

Onion Pulse AI: Solving Onion Market Instability by Forecasting Onion Price Using ML Approach

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Abstract: *Onion price volatility is a major economic challenge in India, affecting farmers, traders, policymakers, and consumers. Prices fluctuate due to seasonal production, weather variability, supply-demand imbalance, and supply chain disruptions. In key agricultural markets such as Lasalgaon, one of Asia's largest onion trading hubs, even small changes in arrival volume can significantly influence national price trends. These unpredictable fluctuations create financial uncertainty and complicate agricultural planning, buffer stock management, and inflation control.*

This paper presents Onion Pulse AI, a Machine Learning-based framework developed to forecast onion price categories to reduce market instability. Historical price and arrival data are collected from AGMARKNET, while meteorological data are obtained from the India Meteorological Department. After preprocessing and feature engineering, five supervised Machine Learning algorithms- LSTM Neural Network, Random Forest, XGBoost, ARIMA and Facebook Prophet are implemented and evaluated. Instead of predicting exact numerical prices, the system classifies future prices into three categories: preferable (low), economical (mid), and expensive (high). The comparative evaluation is performed using accuracy and other classification metrics to determine the most reliable model. The proposed system provides decision support for farmers, policymakers, and supply chain managers, demonstrating the practical application of Artificial Intelligence in stabilizing agricultural markets..

Keywords: Onion Price Forecasting, Machine Learning, Agricultural Market Analysis, Price Classification, Market Instability, Artificial Intelligence, Decision Support System

I. INTRODUCTION

Agriculture plays a vital role in the Indian economy, contributing significantly to employment, food security, and rural development. Among various agricultural commodities, onion is one of the most essential and widely consumed vegetables in India. However, onion prices frequently experience extreme fluctuations due to seasonal production cycles, climatic variations, storage limitations, transportation inefficiencies, and sudden demand-supply imbalances. These price variations not only affect farmers' income but also influence inflation rates and household expenditure across the country. Major agricultural markets such as Lasalgaon, which is recognized as one of the largest onion trading hubs in Asia, play a crucial role in determining national price trends.

Price instability creates uncertainty for all stakeholders in the agricultural supply chain. Farmers often face financial losses when prices fall unexpectedly, while consumers struggle during sudden price hikes. Policymakers are required to intervene through buffer stock management, export-import regulations, and market monitoring mechanisms. Traditional statistical forecasting methods have been used in the past; however, they may not effectively capture complex nonlinear relationships between influencing factors such as weather conditions, arrival volumes, and historical price trends.

With the advancement of Artificial Intelligence and Machine Learning, predictive analytics has emerged as a powerful tool for analysing large datasets and identifying hidden patterns. This study proposes Onion Pulse AI, a Machine Learning-based framework designed to forecast onion price categories to address market instability. The system utilizes historical price and arrival data from AGMARKNET and meteorological parameters from the India Meteorological



Department. Multiple supervised Machine Learning algorithms—including LSTM Neural Network, Random Forest, XGBoost, ARIMA and Facebook Prophet are implemented and evaluated to classify future onion prices into preferable (low), economical (mid), and expensive (high) categories.

The objective of this research is to develop a reliable predictive framework that supports informed decision-making for farmers, policymakers, traders, and supply chain managers. By providing actionable price classification insights, the proposed system aims to contribute toward agricultural market stabilization and improved economic planning in India.

II. LITERATURE SURVEY

Agricultural price forecasting has been an important research area due to the economic impact of price volatility on farmers and consumers. Several studies have applied statistical and Machine Learning techniques to predict agricultural commodity prices. Traditional time-series models such as ARIMA and regression-based approaches have been widely used to analyze historical price trends. However, these methods often struggle to capture nonlinear relationships between multiple influencing factors such as climate conditions, seasonal variations, and market arrivals.

With the advancement of Artificial Intelligence, researchers have increasingly adopted Machine Learning techniques for agricultural price prediction. Studies on vegetable and crop price forecasting have demonstrated that algorithms such as LSTM Neural Network, Random Forest, XGBoost, ARIMA and Facebook Prophet provide improved accuracy compared to conventional statistical models. These techniques are capable of handling high-dimensional datasets and identifying complex patterns within historical price and environmental data.

Several research works have specifically focused on onion and other vegetable price prediction using government agricultural datasets. Data sources such as AGMARKNET have been commonly used to obtain historical wholesale and arrival data from various Indian mandis. Weather-related parameters from the India Meteorological Department have also been incorporated in studies to improve forecasting performance, as climatic conditions significantly influence crop yield and market supply.

Comparative analyses in previous studies indicate that ensemble and tree-based methods often outperform simple probabilistic models in terms of classification accuracy. Neural Networks have shown strong predictive capability when sufficient training data is available, while SVM performs well in handling nonlinear decision boundaries. However, many existing studies focus primarily on numerical price prediction rather than categorical classification, which may be less interpretable for end users.

