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Dynamics of lentil (*Lens culinaris*) production and trade: Global scenario and Indian interdependence

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ABSTRACT

Increasing pulse production is one of the national priorities for food and nutritional security of India. In this context, incremental changes in pulse production can play a pivotal role. During 2003–2022, for example, the area under lentil (*Lens culinaris* L.) registered a decline (2.08%), however; productivity improvement (41.26%) led to the enhancement in its production (by 37%) in the country. This study portrays the temporal trend and patterns of lentil production growth during the period 2003–2022. A substantial growth in imports of lentil from 63.97 thousand tonnes in Triennium estimate (TE) 2003 to 814.20 thousand tonnes in TE 2022 was registered in India. Moreover, the share of lentil imports to total lentil production increased from 6.94% in TE 2002 to 63.24% in TE 2022. Lentil imports exhibited a high annual growth rate (15.83%) and high instability during the overall study period (2003–2022), which was higher than the annual growth rate of imports of overall pulses during the same period. Approximately 0.65 million tonnes of lentils were imported in the year 2022, to meet domestic consumption demands. Canada and Australia accounted for 61% and 36% of the total lentil imports to India in year 2022, while Bangladesh (49.61%) followed by UAE (21.74%) and Nepal (18.33%) were the major export destinations of the total lentil export (2022). The gap between production and consumption, coupled with the changing trade regulations and consumer preferences, contributed to the observed instability in lentil trade in India over the past two decades. Concerted efforts in intensifying the technology transfer, capacity building and convergence of resources among the stakeholders can impact the productivity of lentils, thereby developing strategies for optimizing its import and export dynamics.

Keywords: Export, Import, Lentil, Production, Yield

Lentil (*Lens culinaris* L.) is one of the earliest domesticated crops in the world (Dhuppar *et al.* 2012, Reda 2015, Liber *et al*. 2021). It was possibly the first grain legume to be domesticated (Bahl *et al.* 1993). Lentil cultivation originated in the fertile crescent of the Near East, and then it spread to various regions of the world including Europe, the Middle East, Northern Africa and the Indo-Gangetic plain (Ford *et al.* 2007, Sonnante *et al.* 2009). In India, lentils have been documented in the archaeological record around 2500 BC (Cubero 1981). Lentil is an important grain legume with great nutritional value and is widely cultivated in 46 countries across diverse agro ecological regions (FAOSTAT 2022). It is primarily grown as a cool season crop and demonstrate adaptability to a wide range of soils, from light to heavy, with a *p*H of 5.5–9.0 (Ramírez and Cantero 2024). Lentil crop is valued for its role in providing affordable dietary protein for both humans and animals. Lentil seeds are nutrient dense containing high levels of protein, complex carbohydrates, essential minerals and vitamins, photochemical and dietary fibers (Joshi *et al.* 2017, Dhull *et al*. 2022). The seeds have the potential to provide a major portion of the recommended iron (Fe) and Zinc (Zn) dietary allowances in deficient populations (Podder *et al.* 2021). Notably, lentil seeds contain higher protein than other pulses (Muehlbauer *et al.* 1985).

Lentil crop plays a significant role in maintenance and improvement of soil fertility as its cultivation enriches soil nutrient status by adding nitrogen, carbon and organic matter which promotes sustainable cereal-based systems of crop production (Sarkar and Kumar 2011). It is estimated that this crop can fix free nitrogen up to 107 kg/ha (Abraham 2015), the economic value of which was computed to be about ₹2361/ha (Chand *et al.* 2015). Moreover, lentils are known for their water efficiency compared to other protein sources and are considered as drought-resistant crop (Abraham 2015) with low cultivation costs. Further, lentil crop contributes to the nutritional and economic well-being of cultivators and also play a crucial role in promoting sustainability,

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supporting economic development, and contributing to global food security. Lentils are cultivated on approximately 5.57 million hectares globally, with an annual production of 6.82 million tonnes. The average global productivity of lentils stands at around 1225 kg/ha (FAOSTAT 2022). In India, lentil is an important pulse crop that is cultivated on approximately 1.42 million hectares with a production of about 1.28 million tonnes. Lentil crop contributes about 4.9% of the total pulse area and 5.03% of total pulse production in the country (2021–22).

