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AN ASSESSMENT OF INDIA'S APPLE CROP TRADE PERFORMANCE AND DYNAMICS IN GLOBAL MARKET

Madhulika Thakur[1*], Subhash Sharma[1], Nidhi[1], Ashish Kumar[1], Lalenpuii[2], Ankita Thakur[3] and Sakshi[1]

[1]Department of Social Sciences, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. India

[2]Department of Agricultural Economics, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

[3]Department. of Seed Science and Technology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P., India

*Corresponding author E-mail: madhulikathakur2@gmail.com

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ABSTRACT

The major aim of the study was to examine the trends and dynamics of apple crop's exports and imports in India. Trend analysis examined the growth and instability, whereas dynamics were studied to assess trade relations of India with major exporters and importers in terms of apple crop. The study was carried out particularly for India. All the exports and import values as well as quantities of crop were specifically taken for the country from various online sources. The study was conducted on secondary data collected from various online sources such as APEDA Agri-Exchange, Ministry of Commerce and Industry and FAO Statistics for a period from 2009-10 to 2023-24. The research study was carried out using different analytical tools such as Compound Annual Growth Rate (CAGR), Coefficient of variation (CV) and Cuddy Della Valle Index (CDVI). The dynamics of apple trade with major exporting and importing partners of apple trade with India was carried out using Markov Chain analysis. The major import destinations of Apple for India were Iran, Turkey, Afghanistan, Italy and Poland, amongst which Iran exported highest quantity of Apple to India (28%). During the time period from 2014-15 to 2023-24, Turkey has shown the highest growth in apple exports to India in terms of quantity (97.30%) as well as value (96.70 %). The major export destinations of Apple crop for India were Bangladesh and Nepal. Nepal showed a higher growth in value (9.8%) as well as quantity (8.1%) of apple imports from India. The trade balance of Apple in India observed a continuous declining trend. Imports of apple in India were increasing at a high rate and exports were decreasing. The Nominal Protection coefficient (NPC) values indicated that during the peak harvest season, the market for exports of apple was more competitive for the Indian apple growers. Markov Chain Analysis showed that USA and China retained 67.06 per cent and 49.21 per cent of their exports to India from previous year, however they didn't gain anything from the other countries. The remaining five countries gained a large share of exports of apple to India from other countries including USA and China. The major conclusion of the study was that India being a major producer of apple crop was found to be reliant on apple imports due to structural inefficiencies and lack of proper post-harvest technologies. Thus, indicating effective policy measures to make India self-reliant in consumption.

***Key words*:** Nominal Protection Coefficient (NPC), Markov Chain Analysis, Compound Annual Growth Rate (CAGR), Cuddy Della Valle Index

Introduction

India is second largest producer of fruits and vegetables in the world after China, thus earning the title of "fruit basket of the world" (Choudhary and Kundal, 2015). Amongst fruits, Apple (*Malus domestica*) holds immense significance in India's agricultural landscape, serving as a cornerstone for the economies of several northern and north- eastern states. Apples are not only a vital source of nutrition (rich in dietary fiber, vitamins, and antioxidants) but they also provide substantial economic benefits to farmers and associated industries. The cultivation of apples supports the livelihoods of thousands of small and medium-scale farmers, contributing to rural prosperity and employment as they

are more remunerative than the agricultural crops such as rice, wheat, etc. The major apple producing states of India are Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland, Telangana. The major varieties of apple grown in India are Red Delicious, Royal Delicious, Golden Delicious, Royal Gala, Granny Smith, Jonathan, Ambri Apple (a local variety from Kashmir), McIntosh, Honeycrisp, Fuji etc.

Apple is the 10th largest produced fruit crop in India. The overall production of apple crop in India is 2589 thousand MT, with an area of 315.13 thousand ha. India is the world's fifth largest producer of Apple, accounting for around 2.70 percent of total global production. Apple's total exports from India are 52.892 thousand MT, which amounts to 21346 (1000 USD). India is ranked 27th in the world for apple exports, accounting for 0.68 percent of total global apple exports. India is ranked 4th in the world for Apple imports, accounting for 4.77 percent of overall imports of apple in the world. The total imports of Apple in India are 392.49 thousand MT, which is 314345 (1000 USD). The total domestic supply of Apple crop in India is 2723 thousand MT, and it ranks 5th in global Apple consumption.

