SMART INDIA HACKATHON 2024

- Development of AI-ML based models for predicting prices of agri-horticultural commodities such as pulses and vegetable. (ID: 1647)
- Theme: Agriculture, FoodTech & Rural Development
- Category: Software
- Team ID: 30183

-By Team Maestros

AI-ML MODELS FOR PREDICTING RETAIL PRICES AND MANAGING BUFFER STOCK OF AGRI-HORTICULTURAL COMMODITIES

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Models

- We utilized a SARIMAX model, integrating external factors such as wholesale prices and seasonality for improved retail price predictions.
- Additionally, a GRU-based Neural Network tracks trends from the past 10 days of daily retail prices to predict future prices. (This gave the best MSE of 1.3)
- While we tested SARIMA, LSTM, and RNN, these models were not chosen due to higher Mean Squared Error (MSE).

Addressing the Problem

- Our solution predicts retail prices to address price volatility and assist the government with buffer stock release decisions.
- We developed interactive visualizations that display retail price trends across different crops and states. These tools allow users to explore patterns over time, helping decision-makers understand market movements.
- Additionally, news analysis is integrated to explain price outliers, ensuring the model adapts to significant regional events affecting prices, further the analysis along with the predictions can be immensely useful for keeping farmer unions up to date.

Innovation

- Modelling the Market: We will map the demand-supply of this market after analysing research papers on Game theory and Advanced Economics.
- Chatbot: A multi-language chatbot predicts future retail prices, explains buffer stock releases, and provides region-specific news analysis to explain unusual price shifts.
- Geographical Heatmap: Created using given data from the Department of Consumer Affairs of entered date range in the site, these visualizations show retail price trends(mean, std) by crop and state on the map of India.

TECHNICAL APPROACH

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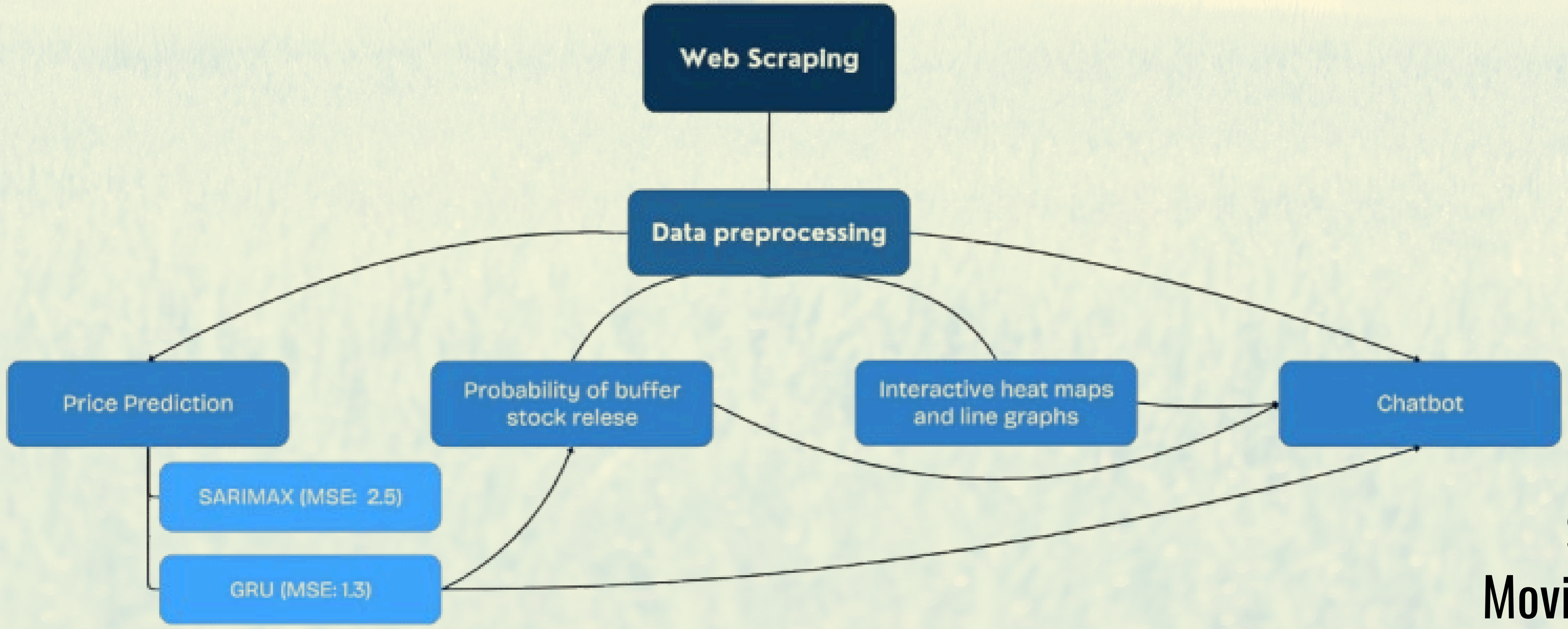
Tech Stacks used:

Python
HTML
Cascading Style Sheet
JavaScript
Django
Selenium
Recurrent Neural Network



Flowise/Langchain
Time series analysis
Gated Recurrent Units
Data Analysis libraries
Long Short Term Memory
Natural Language Processing
Seasonal Autoregressive Integrated Moving Average with Exogenous Factors

FEASIBILITY AND VIABILITY

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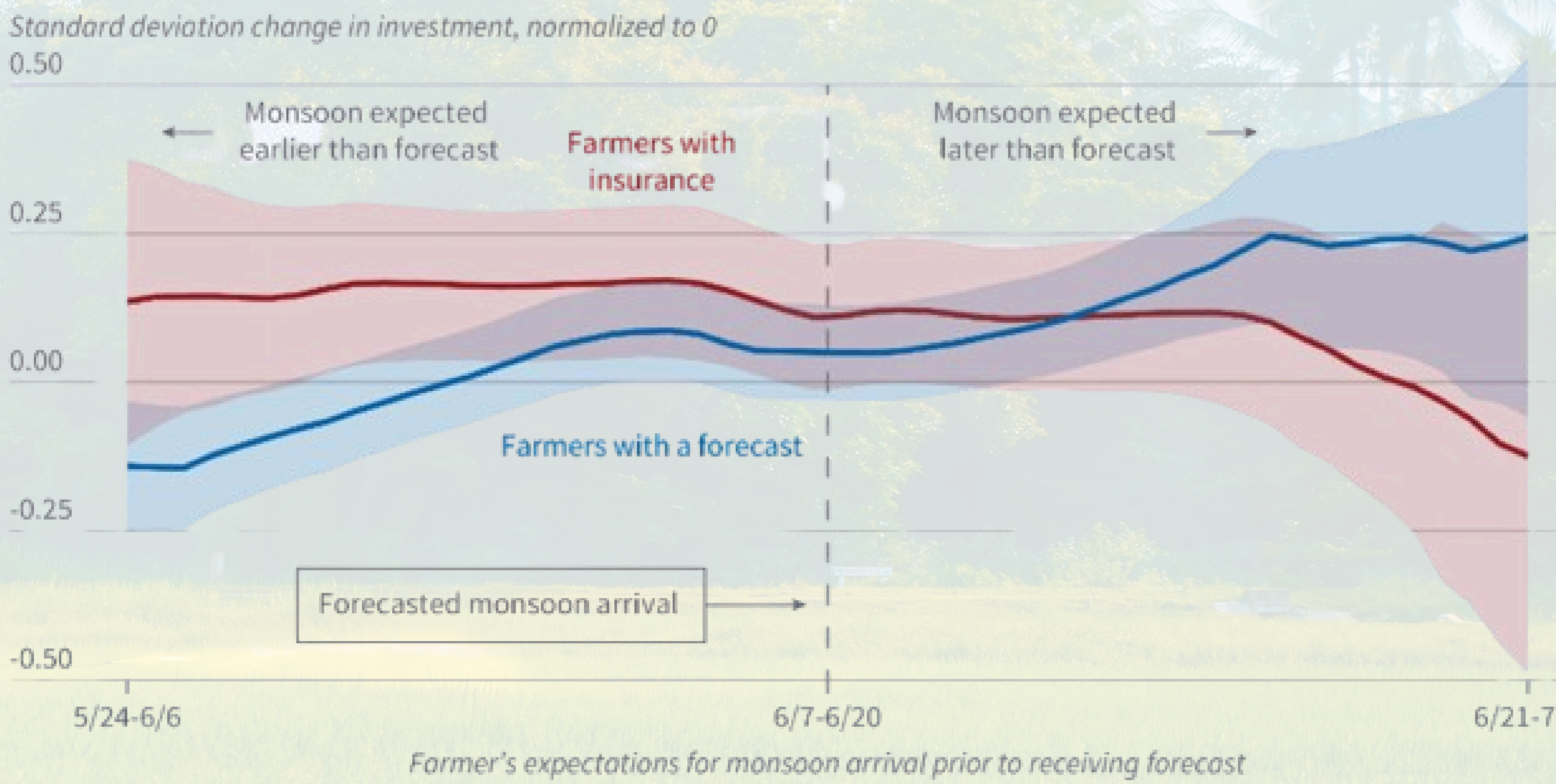
- **Unpredictable events** and market changes disrupt price accuracy. **Solution:** Integrating real-time data and continuous model updates to adapt quickly.
- **Data gaps** and **short-term focus** reduce reliability. **Solution**: Using larger datasets, ensemble modeling, and imputation techniques to improve predictions.
- **Evolving market** behavior degrades performance. **Solution:** Models retrained regularly with adversarial evaluation to stay adaptive.
- **Disruption of third-party data** affects model reliability. **Solution:** Established redundancy with multiple data providers and in-house collection
- **Scaling** to a national level is difficult. **Solution:** Implementing a modular, cloud-based architecture and conducting phased rollouts.