Being an important crop at national and global levels, its production, import and export have undergone variations over time. The research questions on how the area, yield and production of lentils are witnessing temporal variations and what the export-import dynamics of lentils in India in a global perspective demand an empirical probe for consolidating the existing knowledge base. It was therefore attempted in this paper to analyze the temporal dynamics of production and trade-related indicators of lentils at national and global level during the past two decades i.e., period I (2003–12), period II (2013–22) besides the overall period (2003–22).

MATERIALS AND METHODS

Time series data on area, production and yield of lentil for the past 20 years (2003–04 to 2021–22) at global level as well as data on export and import of lentil in India were drawn from FAOSTAT 2022. The data on area, production and productivity of lentil for India was collected from published reports of Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India. To smoothen the fluctuation of data from year to year, Triennium Ending data (TE) on area, production and yield of lentil was computed. The study period (2003–04 to 2021–22) was categories into three major periods, viz. period I (2003–2012), period II (2013–2022) and overall period (2003–2022). The data were subjected to descriptive statistics to ascertain the lentil production scenario in the region. Compound Annual Growth Rates (CAGRs) were computed to estimate trends in area, production, productivity as well as import and export of lentil for the study periods. Following mathematical expression was used for this estimation:

$$Y = ab^t$$

where Y, Variable for which growth rate is calculated; t, Time variable; b, Regression coefficient and a, intercept.

The log form of the above exponential equation is expressed as:

$$\text{Log } (Y) = \text{Log } (a) + t \text{ Log } (b)$$

Compound annual growth rate was, then worked out as:

$$CAGR = [\text{Antilog}(b)-1] \times 100$$

Further, to examine the extent of fluctuation in area, production and productivity as well as the import and export of lentil in different periods, Cuddy Della Valle Index (CDVI) (Cuddy and Della Valle 1978) was used. The CDVI was computed as:

$$CDVI = CV * (1-R^2)^{1/2}$$

where CV, Coefficient of variation; $\overline{R}^2$, Adjusted coefficient of determination from time series trend regression. Taking the insight from Sah *et al.* (2021), based on the value of index, classification was made into low instability (0–15), medium instability (15–30) and high instability (>30).

RESULTS AND DISCUSSION

Lentil scenario in global perspective: During the year 2022, India, Canada, Australia, Turkey, United States of America, Nepal, Russian Federation, Bangladesh, Kazakhstan and Iran emerged as the major lentil producing countries of the world that collectively contributed more than 91.53% and 90.67% of total lentil area and production, respectively (Table 1). India stood out as one of the leading countries, contributing 25.35% of the total global lentil area and 18.60% of the total global lentil production. However, despite its significant contribution, India's lentil productivity was relatively low at 0.90 t/ha.

It could also be noted that Canada was the highest contributor to global lentil area (30.80%) and production (33.72%) with a relatively high productivity of 1.34 t/ha (Table 1). Australia also made substantial contributions, sharing about 10.33% and 14.65% of the total lentil area and production, respectively with the highest global productivity at 1.74 t/ha. Among the top 10 countries of the world with respect to lentil production, Bangladesh's share in area coverage under lentils was relatively small (2.12%), however, the average productivity was quiet high (1.32 t/ha). On the other hand, Iran contributed the least among listed counties, in terms of global lentil area (2.38%) and production (1.12%) with the lowest productivity figures at 0.58 t/ha.

These key results highlight the diverse landscape of lentil production worldwide, with notable variations in productivity among different countries. While some nations like Canada, Australia and Bangladesh demonstrated high productivity levels of lentils. While, countries like India and Iran face challenges in achieving comparable yields.

