



**Boosting Agri Exports
through Investment in
Infrastructure:
Trends, Barriers and Potential**

CAIRA

Centre for Agri Infrastructure Research and Action

An initiative of

**The Infravision
Foundation**

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Boosting Agri Exports through Investment in Infrastructure: Trends, Barriers and Potential

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Contents

1.	Introduction	3
2.	India’s Agricultural, Marine and Processed Food Exports	5
	2.1 Agricultural Products Export Destinations	6
	2.2 Export of Marine Products	7
	2.3 Export of Processed Food	9
	2.4 Key Trends in Agricultural and Marine Product Exports	10
3.	Current challenges in Export of Agricultural Products	12
	3.1 Post Harvest Losses in India.....	12
	3.2 Economic and Environmental Impact of Food Losses.....	14
4.	Challenges in Agricultural Infrastructure	15
	4.1 Specific Supply Chain and Cold Chain Issues.....	15
	4.2 Cold Chain Infrastructure Capacity in India.....	16
	4.3 Transportation and Logistics	20
	4.4 Challenges in Marine and Aquaculture Export Development	23
	4.5 Challenges in Buffalo Meat Export Industry.....	23
	4.6 Challenges in Millet Production and Export Expansion.....	23
	4.7 Barriers to Growth in Processed Food Exports	24
	4.8 Challenges in Plantation Crop Export Business	24
5.	Big Ideas for Strengthening Agricultural Infrastructure and Exports in India	25
	5.1 Implement Strategic Interventions.....	26
	5.2 Develop Transportation Strategies	27
	5.3 Develop Awareness, Capabilities and Technology Adoption.....	28
	5.4 Develop an Integrated Supply Chain & Cold Chain Infrastructure	29
	5.5 Development and Investment in Warehouse Infrastructure	29
	5.6 Expand and Modernize Pack-House Infrastructure	30
	5.7 Strengthen and Modernize Reefer Vehicle Infrastructure	30
	5.8 Strengthen and Optimize Reefer Container Infrastructure for Agricultural and Seafood Exports.....	30
	5.9 Development and Invest in Warehouse Infrastructure	31
	5.10 Enhance Transportation and Logistics Efficiency.....	31

5.11	Technological Advancement in Seafood Processing and Aquaculture.....	32
5.12	Strengthening Specialized Meat Supply Chains and Quality Enhancement.....	32
5.13	Build a Comprehensive Ecosystem for Millets.....	32
5.14	Improve Export Competitiveness in Processed Food	33
5.15	Expand Market and Value Creation including Plantation Crops.....	33
Conclusion	33

List of Figures

Figure 1:	India’s Agricultural Trade (in USD Billion).....	3
Figure 2:	Top commodities (marine and agricultural products) exported in 2023–24.....	5
Figure 3:	India: Export Performance of Marine Products	7
Figure 4:	Export Details of Aquaculture and Capture Fisheries.....	8
Figure 5:	Top Export Items of Processed Food Products (2023–24)	9
Figure 6:	Top Ten Agriculture Products Exported in the Last 5 Years (in USD billion).....	10
Figure 7:	Comparison of Post Harvest Losses Between the NABCONS (2022) Study and the ICAR-CIPHET (2015) Study.....	13
Figure 8:	Supply in Cold Chain Market.....	15
Figure 9:	Registrations of Warehouses Over the Last Five Years (2018–23).....	22

List of Tables

Table 1:	India’s Export of APEDA Products (2023–24) to Different Countries.....	6
Table 2:	Exports of Marine Products for the Last Three Years	7
Table 3:	Share of Aquaculture and Capture Fisheries to Marine Exports.....	8
Table 4:	National Average Post-Harvest Losses by Food Category (%), 2022.....	12
Table 5:	Category-Wise Absolute Losses in Physical Quantity and Monetary Value.....	14
Table 6:	Evaluation of Gaps in Cold Chain Infrastructure Capacity	16
Table 7:	State-Wise Distribution of Cold Storages as on 31.08.2020.....	17
Table 8:	Entity-Wise Number of Warehouses and Capacity.....	22

1. Introduction

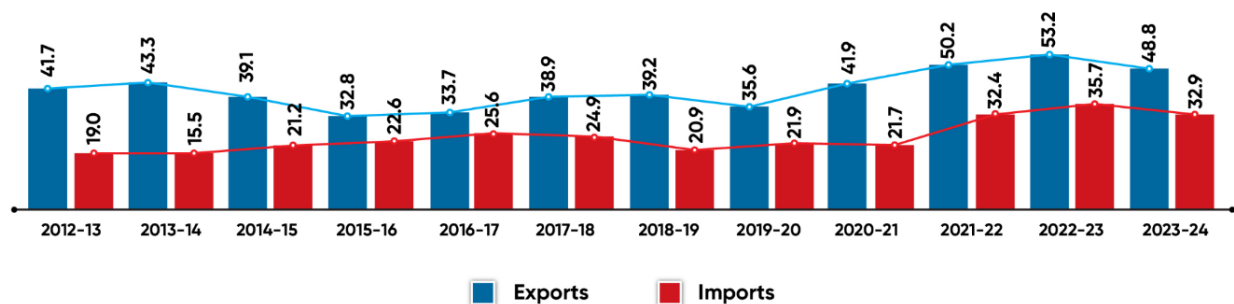
Agriculture is a cornerstone of India’s economy, contributing approximately **18.2%** to the country’s GDP at current prices and employing nearly **42.3% of the population**.¹ It means that a substantial portion of the workforce still depends on agriculture for livelihood.

A notable aspect of Indian agriculture is that approximately **85%** of farmers are classified as Smallholder Farmers, managing less than 2 hectares of land. These farmers cultivate around **45%** of agricultural land, indicating a reliance on small-scale farming practices (Agriculture Infrastructure Fund Scheme Guidelines, 2024).² India’s agricultural sector, heavily reliant on Smallholder Farmers who manage a significant portion of the land, faces critical challenges. The fragmentation of land, low incomes, and reliance on non-agricultural income highlight the need for targeted interventions. By strengthening agriculture ecosystems and related infrastructure, India can boost agricultural productivity.

In recent years, the agriculture sector has shown muted growth, with a compound annual growth rate (CAGR) of **3.07%** from FY2012 to FY2019 (IBEF, 2020).³ As of 2023-24, agriculture contributed approximately **18.2%** to India’s GDP, a decline from **20.3%** in 2020-21 and **19.0%** in 2021-22 (PIB, 2023).⁴ Agriculture’s share of GDP has decreased from **35%** in 1990-91, indicating a long-term trend of diminishing relative importance within the broader economy. This decline reflects the rapid growth of the industrial and service sectors, which have outpaced agricultural growth (Ministry of Agriculture, GoI, 2023).⁵

The value of India’s agriculture trade on a yearly basis from 2012-2024 is represented in Figure 1.

Figure 1: India’s Agricultural Trade (in USD Billion)



Looking ahead, a recent McKinsey study suggests that by 2030, agriculture could contribute an additional USD 600 billion to India’s GDP, reflecting a potential growth of 50% from its 2020 levels.⁶

Beyond its domestic significance, agriculture plays a pivotal role in India’s export landscape, with agricultural products accounting for 11.8% of the country’s total merchandise exports in the fiscal year 2022-23 when they reached USD 53 billion, marking a notable increase from previous years. However, in 2023-2024, the same declined to USD 43.7 billion due to various restrictions on exports of wheat, rice and sugar etc. The restrictions were imposed to keep domestic food inflation under check. This underscores the point that the agriculture sector has to first provide food security to the nation before contributing substantially to exports (Ministry of Commerce, GoI, April 2024).

A summary of recent export restrictions are as follows:

- i. **August 2022:** Ban on broken rice exports.
- ii. **July 20, 2023:** Ban on non-basmati rice exports due to rising domestic prices.
- iii. **August 25, 2023:** 20% export duty imposed on parboiled non-basmati rice.
- iv. **August 27, 2023:** Minimum export price (MEP) requirement of USD 1,200 per tonne introduced for basmati rice, enforced by APEDA, i.e, permit exports only for consignments priced above USD 1,200 per tonne.
- v. **September 2023:** 20% export duty levied on non-basmati rice.
- vi. **October 28, 2023:** Introduction of MEP of USD 800 per tonne for onions.
- vii. **December 8, 2023:** Complete ban on onion exports until March 31, 2024, later extended in April 2024.
- viii. **May 2024:** Onion export ban lifted; 40% export tax and revised MEP of USD 550 per tonne reintroduced.
- ix. **September 28, 2024:** Non-basmati rice export ban lifted; new MEP of USD 490 per tonne imposed.