Indian Farmers' Monsoon Expectations and Investment Behavior



Potential Scaling Plans

Data Expansion:
Training the models on larger datasets, incorporating more regional and seasonal factors, will improve forecasting accuracy and robustness.
Multilingual chatbot:
Reduces market inefficiencies and optimizes resource allocation, improving overall agricultural economy
Real Time Notifications:
Implementing a notification system for early warnings of price volatility or buffer stock instability, ensuring timely interventions for farmers through SMS or voice notifications.

IMPACT AND BENEFITS

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Potential Impact

Farmers' Union:

- Accurate **price forecasts** for better production and sales planning.
- **Timely insights** into market trends to make informed selling decisions.
- Reduction in losses and **optimization of profits**.
- **Potential increase in revenue** through strategic timing.

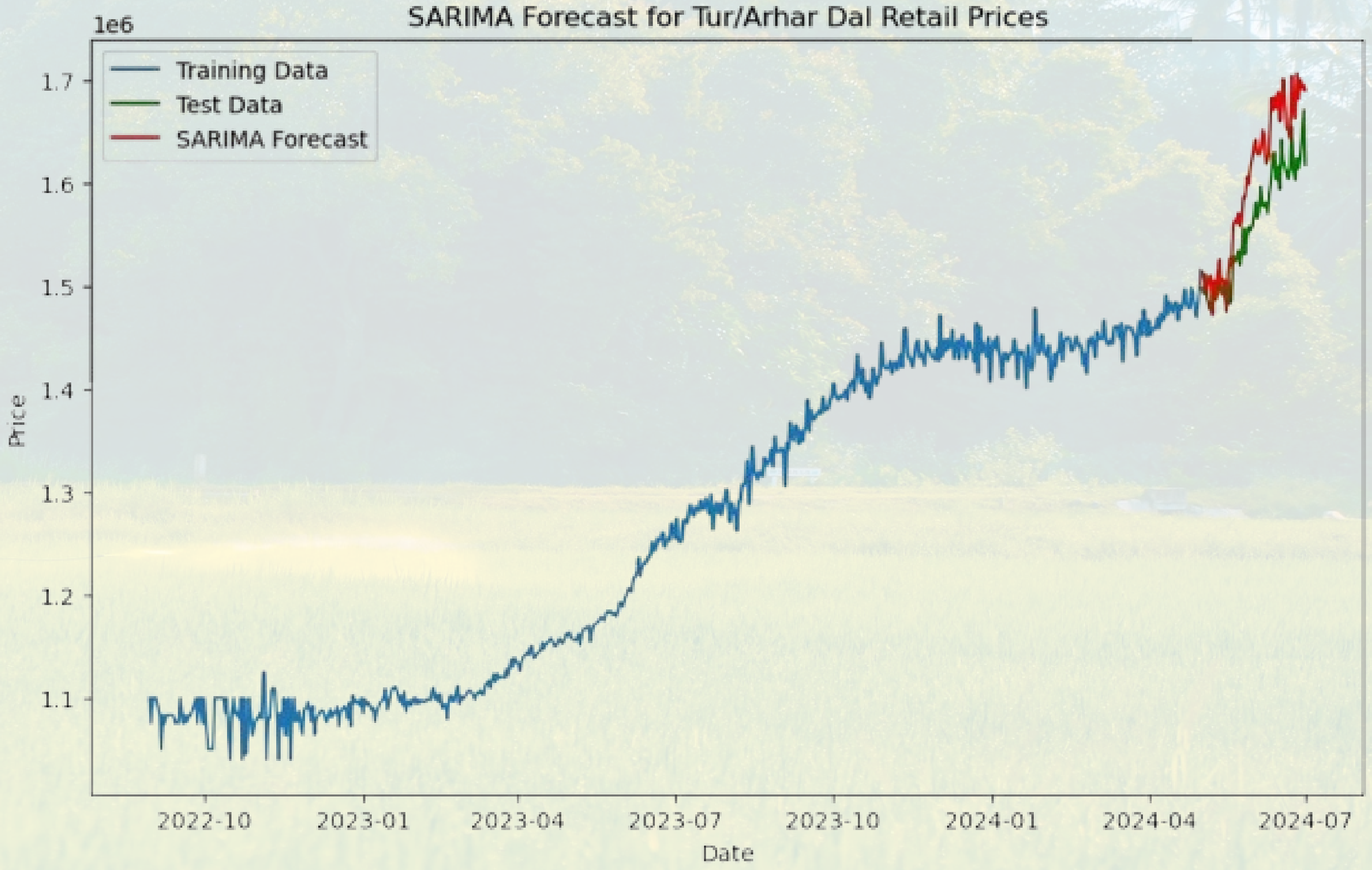
Stock Management Agencies:

- **Improved management of buffer stocks** with precise price volatility predictions.
- Data-driven decisions for **effective buffer stock releases**.
- Enhanced market stability and **prevention of price spikes** or shortages.

Benefits of the Solution

Social: Stabilizes prices, protecting farmers' livelihoods and reducing economic disparities, improves market access for smallholder farmers.

Economic: Reduces market inefficiencies and optimizes resource allocation, improving overall agricultural economy.



Environmental: Reduces food waste by aligning production with demand, decreases environmental impact through more sustainable agricultural practices.

Operational: Streamlines market interventions and buffer stock management, improving overall effectiveness.

RESEARCH AND REFERENCES

$$\text{Upper PTB} = \text{MA}(X,t) + m \cdot \sigma(X,t)$$

$$\text{Lower PTB} = \text{MA}(X,t) - m \cdot \sigma(X,t)$$

- $\text{MA}(X,t)$ is the moving average of the wholesale price X over a time period t,
- $\sigma(X,t)$ is the standard deviation of the wholesale price over the same time period,
- m is a sensitivity parameter that determines the distance of the bands from the moving average.

$$P(\text{release}) = \begin{cases} 0, & \text{if } X(t) \text{ is within the PTBs} \\ k \cdot \overline{\frac{dX}{dt}}, & \text{if } X(t) \text{ crosses the PTBs} \end{cases}$$

- k is a proportionality constant that scales the sensitivity of the buffer release,
- $\overline{\frac{dX}{dt}}$ is the smoothed rate of change of the wholesale price, defined as:

$$\overline{\frac{dX}{dt}} = \frac{1}{5} \int_{t_{\text{crossing}}-2}^{t_{\text{crossing}}+2} \frac{dX}{dt}\, dt$$

$$P(t_{\text{release}}) = \frac{1}{\sigma_{\frac{dX}{dt}} \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\overline{\frac{dX}{dt}} - \mu_{\frac{dX}{dt}}}{\sigma_{\frac{dX}{dt}}}\right)^2}$$

where:

- $\mu_{\frac{dX}{dt}}$ is the mean rate of change of the wholesale price,
- $\sigma_{\frac{dX}{dt}}$ is the standard deviation of the rate of change,
- $\overline{\frac{dX}{dt}}$ is the smoothed rate of change calculated earlier.

This mathematical model gives probability of release of buffer stock. We have used threshold bands to activate the probability function, which in a way is parallel to Bollinger bands in financial markets. Probability is proportional to rate of change of wholesale price to time and we fitted it by mapping it to a normal distribution.

References:

- "Buffer Stock Models and the Theory of Saving" by James Tobin
- "Price Stabilization Models" on the IDEAS/RePEc website
- "Commodity Price Volatility and Inclusive Growth in Low-Income Countries" edited by Rabah Arezki, Catherine Pattillo, Marc Quintyn, & Min Zhu
- "Dynamic Optimization" by Morton I. Kamien and Nancy L. Schwartz
- "Technical Analysis of the Financial Markets" by John J. Murphy
- A Supply Chain Equilibrium Model with General Price-Dependent Demand by Younes Hamdouch , Kilani Ghoudi.