

RESEARCH PAPER

Impact of Export and Import Dynamics on the Balance of Trade for Turmeric-Producing Countries: A Markov Chain Analysis

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ABSTRACT

The study reveals significant fluctuations in turmeric area, production, yield, and trade patterns over time. From 1950 to 2023, average area and output increased by 2.72% and 4.05%, respectively, while yield growth remained at 1.32%. The average production value peaked in Period 4 at 1031.84 before falling to 129.11 in Period 5. The coefficient of variation increased sharply from 16.62 to 81.44 in Period 5, indicating greater unpredictability and variability. From 2015 to 2024, India's turmeric trade experienced fluctuations in export growth, increasing by 39.6% in 2016 and 54.1% in 2018, but decreasing by 17.8% in 2017 and 46.1% in 2024. Germany, Ethiopia, and Myanmar are important hubs in India's turmeric export network. Effective strategies are needed to support sustainable practices, increase value chain efficiency, and improve market access. Policy focus for turmeric cultivation in 2024 should focus on supporting organic farming, investing in research to develop disease-resistant, high-yield varieties, strengthening local processing facilities, implementing cluster-based sustainable development, and integrating digital platforms for direct market access and improved export logistics.

HIGHLIGHTS

- ① Trend of area, production and yield of turmeric in India were showing an increasing trend.
- ① India produces around 80% of the world's turmeric, cementing its dominance in global supply and exports.
- ① The increasing demand for organic turmeric has led to focused efforts on organic cultivation, supported by financial incentives and certification programs.
- ① Strengthening local processing facilities and implementing cluster-based sustainable development for farmer income can boost value addition and raise smallholder farmer incomes.

Keywords: Export & Import, Trade Patterns, Balance of Trade, Instability

Turmeric L.), a herb (*Curcuma longa* Zingiberaceae) thought to be indigenous to South Asia, notably India, has been grown since antiquity (Saran *et al.* 2015). It is a major commercial spice crop farmed in India, sometimes known as "Indian saffron" (Muthusamy, 2013). It is a herbaceous plant produced for its rhizomes, which are used in a variety of ways, including dried rhizomes, dried powder as a condiment, flavouring, and

colouring agent, and as a primary ingredient in Indian curry powder (Naik, 2013; Saran *et al.* 2015a). Roots are a rich source of steroidal saponins with various characteristics and numerous therapeutic applications (Saran *et al.* 2020a). The moniker

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Kum-kum, which is popular among housewives, is also a result of turmeric. It is also known as the Kitchen Queen because its flavour in every kitchen (Lal, 2012). The plant is grown via rhizomes and is available for harvest 6 to 7 months after planting. Curcumin, the major component, has antioxidant and anti-inflammatory properties. India is the world's largest producer, consumer, and exporter of turmeric, accounting for around 65% of the total market. The spice is largely grown in states such as Andhra Pradesh, Maharashtra, and Tamil Nadu, where weather patterns affect yield and market prices. India is the world's top producer, consumer, and exporter of turmeric. Turmeric is a blood thinner that contains anticoagulant and fibrinolytic characteristics (Kanjana *et al.* 2016). However, harsh weather, such as heat waves and little rainfall, have impeded turmeric production, leading to supply shortages and raising prices in domestic and global markets. Increased market access through better export logistics and value-added processing can enhance India's position in the global market (Ravindran *et al.* 2007).

Table 1: Major turmeric-producing states in India, along with selected districts for 2024

Sl. No.	State	Selected Districts
1	Andhra Pradesh	Guntur, Krishna, Prakasam, Kurnool
2	Tamil Nadu	Erode, Salem, Coimbatore, Dharmapuri
3	Maharashtra	Sangli, Hingoli, Nanded, Parbhani
4	Karnataka	Belagavi, Haveri, Chitradurga, Bagalkot
5	Telangana	Nizamabad, Karimnagar, Warangal
6	Odisha	Kandhamal, Ganjam, Koraput
7	West Bengal	Cooch Behar, Jalpaiguri,
8	Gujarat	Surat, Navsari, Tapi
9	Uttar Pradesh	Kushinagar, Maharajganj, Varanasi, Mirzapur, Allahabad
10	Chhattisgarh	Bastar, Dantewada, Raipur
11	Bihar	Purnea, Katihar, Kishanganj and Samastipur

Source: Ministry of Agriculture, India, spices Board of India, Government of India.