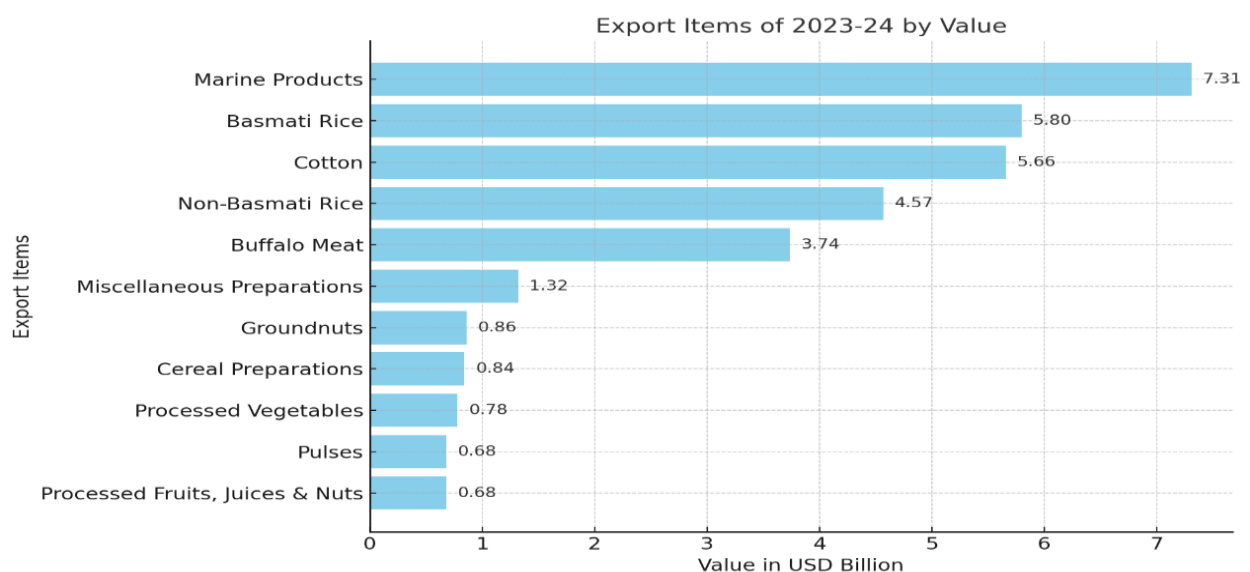
Conclusion

While India's agricultural sector has tremendous potential for growth, there are challenges that must be addressed, particularly the need to balance food security and trade priorities. The interests of both food security and agricultural trade can be harmonized through strategic actions such as enhancing production capabilities, minimizing waste, improving supply chain efficiency, and adopting sustainable farming practices. In addition, substantial investments in agricultural infrastructure—such as better energy supply and consumption, irrigation systems, storage facilities, and transportation networks—are critical for improving productivity and reducing post-harvest losses. By addressing these key areas, India can ensure its food security while simultaneously expanding its agricultural exports in a responsible and sustainable manner, positioning the sector for long-term growth and resilience.

2. India's Agricultural, Marine and Processed Food Exports

Figure 2 below gives the major items of agricultural exports in 2023-24. Marine products top the list with the export of 7.31 billion USD, showcasing the export values (in billion) of various key commodities. The export data of 2023-24 highlights the fact that most of India's agricultural exports are of primary commodities – rice, marine products, buffalo meat.

Figure 2: Top Commodities (Marine and Agricultural Products) Exported in 2023-24



Source: Ministry of Textiles, MPEDA and APEDA

In terms of value, marine products at USD 7.3 billion are followed by basmati rice at USD 5.8 billion and cotton at USD 5.66 billion. Non-basmati rice and buffalo meat also made significant contributions, generating USD 4.57 billion and USD 3.74 billion, respectively. Miscellaneous preparations, groundnuts, and cereal preparations accounted for USD 1.32 billion, USD 0.86 billion, and USD 0.84 billion respectively, showcasing that possibility of diversifying India's export portfolio.

Processed vegetables and processed fruits, juices, and nuts contributed USD 0.78 billion and USD 0.68 billion respectively. These are the products where India has performed below potential and there is a possibility of significant increase in the future.

Cotton contributes significantly as a raw material and as a standalone export commodity. India holds 40% of the world's cotton cultivation area (126.80 lakh hectares out of 313.30 lakh hectares). India ranks second globally in cotton production, with an estimated output of 323.11 lakh bales (5.50 million metric tonnes) during the 2023-24 cotton season, accounting for 23.83% of the global cotton production of 1,429 lakh bales (24.31 million metric tonnes) (Ministry of Textile, GoI). According to the Cotton Corporation of India, India exported 2.8 million bales of cotton in 2023-24, valued at USD 6.78 billion. This is a 27% increase from the 2022-23 crop year.

2.1 Agriculture Products Export Destinations

India's agricultural exports encompass a diverse range of products, including marine products, rice (both basmati and non-basmati), sugar, spices, buffalo meat, and various processed foods. These products reach over 200 countries. India's agricultural exports exhibit significant geographical diversity. The total export volume is 31,586.5 thousand metric tonnes, valued at **USD 25.6 billion**. Major Export Destinations for Indian Agricultural Products are given in Table 1 below (PIB, 10 JUN 2021).⁷

Basmati rice is the largest contributor, accounting for 22.8% of the total export value, with Saudi Arabia, Iraq, and Iran being the primary importers. Non-basmati rice follows, contributing 17.9%, with strong demand in African countries like Benin, Guinea, and Togo.

Table 1: India's Export of APEDA Product (2023-24) to Different Countries

S.N.	Major Importing Countries (value in USD billion and % share) – 2023-24						
		% in value to total					
1	Basmati Rice	22.8	Saudi Arabia (1.9, 7.7)	UAE (1.86, 7.3)	Vietnam (1.62, 6.3)	USA (1.51, 5.9)	Iraq (1.41, 5.5)
2	Non-basmati Rice	17.9	Benin (0.51, 11.2)	Guinea (0.37, 8.2)	Tango (0.27, 6.1)	Vietnam Soc Rep (0.26, 5.8)	Cote D Ivoire (0.24, 5.4)
3	Buffalo Meat	14.6	Vietnam Soc Rep (0.75, 20.1)	Malaysia (0.57, 15.4)	Egypt A Rp (0.54, 14.5)	Iraq (0.33, 8.8)	U Arab Emts. (0.27, 7.3)
4	Miscellaneous Preparations	5.2	USA (0.24, 17.9)	U Arab Emts. (0.12, 9.3)	Malaysia (0.12, 9.1)	Australia (0.07, 5.5)	UK (0.06, 5.3)
5	Groundnuts	3.4	Indonesia (0.26, 31.2)	Vietnam Soc Rep (0.17, 20.0)	Philippines (0.07, 8.2)	Malaysia (0.06, 7.8)	Thailand (0.05, 6.1)

Source: Analytical Report: India's Export of APEDA Product (2023-24)

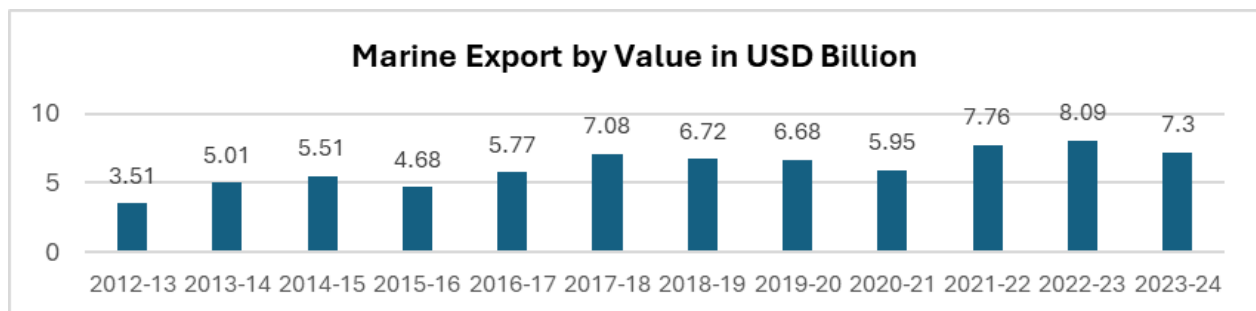
Buffalo meat accounts for 14.6% share, with Vietnam, Malaysia, and Egypt as the leading buyers. The EU, USA, China and Indonesia do not allow import of Indian buffalo meat due to prevalence of foot and mouth disease. If this problem of FMD is addressed and opposition to meat exports by certain groups in parts of India is checked by the Government, it is possible that meat export can go also go up. In 2013-14 buffalo meat export was USD 4.35 billion. Groundnuts contribute 3.4%, with Indonesia and Vietnam driving demand.