Growth and instability in area, production and yield of lentil: The global production of lentils has shown remarkable enhancement over the last two decades, increasing by more than 105%. Specifically, production rose from 3.06 million tonnes in TE 2003 to 6.30 million tonnes in TE 2022, indicating a steep growth trajectory. This growth was consistent throughout the two decades, with increases of 50% in TE 2022 and 37.25% in TE 2012 over TE 2003, respectively (Table 2). Such a substantial growth in production reflects the increasing demand and popularity of lentils among consumers globally.

The area under lentil production at global level also witnessed significant growth, increasing by 43.2% in the last two decades, from 3.75 million hectares in TE 2003 to 5.37 million hectares in TE 2022. Decade-wise analysis reveals that the global lentil area grew by 12.27% from TE 2003

Table 1 Global scenario of area, production and yield of lentil (2022)

Major countries in lentil area			Major countries in lentil Prod.			Major countries in lentil yield	
Country	Area (MHa)	Per cent share in total area	Country	Prod. (Mt)	Per cent share in total prod.	Country	Yield (t/ha)
Canada	1.72	30.80	Canada	2.30	33.72	Australia	1.74
India	1.41	25.35	India	1.27	18.60	Canada	1.34
Australia	0.57	10.33	Australia	0.99	14.65	Bangladesh	1.32
Turkey	0.34	6.15	Turkey	0.44	6.52	Turkey	1.30
USA	0.24	4.37	Russian Federation	0.26	3.78	Nepal	1.27
Russian Federation	0.22	3.89	Nepal	0.25	3.70	Russian Federation	1.19
Nepal	198454	3.56	USA	248980	3.65	USA	1.02
Bangladesh	144454	2.12	Bangladesh	190743	2.80	Kazakhstan	1.02
Kazakhstan	143287	2.57	Kazakhstan	145942	2.14	India	0.90
Iran	132342	2.38	Iran	76738	1.12	Iran	0.58
Total/Average	5568765	91.53		6186510	90.67		1.17

Source: FAOSTAT (2022)

(3.75 million hectares) to TE 2012 (4.21 million hectares) while a more rapid growth of 27.55% was observed from TE 2013 (4.21 million hectares) to TE 2022 (5.37 million hectares) (Table 2). The growth in area under lentil lagged behind the growth in global lentil production during the past two decades (2003–2022). This suggests that a significant share of the increased production of lentil was achieved through improvement in lentil productivity. During the same period, the productivity of lentils increased by 44.4%, rising from 0.81 t/ha in TE 2003 to 1.17 t/ha in TE 2022 (Table 2). This is reflected in better research and development support as well as favourable policy frameworks aimed at promoting lentil cultivation on a global scale. In addition, the international demand and supply dynamics may also have led to global enhancement.

During TE 2003 to TE 2022, the lentil area in India experienced a decline by 2.08 %, with a sharper decline of 8.44% during period II (TE 2013–2022), while a positive growth of 6.94 % was registered during period I (2003–2012). Conversely, the lentil production in India registered an overall increase of 37%, rising from 0.92 Mt in TE 2003 to 1.26 Mt in TE 2022. The growth during period II (TE 2013–2022) was 24 %, while during period I (TE 2003–2012) it was 9.78%. These contrasting trends of lentil area and production in India reflect an increase in lentil productivity in the country. In this direction, the lentil productivity registered a growth of 41.26% during the overall period (TE 2003–2023) with growth rates of 3.17% and 36.92% during period I (TE 2003–TE 2012) and period II (TE 2013–TE 2022), respectively. The high growth in lentil productivity (36.92%) during period II (TE 2013–TE 2023 appeared to have compensated for the decline in lentil area (8.44%) and recording a growth of 24.75% in lentil production in India during that period.

In contrast to the highest global growth (33.33%) in lentil productivity during period I (TE 2003–TE 2012) and lowest (8.33%) in period II (TE 2013–TE 2022), the growth of lentil productivity in India was highest (36.92%) during period II (TE 2013–TE 2022) and lowest (3.17%) in period I (TE 2003–TE 2012) (Table 2). This growth in productivity in India could be attributed to dedicated efforts since 2006–07 to promote pulses cultivation. The increase in lentil production in India and globally over the last two decades TE 2003 to TE 2022 is primarily attributed to increase in per unit productivity.