Although its considerable export footprint, India's trade quantities fluctuate as global demand and markets change, making turmeric a volatile

commodity in international trade. India leads the world in turmeric production and export, accounting for around 78% of global production and 60% of global export (Tholkappian & Devi, 2013). Agriculture is the primary sector and source of revenue and livelihood in rural developing countries such as India. As a result, ensuring agricultural sustainability can address the issue of livelihood (Ghabru *et al.* 2017).

India remains the world's largest turmeric grower, accounting for more than 75% of global output. Turmeric farming covered 3.24 lakh hectares in 2023, producing 11.61 lakh tonnes. The major turmeric-producing states are Maharashtra, Telangana, Karnataka, and Tamil Nadu, with each state having its own district specializing in production. The table below covers significant states and some of their top turmeric-producing districts. These states are critical to India's turmeric supply chain, which contributes heavily to both local consumption and exports. The export business has seen changing trends, with 1.534 lakh tonnes of turmeric exported in 2022-23. Bangladesh, the UAE, the United States, and Malaysia are among the top export destinations.

MATERIALS AND METHODS

The primary source of data used in this analysis is secondary data on turmeric yield, production, and area that was gathered from several published sources over a 73-year span from 1950 to 2023. To gain an insight of decadal performance, the period was split into five sub-periods: 1950–1967 to 1968–1985, 1986–2004 to 2005–23, and 1950–2023. The study used numerous approaches, including growth rate estimation with significance testing, growth slowing or stopping, and instability analysis. India is the world's greatest producer, user, and exporter of spices. The current study focused on one spice, turmeric, based on its export value. The spice crops were chosen based on their worth as exports from India. The country is a major exporter of turmeric, with an estimated 1.534 lakh tonnes of turmeric and turmeric products valued at USD 207.45 million exported in 2022-23. Leading export destinations include Bangladesh, the United Arab Emirates, the United States, and Malaysia. The current study used secondary data from 2012-24. Secondary data were gathered from several official websites of the Spice Board of India, the Ministry of

Commerce and Industry, the Government of India, and the Food and Agriculture Organization (FAO) in Rome, Italy. Different strategies were used to analyses the data.

Growth Rate

The growth rate was measured following the procedure adopted by various authors, Verma. S.K. *et al.* (2024) and many others and the steps followed are presented below. By taking time as independent variable and area, production and yield of the crops as dependent variables, the compound growth rates were estimated.

$$Y = A (1 + r)^t$$

Where,

Y = denotes dependent variables like area, production and yield in the year

t = for which growth rate is estimated.

A = is a constant

r = is the rate of annual increment.

Estimation of instability index

For assessing the instability in the production, the index certain by Cuddy- Della Valle index (Cuddy and Valle 1978) and used by Verma S.K *et al.* (2024):

$$CV_t = (CV) \times \sqrt{1 - R^2}$$

$$C.V. = \frac{\sigma}{\bar{X}} \times 100$$

Where,

σ = Standard Deviation

$\bar{X}$ = Mean

R^2 = coefficient of determination of the variable's linear trend model.

CV_t = CV around trend

Balance of Trade

The balance of trade of turmeric indicates the difference between the exported value of turmeric and the imported value of turmeric in India over a specific period, which was estimated using the approach developed by the Reserve Bank of India (2022):

$$BoT = E_{si} - I_{si}$$

Where,

BoT = Balance of trade,

E_{si} = Total value of turmeric exported by India over a given period.

I_{si} = Total value of turmeric imported by India over a given period.

The negative value of BOT indicates a trade deficit, whereas its positive value shows a trade surplus.

Period of study: The time series data is taken from 2015 to 2023 of turmeric crop of seven major importing countries on a volume basis for this sub-section.

Nature and sources of data: The time series data were collected from secondary sources pertaining to the export of Indian turmeric to major importing countries. The data were collected from a public source.