Although India is third largest producer of apple in the world, yet the export performance of the crop is quite lower as compared to the international market (Kaur and Arundhati, 2024). The disparity is caused majorly due to inefficient infrastructure facilities in the fruit supply chains, inadequate post-harvest management and poor transportation facilities (Yuvraj and Vasu, 2023). In addition to this, scarcity of good cold storage facilities and irrational use of chemical inputs hinder the export of apples due to inability in matching international quality standards (Vasylieva and James, 2021). Various post-harvest and pre-harvest constraints, limit the capacity of preserving harvests and extending marketability throughout the year (Vasylieva and James, 2021). As a result, India is forced to import apples from various exporting countries such as United States and Afghanistan to fulfil its supply gap caused by deficits in domestic production. The present study examines the performance of apple trade in India to build an integrated understanding of the apple trade dynamics along with providing evidence based insights for relevant policy formulations.

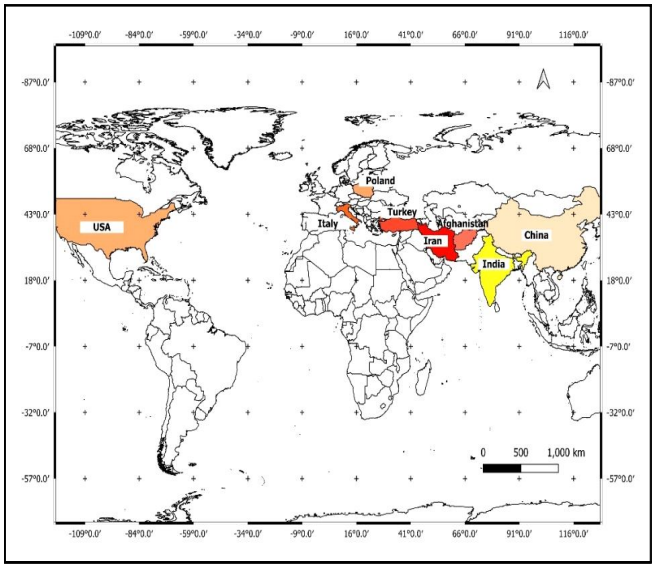

Fig. 1: Major countries exporting apple to India.

Material and Methods

India is one of the largest apple producers in the world. The study was entirely focused on studying the trade scenario of India in context of apple crop. Thus, all the data was collected and analyzed specifically for India along with its major apple trading partners. The major import destination countries were Iran, Turkey, Afghanistan, Italy and Poland depicted in Fig. 1. The major export destination countries to whom India exported apples were Bangladesh, Nepal, Bhutan, UAE and Saudi Arabia depicted in Fig. 2.

The study was entirely based on secondary data. It included the data in terms of value in crore rupees and quantities in metric tons, of imports and exports of apple crop from India. The data was collected from various online sources like APEDA Agri-Exchange, Ministry of Commerce and Industry and FAO Statistics. The duration for the study was fifteen years from 2014-15 to 2023-24.

Data Analysis

Growth Analysis:

The trade growth of India was examined through Compound Annual Growth Rate (CAGR) that captures

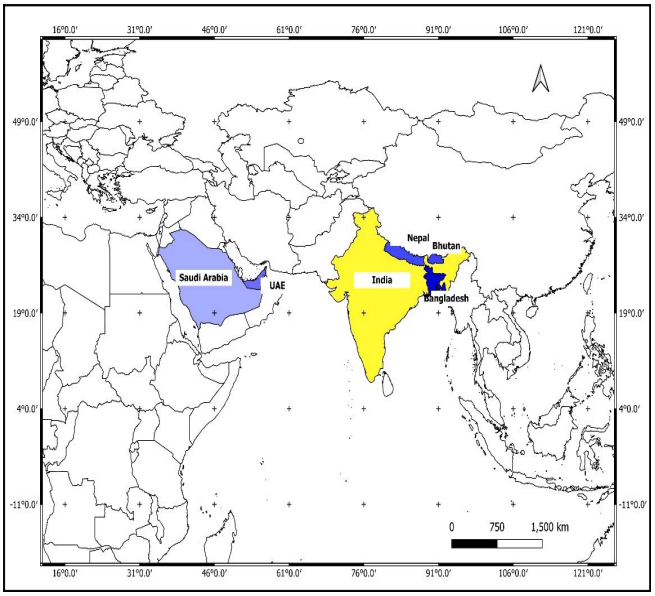

Fig. 2: Major countries importing apple from India.

the pace and direction of the change in trade values as well as quantity. It is calculated by fitting exponential function.