The data underscores the importance of regional market specialization and the need for continued diversification of both the product and geography to sustain export growth. Strategic focus on emerging markets and identifying items and products (like organic food, processed food etc) can further enhance India's export potential.

2.2 Export of Marine Products

The Marine Products Export Development Authority (MPEDA) is the concerned authority entrusted with the primary task of promotion of export of marine products. In the financial year 2023-24, India exported 17,81,602 metric tons (MT) of marine products worth USD 7.38 billion.

Figure 3: India: Export Performance of Marine Products



Source: MPEDA

Frozen shrimp accounted for more than 40% of the total quantity and about 66.12% of the total export value. The MPEDA has outlined a roadmap aiming to boost exports to USD 14 billion by 2025. Additionally, the Department of Commerce has issued guidelines to strengthen processing capacity and develop value-addition infrastructure for marine products (Ministry of Fisheries, Animal Husbandry & Dairying, GoI, Dec 2024).⁸

Despite competition from other countries and rising sea temperature, the seafood sector performed well during 2022-23 and in 2023-24, it showed more growth. The seafood export during the year has increased by 26.73% and 2.67% respectively in quantity.

Table 2: Exports of Marine Products for the Last Three Years

Export Details	2023-24	2022-23	Change %	2021-22	Change %
Quantity in Tons	17,81,602	17,35,286	2.67	13,69,264	26.73
USD in Million	7,381.89	8,094.31	-8.80	7,759.58	4.31
Unit Value (USD/Kg)	4.14	4.66	-11.17	5.67	-17.69

Source: MPEDA

The export performance of marine products shows a steady growth trend over the years, with exports rising from **USD 3.51 billion in 2012-13** to **USD 7.38 billion in 2023-24**. Significant milestones include peaks in 2017-18 (**USD 7.08 billion**) and the highest recorded value in 2022-23 at **USD 8.09 billion**. The sector faced a temporary decline in 2015-16 and 2020-21, reflecting challenges likely due to global trade dynamics and the COVID-19 pandemic. However, it demonstrated strong recovery post-2020-21, indicating resilience and growing demand for marine products globally. USA and China are the major importers of Indian seafood.

Contribution of Aquaculture and Capture fisheries

Table 3: Share of Aquaculture and Capture Fisheries to Marine Exports

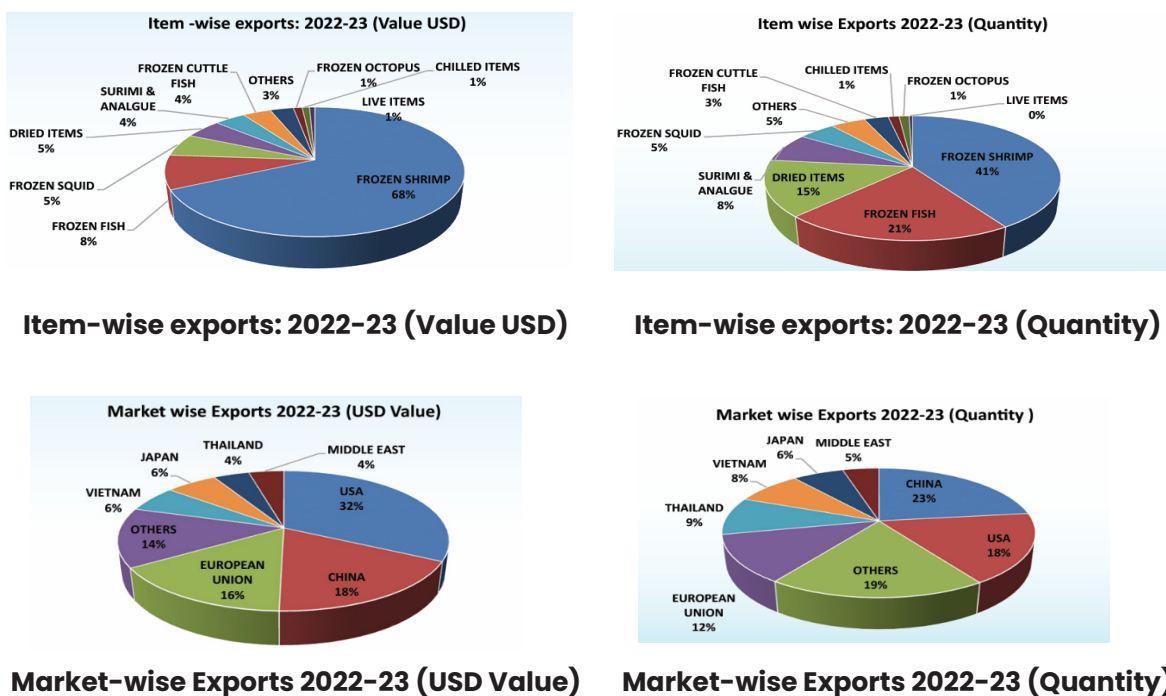
Export Contribution of Aquaculture and Capture Fisheries						
	Aqua Culture (%)			Capture Fisheries (%)		
	2021-22	2022-23	2023-24 ⁹	2021-22	2022-23	2023-24
Qty	49	38	38	51	62	62
Value in USD	70	63	62	30	37	38
USD/KG	8.15	7.72	6.82	3.33	2.79	2.52

Source: MPEDA

In aquaculture, share in total seafood export volume dropped from 49% (2021-22) to 38% (2022-23 & 2023-24). The value contribution declined in both INR (69% to 62%) and USD (70% to 62%) between 2021-22 and 2023-24. Export price fell from USD 8.15 (2021-22) to USD 6.82 (2023-24), indicating reduced unit value realization due to market or competitive pressures.

Capture fisheries’ share rose from 51% in 2021-22 to 62% in 2022-23 and 2023-24, indicating dominance in volume. Value contribution increased from 31% in 2021-22 to 38% in 2023-24, highlighting greater export earnings. The unit value dropped from USD 3.33 in 2021-22 to USD 2.52 in 2023-24, suggesting a shift to lower-value products or price pressures. There is a clear shift in export quantity contribution from aquaculture to capture fisheries over the three years. The data highlights a growing reliance on capture fisheries for marine exports, possibly reflecting shifting demand or supply trends.

Figure 4. Export Details of Aquaculture and Capture Fisheries



Frozen shrimp and fish dominate marine exports, making the establishment of a network of nucleus breeding centres for shrimp brood stock a promising development. To support seafood exports, there is a pressing need for an integrated cold chain system and large-scale chilled storage facilities for marine products (India Today, 2024).¹⁰

2.3 Export of Processed Food

The share of processed food exports in the country's total agricultural exports has risen from **13.7%** in 2014-15 to **25.6%** in 2022-23 and 23.5% in 2023-24 (Ministry of Food Processing Industries and Invest India, 2024).¹¹

Growth Trends

The Food Processing Industry (FPI) is among the largest industries in India, representing 32% of the nation's overall food market. The sector has consistently expanded its contribution to the country's GDP. The contribution of the food processing sector to Indian growth story has consistently increased.