Analytical Framework: The trade directions of turmeric crop (export) were analyzed using the first-order Markov Chain Analysis. The calculation of the P matrix representing the transitional probability is the core component of Markov Chain Analysis. The matrix P 's P_{ij} entries represent the likelihood that exports will eventually shift from country i to country j . The matrix's diagonal elements calculate the likelihood that a country will keep its export market share. In other words, a closer look at the diagonal components of the transitional probability matrix reveals how loyal a country is to its exports. The column elements show the likelihood of trade gains from other competing countries, while the row elements show the likelihood of trade losses due to competing nations.

Markov chain analysis

$$E_{jt} = \sum_{i=1} E_{it-1} P_{ij} + e_{jt}$$

Where,

E_{jt} = exports from India during the year t to j^{th} country

E_{it-1} = export to i^{th} country during the year $t-1$

P_{ij} = the probability that exports will shift from i^{th} country to j^{th} country

e_{jt} = the term which is statistically independent of E_{it-1}

r = the number of importing countries and

t = number of years considered for the analysis

The transitional probabilities P_{ij} which can be arranged in a $(c \times r)$ matrix have the following properties.

$$0 \leq P_{ij} \leq 1$$

$$\sum_{i=1}^n P_{ij} = 1 \text{ for all } i$$

By multiplying the export to these nations in the preceding period ($t-1$) with the transitional probability matrix, the predicted export share of each country during period " t " may then be calculated (Verma S.K. et al. 2024)

RESULTS AND DISCUSSION

1. Growth analysis

Table 1: Growth analysis of Area, Production and yield of turmeric crop India during

PERIOD	India		
	Area	Production	Yield
PERIOD I	1.22	1.23	2.17
(1950-1967)	(1.85)*	(1.56)	(3.94)*
PERIOD II	2.75	4.90	2.23
(1968-1985)	(5.93)**	(4.60)*	(3.50)*
PERIOD III	2.41	4.30	1.79
(1986-2004)	(6.43)*	(5.13)	(2.81)
PERIOD IV	1.79	1.80	1.28
(2005-2023)	(7.44)*	(3.72)*	(2.43)
PERIOD V	2.72	4.05	1.32
(1950-2023)	(22.57)**	(20.40)**	(11.17)*

*Significant at 1 per cent level; **Significant at 5 per cent level.

The growth analysis of turmeric farming in India from 1950 to 2023 reveals significant changes in area, production, and yield. During Period I (1950-1967), area increased by 1.22%, while production increased by 1.23% and yield by 2.17%. During Period II (1968-1985), area expansion accelerated to 2.75%, resulting in a high output increase of 4.90%, while yield increased by 2.23%. From 1986 to 2004 (Period III), area growth averaged 2.41%, with production

at 4.30%, but yield fell to 1.79%. During Period IV (2005-2023), area growth fell to 1.79%, production to 1.80%, and yield to 1.28%, showing productivity problems. Overall, from 1950 to 2023, the average area and output increased by 2.72% and 4.05%, respectively, while yield growth remained at 1.32%, indicating that Increasing production through improved farming techniques and technology is critical for long-term growth.

(A) To analysis the instability analysis of turmeric crop in India;

2. Instability analysis

The average values increased significantly, reaching a peak in the fourth time at 232.53, but then dropping to 129.11 in the fifth time. The standard deviation increased significantly from 8.66 to 75.77, indicating more variability. The coefficient of variation (CV) started at 16.62 and increased to 58.69 in the fifth time, indicating more un predictableness. The CV numbers were initially similar in the first three times, but by the fourth and fifth times, they were very different, indicating more inconsistent data.

The analysis of production instability over five periods highlights fluctuations in consistency and predictability. The R^2 values vary across the periods, starting at 0.13 in Period 1, peaking at 0.85 in Period 5, indicating improved model accuracy in the later period. The coefficient of variation (CV) shows significant changes, especially with a sharp increase to 81.44 in Period 5, signaling higher instability. Comparing the CV with its threshold (CV t), the values diverge notably in later periods, suggesting growing inconsistency. The mean production increases steadily, reaching its highest in Period 4 at 1031.84 before dropping in Period 5. The standard deviation also rises, especially in Period 5, indicating more variation in production levels.

