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# A STUDY ON EXPORT PERFORMANCE AND MARKET EFFICIENCY OF TAMARIND PRODUCTS OF SELECTED DISTRICTS OF TAMILNADU

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## ABSTRACT

Tamarind *(Tamarindus indica L.),* a major tropical tree crop, holds significant commercial value in India, the world's leading producer and exporter, supplying raw tamarind, pulp, and value-added products to global markets. Despite its growing agro-industrial importance, the sector faces persistent challenges, including fragmented marketing systems, the dominance of intermediaries, and weak market integration, with limited integrated evidence available from the major producing districts of Dharmapuri and Krishnagiri in Tamil Nadu. This study aimed to analyse the export performance and market efficiency of tamarind products in these districts. Both primary and secondary data were utilised for the study. Primary data were collected from farmers, traders, processors, wholesalers, retailers, and exporters, while secondary data were used to analyse India's tamarind export trends and market stability. The study employed Compound Annual Growth Rate (CAGR) analysis to assess trends in area, production, and productivity, Markov chain analysis to identify stable export destinations, Acharya's Modified Marketing Efficiency (MME) model to evaluate marketing channel performance, and Garrett ranking technique to prioritise stakeholder constraints. Results revealed that Channel III (Farmer–Trader–Processor–Industrial User) recorded the highest marketing efficiency (MME = 0.40). Export performance indicated an overall positive growth trend with moderate instability, and Markov chain analysis identified Vietnam, Pakistan, and Malaysia as the most stable export destinations, while Malaysia and Vietnam are projected to remain the leading export markets by volume. Garrett ranking revealed that inadequate price realisation and low yield were the major constraints faced by farmers, whereas processors identified low profit margins and climate variability as their primary constraints. The findings highlight the need to strengthen value addition, improve processing infrastructure, and enhance export market linkages to improve the competitiveness and sustainability of India's tamarind sector.

**KEYWORDS**: Export performance; Garrett ranking; Markov chain analysis; Modified marketing efficiency

## INTRODUCTION

Tamarind *(Tamarindus indica L.*), belongs to Fabaceae family, is a major tropical tree crop cultivated extensively across Asia, Africa, and Latin America (1). India is the world's leading producer and exporter of tamarind, supplying raw tamarind, pulp, concentrates, and value-added products to markets across Europe, North America, and the Middle East. The growing global demand for natural food ingredients and processed fruit products has enhanced the commercial significance of tamarind in international agricultural trade (2). Beyond its traditional culinary use, tamarind has emerged as a versatile agro-industrial commodity with applications in food processing, pharmaceuticals, textiles, bioenergy, and other industries. This diversification has created substantial export opportunities and strengthened its contribution to rural livelihoods. However, the tamarind sector continues to face challenges such as fragmented marketing systems, inadequate processing infrastructure, poor market integration, and the dominance of intermediaries, which reduce producers' share in the final consumer price (3). In addition, weak institutional support and limited market information further constrain value realization and profitability among stakeholders in the tamarind value chain (4). Despite the economic importance and export potential of tamarind, comprehensive information integrating production trends, export performance, market stability, marketing efficiency, and stakeholder constraints remains limited. Previous studies have emphasized the importance of export competitiveness in agricultural commodities and highlighted the need for stronger value chain finance and market linkages to improve the performance and sustainability of tamarind-based enterprises (5,6). However, most available studies have examined these aspects independently, providing only a partial understanding of the tamarind sector.

Furthermore, empirical evidence from the major tamarind-producing districts of Dharmapuri and Krishnagiri in Tamil Nadu remains scarce. This lack of integrated analysis represents a significant research gap in understanding how production, marketing, and export dynamics collectively influence the competitiveness of tamarind products. Therefore, the present study aims to analyse trends in area, production, and productivity of tamarind, examine the stability and shifting patterns of exports among major importing countries, evaluate marketing efficiency across different marketing channels, and identify constraints faced by stakeholders involved in value addition activities. The findings are expected to support policy interventions aimed at improving producer returns, strengthening market integration, and enhancing India's competitiveness in the global tamarind trade.

## MATERIALS AND METHODS

The present investigation was undertaken to analyse the export performance and market efficiency of tamarind products using both primary and secondary data sources. The research materials comprised a semi-structured interview schedule for primary data collection and secondary databases obtained from recognised national and international sources. Tamil Nadu was selected as the study area owing to its prominence as one of India's leading tamarind-producing states and its substantial contribution to the tamarind economy. Within the state, the districts of Dharmapuri and Krishnagiri were purposively selected because they account for a significant share of tamarind cultivation and marketing activities.