Sectoral performance of Processed Food Export

The food processing (FP) sector is significant to employment and agricultural value addition. It accounted for about **12.02%** of total organized sector employment and has been growing. During the last seven years ending 2021-22, FP sector has been growing at an Average Annual Growth Rate (AAGR) of around 7.26% (Ministry of Food Processing Industries (PIB: MoFPI, GoI, 2024).¹²

Despite high potential, India ranks as the **16th largest exporter** of processed food globally. India's processed food exports in 2023-24 were valued at **USD 7.70 billion**.¹³ The food processing industry is projected to reach **USD 535 billion** by 2025, growing at a compound annual rate of **15.2%**.¹⁴ While this indicates room for growth, a lot more investment and stability of policies is required.

Figure 5: Top Export Items of Processed Food Products (2023-24)

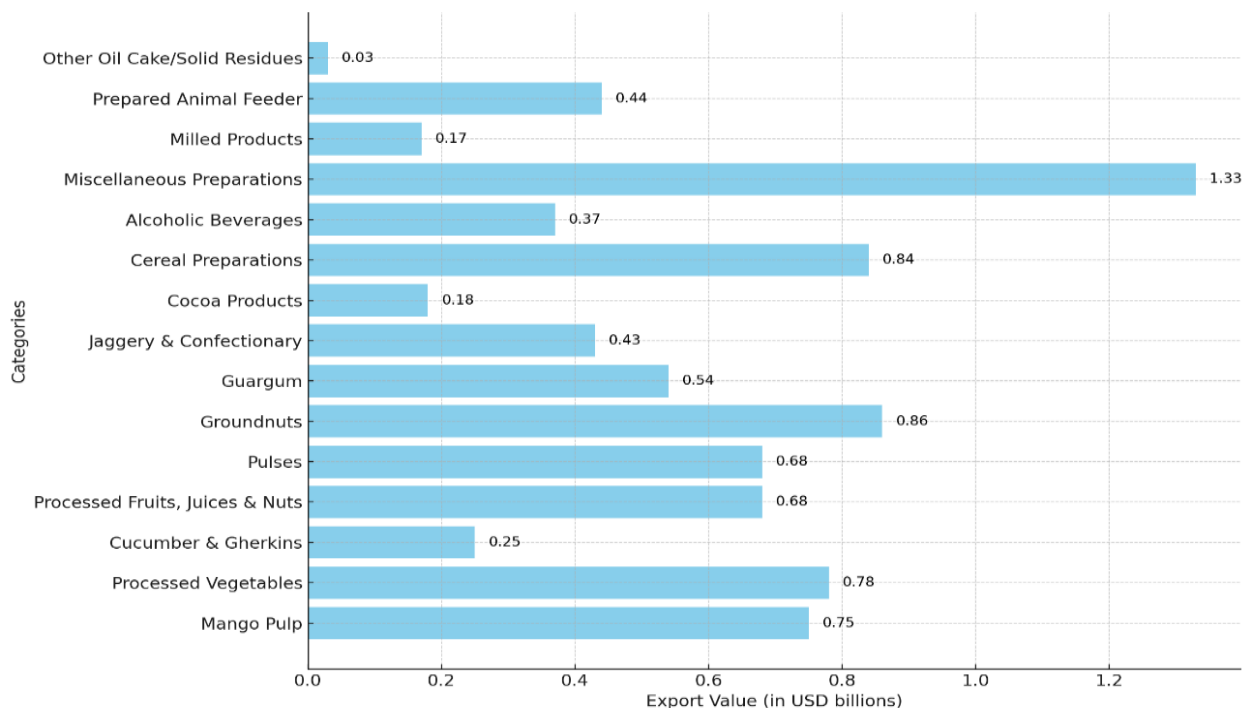


Figure 5 illustrates the export values of selected processed food products from India (2023-24), with “Miscellaneous Preparations” leading at **USD 1.33 billion**, followed by “Groundnuts” and “Cereal Preparations” at **USD 0.86 billion** and **USD 0.84 billion**, respectively. Products like “Other Oil Cake/Solid Residues” and “Milled Products” have the lowest export values, highlighting variations in demand across categories.

2.4 Key Trends in Agriculture and Marine Export

Figure 6 highlights the export performance of India’s top 10 agricultural (including marine) products in terms of value (in USD billion) over five financial years (2019-20 to 2023-24).

Marine Products consistently lead the export categories, showing steady growth from USD 5.96 billion in 2019-20 to USD 7.9 billion in 2023-24, reflecting strong demand in global markets. However, growth appears to have plateaued, emphasizing the need for enhanced value addition and export diversification.

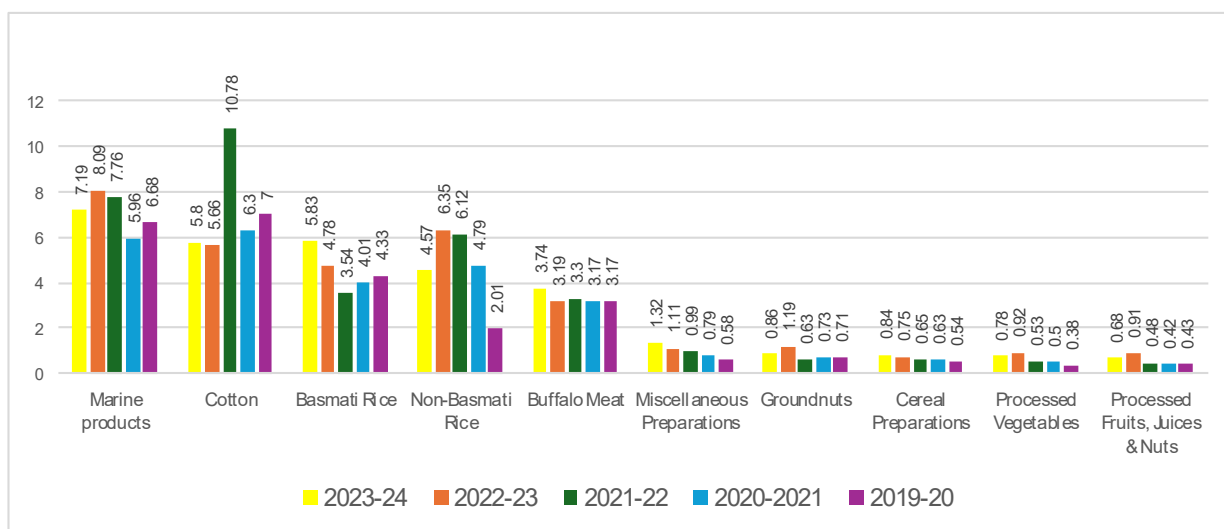
Cotton exports peaked significantly in 2021-22 at USD 10.78 billion, likely driven by high global prices and strong demand. However, subsequent years (2022-23 and 2023-24) witnessed a sharp decline to USD 6.58 billion and USD 5.8 billion, respectively, possibly due to market corrections or reduced production.

Basmati Rice and **Non-basmati Rice** exports show a consistent upward trend, reflecting India’s dominance in global rice markets. Basmati rice rose from USD 4.31 billion in 2019-20 to USD 4.78 billion in 2023-24, while non-basmati rice exhibited more dynamic growth from USD 2.01 billion to USD 5.57 billion over the same period, driven by higher demand and competitive pricing.

Buffalo Meat exports have remained relatively stable, ranging from USD 3.17 billion to USD 3.74 billion across the years, indicating steady market presence.

Processed Vegetables, Processed Fruits, Juices & Nuts, and Cereal Preparations represent smaller categories with minimal fluctuations, reflecting niche export markets. Groundnuts and miscellaneous preparations show incremental growth, with values under USD 2 billion.

Figure 6: Top Ten Agriculture Products Exported in the Last 5 Years (in USD billion)



Source: Ministry of Textile, MPEDA and APEDA

Conclusion

In conclusion, India's agricultural, marine, and processed food exports have shown promising growth and resilience, with marine products leading the way, followed by basmati rice, cotton, and buffalo meat. However, most India's agricultural exports remain cantered around primary commodities, leaving substantial opportunities for growth in value-added products. Marine exports, especially frozen shrimp, account for a significant portion of India's agricultural export earnings, yet the sector faces challenges such as price pressures and competition. The shift from aquaculture to capture fisheries in seafood exports also suggests the need for strategic adjustments to maintain global competitiveness.

