**Trade Dynamics and Performance of Indian Horticulture Sector: An Empirical Study**

**Abstract**

This study investigated the trade performance of Indian horticultural products, focusing on vegetables (HS code 07) and fruits (HS code 08) with five major importing countries. Time series data from 2003 to 2022 was collected from the International Trade Centre (ITC). Various analytical tools were used such as compound annual growth rate, instability index, markov chain analysis, revealed comparative advantage index and trade balance index. The analysis revealed that vegetable export share showed a fluctuating upward trend, while fruit exports recorded overall declined. The growth in several key vegetables and fruits remained positive during 2013-2022. Markov chain analysis revealed Bangladesh and United States emerged as consistent and reliable trade partners of India. Trade balance indices showed that India maintained a net export position for key vegetables like onions, potatoes, sweetcorn, cucumbers & gherkins and mushrooms and for fruits such as coconuts, cashew nuts, almonds, guavas, mangoes, citrus, grapes, strawberries, pears, papayas, and jackfruits. To further enhance horticultural trade performance, the study recommends strengthening bilateral relations with key partners such as Bangladesh, United States, and United Arab Emirates, along with promoting private sector participation, export-oriented farming, and increased investments in infrastructure and logistics. It also emphasized the need to address trade barriers, particularly sanitary and phytosanitary issues, to fully realize India’s export potential in the horticulture sector.

**Keywords:** Horticultural trade, fruits and vegetables, revealed comparative advantage, markov chain analysis, trade balance index

**1. INTRODUCTION**

With a population of over 1.4 billion, India faces the dual challenge of ensuring food and nutritional security (Thakur et al., 2024; Singh et al; 2025) while also tapping into the economic potential of agricultural exports. India comes second after China in the global value of fruits and vegetable production, accounting for 7 and 8 %, respectively (FAOSTAT, 2017; Villacis et al., 2024). According to the Food and Agriculture Organization (FAO), increasing fruit and vegetable consumption has become a global priority. Most nutritional guidelines recommend the consumption of at least two servings of fruits and three servings of vegetables per day (WHO/FAO, 2003; Wang et al., 2021). Consequently, the demand for these commodities has been rising steadily over the past few decades. The volume and variety of fruits and vegetables traded globally have increased significantly due to rising incomes, declining transportation costs, better technology and evolving international agreements (Huang, 2004). India produces a vast variety of horticulture crops all year long because to its diversified agro-climatic conditions, significant genetic diversity, and diversity in crops. Horticulture has not only triggered India’s agricultural growth but, has also given farmers a variety of options for increasing farm profitability, provide livelihood security, and earning foreign currency through exports (Idris et al., 2015).

The global trade in fruits and vegetables has expanded significantly in volume and diversity, driven by rising incomes, reduced transportation costs, technological advancements, and evolving international trade agreements (Huang, 2004). India benefits from a wide range of agro-climatic conditions, rich genetic diversity, and year-round crop availability, making it a major producer of horticultural crops. This diversity has not only supported India’s agricultural growth but has also enhanced farm profitability, ensured livelihood security and contributed to foreign exchange earnings through exports (Idris et al., 2015). The liberalization policies and economic reforms initiated in the 1990s catalyzed a shift in cropping patterns toward high value horticultural crops. This transformation was primarily driven by increasing domestic and international demand for perishable and nutrient rich foods. In response, India introduced a range of technical, institutional, and regulatory measures to promote horticulture and strengthen its participation in global trade (Jha et al., 2019). A landmark initiative was the launch of the National Horticulture Mission (NHM) in 2005-06, focused on increasing production and processing capacity, improving marketing infrastructure, and fostering coordinated efforts across the value chain (Mittal, 2007). The country’s vegetable production rose from 101.2 million tonnes in 2004-05 to 183.17 million tonnes in 2018-19, while fruit production increased from 50.9 to 97.97 million tonnes over the same period (NHB, 2019).

Over the past two decades, India has witnessed remarkable growth in the export of both fresh and processed horticultural products, which now account for around 12% of the country’s total agricultural exports. The export value of fresh fruits surged from ₹4.47 billion in 2002-03 to ₹49.13 billion in 2017-18, growing at an annual rate of 14.16%. Similarly, fresh vegetable exports rose from ₹6.43 billion to ₹52.98 billion during the same period, registering a growth rate of 15.14% per annum (Singh et al., 2020). Indian horticultural exports reach more than 70 countries, with key markets including Southeast Asia, Middle East, European Union, United Kingdom, and United States. In 2022-23, India exported fresh fruits and vegetables worth ₹13185 crores, while exports of processed fruits and vegetables were ₹18090 crores. UAE, Netherlands and Bangladesh emerged as top importers of fresh fruits, while UAE, Bangladesh and Malaysia were the leading destinations for fresh vegetables during this period (APEDA, 2023).