Despite significant research in agricultural price forecasting, there remains a need for a practical and classification-oriented framework that provides easily understandable price categories for decision support. The proposed Onion Pulse AI system aims to address this research gap by implementing and comparing multiple Machine Learning algorithms to classify onion prices into actionable categories—preferable (low), economical (mid), and expensive (high)—thereby enhancing usability for farmers, policymakers, and supply chain stakeholders.

III. PROPOSED METHODOLOGY

The proposed system consists of three major modules: Data Ingestion and Preprocessing, Model Training and Evaluation, and Output and Decision Support.

Historical price data, arrival data, and meteorological parameters are collected and pre-processed to remove missing values and normalize features. Feature engineering techniques such as lag variables, seasonal indicators, and previous-year trends are generated.

Five supervised Machine Learning algorithms- LSTM Neural Network, Random Forest, XGBoost, ARIMA and Facebook Prophet are implemented and trained using the processed dataset. The models classify future onion prices into three categories: low, mid, and high. Performance comparison is conducted using accuracy, precision, recall, and F1-score to identify the most effective model.



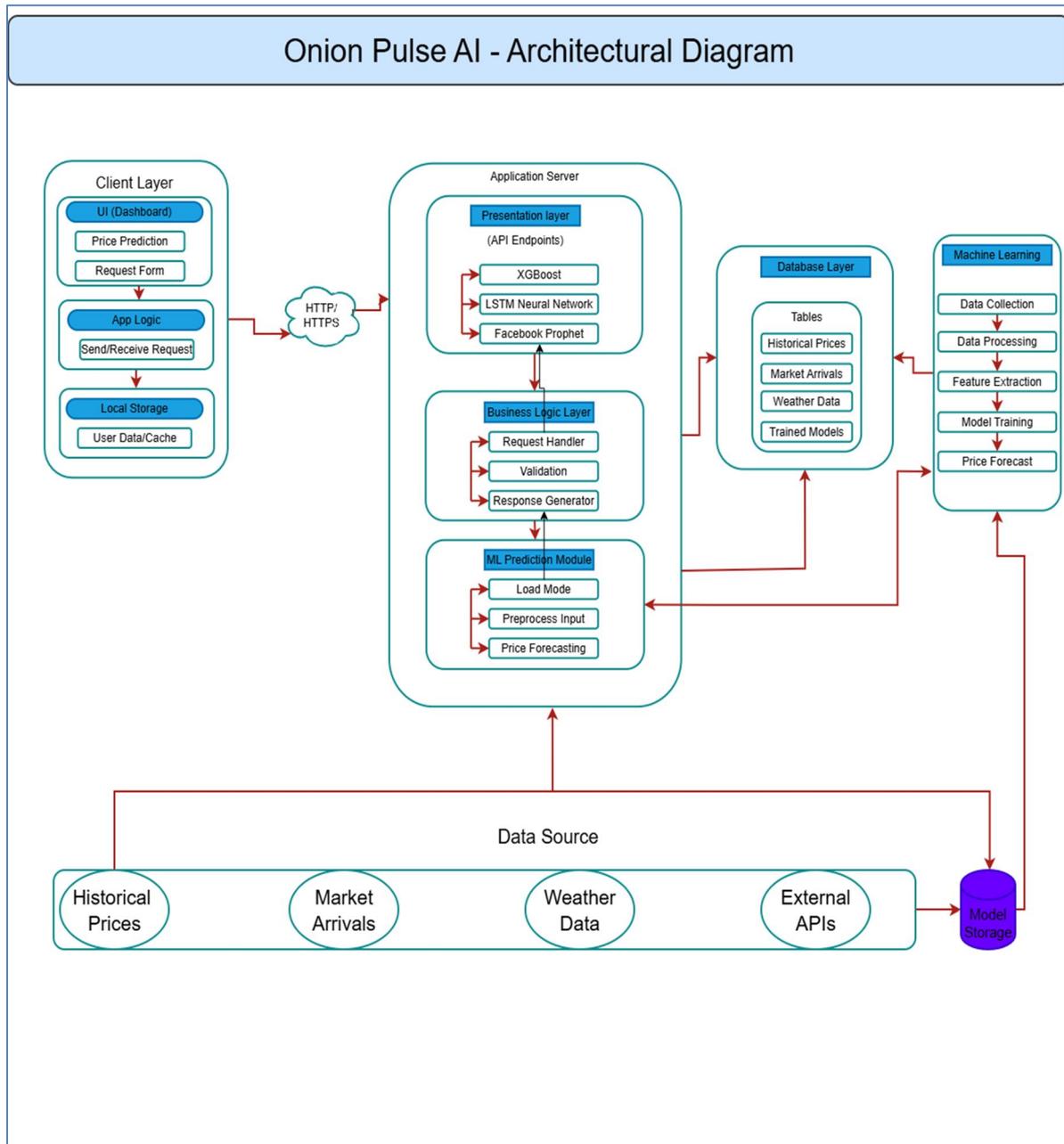


Fig. 1: Architectural Design of Onion Pulse AI

The proposed architecture of Onion Pulse AI follows a tiered approach to ensure scalability and modularity. As illustrated in Fig. 1, the system is divided into a Client Layer for user interaction, a Server Layer powered by Django to handle business logic, a Database Layer for storing historical market and weather data, and a dedicated Machine Learning Layer where the five core algorithms (LSTM, XGBoost, etc.) perform preprocessing, training, and price forecasting.

