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Moringa Demand and Export Forecasting using Time Series Analysis

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ABSTRACT -

This study examines Moringa export trends and projects future demand using two widely used time series forecasting techniques: Autoregressive Integrated Moving Average (ARIMA) and Prophet. The study models Moringa export volumes during the previous five years using FAOSTAT, national trade statistics. The Prophet and ARIMA models are evaluated using the Augmented Dickey-Fuller (ADF) test, RMSE, and MAE. The findings demonstrate that Prophet outperforms ARIMA in terms of accuracy, providing exporters and policymakers with valuable data for future market expansion plans. The 12-month projection predicts that demand will increase in 2025, with seasonal variability.

Keywords- Moringa, forecasting, time series analysis, ARIMA, ADF.

1. INTRODUCTION:

Moringa oleifera is also known as drumsticks. The plant is of high nutrition value because of which it is also known as Miracle tree. It has several uses in various fields such as food, cosmetic items and medicines. There is a high surge shown in the demand of Moringa recently which depicts that individuals are increasing their awareness of the nutritional health advantages of Moringa. The Moringa exporters have incremented the global trade opportunities with some underlying challenges. There are various variable that needs to be taken into consideration by exporters which includes allocating maximum resources to use, the investment per capita should be well directed and mitigating a reliable and sustainable growth strategy in export for which accurate demand forecasting for several months prior is needed. The significant use of this forecasting analysis can be used as a determinant decision making strategy which will lead to reduction in waste, guaranteed supply of product nationwide and globally by pattern identification over the past years.

The study has aimed to forecast Moringa Export Quantity Demand for the upcoming 12 months, i.e. Aug 2025 to July 2026, using the two classic models ARIMA and Prophet. The study also includes a performance comparison insight through various visualizations and tables to be easily understood by the traders at stake.

2. REVIEW OF LITERATURE:

In agricultural exports, time series research is the statistical analysis of the quantitative and price patterns of agricultural exports over time. And growers, shippers, even government workers can use this approach to recognize trends, seasonal patterns and the influence of external factors, which in turn provides a more informed basis for forecasting and other planning.

Furthermore, time series analysis is indispensable in connection with revealing long-term trends in the sphere of agricultural exports. It helps to know if a commodity is declining market interest as well when its global demand is increasing [1]. Similarly, seasonal exports can be pinned down; that, particularly, might be valuable for agricultural products that are sensitive to weather or follow specific harvesting schedules.

Understanding these cyclical patterns allows for better logistics, storage planning, and market timing. Time Series Analysis Application in Agricultural Exports Market Planning Market planning refers to the process of determining prospective markets in which a requirement is anticipated for certain agricultural commodities. Total export demand as well as price movements, and production planning do help in optimization of crop cultivation [2].

For time series prediction, both the Prophet and ARIMA models have their own advantages and limitations. The ARIMA model provides accurate short term forecasts, and is particularly well suited for stationary time series data. It is used in financial and economic forecasting because of its ability to detect linear relationships in data. This works great with agricultural exports being quite often seasonal in the nature, it is designed for time series data with seasonality and trends as well. Prophet's robustness for applications in practice is also enhanced by its ability to handle missing values and automatically detect trend changepoints. Therefore, the aim of this study is to assess the ability of ARIMA and Prophet to predict exports of Moringa through previous Moringa export data.

Recently, with the emergence of hybrid models [3] consisting of machine learning models and traditional statistical methods, the analysis of time series has progressed significantly. Financial markets and energy demand are just two examples of the applications in which hybrid models as ARIMA-LSTM [4] and ARIMA-Prophet have shown promising results. They provide better accuracies and better data flexibility in complex time series by merging the best elements of deep learning and statistical approaches. Prediction of export trends with the hybrid model is expected to grow with the trend towards precision and data driven agriculture.

Aided in the ability of Price Risk Management to make informed decisions regarding hedging strategies for price defensibility. Policy Development develops trade agreements and market access plans, and develops government regulations related to agriculture exports. There had been many studies of agricultural export forecasting using different time series analysis techniques. Ref.(6) "Application of ARIMA model for forecasting agricultural productivity in India" Journal of Agriculture and Social Sciences used methods like ARIMA,) Exponential Smoothing and algorithms from machine learning(4). Prophet, developed by Facebook, is designed to deal with time series data which have strong recurring patterns as well as non-linear growth; while ARIMA is a widely used classical statistical time series model used to forecast stationary time series data. [7]

The impact of external factors such as climate change, international trade policy, and diplomatic conflicts is another critical part of forecasting agricultural exports. It is necessary that climatic variables are introduced into forecasting models, since climatic variability has a significant effect on agricultural production and export quantities. To improve accuracy, studies have investigated upscaling [25, 32, 31 , 36] recommendation with climate data and traditional time series models. Variations in export demand are also strongly determined by trade policy such as tariffs and subsidies. The prospects for future export trends can be further investigated by developing forecasting models that incorporate economic variables and policy changes. Additionally, the availability of real-time data processing has been enabled with advances in artificial intelligence and big data analytics that allow forecasting models to be adaptively modified for inflation.