Despite this growth, Indian horticultural exports face numerous challenges. Trade is hampered by stringent sanitary and phytosanitary (SPS) standards, inadequate infrastructure, inefficient logistics, and non-tariff barriers. Perishable products like fresh fruits and vegetables are especially vulnerable to SPS regulations, which include zero-tolerance policies for pests, lengthy certification processes, and inspections at ports of entry. These restrictions often lead to shipment rejections, delays, quality deterioration, financial losses and damage to India’s trade reputation. In this context, the present study was undertaken to evaluate the performance of India’s horticultural trade with major importing countries, identify strengths and gaps and policy recommendations to enhance its global competitiveness.

**2. MATERIALS AND METHODS**

***2.1 Data***

Time series secondary data on India’s trade with Harmonized System of vegetables (HS code 07) and fruits (HS code 08) with major importing countries i.e., Bangladesh, Nepal, Netherlands, United Arab Emirates (UAE) and United States of America were collected from 2003 to 2022 from International Trade Centre, ITC (Trade Map). In addition, data on the import and export of vegetables and fruits for each of the selected countries were also gathered. To gain deeper insights into India’s horticultural trade performance, detailed data at the 6-digit HS code level were compiled for both product categories across the major importing countries. Only products with export values exceeding USD 1 million were considered. For these products, the Revealed Comparative Advantage (RCA) was calculated, and those with an RCA value greater than 1 were selected for further analysis. The final list of selected vegetable (HS code 07) and fruit (HS code 08) products is presented in Table 1 and Table 2.

**Table 1:** **HS code of vegetables (07) with their respective product detail**

|  |  |
| --- | --- |
| **Code** | **Product label** |
| 070310 | Fresh or chilled onions and shallots |
| 070999 | Fresh or chilled vegetables  |
| 071010 | Potatoes, uncooked or cooked by steaming or by boiling in water, frozen |
| 071040 | Sweetcorn, uncooked or cooked by steaming or by boiling in water, frozen |
| 071140 | Cucumbers and gherkins provisionally preserved... |
| 071190 | Vegetables and mixtures of vegetables provisionally preserved ... |
| 071220 | Dried onions, whole, cut, sliced, broken or in powder... |
| 071231 | Dried mushrooms of the genus “Agaricus”, whole, cut, sliced… |
| 071320 | Dried, shelled chickpeas “garbanzos”, whether or not skinned or split |
| 071331 | Dried, shelled beans of species “Vigna mungo [L.] Hepper... |
| 071335 | Dried, shelled cow peas “Vigna unguiculata”, whether or not skinned or split |
| 071360 | Dried, shelled pigeon peas “Cajanus cajan”, whether or not skinned or split |
| 071390 | Dried, shelled leguminous vegetables, whether or not skinned or split... |

**Table 2:** **HS code of fruits (08) with their respective product detail**

|  |  |
| --- | --- |
| **Code** | **Product label** |
| 080112 | Fresh coconuts in the inner shell “endocarp” |
| 080119 | Fresh coconuts, whether or not shelled or peeled… |
| 080132 | Fresh or dried cashew nuts, shelled |
| 080280 | Fresh or dried areca nuts, whether or not shelled or peeled |
| 080450 | Fresh or dried guavas, mangoes and mangosteens |
| 080590 | Fresh or dried citrus fruit (excl. oranges, lemons “Citrus... |
| 080610 | Fresh grapes |
| 081090 | Fresh tamarinds, cashew apples, jackfruit, lychees... |
| 081340 | Dried peaches, pears, papaws “papayas”, tamarinds and other edible fruits… |

***2.2 Analytical tools***

***2.2.1 Compound annual growth rate***

The growth in India’s horticultural exports was estimated using the given formula

Y = abt

Where, Y = India’s trade with major importing countries

 a = Constant

 b = Regression coefficient

 t = Time

CAGR (%) = (Antilog b-1) x 100

The compound growth rates were estimated for different periods.

***2.2.2 Cuddy-Della Valle instability index***

Cuddy-Della Velle Index was used to examine the instability in export of vegetables and fruits of India to major importing countries.

Coefficient of Variation (CV%) = $\frac{Standard Deviation}{Mean}×100$

Instability Index = CV $×\sqrt{(1-R^{2})}$

where, coefficient of variation is denoted by CV, and the coefficient of determination from a time trend regression is denoted by R2.

***2.2.3 Revealed Comparative Advantage (RCA) index***

Revealed Comparative Advantage index (RCA) is described as the export ratio of a country in relation to its share commodity category in total merchandise export. It was first introduced by Liesner (1958) to determine the comparative advantage of export. Balassa specifically emphasized this model in 1965 (Balassa 1965, Vollrath 1991, Yu et al.,2009. Quddus and Mustafa 2011). If a country’s share of world exports of a commodity category is greater than its share of world exports of all commodities, the RCA value will be greater than one. As a result, a country is said to have a revealed comparative advantage in those commodities where its global market share exceeds its average global export share. RCA for a country ‘I’ in commodity ‘a’, (RCA)a, can be described as

$$(RCAi)\_{a}=\left(^{X\_{ia}}/\_{X\_{wa}}\right)\left(^{X\_{it}}/\_{X\_{wt}}\right)$$

where,

$X\_{ia}$= Export of commodity ‘a’ by country ‘i’,

$X\_{it}=$Agricultural export as a whole, by country ‘i’,

$X\_{wa}$= Exports of commodity ‘a’ globally; and

$X\_{wt}=$ Total export of World for all agricultural products.

To reveal the power of comparative advantage, Hinloopen and Van (2001) suggested a classification based on Balassa’s RCA as follows:

0 < RCA value < 1 demonstrate no comparative advantage,

1 < RCA value < 2 demonstrates weak comparative advantage,

2 < RCA value < 4 demonstrate moderate comparative advantage,

RCA value 4 or more demonstrate strong comparative advantage.

***2.2.4 Markov Chain analysis***

The probability that exports would shift from the P to the jth country over time was represented by the matrix element P. In the transitional probability matrix, the diagonal elements P represents the probability that the export share of a country would be maintained in the consecutive periods, this effectively means, measured an importing country’s loyalty to a specific exporting country (Singh et al., 2023). The average exports to a specific country were thought to be a random variable that was simply dependent on its prior exports to that country and algebraically represented by

$$E\_{jt}= \sum\_{}^{}E\_{jt-1}P\_{jt}+ e\_{jt}$$

where,

$E\_{jt}=$ India exported to the ith country during the year t

$E\_{jt-1}= $Exports to the ith country in the year t-1

$P\_{jt}$ = Probability that exports will switch from the ith country to the jth country

$e\_{jt}= $Error-term that is statistically independent of $E\_{jt-1}$

***2.2.5 Trade Balance Index (TBI)***

The Trade Balance Index (TBI), which was developed by Lafay (1992), is a ratio of the export and the country’s overall trade (export + import). This index indicates whether a nation is a net exporter or importer (Widodo 2009). The Trade Balance Index (TBI) is calculated as:

$${TBI\_{ij}=(X-M)}/{(X+M)}$$

X = Export of commodity ‘j’ from country ‘i’

M = Import of commodity ‘j’ from country ‘i’

TBI represents the ratio in relation to the country’s ‘i’ trade of the product ‘j’. The TBI number can range between -1 to 1. When the Trade Balance Index (TBI) value is equal to 1, the country is depicted as being a net exporter. When the TBI value is equal to -1, the country is displayed as a net importer. If the TBI value is zero, the country’s export value equals the country’s import value. In other words, a positive TBI value indicates that the country is a net exporter, a negative TBI value indicates that the country is a net importer.

**3. RESULTS AND DISCUSSION**

***3.1 Export competitiveness of Indian Fruits and Vegetables***

Revealed comparative advantage (RCA) index was used to assess India’s export competitiveness in vegetables (HS code 07) and fruits (HS code 08) with major importing countries over the period. The analysis was conducted across four trienniums: 2003-05, 2011-13, 2015-17 and 2020-22. The RCA index measures a country’s relative advantage or disadvantage in the export of a specific product compared to the world average (Table 3). The results revealed that during the recent triennium (2020-22), all selected vegetable products recorded RCA values greater than one, indicating a clear comparative advantage in global markets. Similarly, India’s fruit exports (HS code 08) also demonstrated a comparative advantage, as all products under consideration had RCA values exceeding one during the same period (Table 4). Thus, all the identified products were retained for further detailed analysis.

**Table 3: Revealed Comparative Advantage (RCA) of vegetables (HS code 07) during TE 2005 to TE 2022**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Code** | **Product label** | **2003-05** | **2011-13** | **2015-17** | **2020-22** |
| 070310 | Fresh or chilled onions… | 7.43 | 5.24 | 5.47 | 4.47 |
| 070999 | Fresh or chilled vegetables... | - | 0.46 | 1.8 | 1.21 |
| 071010 | Potatoes, uncooked… | 1.06 | 1.4 | 0.19 | 1.25 |
| 071040 | Sweetcorn, uncooked or cooked | 0.1 | 0.55 | 1.02 | 1.43 |
| 071140 | Cucumbers and gherkins... | 29.03 | 15.69 | 21.02 | 23.93 |
| 071190 | Vegetables and mixtures of veg.. | 3.55 | 0.63 | 0.76 | 1.21 |
| 071220 | Dried onions, whole, cut… | 5.62 | 8.55 | 12.13 | 13.33 |
| 071231 | Dried mushrooms… | 5.53 | 3.61 | 2.18 | 1.38 |
| 071320 | Dried, shelled chickpeas… | 1.72 | 7.81 | 3.2 | 4.16 |
| 071331 | Dried, shelled beans of species... | 0.12 | 0.05 | 0.43 | 1.18 |
| 071335 | Dried, shelled cow peas… | - | 0.01 | 0.4 | 5.42 |
| 071360 | Dried, shelled pigeon peas… | - | 0.01 | 3.8 | 4.72 |
| 071390 | Dried, shelled leguminous veg... | 12.87 | 0.54 | 0.98 | 5.55 |

*- denotes data not available*

**Table 4: Revealed Comparative Advantage (RCA) of fruits (HS code 08) during TE 2005 to TE 2022**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Code** | **Product label** | **2003-05** | **2011-13** | **2015-17** | **2020-22** |
| 080112 | Fresh coconuts in the inner | - | 0.74 | 1.12 | 1.87 |
| 080119 | Fresh coconuts… | 1.56 | 8.56 | 9.84 | 3.4 |
| 080132 | Fresh or dried cashew nuts, shelled | 34.5 | 12.22 | 7.89 | 3.8 |
| 080280 | Fresh or dried areca nuts… | - | 0.34 | 1.37 | 1.75 |
| 080450 | Fresh or dried guavas, mangoes… | 11.83 | 5.14 | 3.37 | 2.06 |
| 080590 | Fresh or dried citrus… | 4.63 | 0.9 | 1.16 | 1.68 |
| 080610 | Fresh grapes | 0.66 | 0.78 | 1.2 | 1.36 |
| 081090 | Fresh tamarinds, cashew apples ... | 1.48 | 1.18 | 1.24 | 0.91 |
| 081340 | Dried peaches, pears… | 1.06 | 1.07 | 0.68 | 1.03 |

*- denotes data not available*

***3.2 Trends in India’s Fruit and Vegetable Exports***

The share of India’s export of vegetables (HS code 07) and fruits (HS code 08) to the world from 2013 to 2022 were presented in figure 1. The export of vegetables (HS code 07) to major importing countries, India’s share was highest in 2013 and lowest in 2019 but after that it recorded increasing trend. In case of export of fruits (HS code 08) to major importing countries, the share was found continuously decelerating from 2013 to 2020 and after that it became fairly stable.

**Figure 1: Trend in share of India’s export of vegetables (HS code 07) and fruits (HS code 08) to the world 2013 to 2022**

***3.3 Growth and Instability in India’s Horticultural Exports***

**The growth and instability in India’s vegetable exports (HS code 07) to key importing nations, divided into two periods i.e., 2003-2012 and 2013-2022. Compound annual growth rates (CAGR) and Cuddy-Della Valle indices (CDVI) were computed for various products (Table 5).** During the first period (2003-2012), India’s vegetable exports exhibited exceptional growth across several key products. The highest annual growth was recorded for dried, shelled chickpeas (HS code 071320) at 70.82%, followed by sweetcorn (44.95 %), potatoes (30.81 %), dried onions (25.37 %), fresh or chilled onions (14.17 %), and cucumbers & gherkins (10.50 %). However, a sharp decline was observed in the export of dried, shelled leguminous vegetables (HS code 071390), which fell by 32.67 %. The instability in export varied, with the highest instability recorded for dried, shelled beans (HS code 071331) at 137.17 %, followed by leguminous vegetables (52.48 %) and mixed vegetables (50.27 %). In contrast, fresh or chilled onions (HS code 070310) exhibited the most stable performance with a CDVI of 22.20 %. In second period (2013-2022), the export structure shifted significantly. The most striking growth was observed in dried, shelled cow peas (HS code 071335) at 94.83 % per annum, followed by dried, shelled pigeon peas (73.40 %), dried, shelled beans (40.56 %), and leguminous vegetables (30.61 %). Moderate growth was registered in exports of sweetcorn (10.70 %), mixed vegetables (7.79%), cucumbers & gherkins (5.49 %), and dried onions (5.62 %). In contrast, dried mushrooms (HS code 071231) witnessed the steepest annual decline at 12.82 %, followed by chickpeas (6.04 %) and fresh coconuts (4.53 %). In case of instability indices, potatoes (HS code 071010) and leguminous vegetables (HS code 071390) became the most volatile, with instability values of 86.46 % and 83.65 %, respectively. However, sweetcorn, mixed vegetables, dried onions and cucumbers showed medium volatility as the values were below 20 %. Interestingly, despite strong growth, some products like cow peas and pigeon peas also showed moderate instability (39.74 % and 44.65 %, respectively), indicating vulnerability to external shocks or policy changes.

**Table 5: Growth rates and Cuddy-Della Valle Indices of export of vegetables (HS code 07) from India to major countries, 2003 to 2012 and 2013 to 2022**

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Product label** | **CAGR** | **Instability index** |
| **2003 to 2012** | **2013 to 2022** | **2003 to 2012** | **2013 to 2022** |
| 070310 | Fresh or chilled onions… | 14.17 | -0.01 | 22.2 | 18.68 |
| 070999 | Fresh or chilled vegetables... | - | 1.36 | - | 16.38 |
| 071010 | Potatoes, uncooked… | 30.81 | 4.52 | 49.5 | 86.46 |
| 071040 | Sweetcorn, uncooked or cooked | 44.95 | 10.70 | 45.5 | 9.77 |
| 071140 | Cucumbers and gherkins... | 10.50 | 5.49 | 28.04 | 17 |
| 071190 | Vegetables and mixtures of veg.. | -5.83 | 7.79 | 50.27 | 13.29 |
| 071220 | Dried onions, whole, cut… | 25.37 | 5.62 | 35.68 | 13.71 |
| 071231 | Dried mushrooms… | 4.14 | -12.82 | 34.56 | 22.46 |
| 071320 | Dried, shelled chickpeas… | 70.82 | -6.04 | 38.48 | 35.18 |
| 071331 | Dried, shelled beans of species... | -0.65 | 40.56 | 137.17 | 27.83 |
| 071335 | Dried, shelled cow peas… | - | 94.83 | - | 39.74 |
| 071360 | Dried, shelled pigeon peas… | - | 73.40 | - | 44.65 |
| 071390 | Dried, shelled leguminous veg... | -32.67 | 30.61 | 52.48 | 83.65 |

*- denotes data not available*

The results of compound annual growth rates and Cuddy-Della Valle indices for India’s fruit exports (HS code 08) presented in Table 6. In the first period (2003-2012), India’s fruit exports showed positive growth across most products. Fresh coconuts (HS code 080119) registered the highest annual growth at 64.46 %, followed by dried peaches and pears (25.29 %), fresh tamarinds and cashew apples (21.44 %) and fresh grapes (20.22 %). Guavas, mangoes, and mangosteens (11.11 %) and cashew nuts (7.05 %) also showed moderate growth. The lowest positive growth was recorded for citrus fruits (1.37 %). In terms of instability, citrus fruits were the most unstable with a value of 41.70 %, whereas cashew nuts and tamarind products were relatively stable with indices values of 14.18 % and 16.88 %, respectively. In second period (2013-2022), the export dynamics shifted. Fresh coconuts in the inner shell (HS code 080112) emerged as the fastest growing product, with a CAGR of 32.06 %, followed by dried peaches and pears (14.22 %), areca nuts (15.29 %), and fresh grapes (7.52 %). Despite these positive trends, fresh coconuts (4.53 %), cashew nuts (10.36 %), and guavas/mangoes (1.29 %) experienced declining growth. The steepest decline was observed for cashew nuts, likely due to shifting global demand and competition from other exporters. For instability, fresh or dried areca nuts exhibited the highest volatility (62.05 %), followed by citrus fruits (46.01 %). In contrast, cashew nuts, dried peaches, and fresh grapes showed low instability (<16 %).

The overall export of fruits remained relatively more stable than vegetables during 2013 to 2022. This highlighted a transition in India’s fruit and vegetable export basket in recent years. India’ export competitiveness could be further enhanced through quality improvement, branding and diversification could help maintain stability and drive long term growth.

**Table 6: Growth rates and Cuddy-Della Valle Indices of export of vegetables (HS code 07) from India to major countries, 2003 to 2012 and 2013 to 2022**

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Product Label** | **CAGR** | **Instability index** |
| **2003 to 2012** | **2013 to 2022** | **2003 to 2012** | **2013 to 2022** |
| 080112 | Fresh coconuts in the inner | - | 32.06 | - | 20.22 |
| 080119 | Fresh coconuts… | 64.46 | -4.53 | 27.8 | 16.66 |
| 080132 | Fresh or dried cashew nuts, shelled | 7.05 | -10.36 | 14.18 | 12.65 |
| 080280 | Fresh or dried areca nuts… | - | 15.29 | - | 62.05 |
| 080450 | Fresh or dried guavas, mangoes… | 11.11 | -1.29 | 17.32 | 12.91 |
| 080590 | Fresh or dried citrus… | 1.37 | 2.76 | 41.7 | 46.01 |
| 080610 | Fresh grapes | 20.22 | 7.52 | 20.26 | 15.77 |
| 081090 | Fresh tamarinds, cashew apples ... | 21.44 | 3.4 | 16.88 | 14.99 |
| 081340 | Dried peaches, pears… | 25.29 | 14.22 | 29.61 | 12.7 |

*- denotes data not available*

***3.4 Direction of India’s Horticultural Trade***

The transitional probability matrix (2011-2022) for India’s vegetable exports (HS Code 07), presented in Table 7, captured the shifts in trade direction among key importers: Bangladesh, Nepal, Netherlands, UAE and USA. The diagonal values indicate importer loyalty, rows indicate market share loss and columns show market share gain.

The results of the transitional probability matrix revealed that Bangladesh and United States of America (USA) had a stable market for Indian vegetable export. Bangladesh was having the highest probability retention of 67.31 %, followed by United Sates of America (47.63 %). UAE gained significant market shares from Nepal (28.95%) and USA (27.53%), whereas USA lost its share to both UAE and Nepal. Nepal gained from Netherlands’ market share of 100 % and 24.48 % share of United States of America’s market. Also, Nepal lost its market share of 65.55 % to Bangladesh, 28.95 % to UAE and 5.46 % to USA. Zero transition probabilities values for Nepal, Netherlands and UAE confirmed their volatile nature. The findings confirmed that Bangladesh and USA as India’s most consistent vegetable export markets and a rising role of new and diversified markets in India’s vegetable exports.

**Table 7: Transitional probability matrix of India’s export of vegetables (HS code 07) to major countries, 2011 to 2022**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Countries** | Bangladesh | Nepal | Netherlands | UAE | USA | Other countries |
| Bangladesh | 0.6731 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.3266 |
| Nepal | 0.6555 | 0.0000 | 0.0004 | 0.2895 | 0.0546 | 0.0000 |
| Netherlands | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| UAE | 0.0000 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.9996 |
| USA | 0.0000 | 0.2484 | 0.0000 | 0.2753 | 0.4763 | 0.0000 |
| Other countries | 0.0000 | 0.0024 | 0.0005 | 0.0067 | 0.0020 | 0.9884 |

Table 8 depicted the direction and stability of India’s fruit exports. The findings revealed that Bangladesh, UAE and USA had a stable market for Indian fruits (HS Code 08). Bangladesh was the most stable market for Indian fruits export, indicated by its probability transition value of 87.01 %. USA was at the second place for India’s fruits export, retained 75.55 % of market share and lost 21.12 % of its market share to UAE. UAE retained 40.85 % of its market share, while it lost 15.78 % to Netherlands. Nepal and Netherlands were the most unstable market for India’s fruits export as shown by zero value of probability transition. Netherlands gained 92.59 % market share of Nepal. Overall, Bangladesh, UAE and USA were the loyal partner for Indian fruits exports.

**Table 8: Transitional probability matrix of India’s export of fruits (HS code 08) to major countries, 2011 to 2022**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Countries** | Bangladesh | Nepal | Netherlands | UAE | USA | Other countries |
| Bangladesh | 0.8701 | 0.0000 | 0.0000 | 0.0000 | 0.1299 | 0.0000 |
| Nepal | 0.0000 | 0.0000 | 0.9259 | 0.0000 | 0.0000 | 0.0741 |
| Netherlands | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| UAE | 0.0000 | 0.0000 | 0.1578 | 0.4085 | 0.0000 | 0.4337 |
| USA | 0.0000 | 0.0000 | 0.0151 | 0.2112 | 0.7555 | 0.0182 |
| Other countries | 0.0003 | 0.0008 | 0.0055 | 0.0059 | 0.0000 | 0.9874 |

***3.5 Trade Balance Index***

The Trade Balance Indices (TBI) for India’s export of vegetables (HS Code 07) and fruits (HS Code 08) from 2003 to 2022, presented in Tables 9 and 10. Table 9 showed that India consistently maintained a net exporter position in the global market for vegetables. Most vegetable products exhibited strong export dominance, with the exception of **dried, shelled chickpeas (071320), dried beans (071331), cowpeas (071335)**, and**pigeon peas (071360),** for which India remained a net importer throughout the period. In case of fruits (HS Code 08), India also showed a favourable trade balance, emerging as a net exporter for **8 out of 9** major fruit products. The only exception was **fresh or dried areca nuts (080280),** where imports outweighed exports. Products such as **fresh coconuts (08112 and 08119), guavas and mangoes (080450)**, and**citrus fruits (080590)** consistently recorded TBI values near **+1**, indicating strong and sustained export competitiveness. These findings highlighted that select fruit categories hold significant export potential for India. Therefore, policy and production strategies should prioritize these commodities to further enhance India’s trade surplus in the global fruit market.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **070310** | **070999** | **071010** | **071040** | **071140** | **071190** | **071220** | **071231** | **071320** | **071331** | **071335** | **071360** | **071390** |
| 2003 | 1 | - | 0.52 | 0.32 | 1 | 0.99 | 0.99 | 0.98 | -0.98 | -0.98 | - | - | -0.67 |
| 2004 | 1 | - | 1 | 0.53 | 1 | 0.99 | 0.98 | 0.98 | -0.86 | -1 | - | - | -0.53 |
| 2005 | 0.98 | - | 1 | 0.09 | 1 | 0.98 | 0.99 | 0.99 | -0.67 | -0.99 | - | - | -0.41 |
| 2006 | 1 | - | 1 | -0.01 | 1 | 0.9 | 0.98 | 0.97 | -0.20 | -0.99 | - | - | -0.36 |
| 2007 | 1 | - | 1 | 0.62 | 1 | 0.83 | 0.99 | 0.98 | 0.33 | -1 | - | - | -0.91 |
| 2008 | 1 | - | 1 | 0.23 | 1 | 0.89 | 0.98 | 0.95 | -0.10 | -1 | - | - | -0.95 |
| 2009 | 1 | - | 1 | 0.82 | 1 | 0.85 | 0.97 | 0.97 | -0.33 | -1 | - | - | -0.99 |
| 2010 | 0.99 | - | 1 | 0.93 | 1 | 0.88 | 0.98 | 0.96 | 0.37 | -1 | - | - | -0.98 |
| 2011 | 0.98 | - | 1 | 0.83 | 1 | 0.88 | 0.98 | 0.99 | 0.35 | -1 | - | - | -0.99 |
| 2012 | 1 | - | 0.94 | 0.92 | 1 | 0.83 | 0.99 | 0.97 | -0.32 | -0.99 | - | - | -0.98 |
| 2013 | 0.98 | 0.99 | 0.95 | 0.99 | 1 | 0.72 | 0.99 | 0.94 | 0.03 | -0.99 | -0.98 | -1 | -0.83 |
| 2014 | 1 | 1 | 0.98 | 1 | 1 | 0.68 | 0.99 | 0.93 | -0.05 | -0.99 | -0.99 | -1 | 0.07 |
| 2015 | 0.86 | 1 | 0.90 | 0.98 | 1 | 0.81 | 1 | 0.93 | -0.43 | -0.97 | -0.99 | -0.98 | -0.57 |
| 2016 | 1 | 0.99 | 1 | 0.99 | 1 | 0.78 | 0.99 | 0.84 | -0.65 | -0.95 | -0.99 | -0.93 | -0.71 |
| 2017 | 0.99 | 0.99 | 1 | 0.99 | 1 | 0.76 | 0.99 | 0.95 | -0.80 | -0.90 | -0.99 | -0.91 | -0.70 |
| 2018 | 0.99 | 1 | 1 | 1 | 0.99 | 0.5 | 0.99 | 0.99 | 0.30 | -0.87 | -0.89 | -0.91 | 0.21 |
| 2019 | 0.80 | 0.99 | 1 | 0.99 | 1 | 0.59 | 0.99 | 0.93 | -0.31 | -0.82 | -0.84 | -0.93 | 0.57 |
| 2020 | 0.67 | 0.99 | 1 | 0.99 | 1 | 0.7 | 0.99 | 1 | -0.07 | -0.81 | -0.71 | -0.85 | 0.08 |
| 2021 | 0.94 | 1 | 1 | 1 | 1 | 0.66 | 0.99 | 0.99 | -0.30 | -0.80 | -0.42 | -0.88 | 0.81 |
| 2022 | 1 | 1 | 0.86 | 0.99 | 1 | 0.69 | 0.99 | 0.99 | 0.64 | -0.83 | -0.45 | -0.91 | 0.86 |