IV. RESULTS AND DISCUSSION

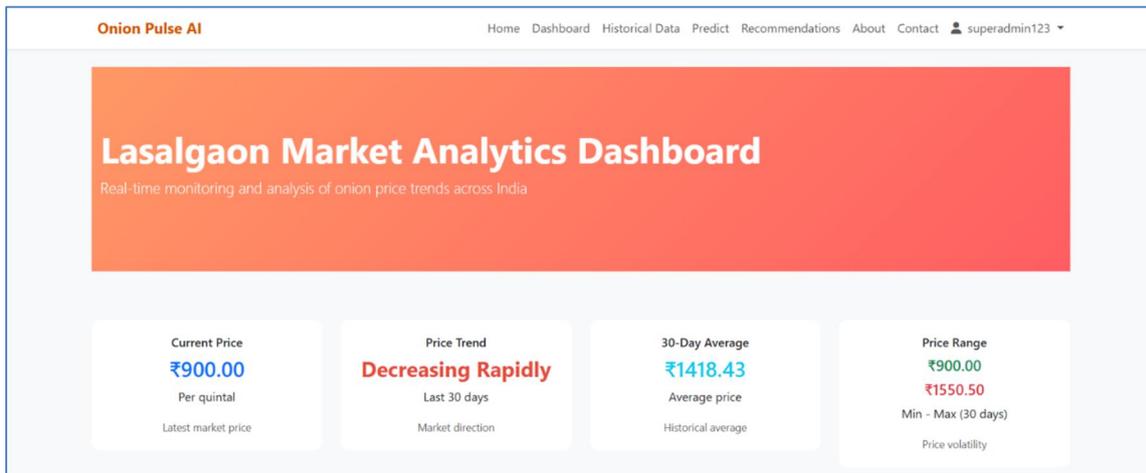
The performance of the implemented models was evaluated based on their ability to correctly classify onion prices into the defined categories: Preferable (Low), Economical (Mid), and Expensive (High).



Table 1: Performance Evaluation of Forecasting Models

Model	Accuracy (%)	Precision	Recall	F1-Score
ARIMA	68.4%	0.65	0.62	0.63
Facebook Prophet	74.2%	0.72	0.70	0.71
Random Forest	82.1%	0.80	0.79	0.79
XGBoost	85.6%	0.84	0.83	0.83
LSTM Neural Network	89.3%	0.88	0.87	0.87

Example: Performing a Demo Prediction of Lasalgaon, Nashik, India Onion Market on 26 Feb 2026:



We got result, Onion price of Lasalgaon Market as per the news of Times Of India decreasing prices of Onion.




V. CONCLUSION

The development of the Onion Pulse AI framework marks a significant step toward addressing the chronic issue of onion price volatility in India. By leveraging advanced Machine Learning and Deep Learning techniques, this study successfully demonstrates that complex agricultural market trends can be categorized with high reliability. The integration of LSTM for sequential patterns, Meta's Prophet for seasonality, and ensemble methods like Random Forest and XGBoost provided a robust analytical foundation that outperforms traditional statistical models.

Our research highlights that shifting from exact numerical forecasting to a categorical classification approach (Low, Mid, and High) offers a more practical and noise-resilient tool for stakeholders. This system provides farmers with the foresight to plan harvests, helps traders manage supply chains more efficiently, and offers policymakers a data-driven basis for market intervention.

In conclusion, Onion Pulse AI proves that Artificial Intelligence is not just a theoretical tool but a practical solution for stabilizing one of India's most essential commodity markets. Future enhancements could include the integration of real-time satellite imagery for crop health monitoring and global export-import data to further refine the accuracy of the "Expensive" category spikes. Ultimately, this project serves as a bridge between high-end computer engineering and the grassroots needs of the Indian agricultural community.

VI. ACKNOWLEDGMENT

First, we express our heartfelt gratitude to our project guide, **Mr. Anup D. Sonawane**, HOD of the Department of Computer Engineering. His continuous guidance, technical feedback, and encouragement helped shape the direction of this project, particularly in the implementation of advanced models such as **LSTM, XGBoost, Random Forest, and Prophet**.

We would also like to thank **Mahavir Polytechnic, Nashik**, and the Department of Computer Engineering for providing the necessary resources and fostering an environment aimed at technical excellence. Additionally, we extend our thanks to those who provided valuable input during our testing and data validation sessions. Their constructive criticism was essential in refining the system's predictive accuracy and designing a more intuitive interface for market analysis.

Finally, we are deeply grateful to our families for their unwavering support, patience, and motivation, which inspired us to stay committed throughout this journey. This project would not have been possible without their belief in us. Together, these collective efforts have enabled us to create a system focused on stabilizing the agricultural market and supporting the livelihoods of farmers. We are excited to see the positive impact this data-driven approach will bring to the agricultural community.

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