The study examines yield instability over five periods, revealing fluctuating R^2 values, varying explanatory power, and a rise in the coefficient of variation (CV) to 35.84 in Period 5. The average yield rises from 2.38 in Period 1 to 4.65 in Period 4, then falls to 3.20 in Period 5. The standard deviation also rises over time, indicating greater fluctuations in yield. The findings suggest an increase in yield instability and variability, particularly in the

Table 2: To analysis the instability of Area, Production and yield of turmeric crop India during

Area (Instability)					
STATISTICS	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5
R ²	0.177250379	0.68769546	0.708947203	0.765116871	0.876246719
CV	16.624	17.519	10.292	23.702	58.686
CV t	15.079	9.791	5.552	11.487	20.645
Mean	52.11111111	83.38888889	141.9473684	232.5263158	129.1081081
Standard Deviation	8.662895107	14.60917878	14.60917878	55.11237855	75.76813361
Production (Instability)					
R ²	0.130163539	0.569965229	0.607960182	0.376888319	0.852643311
CV	19.016	36.815	27.571	15.599	81.439
CV t	17.735	24.142	17.263	12.313	31.262
Mean	120.7777778	176.8333333	516.6315789	1031.842105	469.972973
Standard Deviation	22.96687014	65.10105267	142.4430532	160.957297	382.7406208
Yield (Instability)					
R ²	0.493392304	0.434534482	0.317742203	0.259093005	0.634287472
CV	16.488	19.710	16.565	13.271	35.842
CV t	11.735	14.821	13.683	11.424	21.675
Mean	2.383333333	2.077777778	3.584210526	4.647368421	3.198648649
Standard Deviation	0.392952624	0.409527067	0.593729416	0.616773343	1.146464875

final period, indicating a need for more accurate forecasting and management strategies.

3. Trade of turmeric crop in India

Table 3: Trade of turmeric crop in India during 2015 -2024 (₹ lakh)

Year	Export	Import	Balance of Trade
2015	101058.25	15389.31	+856689.4
2016	141098.72	16898.03	+124200.69
2017	115923.54	18462.36	+97461.18
2018	178572.65	30126.04	+148446.61
2019	139707.6	24678.43	+115029.17
2020	172265.24	22916.95	+149348.29
2021	153442.05	24576.99	+128865.06
2022	166707.32	19579.01	+147128.31
2023	187586.79	15006.51	+172580.28
2024	101160.08	18903.2	+82256.88

From 2015 to 2024, India's turmeric trade had considerable variations in export and import percentages. Exports rose 39.6% in 2016, increasing the trade balance by 44.9%, but fell 17.8% in 2017, lowering the balance by 21.5%. 2018 saw a robust recovery, with exports rising 54.1% and the trade balance growing by 52.3%. However, in 2019, exports declined by 21.7%, reducing the trade

balance by 22.5%. In 2020, a 23.3% increase in exports resulted in a 29.8% increase in the surplus, which was followed by a downturn in 2021, when exports declined by 10.9% and the balance fell 13.7%. The trade balance improved in 2022, with an 8.6% increase in exports, lifting it by 14.2%, and in 2023, exports increased by another 12.5%, boosting it by 17.3%. However, exports dropped by 46.1% in 2024, while the trade balance fell by 52.3%. Despite these changes, the overall trend shows India's steady excess in turmeric trade over the period.

4. Direction of turmeric crop export in value from India (2015 to 2023)

The transition probability matrix for turmeric exports from India (2015–2023) reveals important trade dynamics, with Germany, Ethiopia, and Myanmar emerging as major hubs. The top destinations for Indonesia's turmeric exports are Germany (52.24%), while Ethiopia (39.27%) and Thailand (28.62%) are important destinations for Cambodia. The two countries that Germany sends the most turmeric to are Thailand (32.70%) and Indonesia (35.54%). Germany is Myanmar's top export destination (53.15%), and the country has strong ties to Vietnam (21.75%) and Cambodia (25.35%). Ethiopia accounts for 32.42% of Thailand's