$Y = ae^{bt}$

$\ln Y = \ln a + bt$

CAGR (%) = b × 100

Where,

Y = denotes export/ import,

a = is intercept and t is time.

Instability Analysis:

Further to analyze fluctuations in the exports and imports, instability analysis was carried out using Coefficient of variation (CV) and Cuddy Della Valle Index (CDVI). These measures assess extent of variability over time after accounting for the long-term trends.

$$CV\ (\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

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

Where,

R^2 is Coefficient of Determination

Nominal Protection Coefficient:

The Nominal Protection Coefficient proposed by (Porter, 1990) was used to determine the extent of apple's competitive advantage under free trade. It was simply calculated as ratio of Domestic price of apple to the border or reference price of apple.

$$NPC = \frac{P_d}{P_b}$$

NPC: Nominal Protection Coefficient

P_d: Domestic Price of Commodity

P_b: Border price or reference price of commodity

If NPC> 1, the Apple crop is protected, compared to the situation that would prevail under free trade and if NPC< 1, the Apple crop is not protected.

NPC value greater than 1 depict that the domestic crop is protected.

Markov chain analysis:

Markov chain analysis was specifically applied to identify the stability and shifts in major trading partners. This analysis highlighted the changes in export destinations and import sources over time. Trade directions were analyzed using the first-order Markov chain approach. Estimating the transitional probability matrix P is central to Markov chain analysis. The elements P_{ij} of the matrix P indicates the probability that exports / imports will shift from country 'i' to country 'j' over time. The matrix's diagonal elements represent the probability that a country's export share will be retained. In the context of the current application, structural changes will be considered a random process.

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

E_{jt} : Exports from India to j_{th} country during the year 't' or Imports in India from jth country

E_{it-1}: Exports to/ Imports from i_{th} country during the period t-1

P_{ij}: Probability that the exports/imports will shift from i^{th} country to j^{th} country

e_{jt} : The error term which is statistically independent of E_{it}-1

t : Number of years considered for the analysis

r : Number of importing/exporting countries

The transitional probabilities P_{ij} is arranged in a (c * r) matrix have the following properties;

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

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

Results and Discussion

This section presents the results of the study in various sub-sections analyzing growth and dynamics of apple trade in India. The results cover both exports as well as imports of apple. The results are mostly depicted in terms of quantity as well as monetary value.

Trade Balance of Apple in India

Trade balance (Exports quantity – Import Quantity) of apple crop in Fig. 3 clearly depicts that Apple has continuously shown larger imports than the exports leading to continuous negative trade balance. This negative value has continuously been growing and getting larger through the years. The major reason for falling trade balance of apple in the country is the high domestic consumption.

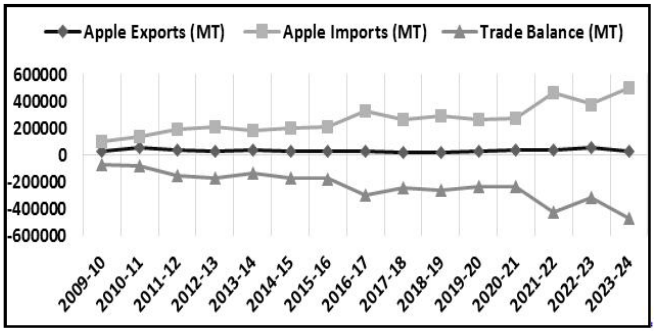

Fig. 3: Trade balance of apple crop in India from 2009-10 to 2023-24.

Table 1: CV (%), CDVI (%) AND CAGR (%) of apple crop imports and exports in India from 2009-10 to 2023-24.

Measure	Imports		Exports	
	Value	Quantity	Value	Quantity
CV (%)	47.55	43.23	44.32	39.58
CDVI(%)	17.79	19.04	35.20	41.05
CAGR(%)	12.00***	9.50***	6.00***	-0.70***
*** means significant at 1% level of significance.				

The population in the country is continuously rising and people are becoming more aware about the importance of healthy and nutritious food. These have lead to an increase in demand and consumption of horticultural crops including apple in the country which outweighs the domestic production (Krishnan, 2023). The similar results were found by (Bhat and Bahadur, 2019) who found deteriorating trade balance of apple crop in India from 1999 to 2016 due to increasing domestic demand and removal of quantitative import restrictions on apples in April 1999.