These models have been applied separately in various contexts [8-12], but a comparative analysis specifically focusing on Moringa export demand forecasting still remains a gap in the existing literature. This study addresses this gap by comparing the predictive power of both the models, i.e., ARIMA and Prophet models for Moringa exports. Here, we are going to analyze the trends and patterns of previous export quantity and depict data related to exported quantity for the next 12 months, which is termed as forecasting analysis. In agricultural economics, the combination of time series forecasting models and real-time data sources opens up new research and application opportunities. In addition to addressing the current gap in Moringa export forecasts, this study demonstrates how future technologies have the ability to completely transform agricultural trade analytics. The results of this study will advance knowledge of forecasting techniques and how they affect trade policy for sustainable agriculture. Using sophisticated forecasting models will be crucial to guaranteeing a steady and lucrative agricultural export market as the demand for Moringa and other superfoods rises globally.

3. PROPOSED WORK:

The methodology for forecasting time series analysis uses several steps, which include data collection, exploratory data analysis, and time series modeling, which includes 2 models: ARIMA and Prophet. Both models will befit for a comparative analysis.

A. Data Collection:

Data collection is a crucial step to get the historical dataset for analyzing periodic trends. Moringa export data, covering 147769 Kilograms from 5 years, is obtained from FAOSTAT, SEAIR EXIM SOLUTION, Volza Grow Global, and merged into a single dataset that is Moring_Export_Data for better observation. Moring_Export_Data provided the export data for Moringa, which covers 147769 kilograms over five years.
In order to guarantee continuity in the time series data, the dataset is preprocessed to handle missing values using forward fill imputation. In addition, data transformation methods were used to improve the overall performance of the model. The Augmented Dickey-Fuller (ADF) test [13] confirms that stationarity is achieved using first-order differencing. In order to stabilize variance, eliminate trends, and prepare the data for time series modeling, these changes were essential.

B. Exploratory Data Analysis:

EDA or Exploratory Data Analysis is essential for getting a thorough idea of the pattern of the data presented in a dataset to have a clear picture of the export quantity inscribed. Plotting the time series allowed for the first exploratory data analysis to visually examine trends, seasonality, and any outliers. The ADF test is conducted to assess the stationarity of the time series. The following picture visualizes the export quantity of Moringa over the past 5 years. The whole analysis is conducted using Jupyter Notebook, which uses various libraries of Python such as matplotlib, seaborn, plotly, pmdarima, prophet and others [14].

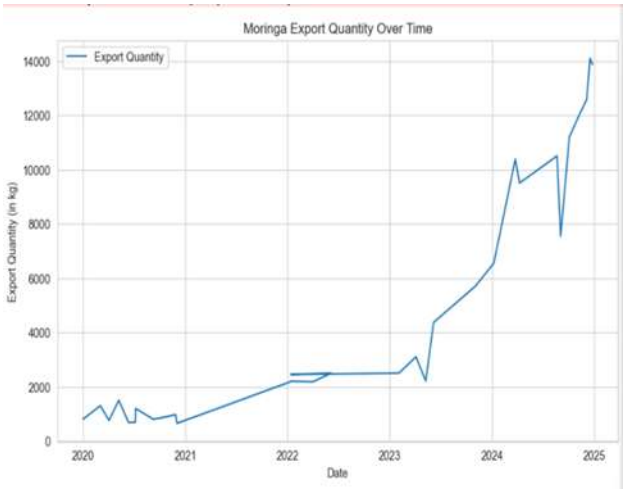

Figure 1: Moringa Export Qty over the years

C. Time Series Modeling:

The two most commonly used forecasting models are ARIMA and the Prophet model. Let's discuss a brief description of both the models.

ARIMA: A statistical time series forecasting technique called ARIMA (AutoRegressive Integrated Moving Average) uses historical data and errors to generate predictions. Its three primary parts are Moving Average (MA), which refines forecasts by taking into account previous forecast errors; AutoRegressive (AR), which analyzes his historical observations to predict future values; and Integrated (I), which adds differencing to make the series stable. ARIMA works well with datasets that exhibit seasonality and distinct trends, but it necessitates that the data be stationary. Demand forecasting, stock market analysis, and economic forecasting all make extensive use of it.

Prophet: Facebook (Meta) created Prophet, a forecasting model that can handle time series data with missing values, holidays, and seasonality. It makes forecasts using an additive model that combines trend, seasonality, and outside variables. Prophet recognizes patterns automatically, enabling flexible trend modifications like logistic and linear growth. It is very helpful for event-driven forecasting, sales analysis, and business forecasting. The model is appropriate for a variety of forecasting applications since it is easy to use and performs well with irregular data. Let us now befit both the models to the dataset to get a predictive forecast analysis

4. Fitting ARIMA Model:

In time series data, the ARIMA (AutoRegressive Integrated Moving Average) model is used to forecast future values and examine historical trends. To determine whether the data is steady, the Augmented Dickey-Fuller (ADF) test is used first. To eliminate trends and stabilize the series, first-order differencing is used if the data is non-stationary (p-value > 0.05). If after differencing the p value is still greater than 0.05, then again second order differencing is used for gaining stationarity. The optimal ARIMA parameters (p, d, and q) are then automatically determined using the auto_arima function, taking historical patterns and seasonality into account. The ARIMA model is trained on the original dataset to determine its structure after the ideal parameters have been determined. If differencing was used, the 12-month forecast produced by the trained model is then reverted to the initial scale. Fig. 2 visualizes a straightforward increment in the forecasting export of Moringa using the ARIMA model.

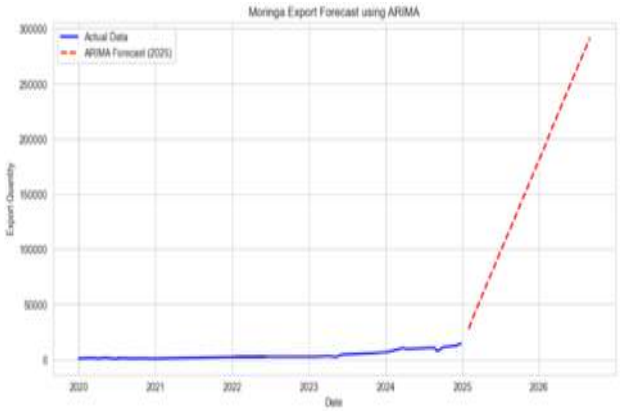

Figure 2: Moringa Export forecast using ARIMA

1. Fitting Prophet Model:

By collecting trends, seasonality, and outside influences, the Prophet model is used to predict future values of the time series data. The dataset is first structured in accordance with Prophet's specifications, with the target variable being renamed "y" and the date column being renamed "ds." After that, historical data is used to initialize and train the model. In order to produce forecasts, a future data frame is constructed for the upcoming 12 months following training. Taking seasonality and other trends into account, the Prophet model automatically finds underlying patterns and predicts future values. To see the anticipated export volume over time, the predicted results are finally shown. Prophet is a versatile and powerful tool for time series forecasting because of this methodology, particularly for datasets with intricate patterns and missing values. Fig. 3 visualizes a plot with frequent shifts in the forecast export of Moringa using the Prophet model [15-16].

5. RESULT AND DISCUSSION:

In this section, we are going to discuss the findings of the forecasting analysis that is found using ARIMA and Prophet models, respectively. The forecasted export quantity of both the models is shown in tabular format, which is followed by a model performance comparison.

A. Statistical Findings:

Because the p-value is higher than 0.05, the Augmented Dickey-Fuller (ADF) test indicates that the first time series analysis for moringa export is non-stationary. Stationarity is attained by applying first-order differencing. Using the Auto-ARIMA approach, the best-fit model is found to be ARIMA(2,2,1), which is the ideal ARIMA(p,d,q) model. The ARIMA model's Mean Absolute Error (MAE) is 93377.92, and its Root Mean Squared Error (RMSE) is 103837.42 [17].

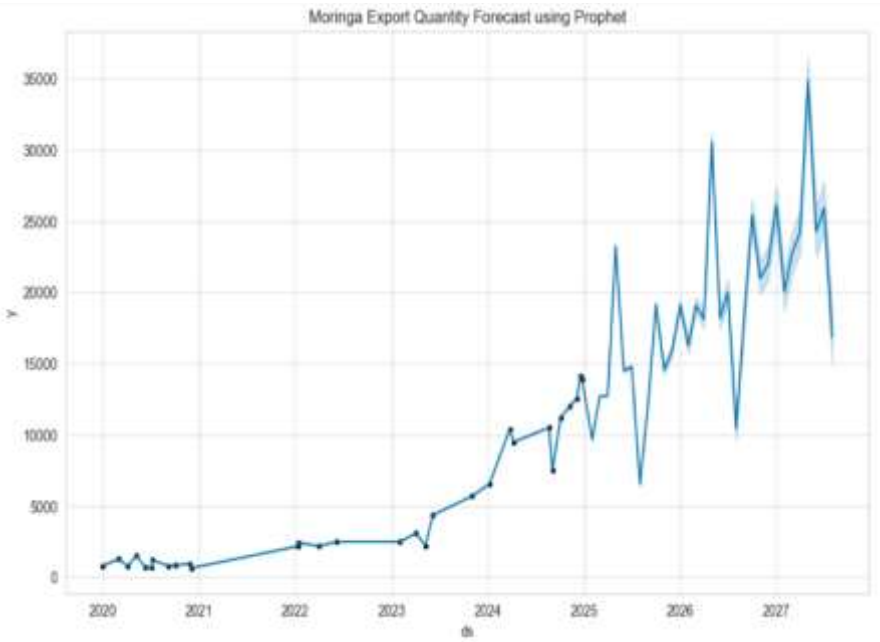

Figure 3: Moringa Export Quantity Forecast using Prophet

12-Month Forecast Analysis: The 12-month forecast (Aug 2025 – Jul 2026) generated by both models is presented.

According to the ARIMA model, the amount of Moringa exported is expected to increase steadily from 124830 kg in Aug 2025 to 277400 kg in Jul 2026. The table in Fig. 4 represents the export quantity of Moringa for the next 12 months using ARIMA.

Similarly, the Prophet model's forecast [19] indicated an upward trend, but with some seasonal fluctuations observed during certain specific months. The forecasts highlight a consistent demand for Moringa exports by which supporting potential market expansion strategies for stakeholders. The table in Fig. 5 represents the forecasted quantity of Moringa Export for the next 12 months using the Prophet Model.

B. Model Performance Comparison:

Time series data with distinct seasonal patterns can benefit from the ARIMA model's ability to capture long-term trends and generate steady, smooth forecasts. It gives accurate forecasts for stable datasets and works effectively when past patterns are consistent. However, because ARIMA expects that historical patterns will persist into the future, it is limited in its ability to adjust to abrupt changes or outside influences. The Prophet model, on the other hand, is very adaptable and very good at capturing seasonal effects, which makes it especially helpful for datasets that contain missing values and irregular patterns. Compared to ARIMA, it can identify trend changes more accurately, enabling greater flexibility. The Prophet's predictions, however, frequently differ greatly from ARIMA's and have lower expected values.

Therefore, on the basis of the evaluation metrics, the ARIMA model is preferred for Moringa export forecasting due to its higher accuracy and lower error rates. However, Prophet remains useful for capturing seasonal and trend variations, making it a valuable complementary mode

TABLE I. ARIMA FORECAST

Month	Arima Forecast
Aug 2025	124830.0
Sep 2025	138700
Oct 2025	152570
Nov 2025	166440
Dec 2025	180310
Jan 2026	194180
Feb 2026	208050
Mar 2026	221920
Apr 2026	235790
May 2026	249660
Jun 2026	263530
Jul 2026	277400

TABLE II. PROPHET FORECAST

Month	Prophet Forecast
Aug 2025	13985
Sep 2025	20602
Oct 2025	15534
Nov 2025	17325
Dec 2025	20025
Jan 2026	15389
Feb 2026	17349
Mar 2026	18753
Apr 2026	30077
May 2026	19453
Jun 2026	19869
Jul 2026	11409

6. CONCLUSION:

This study successfully forecasted the demand for Moringa exports in the next year using the ARIMA and Prophet models. The study predicts that by July 2026, exports of moringa will have increased significantly to 277400 kg, indicating the rising demand for the item. Since the ARIMA(2,2,1) model performed better than the Prophet model in terms of forecasting accuracy, it is the suggested choice for short- to medium-term forecasts. However, the Prophet model remains a valuable tool for understanding long-term trends and patterns. These findings have important implications for exporters and policymakers, suggesting that increased production capacity, efficient supply chain management, and market development strategies are needed to meet growing global demand.

Future Scope

The forecasting precision of Prophet could be further enhanced by taking additional factors such as government policies, climate variation, economy into account. As these external factors become more critical for developing trends, reliable predictions have to take them into consideration. Also, combining the seasonality handling power of Prophet and the steadiness of ARIMA might make a stronger better model. The Prophet can simulate seasonal variability and ARIMA can capture linear trends in their features, so the integration of these two approaches seems to enhance the forecasting performance of the model.

Future research could investigate the impact of exogenous variables on time series forecasting such as international trade laws, economic uncertainties, climatic variability etc. Integrating such predictors into prediction models may improve reliability and provide more depth of knowledge. In addition, performance of prediction could be enhanced by using the state-of-the-art machine learning mechanisms such as LSTM, XGBoost, or hybrid ARIMA-ML models. These models are more accurate than traditional statistical methods, more flexible to account for changing trends, and able to capture complex patterns that are nonlinear.

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