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Millets on the Global Stage: Exploring Export Opportunities for Asia

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Abstract

The experiment was conducted during June, 2024 at the Department of Agri-Business Management SKRAU, Bikaner, Rajasthan, India to study the export opportunities of millets for Asia. Millets are nutrient-rich, climate-resilient grains with increasing global demand. However, their domestic consumption in India has declined due to government policies favouring other cereals. This study examines India's millet export potential using the ARIMA model for forecasting and the Export Potential Indicator (EPI) for market analysis. Results indicate stable export trends with Mexico emerging as a key market. Challenges include processing inefficiencies and trade barriers. Findings highlight India's role in boosting global millet trade and offer insights for other Asian countries to capitalize on rising demand. Asian countries may boost exports, comprehend market trends, and promote millets as a worldwide super food by conducting astute study and planning. Promoting millets can enhance food security, sustainability, and economic growth.

Keywords: Millets, export, global trade, forecasting, EPI

1. Introduction

Millets are increasingly recognized as climate-resilient, resource-efficient, and nutritionally superior alternatives to mainstream cereals like rice and wheat (Kapoor and Suri, 2020). They offer advantages in water use efficiency (Bellad and Belavadi, 2023), nutrient use efficiency (Sheethal et al., 2022), and adaptability to biotic and abiotic stresses (Louhar et al., 2021). Moreover, millets are dense in micronutrients, dietary fiber, and antioxidants, making them a valuable food source to address malnutrition and non-communicable diseases (Kapoor et al., 2023).

Despite their benefits, millet cultivation and consumption witnessed a decline due to the Green Revolution, which prioritized high-yielding varieties of rice and wheat, supported by subsidies, institutional procurement, and research focus (Nelson et al., 2019). Additionally, rising income levels and changing food preferences contributed to reduced millet consumption in India (Saini et al., 2021). This decline coincided with growing concerns about nutrition and sustainability, prompting global and national initiatives to revive millet production. Exploitation of indigenous or improved varieties/hybrids in potential niche areas for their introduction and large-scale adoption may play a significant role in the productivity improvement of these crops (Bhandari et al., 2024).

Recognizing millets' potential, the United Nations declared 2023 as the International Year of Millets (IYOM), with strong advocacy from India. This declaration is a global acknowledgement of millets' role in sustainable agriculture, food security, and climate adaptation (Anonymous, 2021). India has launched several initiatives under this framework, including the National Food Security Mission (NFSM), which promotes millet cultivation in rainfed and semi-arid regions through subsidies, seed distribution, and training (Gupta et al., 2024).

Recent field-level research supports the efficacy of millet-based interventions. For instance, Kumar et al. (2022) found that intercropping finger millet with amaranth significantly improved productivity and land-use efficiency in rainfed hill regions of Uttarakhand. This evidence supports the integration of millets into diversified cropping systems that enhance both yield and farmer incomes.

In addition to cultivation efforts, India has reformed its Public Distribution System (PDS) to include millets, aiming to enhance nutritional security for low-income households while creating stable demand for millet producers. Millets are also being integrated into national nutrition programs such as POSHAN Abhiyaan and the Mid-Day Meal Scheme, ensuring millet-based meals for children and vulnerable populations (Kapur and Suri, 2020). These moves address both nutritional deficiencies and market constraints for farmers.

Genetic improvement is another critical area of intervention. A study by Yadav et al. (2023) revealed substantial variability and high heritability in agro-morphological traits among finger millet genotypes, indicating strong potential for selective breeding and crop improvement. This aligns with ongoing R&D efforts led by the Indian Institute of Millets Research (IIMR) to develop high-yielding, climate-resilient millet varieties (Seetharam and Bhat, 2021).

In terms of biodiversity and breeding, Toppo et al. (2023) reported significant variability among foxtail millet genotypes, which can be strategically utilized to improve yields and adaptability under diverse agro-climatic conditions. Such findings underscore the scientific basis for renewed policy and research focus on millets.

Internationally, India is promoting millets through export-focused initiatives. Events like the Global Millets (Shree Anna) Conference and efforts by APEDA have opened up markets in the Middle East, Africa, and Southeast Asia (Kanwar, 2024). Millet exports from India reached over $300 million and 1.2 million metric tons in 2023–24, with countries like Nepal, UAE, and Saudi Arabia emerging as key buyers (Singh and Singh, 2024; Madhu et al., 2024).

Against this backdrop, the present study aims to evaluate India's comparative advantage in millet trade and its potential economic and policy implications. Given the rising global demand for gluten-free, sustainable, and nutrient-dense grains, this study also seeks to identify export opportunities for India and other Asian countries by leveraging their agroecological strengths and millet innovation systems (Anonymous, 2024).

2. Materials and Methods

The experiment was conducted during June 2024 at Department of Agri Business Management, Bikaner, Rajasthan, India.This research employs a comprehensive quantitative approach to forecast millet export trends and identify optimal export destinations for Asian millet producers. The methodological framework is built around two key analytical techniques: (1) Autoregressive Integrated Moving Average (ARIMA) for forecasting future millet export trends, and (2) Export Potential Indicator (EPI) to evaluate and rank the export potential of various global markets. Both methods provide robust insights into the evolving landscape of millet exports and help identify strategic opportunities for maximizing export performance.

The study utilizes secondary data sourced from the International Trade Centre (ITC), Food and Agriculture Organization (FAO), and national trade databases of key millet-producing countries in Asia. Export data from 1990 to 2023, including volume, value, and destination markets, are gathered for a comprehensive time-series analysis.

2.1. Export trend forecasting using auto ARIMA model

To forecast future export trends of millets, the study adopts the Autoregressive Integrated Moving Average (ARIMA) model. ARIMA is widely used for time-series forecasting due to its ability to handle non-stationary data and capture both autoregressive and moving average components within a series (Box and Jenkins, 1970). The ARIMA (p, d, q) model is selected based on the following steps:

2.2. Market analysis using export potential indicator (EPI)

To identify the most promising export destinations for millets, the Export Potential Indicator (EPI) is applied. EPI evaluates the export performance of a product by analyzing the untapped export potential in existing markets and identifying new markets with favorable trade conditions (Anonymous, 2019). The methodology comprises the following steps:

2.2.1. Market selection criteria

Markets are shortlisted based on millet demand, growth potential, and trade openness. The selection criteria include GDP per capita, population size, tariff structures, and bilateral trade agreements between Asian countries and target markets.

2.2.2. EPI calculation

The Export Potential Indicator (EPI) is calculated by integrating three dimensions:

2.2.2.1. Supply-side potential

This dimension assesses the capacity of Asian countries to supply millets based on historical export performance, production capacity, and price competitiveness.

2.2.2.2. Demand-side potential

Market demand is evaluated by analyzing import growth rates, consumer preferences, and the presence of millet-based product innovations.

2.2.2.3. Trade accessibility

Factors such as tariffs, non-tariff barriers, and logistical connectivity (e.g., shipping routes, port infrastructure) are considered to estimate the ease of market entry.

- EPI=Supply capacity×Demand in target market×Market access conditions

2.2.3. Ranking of export destinations

The calculated EPI scores are used to rank export destinations based on their attractiveness and potential for future export growth. This ranking provides insights into both established markets (e.g., Middle East and Europe) and emerging markets (e.g., Africa and Southeast Asia) that offer lucrative opportunities for millet exporters.

2.3. Statistical software and tools

The statistical analyses are conducted usingPython for time-series modeling, with the Auto ARIMA model implemented via the forecast package in Python. The Export Potential Indicator (EPI) analysis is performed using data visualization and multi-criteria decision-making techniques in Python, utilizing the pandas, NumPy, and Matplotlib libraries for processing and visualizing market data.

3. Results and Discussion

This section presents the principal findings obtained from the comprehensive data analysis undertaken in this study. The results are systematically presented in alignment with the research objectives defined in the methodology section.

3.1. Model selection process

The Auto ARIMA algorithm evaluated several model specifications through a stepwise search process. Table 1 presents the comparison of different ARIMA models considered.

Table 1: Model selection results

Model specification	AIC	Computation time (sec)
ARIMA (0,1,0) with intercept	497.149	0.03
ARIMA (1,1,0) with intercept	499.175	0.03
ARIMA (0,1,1) with intercept	499.603	0.06
ARIMA (0,1,0) without intercept	495.516	0.03
ARIMA (1,1,1) with intercept	500.864	0.43

The ARIMA (0,1,0) without intercept emerged as the optimal model, demonstrating the lowest AIC value of 495.516.

The selected ARIMA (0,1,0) model, also known as a random walk model, indicates that millet exports follow a relatively simple time series pattern. The model's selection was based on its superior AIC value (495.516) compared to more complex specifications, suggesting that additional parameters do not significantly improve the model's explanatory power.

3.2. Model specifications and diagnostics

Table 2 depicts the diagnostic tests provided critical insights into the model's adequacy and Table 3 shows residual independence, Distributional characteristics and Variance structure of data.

3.3. Diagnostic insights

The diagnostic tests provided critical insights into the model's adequacy:

Table 2: Model summary statistics

Parameter	Value
Observations	21
Log Likelihood	-246.758
AIC	495.516
BIC	496.512
HQIC	495.711
Sigma²	2.9e+09
Sigma² Std Error	4.31e+08

Source: Researchers own computation from secondary data

Table 3: Diagnostic test results

Test	Statistic	*p*-value
Ljung-Box (Q)	0.00	.99
Jarque-Bera (JB)	36.13	0.00
Heteroskedasticity (H)	24.44	0.00
Skewness	1.82	-
Kurtosis	8.49	-

Source: Researchers own computation from secondary data

3.3.1. Residual independence

The Ljung-Box test (Q=0.00, p=0.99) confirmed no significant autocorrelation in the residuals, validating the model's adequacy for forecasting.

3.3.2. Distributional characteristics

The residuals exhibited a non-normal distribution (Jarque-Bera test: JB=36.13, $p<0.00$), characterized by positive skewness (1.82) and high kurtosis (8.49), suggesting a right-skewed, heavy-tailed distribution.

3.3.3. Variance structure

The presence of significant heteroskedasticity (H=24.44, $p<0.00$) indicated that the residual variance changed over time, which may affect forecast precision.

3.4. Forecast results

The model predicted stable millet export volumes of 146,289.15 metric tonnes for both 2024 and 2025. However, the forecast is marked by growing uncertainty, as reflected in widening confidence intervals:

For 2024, the prediction ranges between 40,743.52 and 251,834.78 metric tonnes.

For 2025, the prediction spans from -2,974.92 to 295,553.22 metric tonnes, with a negative lower bound underscoring substantial forecast uncertainty (Table 4).

The figure 1 illustrates India's historical millet export trends and the forecasted values generated by the Auto ARIMA model, accompanied by a 95% confidence interval. The historical data shows fluctuating export volumes over the

Table 4: Two-year export predictions with confidence intervals

Year	Predicted export	Lower CI (95%)	Upper CI (95%)
2024	146,289.15	40,743.52	251,834.78
2025	146,289.15	-2,974.92	295,553.22

Source: Researchers own computation from secondary data

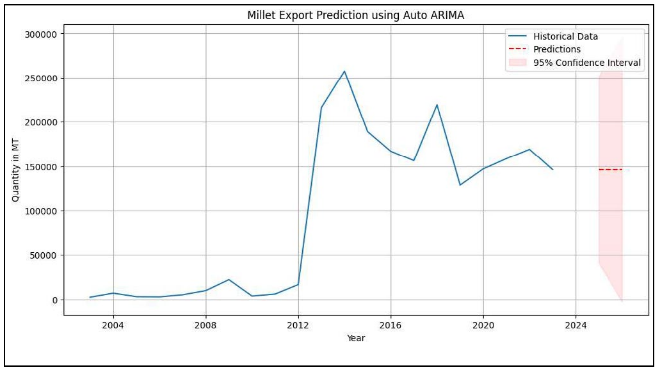

Figure 1: Millet export prediction using auto ARIMA

years, with a sharp surge around 2012, followed by periods of decline and recovery. From 2018 onward, the exports appear to stabilize with moderate variations, indicating a relatively consistent trend.

The forecast for 2024 and 2025 predicts stable export volumes of 146,289.15 mt each year, as represented by the red dashed line. This stability aligns with the simplicity of the ARIMA (0,1,0) model, which assumes no significant changes in trend or seasonality. However, the widening confidence intervals for the forecasted period highlight growing uncertainty, especially for 2025.

The widening confidence intervals point to significant uncertainty, particularly for long-term planning. Factors such as policy shifts, market dynamics, and environmental conditions-none of which are captured by the current model-could greatly influence export trends.

3.5. Export potential indicator

Source: Researchers own computation from secondary data

Table 5 depicts top importer countries of millets from the worldwide and the supply capacity of India is 4.1% to these countries and demand in target market which was 89% highest Mexico country and market access conditions which is tariffs and barriers and taxes in import.

Table 6 shows the EPI (Export Potential Indicator) score for India which is highest for the country Mexico 3.10 which means Mexico country has a higher potential to export the product to the market than it currently does. This is a good sign, and it suggests that the country has an opportunity to increase its exports of the product to the Mexican markets.

Table 5: Top importer countries

Sl. No.	Top importer countries	Supply capacity (%)	Demand in target market (%)	Market access condition (%)
1.	Indonesia	4.1	10	98
2.	Belgium	4.1	7	1
3.	Japan	4.1	12	1
4.	Germany	4.1	10	1
5.	Mexico	4.1	89	85

Source: Researchers own computation from secondary data

Table 6: EPI Score of different country

Sl. No.	Top importer countries	EPI Score
1.	Indonesia	0.0040
2.	Belgium	0.0029
3.	Japan	0.0049
4.	Germany	0.0041
5.	Mexico	3.1016

4. Conclusion

Millets, celebrated for their climate resilience and nutritional value, are emerging as a key driver of sustainable agriculture and global food security. India, through strategic policies and global advocacy-especially during the International Year of Millets 2023-has boosted millet exports to a record $300 million. ARIMA forecasts stable growth, with Mexico identified as a promising new market. Addressing post-harvest challenges, enhancing branding, and fostering global partnerships are crucial to positioning millets as a global superfood and advancing resilient agri-food systems.

5. Implications for Asian Countries

For Asian countries, the findings underscore the importance of leveraging India's position as a major millet exporter to establish stronger trade partnerships and explore collaborative export opportunities. As millet is a climate-resilient crop, expanding its production and trade can contribute to food security and sustainable agriculture in the region. Countries in Asia can benefit from adopting similar analytical approaches to evaluate their export potential, focusing on diversifying agricultural exports to meet rising global demand for millets as a health-conscious and eco-friendly food choice. This research also provides a framework for Asian countries to identify market trends and plan strategic interventions for boosting their millet trade.

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