The compound annual growth rate of lentil production (3.06%) and yield (2.19%) in India was the highest during period II (2013–22), with 0.84% growth in area under lentil cultivation in the country. In contrast during the same period, the global lentil area registered the highest growth rate (2.94%), while the growth rate in yield level recorded an annual decline by 0.71% (Table 2). Further, the increase in over-all lentil production in all three periods (period I 2003–2012, period II 2013–2022, overall period (2003–2022) at India and world level could be attributed to increase in productivity and area coverage under lentil during the mentioned periods. The lower growth rate of area and production of lentil in India during the overall period (2003–2022) was recorded compared to the corresponding global growth rates. However, the annual growth rate of average lentil productivity during the same period was higher in India (2.08%) as compared to the global figure (1.82%). This could be attributed to dedicated lentil research and development efforts in the positive policy framework for the promotion of lentil cultivation in the country. These include development of suitable lentil varieties for different production niches of the country along with the matching production technologies, large-scale technology demonstrations in compact blocks and similar other efforts. Additionally, various agricultural programmes focusing on quality seeds, distribution of seed kits, and technology demonstrations may have contributed to the positive growth rate in lentil yield in India. This includes of National Food Security Mission, Rashtriya Krishi Vikas Yojana and

Table 2 Growth and Instability in area, production and yield of lentil at national and global level

	India			World		
	Area (Mha)	Production (Mt)	Yield (t/ha)	Area (Mha)	Production (Mt)	Yield (t/ha)
TE 2003	1.44	0.92	0.63	3.75	3.06	0.81
TE 2012	1.54	1.01	0.65	4.21	4.59	1.08
TE 2022	1.41	1.26	0.89	5.37	6.30	1.17
CAGR (%)						
Period I (2003–2012)	1.02	0.70	-0.312	1.08	3.74	2.63
Period II (2013–2022)	0.84	3.06	2.19	2.94	2.24	-0.71
Overall Period (2003–2022)	0.09	2.18	2.08	2.52	4.39	1.83
CDVI						
Period I (2003–2012)	5.29	7.93	7.08	7.49	14.28	8.07
Period II (2013–2022)	8.99	14.72	9.47	10.64	11.05	6.73
Overall Period (2003–2022)	7.38	14.64	11.96	10.04	12.90	9.01

CAGR, Compound annual growth rate; CDVI, Cuddy della valle index; TE, Triennium ending.

Bringing Green Revolution in eastern India programmes emphasizing quality seed, distribution of seed mini-kits, demonstration of production and protection technologies, and strengthening of irrigation infrastructure. In contrast, Malik *et al.* (2022) also revealed that area under lentil registered a negative growth rate during 2000s due to the shifting of its area to other crops like field pea, chickpea, wheat and barley in central and eastern India.

Thus, the data (Table 2) help to comprehend a low variability (CDVI<15) with respect to lentil area, production and productivity across all the periods under study, both at the national and global level. This stability suggests a consistent demand for lentils in the country as well as globally among consumers. It also indicates that lentils are a staple food item and are perceived as a reliable source of nutrition and are integrated into diets across various cultures and regions.

Temporal variations in export and import of pulses in India: The data provided in the Table 3 offers a comprehensive overview of lentil imports and exports, availability, growth, and variability in the Indian context over the period of past two decades i.e., from TE 2003 to TE 2022. During the mentioned period (2003–2022), a consistent upward trajectory in total imports of lentil along with overall total pulses by India was observed. Lentil imports in India registered an increase from 63.97 thousand tonnes in TE 2003 to 814.20 thousand tonnes in TE 2022, registering a substantial growth of 1172%. Consequently, the share of lentil in total pulse imports also notably increased from 4.26% in TE 2002 to 33.25% in TE 2023. Additionally, the share of lentil imports to total lentil production in India also saw a significant increase from 6.94% in TE 2003 to 63.24% in TE 2023. In similar lines pulses imports also registered an overall increase by 63.17% in TE 2022 (2449 thousand tonnes) over TE 2003 (1501 thousand tonnes).