Processed food exports have seen growth but remain below potential. Products like processed vegetables, fruits, and juices offer untapped opportunities for expansion, signalling the need for further investment in processing infrastructure and technology. The food processing sector's contribution to India's GDP and employment is vital, and with a projected market size of USD 535 billion by 2025, it presents a crucial area for investment.

The data highlights the necessity of enhancing value addition across sectors to diversify export portfolios. While primary agricultural exports like rice and cotton continue to perform well, the future growth of India's agricultural export sector hinges on substantial investments in infrastructure, especially in areas like cold chain systems, processing facilities, and technology for value-added products. The development of such infrastructure will not only support existing export categories but also create new opportunities for growth, particularly in emerging markets and niche product segments.

Considering these opportunities, it is imperative for both the public and private sectors to focus on investing in agriculture infrastructure. A robust infrastructure will streamline supply chains, reduce post-harvest losses, and create a competitive edge for Indian products in the global market. Strengthening infrastructure, particularly in value-added food processing and cold chain logistics, is essential to boosting India's agricultural exports and meeting the growing global demand for high-quality, processed agricultural products.

3. Current challenges in Export of Agricultural Products

3.1 Post Harvest Losses in India

Post-harvest losses remain a critical issue for India, one of the largest global producers of food grains, fruits, and vegetables. These losses occur across harvesting, storage, transportation, processing, and distribution, leading to economic losses and food insecurity. NABCONS (2022) estimates annual losses across 54 crops at **USD 18.5 billion, 2.35% of GDP**. Livestock products account for **21.7%** of these losses, followed by fruits (**19.34%**) and vegetables (**17.97%**).

Studies by ICAR-CIPHET (2012, 2015) highlighted significant losses: cereals (4.65%-5.99%), pulses (6.36%-8.41%), oilseeds (3.08%-9.96%), fruits (6.7%-15.88%), and vegetables (4.58%-12.44%). Plantation crops and spices faced lower losses (1.18%-7.89%). Among animal products, eggs saw 7.19%, fish 5.23%-10.52%, meat 2.71%-6.74%, and milk the least at 0.92%. The economic impact of losses in **2015** was **USD 11.01 billion**, underscoring the urgent need for improved post-harvest management in agriculture and food sectors.

MoFPI commissioned a study through NABARD Consultancy Services Pvt. Ltd. (NABCONS) in 2020, which provided updated insights into post-harvest losses in India’s agriculture and allied sectors which is as follows:

Table 4: National Average Post-Harvest Losses by Food Category (%), 2022

Categories	Overall national average post- harvest losses (%)
Fruits	6.02 (pineapple) – 15.05 (guava)
Vegetables	4.87 (tapioca)- 11.61 (tomato)
Cereals	3.89 (maize) – 5.92 (sorghum)
Pulses	5.65 (pigeon pea)- 6.74 (chickpea)
Oilseeds	2.87 (cottonseed)- 7.51 (soybean)
Plantation Crops & Sugarcane	1.72 (cashew nut)- 4.41 (areca nut) 7.33 (sugarcane)
Spices	1.29 (black pepper)- 6.11 (chilli)
Milk	0.87
Egg	6.03
Meat	2.34 (meat) – 5.63 (poultry meat)
Inland Fish	4.86
Marine Fish	8.76

Source: Study to determine post- harvest losses of agri produces in India (by NABCONS)¹⁵ in 2022

Figure 7: Comparison of Post Harvest Losses between the NABCONS (2022) Study and the ICAR-CIPHET (2015) Study¹⁶



Source: NABCONS (2022) and ICAR-CIPHET (2015)

The category-wise absolute losses in physical quantity and monetary value are highlighted as per NABCONS (2022) in Table 5.

Table 5: Category-wise absolute losses in physical quantity and monetary value

S. No.	Category	Production (million MT)	Quantity lost (million MT) NABCONS (2020-21)	Monetary Loss NABCONS (USD Billion)	% Contribution of the total loss (in monetary value)
1	Cereals	281.28	12.49	3.09	17.02
2	Pulses	21.55	1.37	1.10	6.08
3	Oilseeds	37.27	2.11	1.29	7.15
4	Fruits	90.82	7.36	3.51	19.34
5	Vegetables	164.74	11.97	3.26	17.97
6	Plantation Crops	426.13	30.59	1.95	10.74
7	Livestock Produce (milk, meat and fish)	232.86	3.01	3.55	21.70
Total		1254.65	68.90	14.95	
8	Eggs	122110	7363	0.39	
Grand Total				18.17	

Source: Study to determine post-harvest losses of Agri produces in India (NABCONS), 2022

3.2 Economic and Environmental Impact of Food Losses

1. Economic Losses

Post-harvest losses result in substantial financial losses for farmers, processors, and the overall economy. Losses in India’s fruit and vegetable sector alone reached **USD 25.33 Billion** in 2011-12 and were projected to rise further, severely impacting the country’s agricultural profitability.

2. Environmental Costs

The post-harvest loss contributes significantly to greenhouse gas emissions due to the decomposition of organic matter. Wastage of such resources implies wastage of water, energy, and soil degradation, land used in production, biodiversity loss and exacerbating resource inefficiency.

The transport and storage of perishable goods that spoil also add to carbon footprints. Rail transport has lower emissions per kilometre and unit transported than road transport. One freight train can replace hundreds of trucks, reducing greenhouse gas (GHG) emissions by up to 75% (European Environment Agency, 2021)¹⁷.

Conclusion

In conclusion, addressing post-harvest losses in India through strategic investments in agricultural infrastructure is essential to boost the country’s export potential. The current high levels of waste, particularly in perishable goods such as fruits, vegetables, and livestock products, not only result in substantial economic losses but also contribute to environmental damage.

4. Challenges in Agricultural Infrastructure

In India, agriculture continues to face significant infrastructure challenges that hamper its potential for growth and global competitiveness. The lack of adequate storage facilities, inefficient transportation networks, and limited adoption of modern technologies contribute to substantial losses and inefficiencies across the agricultural value chain.

1. Infrastructure Deficiency

Inadequate storage facilities, including lack of scientific warehousing, remain a critical issue. Cold storage facilities for perishable commodities like fruits and vegetables are insufficient to meet demand leading to significant spoilage, especially for perishable items.

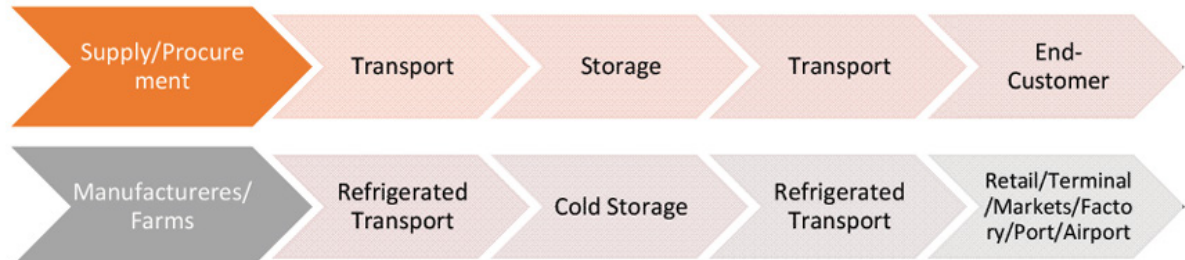
2. Transportation Inefficiencies

Poor road and transport infrastructure exacerbate losses during the movement of produce from farms to markets.

3. Lack of Awareness and Technology Adoption

Farmers often lack awareness of post-harvest best practices and the benefits of scientific storage systems.

Figure 8: Supply in Cold Chain Market



4.1 Specific Supply Chain and Cold Chain Issues

The cold chain market plays a critical role in ensuring the quality and safety of marine, processed food, and agricultural products, especially for exports. It involves a temperature-controlled supply chain that includes refrigerated transport and storage to maintain product integrity from the point of origin to the end customer. The cold chain infrastructure is vital for meeting global standards in export markets, reducing waste, enhancing shelf life, and enabling producers to access international markets effectively.