Growth and instability of Exports and Imports of Apple in India

Table 1 shows the CV (%), CDVI (%) and CAGR(%) of Apple crop's Imports and Exports in India computed for a period from 2009-10 to 2023-24. The values of CAGR (%) showed that imports of Apple showed a higher growth during the years both in terms of value as well as quantity, however, growth in terms of value was higher (12.00%) as compared to quanity (9.50%). The CAGR (%) values of exports revealed that value of apples showed a growth of (6.00%) whereas, a negative value of CAGR was shown by quantity of imports (-0.70%) which means quantity experienced a declined over the time period under study. The significant and stable increase in apple imports can be inferred to the rising domestic demand and inefficiencies in domestic production (Vasylieva and James, 2021) along with post-harvest losses suffered from inadequate infrastructure (Golombek and Blanke, 2020). The decline in exports reflect challenges due to failure in meeting international quality standards and inefficient domestic cold chains (Kumari and Dhingra, 2024). CDVI (%) values evidenced more stability in imports value as well as quanity viz., 17.79 and 19.04 per cent, respectively. Both these values depicted a medium instability. On the other hand, higher instability was experienced in exports, in value (35.20%) and quantity (41.05%). This instability was also explicitly found in the study by (Nadeerpoor and Patil, 2022) which analyzed the trade of agricultural commodities and inferred high instability in agricultural commodities including apples.

Table 2: CV (%), CDVI (%) AND CAGR (%) of imports from major import destinations from 2014-15 to 2023-24.

Country	Particulars	%	CV	CDVI	CAGR
Iran	Value	21	121.64	65.39	61.3***
	Quantity	28	118.25	57.93	66.1***
Turkey	Value	22	110.79	41.45	96.7***
	Quantity	23	110.13	41.21	97.3***
Afghanistan	Value	10	160.61	139.47	24.4***
	Quantity	8	145.76	127.99	19.9***
Italy	Value	8	59.78	34.34	23.5***
	Quantity	7	58.95	34.42	22.6***
Poland	Value	7	104.69	58.28	70.5***
	Quantity	7	100.985	58.01	65.1***
Others	Value	32			
	Quantity	27			
%: Per cent share (%), CV: CV (%), CDVI: CDVI (%); CAGR: CAGR (%) *** means significant at 1% level of significance					

For the country-wise analysis, a period of ten years was considered from 2014-15 to 2023-24. The top five major import destinations of apple crop for India are Iran, Turkey, Afghanistan, Italy and Poland. Table 2 shows that the major share of the apple imports to India in terms of value was from Turkey (22%) followed by Iran (21%) and Afghanistan (10%). In terms of quantity, the highest share was of Iran (28%) followed by Turkey (23%) and Afghanistan (8%). The India's agricultural trade as a whole is heavily influenced by trade agreements and policies (Bhurat, 2025). Over the years, an increasing trend has been observed in imports of apple from all these countries to India. The historical data on imports of apple in India show that up to the year 2018 China and U.S.A were the major apple exporters to India. In the year 2019, the Chinese apple imports in India reduced to a significant level due to production losses (Murder *et al.*, 2022) and U.S.A apple imports decreased around the same time period due to imposition of additional 20 per cent retaliatory duty over and above 50 per cent MFN duty on Washington

Table 3: CV (%), CDVI(%) AND CAGR(%) of exports of apple to major export destinations from 2014-15 to 2023-24.

Country	Particulars	%	CV	CDVI	CAGR
Bangladesh	Value	30	51.24	42.59	9.1***
	Quantity	50	58.71	56.13	7.5***
Nepal	Value	48	40.12	29.48	9.8***
	Quantity	46	34.61	26.90	8.1***
Others	Value	13			
	Quantity	4			
%: Per cent share (%), CV: CV (%), CDVI: CDVI (%); CAGR: CAGR (%) *** means significant at 1% level of significance					

Table 4: Monthly NPC of exports of Apples from India (2014 To 2023).