Secondary data on tamarind area, production, and productivity in India for the period 2011–2025, selected to capture long-term trends over more than a decade while incorporating the most recent available data, were sourced from Indiastat.com, India (2025). Since the terminal year (2024–25) represents an advance estimate, the growth trends were interpreted with due consideration. Annual export data for both fresh and dried tamarind covering the period 2011–2024, chosen to assess changes in export performance, market stability, and shifting trade patterns among major importing countries over time, were obtained from the International Trade Centre (ITC) Trade Statistics Database, Geneva, Switzerland (ITC, 2024). Content analysis and data triangulation were employed to improve the validity and reliability of the findings.

### Sampling Design and Respondent Selection

A multistage sampling procedure was adopted to identify and select study respondents, yielding a final sample of 46 stakeholders comprising 36 farmers, 6 processors, 3 wholesaler-cum-traders, and 1 exporter. The sample size, though limited by the purposive and snowball sampling strategy required to reach processors and exporters in the study area, is acknowledged as a constraint on the generalisability of findings. Therefore, the findings should be interpreted with caution when generalising beyond the study area. Primary data were gathered through semi-structured questionnaires administered via in-depth interviews, non-participant observation, and field study methods.

### Analytical Framework

#### Growth rate analysis

Compound annual growth rates (CAGR) for area, production, and productivity of tamarind were computed using an exponential growth function of the form:

$Yt = a \,.\, bt \,.\, ut$

where Yt denotes the dependent variable (area, production, or productivity); a represents the intercept; b = (1+r) and 'r' is the compound growth rate; t is the time trend; and ut is the error term. Statistical significance of each state's growth trend was assessed based on the regression coefficient (b) and $R^2$ value; trends with $p > 0.05$ are considered statistically non-significant (7).

#### Marketing efficiency analysis

An ideal measure of marketing efficiency for comparing alternate marketing channels should account for all costs and margins (8). The Modified Marketing Efficiency (MME) was computed as:

$ME = FP / (MC + MM)$

where ME= Marketing Efficiency; FP = Price received by the farmer; MC = Total Marketing Costs; and MM = Net marketing margin. A higher MME value indicates greater channel efficiency in transferring value to the producer (9)

#### Markov chain analysis

To examine the dynamics of export destination for both fresh and dried tamarind, a first-order Markov chain approach was employed (10). This method involves the estimation of a transitional probability matrix (P), wherein each element $P_{ij}$ represents the probability that export share will shift from importing country i to importing country j over a given time interval. The diagonal elements of the matrix ($P_{ij}$) reflect the degree of retention or loyalty of importing countries with respect to Indian tamarind exports higher diagonal values signifying greater stability in trade relationships. The matrix is estimated using the following formulation:

$E_{jt} = \Sigma\, E_{i(t-1)} \cdot P_{jj} + e_{jt}$

where $E_{jt}$ is the volume of exports from India to the $j^{th}$ country in year t; $E_{i(t-1)}$ represents exports to the $i^{th}$ country in the preceding period; $P_{ij}$ is the transitional probability of export shift from country i to country j; ejt is the stochastic error term; and t and r denote the number of years and importing countries considered, respectively. The transitional probabilities satisfy the standard constraints: $0 \leq Pij \leq 1$ and $\Sigma\, P_{ij} = 1$ for all i.

The validity of the Markov chain model was confirmed by ensuring that all transition probabilities ranged between 0 and 1 and that the probabilities in each row summed to unity. This indicated that the estimated transition probability matrix was consistent and suitable for analysing export market stability and shifts.

**Garrett ranking analysis**

To identify and prioritise the constraints perceived by tamarind growers and processors, Garrett's ranking technique was employed following (11). The percentage position was calculated using the formula:

*Percent Position = [100 × ($R_{ij}$ − 0.5)] / $N_j$*

where Nj = total number of constraints ranked by respondents (Nj = 5 for farmers; Nj = 3 for processors). Given the limited processor sample (n = 6), Garrett scores for processors are interpreted with caution and accompanied by raw rank distributions

## RESULTS AND DISCUSSION

**Growth rate analysis of area, production, and productivity**

Table 1 presents the compound annual growth rates of area, production, and productivity of tamarind across major producing states in India for the period 2011–2025(12).

**Table 1. Compound annual growth rates (CAGR) of area, production, and productivity of tamarind in India (2011–2025)**

| State | Area (CAGR %) | Production (CAGR %) | Productivity(CAGR %) |
|---|---|---|---|
| Tamil Nadu | −1.6 | −1.7 | +0.1 |
| Andhra Pradesh | −0.47 | +11.6** | +12.5** |
| Karnataka | −8.04** | −13.02** | −5.4** |
| Telangana | −27.9** | −19.06** | +11.5** |
| Maharashtra | −3.9* | −2.5 | +1.5 |
| Kerala | −2.4 | +2.7* | +5.3** |

*Source: Computed from Indiastat.com (2025). * p < 0.05; ** p < 0.01. Note: 2024–25 production figures represent advance estimates. Unmarked values are statistically non-significant (p > 0.05).*

The results reveal pronounced inter-state variability in growth performance. Tamil Nadu recorded marginal negative growth in both area (−1.6 per cent) and production (−1.7 per cent), with negligible positive change in productivity (+0.1 per cent), and these trends are statistically non-significant. In Andhra Pradesh, despite a slight contraction in area (−0.47 per cent), production and productivity registered strong positive growth of +11.6 and +12.5 per cent, respectively ($p < 0.01$), indicative of significant adoption of improved management practices and advanced cultivation technologies, in line with observations .

Karnataka exhibited a consistent and statistically significant decline across all three parameters - area (−8.04 per cent), production (−13.02 per cent), and productivity (−5.4 per cent, $p < 0.01$) - reflecting systemic contraction in tamarind cultivation. Telangana similarly experienced a sharp decline in area (−27.9 per cent) and production (−19.06 per cent, $p < 0.01$), though productivity recorded a positive and significant trajectory (+11.5 per cent, $p < 0.01$), suggesting intensification among remaining cultivated holdings. In Maharashtra, declines in area (−3.9 per cent, $p < 0.05$) and production (−2.5 per cent, non-significant) were accompanied by a slight productivity gain (+1.5 per cent, non-significant). Kerala, despite area contraction (−2.4 per cent, non-significant), demonstrated positive and significant growth in both production (+2.7 per cent, $p < 0.05$) and productivity (+5.3 per cent, $p < 0.01$), indicating that technological intensification has partially offset the impact of area decline. Collectively, these data suggest that while area under tamarind is contracting in most states, productivity improvements in select states are sustaining overall production volumes

**Marketing efficiency analysis**

The channels are,

Channel I (Deseeded Tamarind) Farmer – Trader – Processor – Trader – cum -Wholesaler – Exporter

Channel II (Deseeded Tamarind) Farmer – Trader – Processor – Wholesaler – Retailer –Consumer;

Channel III (Seed Powder) Farmer – Trader – Processor – Industrial User.

The marketing efficiency of the three identified tamarind marketing channels was evaluated using Modified Marketing Efficiency (MME). The results are presented in Table 2.

**Table 2. Marketing Efficiency across tamarind marketing channels**

| Particulars | Channel I | Channel II | Channel III |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Total Marketing Cost (₹/kg) | 65.27 | 93.27 | 47.00 |
| Total Marketing Margin (₹/kg) | 46.91 | 88.91 | 50.50 |
| Net Price Received by Farmer (₹/kg) | 38.00 | 38.00 | 39.00 |
| Modified Marketing Efficiency (MME) | 0.34 | 0.21 | 0.40 |

*Source: Primary survey data.*

The results revealed variation in marketing performance across the channels due to differences in marketing costs and margins. Channel III recorded the highest MME value (0.40), followed by Channel I (0.34) and Channel II (0.21). The relatively higher MME of Channel III was attributed to its lower marketing cost (₹47.00/kg) and fewer intermediaries. In contrast, Channel II exhibited the lowest MME due to higher marketing costs (₹93.27/kg) and margins (₹88.91/kg) resulting from the involvement of multiple intermediaries. However, all MME values were below unity, indicating that none of the channels achieved satisfactory marketing efficiency. These findings suggest that a considerable portion of the consumer price was absorbed by marketing costs and intermediary margins, thereby reducing the producer's share. Therefore, measures to reduce transaction costs, strengthen direct market linkages, and improve value chain coordination are necessary to enhance marketing efficiency in the tamarind sector.

**Direction of trade for fresh tamarind**

The transition probability matrix for fresh tamarind exports (Table 3) reveals the stability and loyalty patterns of major importing markets for Indian fresh tamarind over the period 2011–2024 All export quantities are in metric tonnes (MT) using Indian notation (1,00,000 MT = 100,000 MT) (13).

**Table 3. Transitional probability matrix – fresh tamarind exports from India (2011–2024)**

| From / To | Malaysia | Pakistan | Vietnam | Saudi Arabia | Egypt | UAE | Iraq | Nepal | Others |
|---|---|---|---|---|---|---|---|---|---|
| Malaysia | 0.4313 | 0.0561 | 0.0947 | 0.1141 | 0 | 0.0225 | 0.0831 | 0.1226 | 0.0752 |
| Pakistan | 0.0000 | 0.4671 | 0 | 0 | 0.1852 | 0 | 0.0000 | 0 | 0.3474 |
| Vietnam | 0.0000 | 0.0000 | 0.0000 | 0 | 0.0000 | 0 | 0.0000 | 0 | 1 |
| Saudi Arabia | 0.0000 | 0.0162 | 0.4327 | 0.1070 | 0.3889 | 0 | 0.0549 | 0 | 0 |
| Egypt | 0 | 0.3885 | 0 | 0.1876 | 0.2344 | 0.0000 | 0.1894 | 0 | 0 |
| UAE | 0.9363 | 0.0000 | 0.0584 | 0.0053 | 0 | 0.0000 | 0 | 0.0000 | 0.0000 |
| Iraq | 0.0000 | 0 | 0.1282 | 0.0000 | 0 | 0.0378 | 0.5326 | 0.2334 | 0.0677 |
| Nepal | 0.7665 | 0 | 0 | 0 | 0.0000 | 0.0000 | 0 | 0.2334 | 0.0000 |
| Others | 0 | 0.0000 | 0.0000 | 0.0546 | 0 | 0.1600 | 0 | 0.0713 | 0.7139 |

*Source: Computed from ITC Trade Statistics database (ITC 2024).*

The transition probability matrix revealed that, apart from the 'Others' category (0.7139), Iraq (0.5326) exhibited the highest retention probability among the specific importing countries, followed by Pakistan (0.4671) and Malaysia (0.4313), indicating that these markets remained the most stable destinations for fresh tamarind exports from India during the study period. Egypt (0.2344) and Nepal (0.2334) also retained a moderate share of their imports, while Saudi Arabia (0.1070) showed comparatively lower retention. In contrast, Vietnam and UAE showed negligible or zero retention probabilities, indicating indicating that exports to these markets were completely redirected to other destinations over time, reflecting highly dynamic trade relationships

**Table 4. Forecasted export quantities of fresh tamarind from India (2024–25 to 2028–29) (MT)**

| Year | Malaysia | Pakistan | Vietnam | Saudi Arabia | Egypt | UAE | Iraq | Nepal | Others |
|---|---|---|---|---|---|---|---|---|---|
| 2024–25 (Base year) | 981669.5617 | 79489.52061 | 213566.986 | 215839.0943 | 42969.7948 | 172830.6942 | 241324.4272 | 371531.9199 | 1127916.672 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2025–26 | 896027.1532 | 115768.0193 | 234298.0808 | 211936.7713 | 112021.9277 | 218093.4351 | 237080.3487 | 354220.3553 | 1170682.874 |
| 2026–27 | 887963.8939 | 155837.5507 | 226360.9592 | 217440.4982 | 134057.3902 | 222986.5119 | 240665.1104 | 341361.5017 | 1229522.932 |
| 2027–28 | 878948.6082 | 183557.7738 | 228794.8902 | 224698.4091 | 149233.8872 | 232635.9482 | 246550.8569 | 342436.8922 | 1278575.392 |
| 2028–29 | 885097.8092 | 202566.8227 | 232507.8112 | 230187.1666 | 161098.9869 | 240739.8689 | 252378.3714 | 346575.7034 | 1326780.057 |

*Source: Projections derived from Markov chain analysis. Note: Figures presented in Indian notation (1 lakh = 100,000 MT).*

The forecast results indicate that Malaysia is expected to remain the major export destination despite a gradual decline from 981669.56 MT in the base year (2024–25) to 885097.81 MT by 2028–29. Exports to Pakistan, Saudi Arabia, Egypt, the UAE and Iraq are projected to increase steadily during the forecast period, indicating strengthening trade relationships and increasing demand. Vietnam and Nepal are expected to experience only minor fluctuations, while exports to the 'Others' category are projected to increase continuously, suggesting further diversification of India's fresh tamarind export markets.


**Fig. 1. Transition Probability Matrix (TPM) for fresh tamarind exports**

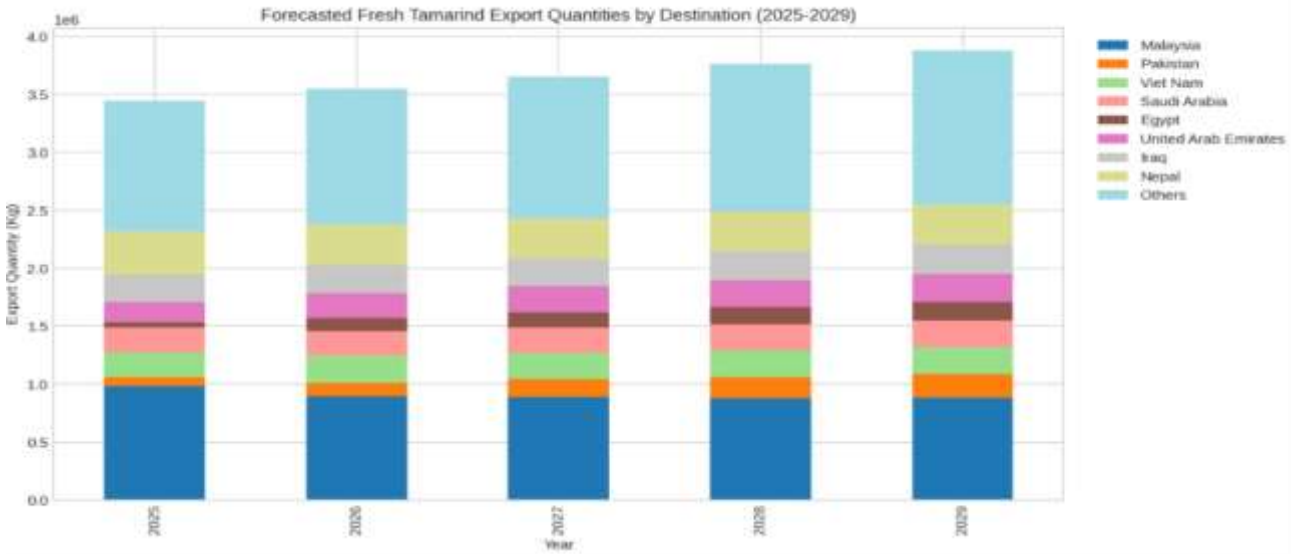


**Fig. 2. Forecasted fresh tamarind exports (2024–25 to 2028–29)**

**Direction of trade for dried tamarind**

The transitional probability matrix for dried tamarind exports (Table 5) presents the retention dynamics for India's dried tamarind trade over the same period.

**Table 5. Transitional probability matrix – dried tamarind exports from India (2011–2024)**

| From / To | UAE | Vietnam | Bangladesh | Saudi Arabia | Malaysia | Egypt | Pakistan | Iraq | Others |
|---|---|---|---|---|---|---|---|---|---|
| UAE | 0.0000 | 0.0000 | 0.0000 | 0.0153 | 0.0000 | 0.0000 | 0.0516 | 0.2692 | 0.6637 |
| Vietnam | 0.0440 | 0.0217 | 0.4693 | 0.0000 | 0.4177 | 0 | 0.0000 | 0.0471 | 0 |
| Bangladesh | 0 | 0.3946 | 0.4870 | 0.0000 | 0.1183 | 0 | 0.0000 | 0 | 0 |
| Saudi Arabia | 0.0000 | 0 | 0.1404 | 0.0131 | 0.0580 | 0.5836 | 0 | 0.0407 | 0.1639 |
| Malaysia | 0.1200 | 0.4554 | 0.0879 | 0.1394 | 0.0203 | 0.0000 | 0.0000 | 0.0000 | 0.1767 |
| Egypt | 0.3149 | 0 | 0.0000 | 0.0562 | 0.0891 | 0 | 0.2607 | 0 | 0.2788 |
| Pakistan | 0.0860 | 0.0000 | 0 | 0.0614 | 0 | 0.0887 | 0.1489 | 0.0000 | 0.6148 |
| Iraq | 0 | 0.7466 | 0.0782 | 0.0000 | 0 | 0 | 0.0114 | 0.1636 | 0.0000 |
| Others | 0.3178 | 0 | 0.0000 | 0.1876 | 0 | 0.0625 | 0.0000 | 0 | 0.4318 |

*Source: Computed from ITC Trade Statistics database (ITC 2024).*

For dried tamarind, Bangladesh (0.4870) exhibited the highest import retention probability, followed by the 'Others' category (0.4318), Iraq (0.1636) and Pakistan (0.1489). Vietnam (0.0217), Malaysia (0.0203) and Saudi Arabia (0.0131) recorded comparatively lower retention probabilities, while UAE and Egypt showed negligible retention, indicating frequent shifts in trade patterns. These findings suggest that Bangladesh, the 'Others' category, Pakistan and Iraq represent relatively stable export destinations for Indian dried tamarind, whereas exports to the remaining markets are more dynamic and influenced by changing sourcing behaviour.

**Table 6. Forecasted export quantities of dried tamarind from India (2024–25 to 2028–29) (MT)**

| Year | UAE | Vietnam | Bangladesh | Saudi Arabia | Malaysia | Egypt | Pakistan | Iraq | Others |
|---|---|---|---|---|---|---|---|---|---|
| 2024–25 (Base year) | 2454029 | 4364965 | 8015980 | 1290005 | 4806959 | 1174207 | 372592.7 | 1506109 | 5026595 |
| 2025–26 | 2882562 | 6842019 | 6948013 | 1829283 | 3174898 | 1145803 | 526598.8 | 1213173 | 5639580 |
| 2026–27 | 2994757 | 5449321 | 7510844 | 1731787 | 4109495 | 1525280 | 561448.3 | 1425530 | 6083957 |
| 2027–28 | 3317041 | 6246973 | 7194378 | 1975964 | 3617889 | 1496104 | 677295.3 | 1418667 | 6638597 |
| 2028–29 | 3471373 | 5889759 | 7403281 | 2024268 | 3921243 | 1688477 | 703573.1 | 1554812 | 7116611 |

*Source: Projections derived from Markov chain analysis. Note: Figures presented in Indian notation (1 lakh = 100,000 MT).*

The forecast for dried tamarind exports indicates that Bangladesh is expected to remain the leading export destination, despite moderate fluctuations during the forecast period. Vietnam is projected to remain one of the major importing markets, with exports increasing from 43,64,965 MT in the base year (2024–25) to 68,42,019 MT in 2025–26, followed by moderate fluctuations, reaching 58,89,759 MT by 2028–29. Exports to the UAE, Saudi Arabia, Egypt and Pakistan are expected to increase steadily, indicating strengthening demand in these markets. Malaysia is projected to decline initially before recovering gradually, while exports to the 'Others' category are expected to increase continuously, suggesting continued diversification of India's dried tamarind export markets.

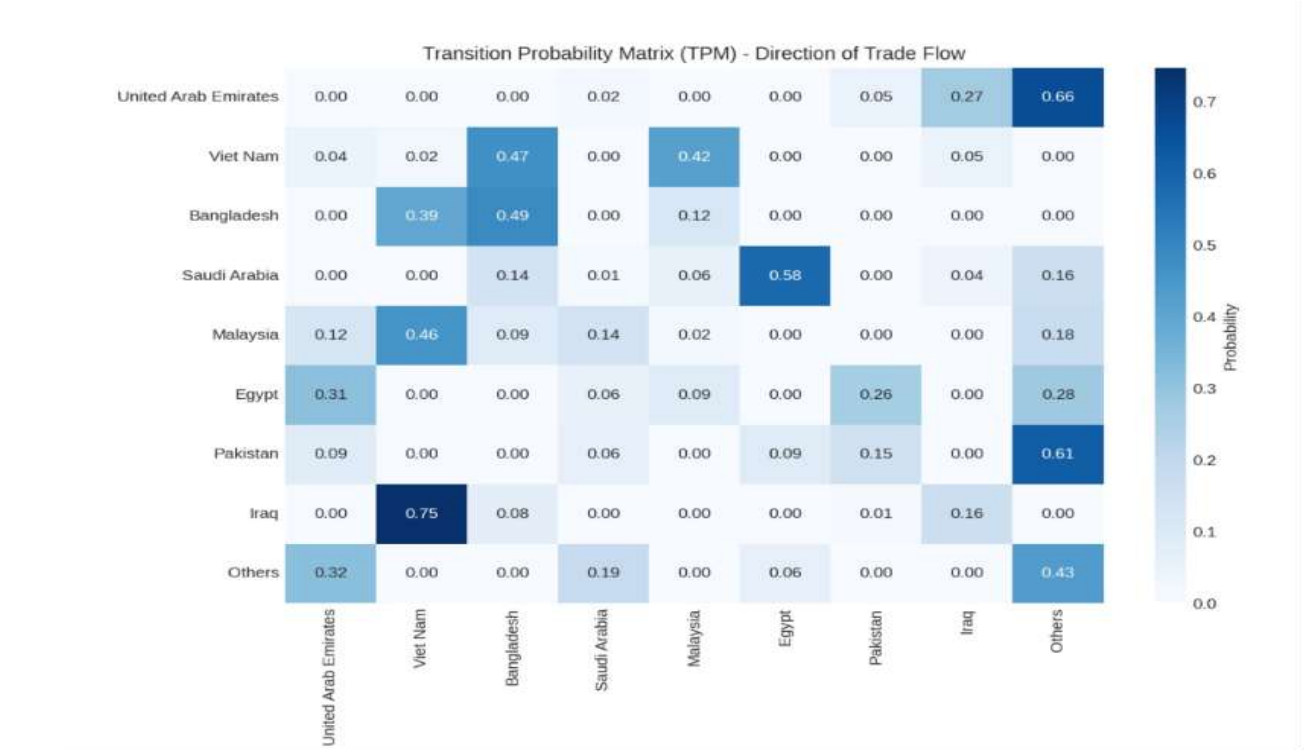


**Fig. 3. Transition Probability Matrix (TPM) for dried tamarind exports**

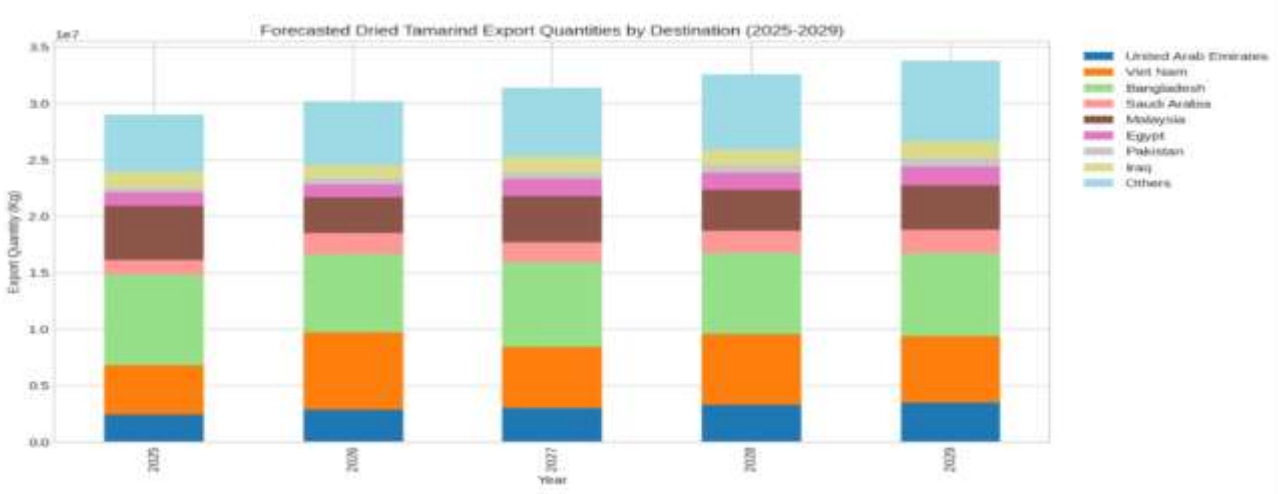


**Fig. 4. Forecasted dried tamarind exports (2024–25 to 2028–29)**

**Constraints faced by tamarind growers**

The constraints confronting tamarind farmers were systematically evaluated using Garrett's ranking technique (14), with Nj = 5 constraints presented to farmer respondents. The results, presented in Table 7, identify and prioritise the key impediments to tamarind production as perceived by the farming community.

**Table 7. Constraints faced by tamarind growers in the study area (Garrett ranking)**

| Constraint | Mean Score | Rank |
|---|---|---|
| Low price received by farmers | 67.05 | I |
| Low yield | 59.05 | II |

| | | |
|---|---|---|
| Market price fluctuation | 46.27 | III |
| Impact of climate change | 42.30 | IV |
| Pest and disease incidence | 32.36 | V |

*Source: Primary survey data. N = 36 farmers; Nj = 5 constraints ranked.*

Among the constraints identified, inadequate price realisation emerged as the most severe impediment, recording the highest mean Garrett score of 67.05 (Rank I). Farmers consistently reported receiving prices that fail to cover the true cost of production, adversely affecting economic viability and investment motivation. Low yield was ranked second (mean score: 59.05), with respondents attributing poor productivity to deficient agronomic management and the adverse impacts of erratic weather patterns. Market price fluctuation was ranked third (mean score: 46.27), reflecting the vulnerability of tamarind farmers to volatile market conditions. Climate change impacts were ranked fourth (mean score: 42.30), while pest and disease incidence ranked fifth (mean score: 32.36). These findings are consistent , who also identified price-related and productivity constraints as the most pressing challenges facing farmers in comparable dryland crop systems.

**Constraints faced by tamarind processors**

The constraints impeding tamarind processing activities were similarly evaluated through Garrett's ranking analysis with Nj = 3 constraints presented to processor respondents. Given the limited processor sample (n = 6), the following scores should be interpreted as indicative rather than generalisable, and are supplemented by raw rank observations. Table 8 summarises the results obtained from processor respondents.

**Table 8. Constraints faced by tamarind processors in the study area (Garrett ranking)**

| Constraint | Mean Score | Rank |
|---|---|---|
| Low profit margin | 62.66 | I |
| Climate variability | 48.00 | II |
| Labour shortage | 33.33 | III |

*Source: Primary survey data. N = 6 processors; Nj = 3 constraints ranked. Results are indicative given the small sample size*

Low profit margin was identified as the most critical constraint by tamarind processors, registering the highest mean score of 62.66 (Rank I). The narrow margins arise from elevated raw material acquisition costs, high labour expenses for deseeding, drying, and packaging operations, and competitive market pressures. Climate variability ranked second (mean score: 48.00), as fluctuations in annual precipitation and temperature directly affect the availability and quality of raw tamarind supply. Labour shortage was ranked third (mean score: 33.33), with processors citing difficulties in mobilising adequate seasonal labour for the labour-intensive processing stages. These findings underscore the need for targeted interventions to improve processing profitability through value addition, mechanisation of key operations, and the development of stable, contracted supply arrangements

## CONCLUSION

The compound growth analysis revealed a declining trend in tamarind cultivation area in Karnataka and Tamil Nadu, while Andhra Pradesh, Telangana, and Kerala recorded improvements in productivity, indicating the role of better production technologies and management practices in sustaining output. Markov chain analysis identified Iraq, Pakistan and Malaysia as the relatively stable export destinations for fresh tamarind, and Bangladesh, the 'Others' category, Pakistan and Iraq as the relatively stable destinations for dried tamarind, with Malaysia and Vietnam projected to remain the leading export markets and Egypt, Saudi Arabia, UAE and Pakistan emerging as potential markets for future export expansion. Among the marketing channels, Channel III (Farmer–Trader–Processor–Industrial User) was the most efficient (MME = 0.40), highlighting the advantages of shorter marketing chains in improving producer returns and market efficiency. Garrett ranking showed that inadequate price realization, low yield, and price fluctuations were the major constraints faced by farmers, while processors were primarily affected by low profit margins, climate variability, and labour shortages. Future research may focus on assessing India's export competitiveness, evaluating the economics of value-added tamarind products, and examining the role of Farmer Producer Organizations (FPOs) and contract marketing in enhancing market efficiency and stakeholder income

**Limitations of the Study**

The study was confined to the Dharmapuri and Krishnagiri districts of Tamil Nadu; therefore, the findings may not fully represent the production, marketing, and export conditions prevailing in other tamarind-producing regions of India. The sample size was relatively small, particularly for processors and exporters, due to the limited number of active processing units and export firms operating in the study area, which may restrict the generalizability of the results. The analysis was

based on cross-sectional primary data collected during a specific period and may not capture seasonal and temporal variations in marketing practices and stakeholder behaviour. Further, the Markov chain analysis was based on historical trade patterns and assumes that future market shares depend on past transitions, which may not fully reflect the effects of unforeseen policy changes, trade disruptions, climatic events, or fluctuations in global markets.

**Authorship Contribution Statement**
M Vaishnavi: Conceptualisation, methodology, data collection, analysis, interpretation, manuscript Preparation
K Divya: Conceptual development, supervision, project administration, critical revision.
N Deepa: Validation, supervision, manuscript review.
A Janaki Rani: Validation, manuscript review.
S T Bini Sundar: Statistical analysis, data interpretation, manuscript review.
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**Conflict of Interest**
The authors declare no conflict of interest.

**Data Availability Statement**
The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Declaration of Generative AI and AI-Assisted Technologies in the Writing Process**:
The authors acknowledge the use of ChatGPT for grammar correction and language refinement during the preparation of this manuscript. All generated content was thoroughly reviewed and revised by the authors , who accept full responsibility for the accuracy, originality and integrity of the final published work

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