Lentil imports exhibited a high annual growth rate (15.83%) during the overall study period (2003–2022), that was higher than the annual growth rate of imports of overall pulses during the same period. During period I (2003–2012), imports of lentil along with overall pulses, experienced a positive annual growth rate (10.30%, 12.31%), while during period II (2013–2022) negative growth rate (-8.15%, -1.32%), respectively. During the overall period III (2003–2022), the pulse imports registered positive CAGR suggesting moderate growth (4.33%) whereas lentil imports saw a significant growth in the volume with a CAGR of 15.83% was witnessed. Furthermore, high instability in the imports of lentil as well as overall pulses was observed during all the three periods indicating fluctuations in import patterns over time (very high CDVI). This instability may be influenced by various factors such as changes in trade regulations, market conditions, and domestic demand dynamics.

The export data (Table 3) indicate a significant decline in lentil exports from India, contrasting with a high growth rate in combined pulse exports over the period from TE 2003 to TE 2022. Specifically, lentil exports from India experienced a substantial decline of 66.4% from 91.85 thousand tonnes in 2003 to 30.84 thousand tonnes in 2022. In contrast, combined pulse exports witnessed a remarkable growth rate of 312.8% during the same period.

The lentil exports were lowest in TE 2012 (0.47 thousand tonnes) marking a staggering decline by 99.48% over TE 2003 (91.85 thousand tonnes). Meanwhile, combined pulse exports grew by 83.84% during this period. The export of overall pulses and lentils from India registered annual growth rate of 4.54% and 2.48%, respectively during overall study period III (2003–2022) with high instability. The share of lentil exports in the total pulse export during the study period declined significantly from 93.11% in TE 2003 to 0.26% in TE 2012 and then grew slightly to 7.57% in TE 2022. The rise in the demand of lentil in the country along with changes in the trade policies of India at different point of time could be the reason dynamic scenario of lentil exports.

These trends indicate that a significant portion of

Table 3 Growth and variability in import and export of lentil

TE Averages/CAGRs/CDVI_ Import	Import		Export		Availability (000 tonnes)	Import (%) of production
	Pulses (000 t)	Lentil (000 t)	Pulses (000 t)	Lentil (000 t)		
TE 2003	1500.78	63.97 (4.26)	98.65	91.85 (93.11)	893.05	6.94
TE 2012	2659.66	231.27 (8.70)	181.36	0.47 (0.26)	1242.17	22.87
TE 2022	2448.87	814.20 (33.25)	407.24	30.84 (7.57)	2070.65	63.24
CAGR (%)						
Period I (2003–2012)	10.30	12.32	0.32	-55.62	-	-
Period II (2013–2022)	-8.15	-1.32	5.22	35.17	-	-
Period III (2003–2022)	4.33	15.83	4.54	2.48	-	-
CDVI						
Period I (2003–2012)	20.40	101.40	41.71	112.78	-	-
Period II (2013–2022)	36.96	35.00	45.07	81.30	-	-
Period III (2003–2022)	45.59	57.00	46.29	162.55	-	-

CAGR, Compound annual growth rate; CDVI, Cuddy della valle index; TE, Triennium ending.

lentil production in the country was utilized for domestic consumption purposes. The increasing imports of lentils and decreasing exports of lentils over the last two decades (2003–2022) suggests a gap between production and consumption of lentils in India, indicating a growing preference for lentil consumption among consumers in the country. This shift also reflects on changing dietary preferences or increased awareness about nutritional goodness of lentils. The high instability in import and export of lentils and pulses throughout all three periods could be attributed to factors, like changing trade regulations imposed to protect the interests of pulse growers in India. These measures could influence the flow of lentils in and out of the country, leading to variations in import and export volumes. Overall, the gap between production and consumption, coupled with the changing trade regulations and consumer preferences, has contributed to the observed instability in lentil trade in India over the past two decades.