4.2 Cold Chain Infrastructure Capacity in India

Table 6: Evaluation of Gaps in Cold Chain Infrastructure Capacity

Type of Infrastructure	Infrastructure Requirement (A)	Infrastructure Created (B)	All India Gap (A-B)
Cold Storage (Mn tons)	35.1	31.82	3.28
Pack-house (in no.)	70080	249	69831
Refer Vehicles (in no.)	61826	9000	52826
Ripening Chambers (in no.)	9131	812	8319

Source: National Centre for Cold Chain Development, Government of India, 2015¹⁸

The data in Table 6 highlights significant infrastructure gaps in India’s cold chain and allied infrastructure, which are critical for the food processing and agriculture sectors. The referenced data originates from a study conducted in 2015. The National Centre for Cold Chain Development (NCCD) commissioned NABARD Consultancy Services (NABCONS) to conduct the 2015 study titled All India Cold-chain Capacity Assessment (Status & Gaps), rendering it outdated for current strategic and policy applications. Accordingly, it is recommended that a comprehensive and updated assessment be undertaken to evaluate the existing gaps in cold chain infrastructure capacity across the country. Some of the issues related to Cold Chain Supply Infrastructure are described below.

4.2.1 Cold Storage Infrastructure Gaps

India’s cold storage infrastructure for agricultural products is facing significant gaps, with a current shortfall of 3.28 million tons in required cold storage capacity. Insufficient cold storage facilities, particularly near production sites, result in high post-harvest losses, especially for perishable items like fruits and vegetables. Furthermore, many existing cold storage units lack modern, energy-efficient technologies and climate control systems, leading to inefficiencies and higher operational costs. The challenges related to cold storage infrastructure are as follows.

- a. The requirement for cold storage capacity is 35.1 million tons, but only 31.82 million tons have been created, leaving a **gap of 3.28 million tons**.
- b. Insufficient cold storage facilities near production sites lead to high post-harvest losses.
- c. Existing cold storage units lack energy-efficient technology and climate control systems, further increasing operational inefficiencies (Cargo Talk, 2023).¹⁹
- d. Limited deployment of technologies like temperature monitoring, blockchain, and real-time tracking hampers efficiency and traceability.
- e. Existing cold storage facilities are not energy-efficient, increasing operational costs and losses.
- f. Limited use of innovations like temperature monitoring, blockchain, and real-time tracking hampers quality control and traceability.
- g. Adoption of tools such as phase change materials (PCM), digital inventory management, and barcoding is minimal, despite their potential to optimize operations.
- h. This gap, although smaller in comparison to other infrastructure elements, indicates the need for expansion to prevent post-harvest losses.

State-Wise Cold Storage Infrastructure Facilities

As of August 2020, India's cold storage infrastructure displays significant regional disparities in terms of capacity and distribution, as reported by the Ministry of Agriculture & Farmers Welfare. While states like Uttar Pradesh and Gujarat contribute heavily to the national cold storage capacity, smaller regions and Union Territories like Lakshadweep and Andaman & Nicobar Islands show minimal infrastructure, highlighting the urgent need for targeted investments and optimization across the country. (Ministry of Agriculture & Farmers Welfare in year 2020) (PIB, Ministry of Agriculture & Farmers Welfare, GoI, Sep 2020)²⁰

Table 7: State wise distribution of Cold Storages as on 31.08.2020.

S. No.	Name of the State	Total	
		No.	Capacity (MT)
1	Andaman & Nicobar Islands (UT)	3	810
2	Andhra Pradesh & Telangana	405	1567664
3	Arunachal Pradesh	2	6000
4	Assam	39	178096
5	Bihar	311	1479122
6	Chandigarh (UT)	7	12462
7	Chhattisgarh	99	487292
8	Delhi	97	129857
9	Goa	29	7705
10	Gujarat	969	3822112
11	Haryana	359	819809
12	Himachal Pradesh	76	146769
13	Jammu & Kashmir	69	250169
14	Jharkhand	58	236680
15	Karnataka	223	676832
16	Kerala	199	81705
17	Lakshadweep (UT)	1	15
18	Madhya Pradesh	302	1293574
19	Maharashtra	619	1009693
20	Manipur	2	4500
21	Meghalaya	4	8200
22	Mizoram	3	4001
23	Nagaland	3	7150
24	Orissa	179	572966
25	Pondicherry (UT)	3	85
26	Punjab	697	2315096
27	Rajasthan	180	611831
28	Sikkim	2	2100
29	Tamil Nadu	183	382683
30	Telangana	74	410905
31	Tripura	14	46354
32	Uttar Pradesh	2406	14714235
33	Uttarakhand	55	191314
34	West Bengal	514	5947311
		8186	37425097

Source: Directorate of Marketing and Inspection (DMI) upto 2009, National Horticulture Board (NHB), National Horticulture Mission (NHM), Horticulture Mission for North East & Himalayan (HMNEH) & Ministry of Food Processing Industries (MoFPI)²¹

- i. Highest Total Capacity in Uttar Pradesh: Uttar Pradesh stands out with the highest total capacity of 14,714,235 metric tons (MT), which is more than 39% of the total capacity across all states and UTs.
- ii. Highest Number of Units in Gujarat: Gujarat leads with 969 units, contributing 3,822,112 MT to the total capacity, indicating a high density of facilities.
- iii. State with the Lowest Capacity: Lakshadweep (UT) has the smallest capacity with just 15 MT from a single unit, which is significantly lower compared to other states and UTs.
- iv. Significant Contribution by Major States: States like Maharashtra (1,009,693 MT), Punjab (2,315,096 MT), and West Bengal (5,947,311 MT) have large capacities, each making substantial contributions to the national total.
- v. Union Territories with Minimal Capacity: Andaman & Nicobar Islands (810 MT), Chandigarh (12,462 MT), and Pondicherry (UT) (85 MT) have relatively small capacities, highlighting the regional disparities in storage and distribution capabilities.

There is need for targeted cold storage investments, addressing regional disparities, and optimizing infrastructure to support India's horticulture sector effectively.

4.2.2 Pack-houses

The country requires **70,080 pack-houses**, but only 249 have been established, resulting in a massive **gap of 69,831 pack-houses**. This indicates severe underdevelopment in on-farm post-harvest infrastructure, essential for grading, sorting, and minimal processing.

4.2.3 Reefer Vehicles

The need for **61,826 refrigerated vehicles** contrasts sharply with the creation of only **9,000 vehicles**, leaving a **gap of 52,826 vehicles**. This gap significantly affects the efficiency of cold chain logistics and the timely transport of perishable goods.

A major challenge in India's agricultural logistics is the inefficient booking and limited availability of reefer trucks, which are critical for transporting perishable goods. The lack of a centralized system to track and book vehicles creates significant visibility gaps, making logistics planning difficult. Companies like **Celcius** have introduced tech-based solutions, such as a **SaaS** marketplace, to streamline reefer logistics and connect stakeholders in the cold-chain ecosystem, but these solutions are not yet widely adopted.

India faces a massive shortfall in reefer trucks, with only 20,000 vehicles available against a demand of 70,000 (Ajay, M. 2023)²². This gap is worsened by several challenges as follows:

Reefer Vehicle- Challenges

- i. **Cost Barriers:** Reefer trucks are more expensive to own and operate than regular trucks, and their higher costs often deter customers, particularly in the agricultural sector, where margins on perishable goods are low compared to pharmaceuticals.
- ii. **Underutilization:** The lack of return loads for reefer trucks further reduces profitability, as these vehicles often travel empty on return journeys. Smaller or inefficient vehicles used for cold chain transport result in higher per-unit costs, particularly when ferrying large quantities of perishables.
- iii. **Limited Investments:** Fleet owners are hesitant to invest in expanding their reefer truck fleets due to price competition, seasonal fluctuations in demand, high toll costs, and the added expense of managing specialized systems like cooling units.

- iv. **Inadequate Infrastructure:** Poor road connectivity and congestion further impede the efficient use of reefer trucks, particularly in rural and remote areas where agricultural produce originates.
- v. **High Transportation Costs:** The inefficiency of existing cold chain systems adds to operational expenses, making it harder for farmers and producers to access reliable logistics solutions.
- vi. **Reliance on Inefficient Vehicles:** The cold chain sector depends heavily on smaller vehicles, which are less efficient for transporting larger quantities of perishables. This reliance increases transportation costs and often leads to delays and product losses.
- vii. **Limited Infrastructure in Remote Areas:** Rural and interior regions, where much of India's perishable produce originates, lack adequate cold storage and transportation facilities. This gap in infrastructure is a major cause of post-harvest losses and food wastage.
- viii. **Temperature Control Challenges:** Ensuring that temperature-controlled vehicles maintain the desired range throughout transit remains a significant issue, directly affecting the quality and marketability of perishables.
- ix. **Need for Reforms and Investments:** The lack of private investments and policy support hampers the expansion of cold chain infrastructure. Simplified regulations and targeted incentives are essential to attract investment and enhance operational efficiency.