Years / Month	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
January	0.40	0.90	0.90	1.20	0.70	0.90	0.80	1.40	1.10	1.10
February	0.50	0.80	0.90	1.30	0.70	0.80	0.90	1.50	1.50	1.40
March	0.60	0.90	0.80	1.30	0.80	0.90	0.90	1.40	2.20	1.70
April	0.70	0.90	0.90	1.30	0.70	0.90	0.00	1.50	1.60	1.70
May	0.70	0.90	0.90	1.30	0.60	0.90	0.80	0.00	1.20	1.20
June	0.00	1.00	0.90	1.20	0.60	0.90	0.80	1.90	1.30	1.30
Jully	0.00	1.00	1.00	1.20	0.60	0.90	0.90	1.20	0.90	1.20
August	0.60	0.90	0.90	0.90	0.70	0.80	0.90	0.60	0.60	0.70
September	0.70	0.80	0.90	0.70	0.60	0.70	0.80	0.80	0.80	0.70
October	0.80	0.90	1.10	0.70	0.80	0.80	0.80	1.20	0.90	0.90
November	0.80	0.80	1.20	0.70	0.90	0.90	1.00	1.30	1.10	1.00
December	0.80	1.30	1.20	0.70	0.80	0.90	1.40	1.20	1.10	1.00

apples. These retaliatory tariffs effected India-US trade relations (Idrisi *et al.*, 2025). During the recent times Iran and Turkey have been seen to be the largest exporters of apple to India. Iranian apples are famous in India for their lower prices. Table 2 shows the growth and instability in imports of apple from the major five apple exporters to India. The largest growth was observed in Turkey apples both in terms of quantity as well as value. The growth in value over the period 2014-15 to 2023-24 was 96.7 percent , whereas growth in terms of quantity during the same time period was observed to be 97.30 per cent. The computation of CV and CDVI show that the least instability was observed in case of imports of apple from Italy both in terms of quantity as well as value. An extremely high instability was observed in case of imports from Afghanistan which can be attributed to geopolitical disruptions and challenges in maintaining a consistent agricultural supply chain (Nasiri *et al.*, 2024). Italy saw a boom in apple exports to India for a period around 2019 due to certain market conditions but the exports were inconsistent (Muder *et al.*, 2022). Poland emerged to be a major exporter to India due to its growing production and decreasing domestic consumption (Matachowska and Tomala, 2023).

Table 3 depicts the growth and instability of apple crop exports to major two destinations viz., Bangladesh and Nepal during a time period from 2014-15 to 2023-24. These two practically cover more than 50 per cent of exports of India apples. The share of Nepal was highest in terms of value viz., 48 per cent followed by Bangladesh 39 per cent. In terms of quantity the highest share was of Bangladesh viz., 50 per cent followed by Nepal (46 %). It can be clearly seen from the table that the positive growth in terms of both quantity as well as value was observed in case of Nepal. The growth of apple exports in Nepal in terms of value was 9.8 per cent and growth in terms of quantity was 8.1 per cent. The growth in terms of value was slightly larger as compared to the quantity. India's apple exports were dominated by its neighboring countries Bangladesh and Nepal due to regional trade dynamics and geographical proximity of these nations effecting agricultural exports (Golombek and Blanke, 2020; Srivastava *et al.*, 2025). The level of instability in the exports was also more in case of Nepal as compared to Bangladesh.

Nominal Protection Coefficient of apple trade in India

Table 4 depicts computed values of monthly NPC. A general pattern can be observed that during the harvest months of apple i.e. August and September, the NPC is less than 1 for most of the years. The NPC value remained low during the months of September, October and

Table 5: Transitional Probability Matrix for shifts in Imports of Apple in India (2014-15 to 2023-24).

Countries	Iran	Turkey	Afghanistan	Italy	Poland	USA	China
Iran	0.0000	0.7752	0.0000	0.2248	0.0000	0.0000	0.0000
Turkey	0.6956	0.0901	0.0000	0.0000	0.2143	0.0000	0.0000
Afghanistan	0.4482	0.2361	0.0000	0.3156	0.0000	0.0000	0.0000
Italy	0.4239	0.3900	0.0000	0.1861	0.0000	0.0000	0.0000
Poland	0.0474	0.0000	0.9526	0.0000	0.0000	0.0000	0.0000
USA	0.0000	0.0348	0.0052	0.2225	0.0650	0.6706	0.0019
China	0.0000	0.0000	0.0000	0.0000	0.0000	0.5079	0.4921

Table 6: Transitional probability matrix for shifts in exports of apple from india (2014-15 to 2023-24).