**Table 9: Trade balance index of India’s trade of vegetables (HS code 07) with major importing countries from 2003 to 2022**

**Table 10: Trade balance index of India’s trade of fruits (HS code 08) with major importing countries from 2003 to 2022**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **080112** | **080119** | **080132** | **080280** | **080450** | **080590** | **080610** | **081090** | **081340** |
| 2003 | - | 0.97 | 0.99 | - | 1 | 0.98 | 0.96 | 0.99 | 0.94 |
| 2004 | - | 0.44 | 1 | - | 1 | 0.99 | 0.89 | 0.93 | 0.42 |
| 2005 | - | 0.94 | 1 | - | 1 | 1 | 0.92 | 0.96 | 0.91 |
| 2006 | - | 1 | 1 | - | 1 | 1 | 0.93 | 0.94 | 0.93 |
| 2007 | - | 1 | 1 | - | 1 | 0.98 | 0.85 | 0.90 | 0.83 |
| 2008 | - | 1 | 1 | - | 1 | 1 | 0.87 | 0.83 | 0.77 |
| 2009 | - | 1 | 0.99 | - | 1 | 1 | 0.87 | 0.89 | 0.81 |
| 2010 | - | 1 | 0.97 | - | 1 | 0.99 | 0.87 | 0.71 | 0.86 |
| 2011 | - | 1 | 0.98 | - | 0.99 | 1 | 0.79 | 0.85 | 0.95 |
| 2012 | - | 1 | 0.97 | - | 0.99 | 1 | 0.87 | 0.9 | 0.94 |
| 2013 | 0.97 | 1 | 0.95 | -0.45 | 0.99 | 1 | 0.9 | 0.86 | 0.87 |
| 2014 | 1 | 1 | 0.99 | -0.83 | 0.99 | 1 | 0.92 | 0.84 | 0.88 |
| 2015 | 1 | 1 | 0.96 | -0.84 | 0.99 | 1 | 0.81 | 0.8 | 0.89 |
| 2016 | 1 | 1 | 0.92 | -0.38 | 0.99 | 1 | 0.91 | 0.81 | 0.98 |
| 2017 | 1 | 0.99 | 0.92 | -0.66 | 0.99 | 0.99 | 0.92 | 0.82 | 0.93 |
| 2018 | 1 | 1 | 0.89 | -0.73 | 0.99 | 0.99 | 0.92 | 0.76 | 0.68 |
| 2019 | 1 | 1 | 0.87 | -0.62 | 0.98 | 0.66 | 0.92 | 0.71 | 0.81 |
| 2020 | 1 | 0.98 | 0.89 | -0.76 | 0.99 | 1 | 0.93 | 0.76 | 0.80 |
| 2021 | 1 | 0.99 | 0.89 | -0.56 | 1 | 1 | 0.93 | 0.66 | 0.78 |
| 2022 | 1 | 1 | 0.91 | -0.69 | 0.99 | 0.99 | 0.90 | 0.40 | 0.87 |

*- denotes data not available*

**4. CONCLUSION**

This study examined the growth and performance of India’s horticultural exports from 2003 to 2022. The findings revealed that the share of vegetable exports exhibited a fluctuating but overall rising trend, whereas fruit exports declined over time, with a modest rebound after 2020. India’s vegetable and fruit exports exhibited mixed growth trends with declining instability for majority of selected products. Transitional probability matrix found that Bangladesh and United States emerged as consistent and loyal trading partners for India’s vegetable and fruit exports. Trade Balance Index analysis revealed India as a net exporter of key vegetables such as onion, potato, sweetcorn, cucumber & gherkins, and mushroom, while remaining a net importer of cowpea and pigeon pea. For fruits, India maintained a strong export position in coconuts, cashew nuts, almonds, guava, mango, citrus, grapes, strawberries, pears, papaya, and jackfruit, but continued to import areca nuts. Strengthening trade relationships with Bangladesh, the USA, and the UAE is crucial for sustaining future export growth. To enhance horticultural exports, private sector participation and a shift toward export-oriented farming must be encouraged. The sector faces major constraints, notably inadequate infrastructure and transportation. Addressing these challenges requires targeted policy interventions to boost investment in modern technologies and logistics systems. Furthermore, overcoming non-tariff barriers, particularly sanitary and phytosanitary restrictions, will be key to unlocking India’s untapped export potential in horticulture.

**DISCLAIMER (USE OF ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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