Despite growing demand for temperature-controlled transportation driven by India's expanding agricultural exports and domestic markets, these issues hinder the development of an efficient **cold-chain logistics system**.

4.2.4 Reefer Container Shortages

Indian exporters in the cold chain sector face **major challenges** in meeting export commitments, especially during peak seasons, due to a **severe shortage of refrigerated (reefer) containers**. Key issues include the following:

- i. **Limited availability of reefer container** in time-sensitive agricultural and seafood shipments.
- ii. **Extended turnaround times** further straining supply chains.
- iii. **Global disruptions**, such as the Red Sea crisis, causing vessel congestion and soaring freight rates.
- iv. **Impact on major ports** like Cochin and Visakhapatnam, with minimal seafood shipments in recent weeks.
- v. **Booking difficulties** for perishable cargo transport.

India's heavy reliance on reefer containers for agricultural and seafood exports has made the situation critical, jeopardizing schedules and market opportunities. Immediate measures to address container shortages and stabilize cold chain infrastructure are essential to safeguard export operations and leverage international markets effectively (Mathias, A., 2024).²³

4.2.5 Ripening Chambers

Out of a required **9,131 ripening chambers**, only **812 have been created**, leading to a **gap of 8,319 chambers**. This gap hampers the controlled ripening of fruits, which is critical for quality and market readiness.

4.3 Transportation and Logistics

4.3.1 Port and Air Cargo Handling

1. **Ports:** Inefficient cargo handling at major ports leads to delays and quality degradation of agricultural goods.
2. **Dependence on Foreign Carriers**
 - i. **90–95%** of India's export cargo is transported by foreign liners, leaving exporters vulnerable to rising freight costs and logistical uncertainties (Press Trust of India, 2024).
 - ii. Reliance on Chinese containers (India produces between 10,000 and 30,000 containers annually, while China, the global leader, produces around 2.5 to 3 million containers per year) makes India susceptible to global supply chain disruptions (Press Trust of India, 2024).
3. **High Freight Costs**
 - i. Shipping rates for 40-foot containers surged to USD 4,775 in 2024, compared to USD 1,420 pre-pandemic, inflating export costs.²⁴
 - ii. 25% of India's cargo is transhipped via hubs like Colombo and Singapore, further increasing costs and transit times.
4. **Port Congestion**

Long waiting times at ports add to delays and costs, reducing competitiveness (APEDA, 2024).²⁵

4.3.2 Air Transport

The export of agricultural produce via air in India is growing rapidly, with East Uttar Pradesh (UP) emerging as a key hub for fresh fruits, vegetables, and cereals. Between 2019 and 2023, the region saw a remarkable **420% growth** in exports, rising from 4 metric tons (MT) in 2020 to 561 MT in 2022–23. However, this impressive growth trajectory is being impeded by several significant challenges, particularly in transportation and infrastructure.

1. **Limited Freight Capacity**
 - i. For instance, the Lal Bahadur Shastri International (LBSI) Airport in Varanasi has a freight capacity of only **3–4 MT per day**, which is already fully utilized. With increasing production and export demand, the lack of additional capacity poses a serious bottleneck (Times of India, 2023).²⁶
 - ii. Only one international flight, bound for Sharjah, operates from the airport daily, offering direct connectivity to the Gulf. Exporters targeting markets like London or the EU must rely on transshipment via domestic flights to Delhi or Mumbai, increasing costs and delays.
2. **High Transportation Costs**

East UP is a landlocked region, and inland transportation costs from cities like Varanasi and Lucknow to ports in Mumbai are significantly higher than those from export-focused regions such as Nashik. This creates a competitive disadvantage for Farmer Producer Organizations (FPOs) and exporters in East UP.

3. **Insufficient Air Connectivity**

Many airlines have not obtained transshipment bonds for international cargo, restricting the number of carriers that can handle agricultural exports. While some airlines like Indigo and Air India Express have secured the required permissions, others, such as Air India and Vistara, still needs to undergo the permit processes.

4. **Inadequate Infrastructure for Horticultural Exports**

- i. Horticultural products, which are low in weight but high in volume, require significant cargo space. The limited capacity and infrequency of flights create logistical challenges, making it difficult to achieve the full potential of horticultural exports.
- ii. Despite the establishment of integrated pack houses, such as the one inaugurated in Varanasi, the lack of **tiered infrastructure for storage**, cold chain logistics, and efficient airport handling remains a critical hurdle.

5. **Challenges in Tier II and Tier III Cities**

- i. Export growth in the next 4-5 years is expected to come from Tier II and Tier III cities. However, these regions lack world-class airport infrastructure, regulatory systems, and sufficient cold chain facilities to support large-scale exports.
- ii. The absence of belly capacity deployment for agricultural cargo from airlines in these regions further limits their export potential.

6. **Supply Chain Inefficiencies**

- i. Significant gaps exist in the transportation, packaging, cold chain, and interim storage facilities required for agricultural exports. Producers in hinterlands face logistical challenges in getting their produce to major airports for export.
- ii. The long distances covered from production centres to export hubs result in delays and quality deterioration, reducing India's competitiveness in the global market.

4.3.3 Land Routes

India secured the 38th position out of 139 countries in the World Bank's *Logistics Performance Index Report (2023): Connecting to Compete 2023*. This marks an improvement of six spots compared to its 44th rank in 2018 and a significant rise of sixteen positions from 54th in 2014 (PIB, Ministry of Commerce & Industry, 2024).^{27 28}

1. **Congestion and inadequate connectivity:** National highways face frequent congestion, limiting their capacity to handle bulky and heavy goods. Inadequate connectivity adds to delays and inefficiencies. Poor connectivity between farms and highways, especially in remote states like Bihar, Jharkhand, and the Northeast, hinders efficient transport of goods to ports. Congested road networks and underdeveloped link roads increase delays and spoilage risks.
2. **Fleet Management:** Poor management of transport fleets exacerbates delivery delays.
3. **Logistics Costs:** High logistics costs further burden the supply chain and reduce competitiveness, adding to the cost of the commodity.
4. **Connectivity Issues in the Northeast**

The Northeast region holds immense potential for exporting exotic fruits and vegetables, due its location with the ASEAN countries. However, air cargo capacity alone is insufficient to move products efficiently. Enhanced connectivity through rail and road networks is essential for creating a seamless distribution chain. Currently, the lack of such linkages limits the export opportunities from this region.

4.3.4 Warehouse Infrastructure

The number of registered warehouses increased steadily from **240 in 2011-12 to 1,005 in 2019-20**, before declining sharply to **337 in 2020-21** and further increased to **610** in 2021-22 and **1522** in 2022-23.

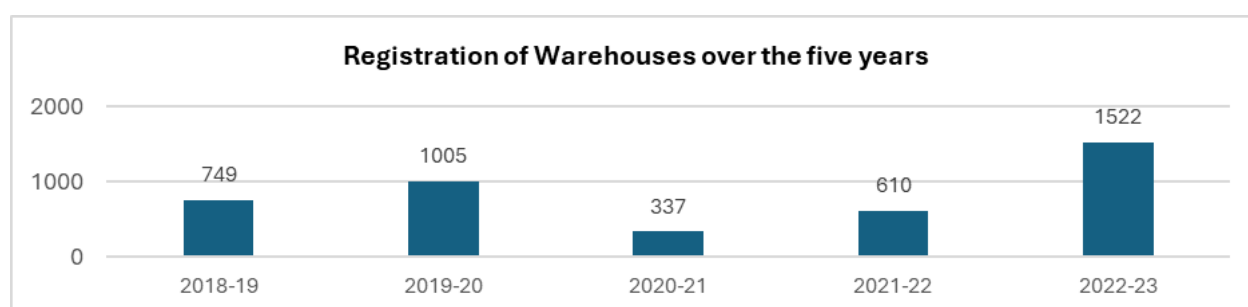
On average, WDRA has been registering 386 warehouses annually which increased to 610 warehouses in 2021-22. Several measures taken by WDRA helped in significant increase in the number of warehouses registered to 1522 in 2022-23. This is about 150% increase on YoY basis. The entity wise registration numbers are given below:

Table 8: Entity wise number of warehouses and capacity

Sl. No.	Type of Entity	No. of Warehouses	Capacity
1	Company	86	4.61
2	Individual	310	17.20
3	PACS	82	0.13
4	Partnership Firm	49	4.22
5	PSU	174	7.08
6	PSU-SWC	821	95.22
	Total	1522	128.46

Source: WDRA Annual Report, 2022-23 ²⁹

Figure 9: Registrations of Warehouses Over the Last Five Years (2018-23)



Issuance of negotiable warehouse receipts (NWRs/e-NWRs) peaked in **2019-20** with **1,38,637 issued** but saw fluctuations in subsequent years. Registration of warehouses registered during FY 2018-19 to 2022-23 is shown in Figure 9.

Source: Annual Reports of WDRA, 2022-23 ³⁰

Decline in Projects under Warehouse Infrastructure Fund (WIF)

Sanctioned projects under WIF have declined significantly:

- i. USD 125.95 Million sanctioned in 2020, reducing to zero in 2022.

- ii. Disbursements have also dropped from USD 100.4 Million in 2020 to USD 70.6 Million in 2022.

The declining investment in warehousing and infrastructure will gradually hinder the agricultural product export growth. The lack of new projects stifles the sector's potential for modernization.

Digitalization and Extension Services

Inadequate digital infrastructure limits the implementation of mandatory e-NWR systems introduced in 2017-18.

Lack of awareness among farmers regarding e-NWR benefits. Limited digital infrastructure in rural areas hampers widespread adoption of e-Negotiable Warehouse Receipts and real-time market access.

4.4 Challenges in Marine and Aquaculture Export Development

- i. **Dependence on Labor- Intensive Processes:** The seafood industry remains highly labour- intensive, facing a shortage of young workers willing to take up factory jobs. High housing and labour costs add to the problem.
- ii. **Unorganized farming practices** and the use of chemicals during pond cleaning hinder India's ability to produce organic seafood.
- iii. **Overfishing and Aquaculture Shift:** The transition from wild- caught marine products to aquaculture is driven by overfishing and restrictions, but it brings new challenges in quality and sustainability.

4.5 Challenges in Buffalo Meat Export Industry

- i. **Quality Issues:** India is price-competitive in the global market but faces quality challenges due to sourcing buffaloes from the dairy sector when they are no longer productive for farmers.
- ii. **Lack of Specialized Meat Production:** The absence of animals raised specifically for meat production reduces the quality and appeal of Indian buffalo meat.

4.6 Challenges in Millet Production and Export Expansion

- i. **Lack of Ecosystem Development:** Despite millets gaining attention due to their sustainability and nutritional value, there is no robust ecosystem to ensure production, processing, and product standardization.
- ii. **Underutilization of Export Potential:** Limited awareness and market development restrict the export of millet- based products to health- conscious international markets.

4.7 Barriers to Growth in Processed Food Exports

- i. **Non- Adherence to International Standards:** Indian processed food exports often fail to meet international certifications and quality benchmarks
- ii. **Lack of Customer-Centric Products:** Limited focus on developing export-market-specific and innovative products affects global competitiveness.

4.8 Challenges in Plantation Crop Export Business

- i. **Price Volatility:** Plantation businesses like coffee are heavily dependent on global commodity markets, leading to revenue instability.
- ii. **Limited Value Addition:** A focus on upstream plantation production without downstream value addition restricts profitability.
- iii. **Dependence on Single Crops:** Over- reliance on coffee plantations limits diversification and long-term sustainability.

Conclusion

In conclusion, addressing the significant infrastructure gaps in India's agricultural sector is crucial for enhancing its global competitiveness, particularly in exports. Investments in cold storage, pack-houses, refrigerated transport, and other critical elements of the cold chain are vital to reduce post-harvest losses and ensure the quality of perishable products, which is a key requirement for meeting international standards. By modernizing storage facilities and improving transportation logistics, India can unlock greater export potential, especially in high-demand markets. Furthermore, the adoption of advanced technologies, better regulatory frameworks, and targeted investments in rural infrastructure will improve supply chain efficiency and reduce costs. A robust cold chain infrastructure, coupled with improved warehousing systems, will not only reduce spoilage but also foster greater access to global markets, enabling India to become a leading player in the global agricultural export sector. Addressing these challenges through public-private partnerships and strategic policy reforms will ensure India's agricultural sector can realize its full potential in a rapidly growing global economy.

5. Big Ideas for Strengthening Agricultural Infrastructure and Exports in India

Achieving the target of USD 100 billion in agricultural exports by 2030 remains within India's reach, provided decisive and transformative measures are undertaken. Establishing an enabling ecosystem for Agri and Marine exports necessitates a cohesive inter-ministerial vision, a predictable and stable export policy framework, and significant investments in cold chain, storage, and logistics infrastructure.

This comprehensive research undertaken in the agricultural export strategies emphasized the importance of balancing economic growth with sustainable and inclusive practices. The paper explored the complexities of market dynamics, policy frameworks, and infrastructure needs, all of which play a crucial role in shaping a resilient agricultural sector. Identifying trade-offs, shifting mindsets, and defining actionable next steps emerged as essential components in aligning national policies with global market demands.

Firstly, the inherent trade-offs that require thorough evaluation were identified during the research. One critical aspect involved the balance between establishing large agricultural clusters while integrating small farmers. Some of the important issues that need urgent attention are – the implications of local price instability on global policies, emphasizing the need to account for local inflation dynamics and food supply factors when formulating export and import strategies. Furthermore, there is lack of clarity regarding price-to-quantity (P-Q) dynamics in achieving the \$100 billion export target. It remains uncertain whether this goal will be met through high-volume, lower-price exports or lower-volume, premium-price exports. Understanding these trade-offs is crucial for developing effective action plans.

Secondly, a significant shift in mindset is required. The transition from a food security and producer-first approach to an export-oriented, customer-first perspective is a deemed essential breakthrough, though challenging. Additionally, there are concerns regarding the disparity between export standards and domestic food standards, highlighting the need for uniform quality benchmarks. The balance between public and private sector roles, emphasizing the importance of private solutions for addressing market challenges rather than relying solely on government interventions will be crucial.

Finally, the next steps for CAIRA focusing on three key action areas were identified. The development of hard infrastructure, including cold chains and logistics, as a foundational requirement. Additionally, the importance of digital infrastructure—such as information systems, traceability mechanisms, and sustainability monitoring—to enhance agricultural planning and execution. Lastly, the necessity of integrating policy stakeholders and industry representatives to create a cohesive regulatory and operational framework as a critical factor in ensuring long-term success.

These considerations provide a structured pathway for further deliberation and action, guiding future efforts towards a more resilient and strategically aligned agricultural export framework.

5.1 Implement Strategic Interventions

- i. **Ensure Stable Policies and Develop Data Systems for Reliable Agricultural Export Growth:** Develop comprehensive, forward-looking policy frameworks to ensure stable export surpluses for key crops such as sugarcane, maize, wheat, and rice. Replace ad-hoc and reactive measures with consistent, predictable policies to build confidence among exporters and importers. Support these policies with robust and accurate data systems to enhance decision-making and foster resilience in the agricultural export sector. Exempt identified export clusters from export restrictions to encourage growth and reliability in international markets, positioning India as a trusted global exporter.
- ii. **Attract Private Sector Investment in Export Infrastructure and Scalable Solutions:** The Union Government should directly invest in agriculture infrastructure, especially that centered on exports. At the same time, encourage private sector investment in export infrastructure through tax benefits and subsidies. Foster private sector participation in logistics, storage, processing units, innovative, R&D and scalable solutions that reduce reliance on government interventions.
- iii. **Establish Cluster-Based Export-Oriented Agriculture and Integrate Farmers:** Adopt a cluster-first approach to align agricultural production priorities with global market demands while maintaining focus on domestic food security. