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AI-Driven Time Series Forecasting Model for Predicting Prices of Agricultural and Horticultural Commodities

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ABSTRACT

Agricultural commodity price prediction plays a crucial role in supporting farmers, traders, and policymakers in making informed decisions. Price fluctuations in agricultural and horticultural commodities are influenced by various factors such as seasonal variations, supply-demand dynamics, climatic conditions, and market trends. Accurate forecasting of commodity prices can help in reducing uncertainty, improving profitability, and ensuring market stability. This research proposes an AI-driven time series forecasting model for predicting the prices of agricultural and horticultural commodities using historical data.The proposed system utilizes the Seasonal AutoRegressive Integrated Moving Average with eXogenous variables (SARIMAX) model, which is well-suited for handling time series data with seasonal patterns. The implementation is developed using Python and integrates data processing, model training, forecasting, and visualization within a graphical user interface. The system allows users to select a commodity and generate future price predictions based on historical trends.The dataset used in this study contains historical price data of multiple commodities. The data is preprocessed by handling missing values, converting it into a time-indexed format, and ensuring consistency in frequency. The SARIMAX model is trained on this processed dataset, capturing both seasonal and non-seasonal patterns in the data.The system forecasts commodity prices for a period of five years, providing insights into future market trends. The results are presented in both tabular and graphical formats, enabling users to interpret predictions effectively. The model's performance is evaluated using Root Mean Square Error (RMSE), which measures the difference between predicted and actual values.The graphical user interface enhances usability by allowing users to interact with the system easily. Users can select commodities, view forecasts, and analyze trends without requiring technical expertise. The visualization module displays actual and forecasted prices, providing a clear comparison of model predictions.Experimental results demonstrate that the SARIMAX model effectively captures seasonal patterns and provides accurate forecasts for agricultural commodity prices. The system offers a scalable and efficient solution for price prediction, which can be extended to include additional factors such as weather conditions and market demand.This research contributes to the field of agricultural analytics by providing a practical tool for commodity price forecasting. The proposed system can assist farmers in planning crop production, traders in making investment decisions, and policymakers in managing market stability. Future work can focus on integrating machine learning and deep learning techniques to further improve prediction accuracy and adaptability.

Keywords: Commodity Price Prediction, Time Series Forecasting, SARIMAX, Agricultural Economics, Machine Learning, Price Volatility, Forecasting Models

I. INTRODUCTION

Agriculture remains a fundamental sector in many economies, particularly in developing countries, where it plays a vital role in employment and food security. The pricing of agricultural and horticultural commodities is highly dynamic and influenced by multiple factors, including seasonal variations, weather conditions, supply-demand imbalances, and market trends. These fluctuations often create uncertainty for farmers and stakeholders, making it difficult to make informed decisions.Accurate prediction of commodity prices is essential for effective planning and risk management. Farmers can use price forecasts to decide which crops to cultivate, while traders can optimize their buying and selling strategies. Policymakers can also benefit from price predictions to ensure market stability and prevent price shocks.Traditional methods of price prediction rely on statistical techniques and historical trend analysis. While these methods provide some insights, they often fail to capture complex patterns and seasonal variations present in agricultural data. With the advancement of artificial intelligence and machine learning, more sophisticated models have been developed to analyze time series data and improve forecasting accuracy.Time series forecasting models, such as ARIMA and SARIMAX, have gained popularity for their ability to model temporal dependencies in data. SARIMAX, in particular, extends ARIMA by incorporating seasonal components, making it suitable for agricultural data that exhibits periodic patterns.This research focuses on developing an AI-driven forecasting system using the SARIMAX model to predict commodity prices. The system is designed to process historical data, train forecasting models, and generate future predictions. A graphical user interface is implemented to enhance usability and provide an interactive platform for users.The motivation behind this work is to create a reliable and accessible tool for commodity price prediction. By leveraging time series analysis and AI techniques, the system aims to reduce uncertainty and support decision-making in the agricultural sector.The key contributions of this research include the development of a forecasting model, integration of data visualization techniques, and implementation of a user-friendly interface. The study demonstrates the effectiveness of SARIMAX in capturing seasonal trends and highlights the potential of AI in agricultural analytics.