Countries	BD	NP	BH	UAE	SA
Bangladesh	0.9999	0.0000	0.0000	0.0000	0.0000
Nepal	0.0000	0.9912	0.0088	0.0000	0.0000
Bhutan	0.0000	0.0000	0.7464	0.2536	0.0000
UAE	0.8185	0.0000	0.0000	0.0000	0.1815
Saudi Arabia	1.0000	0.0000	0.0000	0.0000	0.0000

BD: Bangladesh; NP: Nepal; BH: Bhutan; SA: Saudi Arabia

November and after that, it starts increasing. This means that during the peak harvest season, the exports of apple from India are more competitive but during the rest of the months, the apples from India face lesser competition. The seasonality in apple production in India and negative relationship between prices and arrivals also depicted by (Ali, 2018) result in lower domestic prices during the bumper harvest seasons that naturally lead to more competition from domestic as well as foreign producers. This also indicated that in India, the production of apples is seasonal and during the peak harvest season the domestic prices of apples are lesser due to large supply in the country. After the end of harvest season and with the beginning of the lean period NPC starts increasing. An increased value of NPC means that the competition faced by apple growers is less. This means that effective protection is provided to the apple growers in the country. The 50 per cent MFN duty applied on apple is one of the highest import duties applied to any of the crop. This significant MFN duty, protect domestic apple growers particularly during the lean periods (Codron *et al*., 2019; Kwan-Young *et al*., 2019).

Dynamics of Exports and Imports of Apple in India. The direction of apple imports in India can be interpreted from transitional probability matrix given in Table 5. It can be assessed through the matrix that USA and China have retained 67.06 per cent and 49.21 per cent of their exports to India from previous year. China has gained 0.10 per cent of exports from USA, whereas USA has gained 50.79 per cent of China. Iran has shown no retention but it has gained a huge share of exports from other countries., viz Turkey (69.56 %), Afghanistan (44.82 %) and Italy (42.39 %). Turkey has retained 9 per cent of its exports from previous year. It has gained exports share from Iran (77.52 %), Italy (39.00%) and Afghanistan (23.61 %). Afghanistan has gained its exports share from Poland which is around 95.26 per cent. Italy's apple exports retention from previous year was 18.61 per cent. In addition to this, it gained its exports share from Afghanistan (31.56%) and USA (22.25%). Poland has majorly gained its trade share from Turkey i.e. 21.43 per cent and it has also gained a minor potion from USA viz., 6.5 per cent. The dynamic trading environment of apples in India can be largely attributed to competition of key exporters USA and China (Kwang-Young *et al.*, 2019) and was also influenced by trade policies adopted by India such as imposition of import duties (Golombek and Blanke, 2020).

Analysis of transitional probability matrix in case of apple exports from India clearly indicated that Bangladesh as well as Nepal retained almost entire share of exports from previous year viz., 99.99 per and 99.12 per cent which means India has continued to export its apples consistently to these two countries. Bangladesh has also captured alomost entire exports share of apple from India. Bhutan has also retained a large proportion viz., 74.64 per cent from previous year. UAE has gained export share majorily from Bhutan viz., 25.36 per cent and Saudi Arabia has gained from UAE viz., 18.15 per cent. The study by (Golombek and Blanke, 2020) explicitly mention 18000 t apple exports to its neighboring countries Nepal and Bangladesh which supported their consistent roles as export destinations for India.

Conclusion

The study highlighted the fact that India is a significant apple producer, although its international trade depicts structural imbalances due to reliance on imports and weaker expansion in exports. The consistent trade deficit can be attributed to limited productivity, post-harvest losses and inefficient supply chains. The study reflected upon India's stable export relations with neighboring countries such as Bangladesh and Nepal, whereas limited presence in diverse global market. A seasonal competitive advantage was observed in the peak harvest months; however, it was not consistent throughout the year. The evolving nature of India's apple trade structure was evidently inferred from shifting dynamics amongst the importing nations. The findings emphasized need for strengthening infrastructure, enhancement in value chains, improvement in quality standards, and promotion of exports diversification to improve the competitiveness and more balanced and sustainable apple trade in India.

Authors' Contributions

Authors 1 and 2 designed the study. Author 1 collected data, performed analysis, prepared results and prepared the text. Author 3, 4 and 5 searched for references for the manuscript. Author 6 and 7 checked the references, material and language of the manuscript. Author 1 and 2 checked the compliance of manuscript with journal formatting. All authors read and approved of the final manuscript.

Abbreviations

CAGR: Compound Annual Growth Rate

CV: Coefficient of variation

CDVI: Cuddy Della Valle Index

NPC: Nominal Protection Coefficient

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