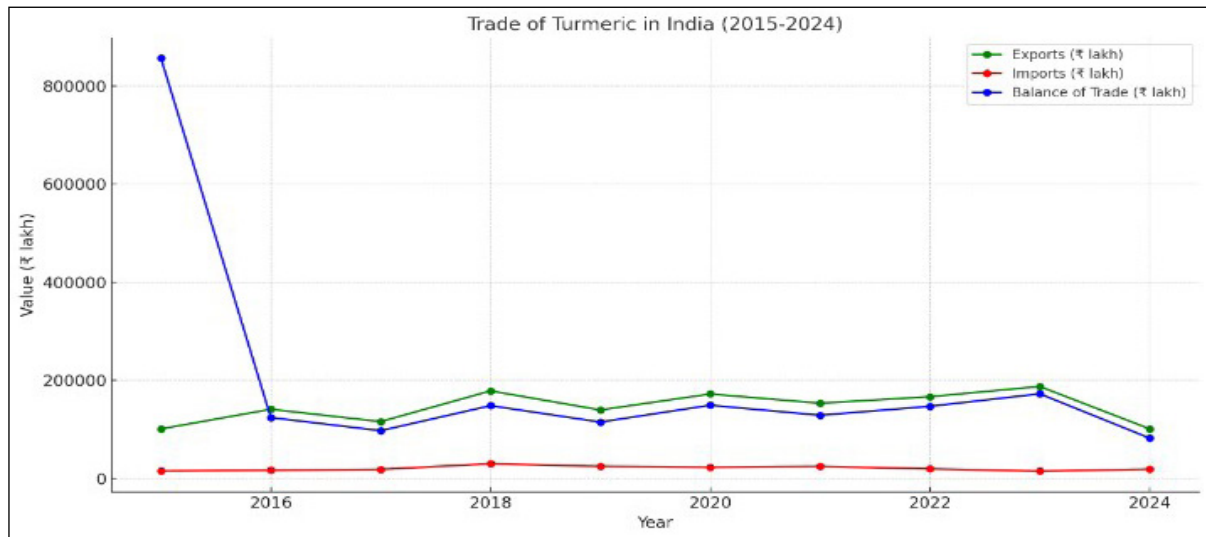


Fig. 1: Directional Graph of Trade of turmeric in India

Table 4: Transition probability matrix of turmeric crop export in Value from India (2015 to 2023)

Country	Indonesia	Cambodia	Germany	Myanmar	Thailand	Vietnam	Ethiopia	Others
Indonesia	0.0000	0.0000	0.5224	0.0000	0.1294	0.1737	0.0000	0.1764
Cambodia	0.3251	0.0000	0.0000	0.0000	0.2862	0.0000	0.3927	0.0000
Germany	0.3554	0.0000	0.1135	0.0805	0.3270	0.0010	0.0200	0.0981
Myanmar	0.0000	0.2535	0.5315	0.0000	0.0000	0.2175	0.0000	0.0000
Thailand	0.0000	0.2620	0.0000	0.1245	0.1915	0.0938	0.3242	0.0000
Vietnam	0.0000	0.0000	0.4253	0.0000	0.0000	0.0000	0.5780	0.0000
Ethiopia	0.2195	0.2354	0.4519	0.0020	0.0934	0.0000	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.4136	0.0678	0.0000	0.4588	0.0600

exports, followed by Cambodia (26.20%), whereas Vietnam prioritizes Ethiopia (57.80%) and Germany (42.53%). Ethiopia's exports are broadly distributed, with Germany being the primary destination (45.19%). The final two countries that "Others" exports to most are Ethiopia (45.88%) and Myanmar (41.36%). This data shows how these nations interact in a complex way, emphasizing Ethiopia, Germany, and Myanmar is one of the biggest centers for India's turmeric export network.