Major import sources and export destination for lentil in India: India imported approximately 0.65 million tonnes of lentils in 2022, to meet domestic consumption demands. Canada has remained a consistent source of imports of lentil for India over the past two decades, followed by Australia and the USA (Fig. 1). Canada and Australia accounted for 61% and 36% of the total lentil imports to India in year 2022, respectively. Similarly, India's lentil imports from Australia grew from 75.9 thousand tonnes in TE 2003 to 169.8 thousand tonnes in TE 2022. USA also emerged as an important country for lentil imports to India. The volume of imports from Turkey varied from 1.5 thousand tonnes in TE 2003 to 3.0 thousand tonnes in TE 2022. Myanmar emerged as a consistent source of lentil imports to India since the year 2011. Ahlawat *et al.* (2016) also identified Canada and the United States of America as major source for lentil import in India, substantiating the significance of these countries in meeting India's lentil import needs. This scenario highlights the dependence of India on these key countries to meet its lentil import needs and highlights the importance of trade relationships for meeting domestic consumption.

Export destinations of Indian lentil: The data presented in Fig. 2 reflect India's lentil export landscape in the year 2022, offering insights into both the absolute quantities dispatched to different nations and the proportional contribution each country made to the total lentil export. Bangladesh emerged as the leading export destination receiving a significant 32.06 thousand tonnes of lentils, which accounted for approximately 49.61% of India's overall lentil exports. The United Arab Emirates (UAE) and the Nepal were also the major lentil export destination, receiving approximately 21.74% and 18.33% of the total lentil export in the year 2022, respectively. Further, with

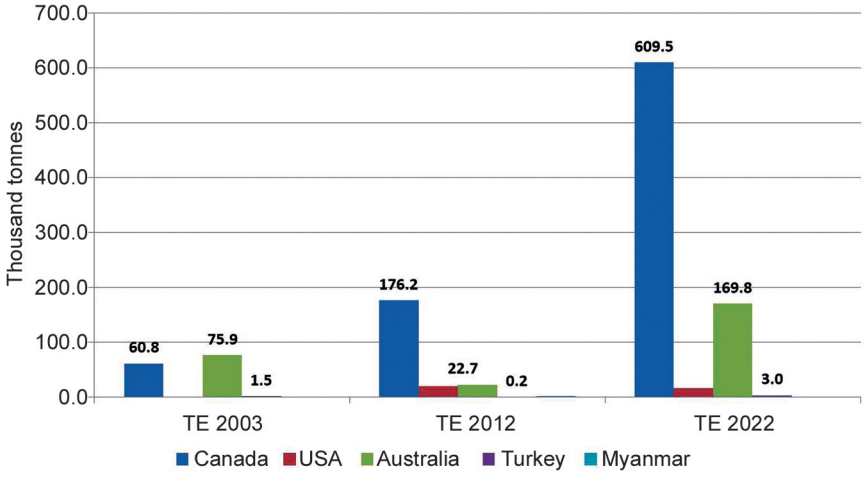

Fig. 1 Major countries as source lentil imports to India. TE, Triennium ending.