II. LITERATURE SURVEY (WITH EXISTING METHODS)

Commodity price prediction has been widely studied using various statistical and machine learning techniques. Traditional approaches primarily rely on time series models such as AutoRegressive Integrated Moving Average (ARIMA), which is effective for modeling linear relationships in data. However, ARIMA does not account for seasonal variations, limiting its applicability in agricultural forecasting.To address this limitation, the Seasonal ARIMA (SARIMA) model was introduced, incorporating seasonal components into the forecasting process. SARIMA has been widely used for agricultural price prediction due to its ability to capture periodic patterns. However, it assumes linear relationships and may not perform well in complex scenarios.The SARIMAX model extends SARIMA by including exogenous variables, allowing the incorporation of external factors such as weather conditions and market indicators. This makes it more flexible and suitable for real-world applications.Machine learning techniques, such as Support Vector Machines, Random Forests, and Neural Networks, have also been applied to commodity price prediction. These models can capture nonlinear relationships and handle large datasets. However, they often require extensive training data and computational resources.Recent studies have explored hybrid models that combine statistical and machine learning approaches. These models aim to leverage the strengths of both techniques to improve prediction accuracy. Deep learning models, such as Long Short-Term Memory (LSTM) networks, have also shown promising results in time series forecasting.Despite these advancements, challenges remain in handling data variability, seasonal patterns, and external influences. Many existing systems lack user-friendly interfaces, making them less accessible to non-technical users.This research builds upon existing methods by implementing a SARIMAX-based forecasting system with an interactive interface. The approach focuses on balancing accuracy, efficiency, and usability.

III. EXISTING SYSTEM

Existing systems for commodity price prediction primarily rely on traditional statistical models and manual analysis. These systems often use ARIMA or basic regression techniques to forecast prices based on historical data. While effective for simple datasets, these models struggle to capture seasonal patterns and complex relationships.Many existing tools are designed for research purposes and lack user-friendly interfaces. This makes them difficult to use for farmers and non-technical stakeholders. Additionally, these systems often require manual data preprocessing and parameter tuning, increasing complexity.Another limitation is the lack of visualization and interactive features. Users are often required to interpret raw numerical outputs, which can be challenging. Furthermore, many systems do not provide long-term forecasts, limiting their usefulness for strategic planning.Existing approaches also face challenges in handling missing data and ensuring data consistency. This can negatively impact prediction accuracy and reliability.Overall, existing systems provide basic forecasting capabilities but lack scalability, usability, and advanced features required for practical applications.

IV. PROPOSED METHOD

The proposed system introduces an AI-driven framework for predicting agricultural and horticultural commodity prices using the SARIMAX model. The system is designed to provide accurate forecasts while ensuring ease of use through an interactive graphical interface.The system begins with data preprocessing, where historical price data is cleaned, structured, and converted into a time-indexed format. Missing values are handled using forward filling techniques to ensure data continuity.The SARIMAX model is then applied to capture both seasonal and non-seasonal patterns in the data. The model is trained using historical data and used to generate future price forecasts for a specified period.The system includes a graphical user interface that allows users to select commodities and view predictions. Results are displayed in both tabular and graphical formats, providing clear insights into price trends.Performance evaluation is carried out using RMSE to measure prediction accuracy. The system also provides visualization of actual and forecasted values, enabling users to analyze model performance.The proposed system addresses the limitations of existing approaches by providing accurate forecasts, user-friendly interaction, and comprehensive visualization. It offers a practical solution for stakeholders in the agricultural sector, supporting informed decision-making and market planning.

V. IMPLEMENTATION

The implementation of the proposed agricultural commodity price prediction system is carried out using Python, integrating time series forecasting techniques with a graphical user interface for enhanced usability. The system utilizes libraries such as Pandas and NumPy for data manipulation, Statsmodels for implementing the SARIMAX model, and Matplotlib for visualization. Additionally, Tkinter is used to develop a user-friendly interface that allows interaction with the forecasting system.The implementation begins with loading the dataset from a CSV file containing historical price data of various agricultural commodities. The dataset is preprocessed by setting the commodity names as indices and transposing the data to align it with time series requirements. A monthly date range is generated and assigned as the index, ensuring uniform temporal representation. Missing values in the dataset are handled using forward filling techniques, which

