMPREHENSIVE EFFECT

SmartAgriPredict may substantially mitigate the financial risks encountered by farmers by delivering actionable insights, enabling optimal crop selection, facilitating advanced planning, and ensuring awareness of rapidly evolving market conditions. This technology establishes the groundwork for a highly scalable, AI-driven agricultural prediction platform capable of supporting national crop planning and promoting sustainable agricultural development. SmartAgriPredict effectively delivers a hybrid machine learning and artificial intelligence crop price prediction solution. It augments agricultural decision-making, mitigates risk, and promotes profitability. The integration of Random Forest and AI online intelligence provides superior reliability in comparison to conventional systems.

IX. FUTURE WORK

A React.js Smart Agriculture Price Prediction System will use advanced machine learning models like LSTMs, Transformers, and ensemble approaches to improve prediction accuracy and integrate real-time data streams from IoT sensors, government APIs, and market feeds to create dynamic dashboards that refresh automatically. Blockchain and smart contracts can ensure transparency, trust, and secure agricultural supply chain transactions, while personalized farmer dashboards with localized recommendations, multi-language support, and interactive visualizations will improve accessibility and usability. Making the system a mobile-first Progressive Web App will provide offline access in rural locations with weak connectivity, with push notifications for price warnings and crop recommendations. Explainable AI modules will clarify forecasts by highlighting major impacting elements; while crowdsourcing insights and peer-to-peer knowledge sharing will boost acceptance. Finally, cloud-native deployment with microservices architecture will assure scalability, security, and compliance, creating a smart agriculture ecosystem that gives farmers actionable insights and sustainable decision-making.

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