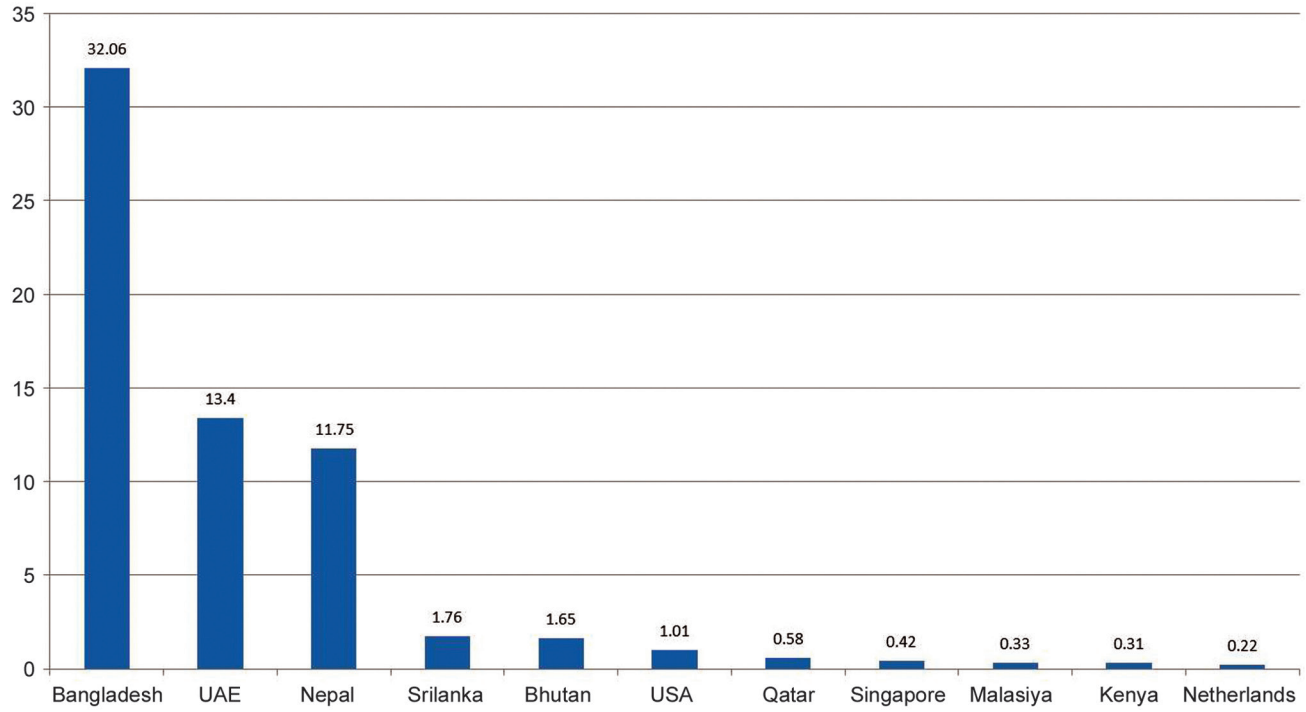

Fig. 2 Export destinations of India's lentil (Thousand tonnes).

recipients such as the Nepal, Sri lanka, Bhutan, USA, Qatar, Djibouti, Singapore, Malasiya and Kenya, signifies a diverse export network of India's lentil spread across the globe. Malik *et al*. (2022) also highlighted that lentil was primarily exported to Bangladesh, Pakistan, Sri Lanka, United Kingdom and gulf countries. This highlights India's significant role as a major player in the international lentil market and emphasizes its commitment to provide this essential commodity to a wide range of nation

Conclusion and policy implication

Pulse group of crop species in general has great role to play in food and nutritional security of India. Pulses contribute significantly to the sustainability of agri-production systems, in supporting economic development, and towards contributing to food security globally. Out of this group, analyzing the production of lentil, its trade, and consumption trends over time is essential for well informed decisions in agriculture and trade policies. It could be concluded that the significant share of increased lentil production was gained through productivity enhancement rather than area expansion. The dedicated lentil research and development efforts in positive policy framework for promotion of lentil cultivation in the country could explain the higher annual growth rate of lentil productivity (2003–2022), as compared to the corresponding global figure (1.82%). A consistent upward trajectory in total imports of lentil along with overall pulses by India was observed over last two decades (2003–2022) with annual growth rate of 15.83%. The trend of increasing imports and decreasing exports of lentils over the last two decades in the country suggests a gap between demand and supply of lentil in India, indicating a growing preference for lentil consumption among consumers in the country. There has been an appreciable initiative from the Government of India for promoting pulses through the NFSM (National Food Security Mission) to ensure sufficiency in it by considering CFLD (Cluster Frontline Demonstration)-on pulses. Moreover, the favourable export-import regime for lentil trade has been enacted by the Government of India. Still there is ample scope to enhance the productivity of lentil in India by intensifying the central and state governments efforts on technology transfer (e.g., crop varieties), capacity building (field functionaries and farmers) and convergence of resources (e.g., integration among different policies) available with different stakeholders. The favourable exim policy oriented towards reduced export may further augment the issue of pulses production, particularly in the case of lentil.

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