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maintain continuity in the time series data.The system provides a graphical interface where users can select a specific commodity from a dropdown menu. Upon selection, the SARIMAX model is applied to the corresponding time series data. The model is configured with both non-seasonal and seasonal parameters, enabling it to capture trends, cycles, and seasonal variations in commodity prices. SARIMAX is particularly effective in modeling seasonal agricultural data due to its ability to incorporate periodic patterns and external influences .Once the model is trained, it generates forecasts for a period of five years (60 months). The forecasted values are stored in a structured format and displayed in the interface. The system also plots both actual and predicted values on a graph, allowing users to visually analyze trends and compare model performance.To evaluate the model's accuracy, Root Mean Square Error (RMSE) is calculated by comparing predicted values with actual training data. RMSE provides a quantitative measure of prediction error, helping assess the reliability of the model.The integration of visualization and GUI enhances the usability of the system, making it accessible to users without technical expertise. The modular implementation allows easy extension of the system to include additional models or external variables such as weather and market indicators. Studies suggest that incorporating such external factors can significantly improve forecasting accuracy .Overall, the implementation demonstrates a practical and scalable solution for commodity price forecasting, combining statistical modeling with interactive visualization.

VI. ALGORITHMS

The system follows a structured algorithm for forecasting agricultural commodity prices:

Step 1: Data Collection

Load historical commodity price data from a dataset.

Step 2: Data Preprocessing

- Set commodity names as indices
- Transpose dataset
- Assign time index
- Handle missing values using forward fill

Step 3: Commodity Selection

Allow user to select a commodity through the GUI.

Step 4: Model Initialization

Initialize SARIMAX model with parameters:

- Order (p, d, q)
- Seasonal order (P, D, Q, s)

Step 5: Model Training

Fit the SARIMAX model using historical data.

Step 6: Forecast Generation

Generate future price predictions for 60 months.

Step 7: Visualization

Plot actual vs predicted values using graphical representation.

Step 8: Performance Evaluation

Calculate RMSE to evaluate prediction accuracy.

Step 9: Output Display

Display forecast values and evaluation metrics in the GUI.

This algorithm ensures efficient time series modeling and accurate price prediction. Time series models like SARIMA and SARIMAX are widely used for capturing seasonal trends in agricultural data

VII. SYSTEM DESIGN

The system design follows a modular architecture to ensure flexibility, scalability, and efficient data processing.

1. Data Input Module

This module loads historical commodity price data from external sources such as CSV files. It ensures proper formatting and accessibility of data.

2. Data Preprocessing Module

The preprocessing module prepares data for analysis by:

- Handling missing values
- Structuring time series data
- Normalizing data formats

3. User Interface Module

The system includes a graphical interface developed using Tkinter. It allows users to:

- Select commodities
- View forecasts
- Analyze results visually

4. Forecasting Module

This is the core component of the system. It uses the SARIMAX model to analyze time series data and generate predictions. The model captures both seasonal and non-seasonal patterns, making it suitable for agricultural data.

5. Visualization Module

The visualization module generates plots comparing actual and forecasted prices. This helps users understand trends and evaluate model performance.

6. Evaluation Module

This module calculates RMSE to measure prediction accuracy. It provides quantitative insights into model performance.

7. Backend Processing Module

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The backend manages model execution, data flow, and integration between modules. It ensures efficient processing and system stability.

8. Forecast Output Module

The system displays forecasted values in tabular format along with graphical representation.

9. Scalability and Extension

The modular design allows integration of advanced techniques such as machine learning and deep learning models. Research indicates that hybrid models combining statistical and AI approaches can significantly improve forecasting accuracy .

10. Real-World Applicability

The system can be deployed for real-time forecasting, helping farmers and stakeholders make informed decisions. It can also be extended to include external variables such as weather and economic indicators, which influence commodity prices.

The overall design ensures efficient data handling, accurate forecasting, and user-friendly interaction, making it suitable for practical applications.

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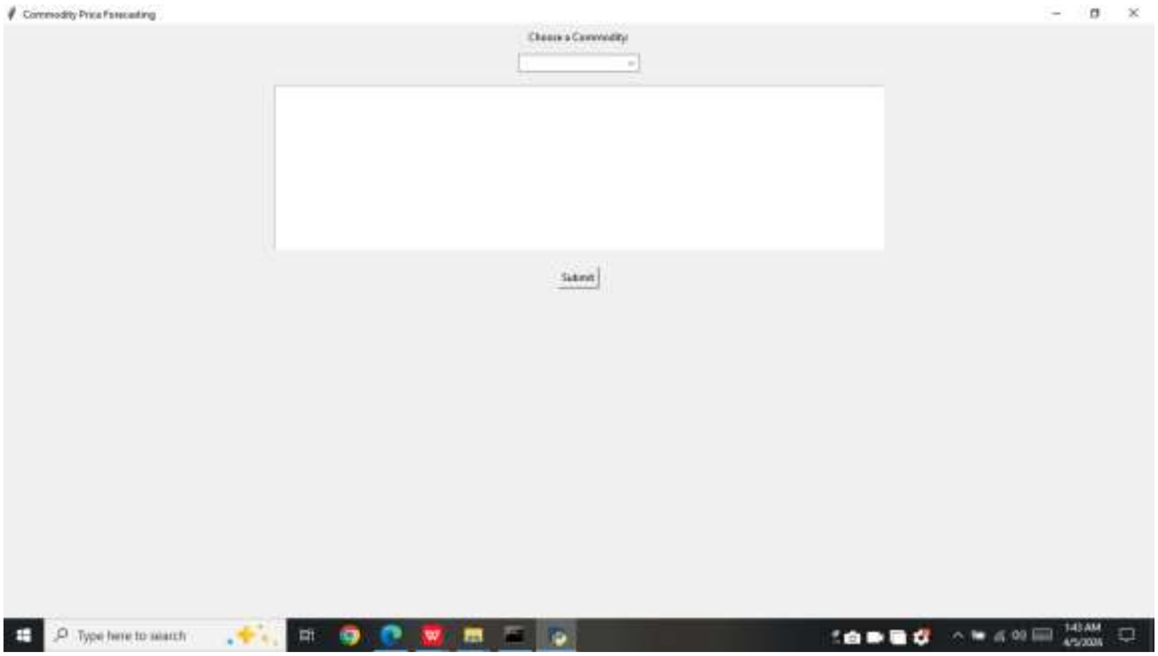
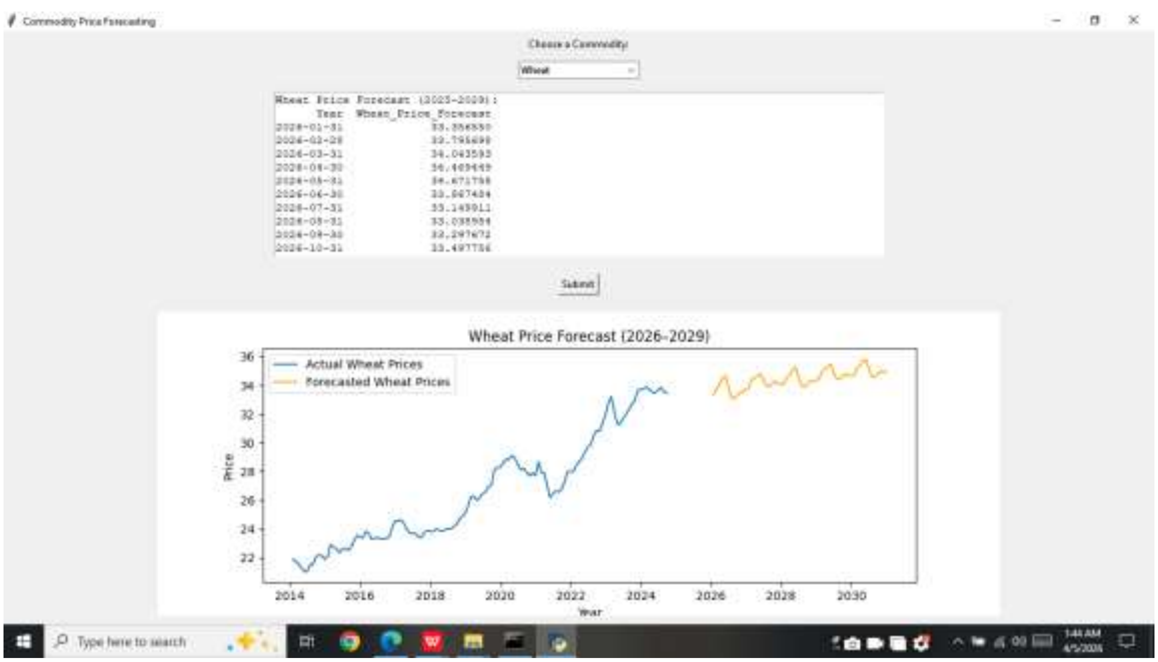
SYSTEM DESIGN IMAGES





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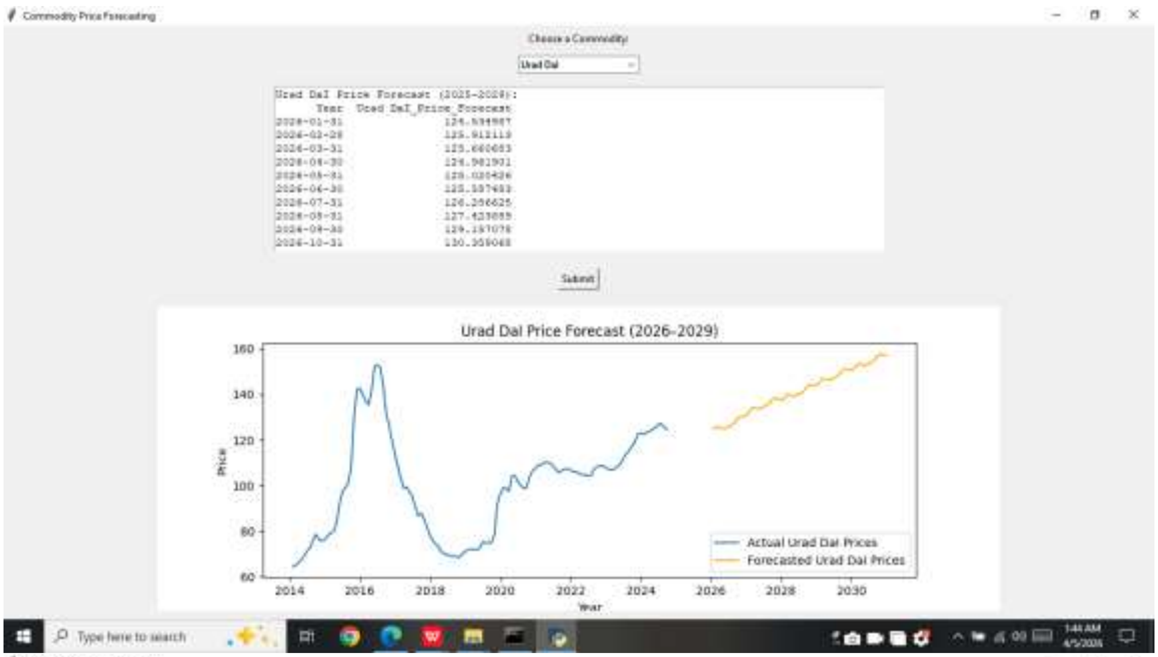

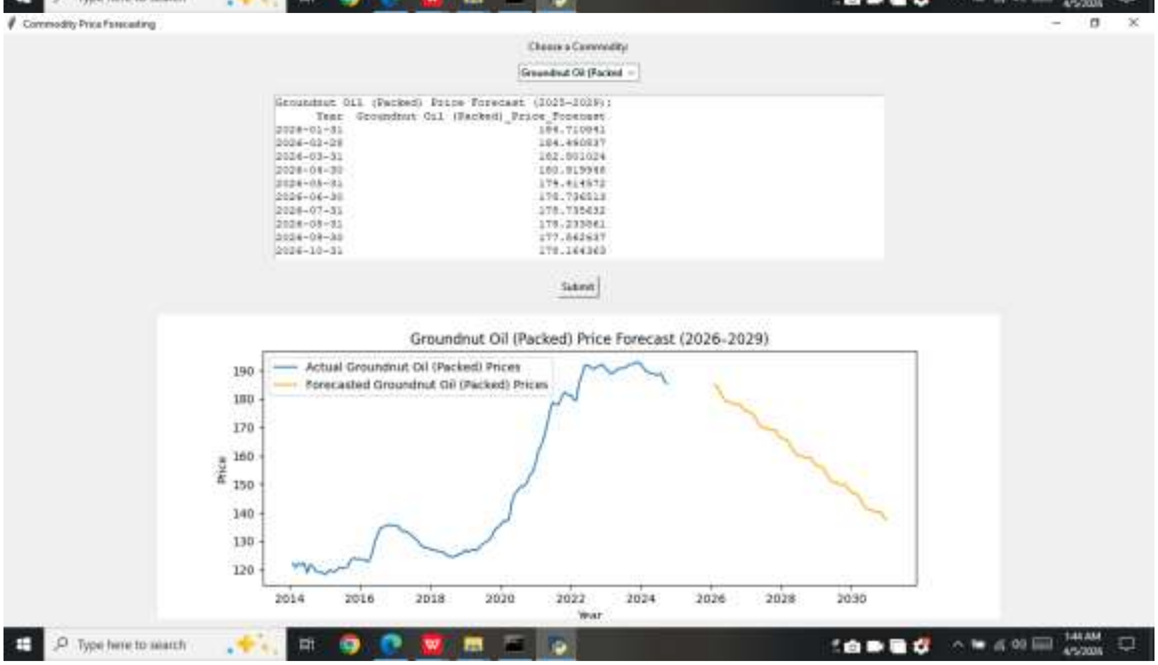

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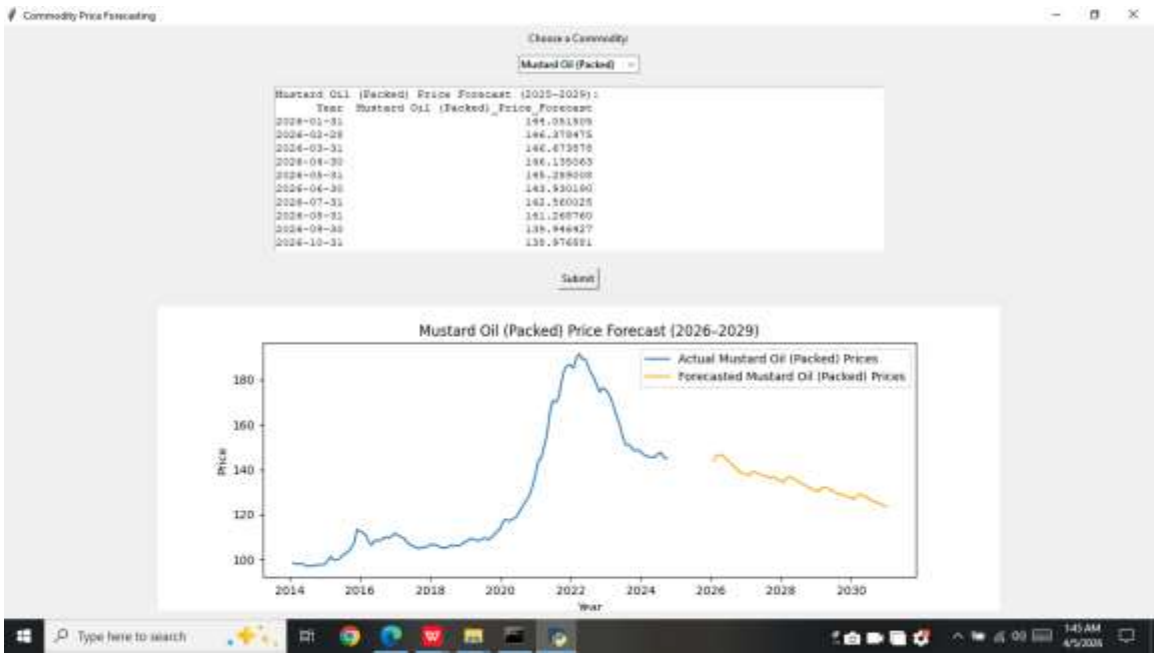

VIII. CONCLUSION

This research presents an AI-driven system for predicting agricultural and horticultural commodity prices using time series forecasting techniques. The proposed system leverages the SARIMAX model to capture both seasonal and non-seasonal patterns in historical price data, enabling accurate and reliable predictions.The implementation demonstrates the effectiveness of integrating statistical models with a graphical user interface, making the system accessible to a wide range of users. By providing both numerical and visual outputs, the system enhances understanding of price trends and supports informed decision-making.The use of SARIMAX allows the system to handle seasonal variations, which are a critical aspect of agricultural data. Additionally, the evaluation using RMSE provides a clear measure of model performance, ensuring reliability of predictions.One of the key strengths of the system is its scalability and adaptability. The modular design allows integration of advanced techniques such as machine learning and deep learning models. Recent studies highlight the potential of hybrid models in improving forecasting accuracy and handling complex data patterns .The system has significant practical applications, including crop planning, market analysis, and policy formulation. By providing accurate forecasts, it helps reduce uncertainty and supports better decision-making in the agricultural sector.However, challenges remain in incorporating external factors such as weather conditions and market dynamics. Future work can focus on integrating these variables and exploring

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advanced models such as LSTM and hybrid approaches.In conclusion, the proposed system provides a robust and efficient solution for agricultural commodity price prediction, contributing to the advancement of agricultural analytics and decision support systems

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