5. Direction of turmeric crop export in quantity from India (2015 to 2023)

The transition probability matrix for turmeric crop exports from India (2015–2023) in terms of quantity highlights major trade patterns. Indonesia exports turmeric largely to Germany (55.81%), with smaller but significant amounts going to Thailand (18.66%) and "Others" (18.86%). Cambodia's exports are

primarily aimed towards Ethiopia (38.15%) and Thailand (25.30%), with a sizable amount remaining inside its market (31.22%). Germany's exports are divided among Vietnam (33.28%), "Others" (22.31%), and Indonesia (10.49%). Myanmar has a substantial export link with Germany (60.30%) and sends a share to Cambodia (22.87%) and Vietnam (17.18%). Thailand's biggest export destinations are Cambodia (29.39%) and Vietnam (26.22%), with a smaller share going to Ethiopia (12.91%). Vietnam mainly exports to Ethiopia (53.86%) and Germany (41.87%). Ethiopia's turmeric exports are primarily destined for Germany (50.53%) and Thailand (32.65%). Finally, the "Others" category has significant exports to Myanmar (49.68%), Ethiopia (19.74%), and "Others" (28.42%). This distribution identifies Germany, Ethiopia, and Myanmar as key hubs in India's turmeric export network in terms of quantity.

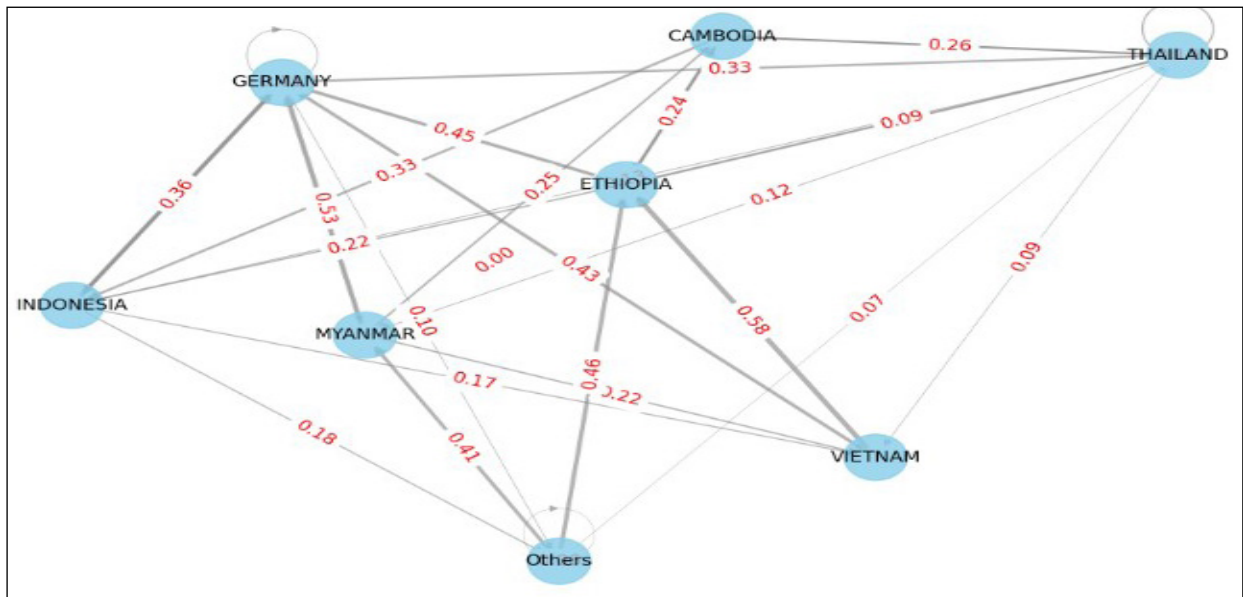


Fig. 2: Directional Graph of turmeric crop export in Value from India

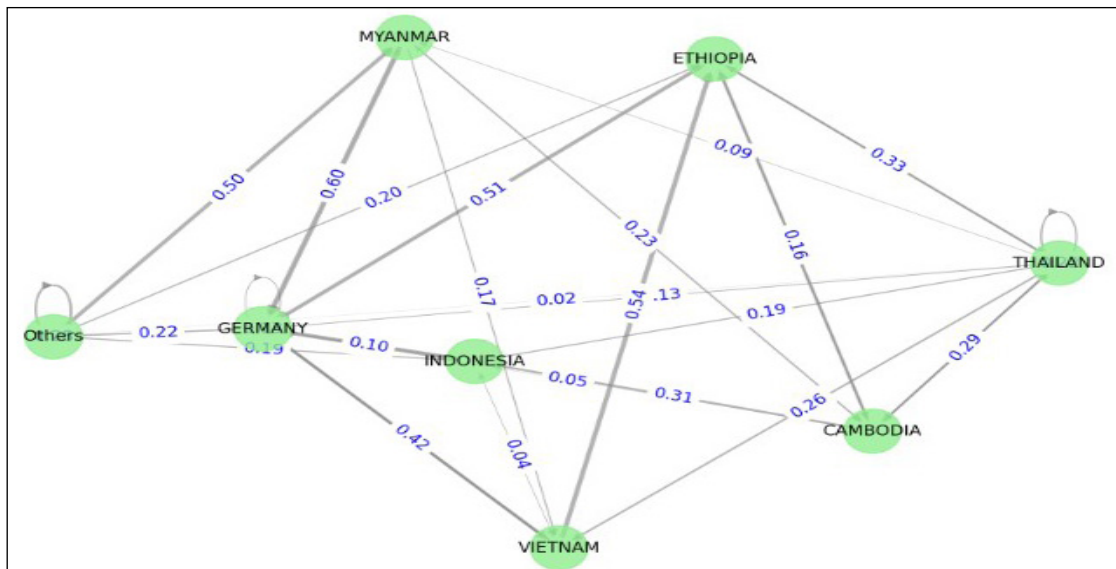


Fig. 2: Directional Graph of turmeric crop export in Quantity from India

Table 5: Transition probability matrix of turmeric crop export in quantity from India (2015 to 2023)

Country	Indonesia	Cambodia	Germany	Myanmar	Thailand	Vietnam	Ethiopia	Others
Indonesia	0.0000	0.0000	0.5581	0.0000	0.1866	0.0715	0.0000	0.1886
Cambodia	0.3122	0.0000	0.0503	0.0011	0.2530	0.0000	0.3815	0.0000
Germany	0.1049	0.0000	0.1253	0.0604	0.1337	0.3328	0.0169	0.2231
Myanmar	0.0000	0.2287	0.6030	0.0000	0.0000	0.1718	0.0000	0.0000
Thailand	0.0000	0.2939	0.0000	0.0887	0.2234	0.2622	0.1291	0.0000
Vietnam	0.0429	0.0000	0.4187	0.0000	0.0000	0.0000	0.5386	0.0000
Ethiopia	0.0000	0.1644	0.5053	0.0000	0.3265	0.0000	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.4968	0.0236	0.0000	0.1974	0.2842

CONCLUSIONS & SUGGEST SUITABLE POLICY IMPLICATIONS

The study reveals significant fluctuations in turmeric area, production, yield, and trade patterns over time. From 1950 to 2023, average area and output increased by 2.72% and 4.05%, respectively, while yield growth remained at 1.32%. The average production value peaked in Period 4 at 1031.84 before falling to 129.11 in Period 5. The coefficient of variation increased sharply from 16.62 to 81.44 in Period 5, indicating greater unpredictability and variability. The R-squared values began at 0.13 in Period 1 and peaked at 0.85 in Period 5, indicating increased predictability but weakened production consistency in later periods. From 2015 to 2024, India's turmeric trade experienced fluctuations in export growth, increasing by 39.6% in 2016 and 54.1% in 2018, but decreasing by 17.8% in 2017 and 46.1% in 2024. Germany, Ethiopia, and Myanmar are important hubs in India's turmeric export network. Germany imports 55.81% of turmeric from Indonesia, exports 33.28% to Vietnam, and primarily targets Ethiopia (50.53%) and Thailand (32.65%). Myanmar's strongest export link is with Germany (60.3%). These trade relationships underscore the need for effective strategies. The policy focus for turmeric cultivation in India in 2024 should be on supporting sustainable practices, increasing value chain efficiency, and improving market access. Encouraging organic turmeric growing with financial incentives and certification support can help farmers enter higher-value export markets. Investment in research to develop disease-resistant, high-yield and high curcumin varieties will increase output while lowering cultivation risks. Strengthening local processing facilities and implementing cluster-based sustainable development for farmer income can boost value addition and raise smallholder farmer incomes. Integrating digital platforms for direct market access and improving export logistics can connect farmers directly with global buyers, resulting in higher pricing. These policies seek to maintain India's leadership in the global turmeric industry while also assuring sustainability and farmer welfare.

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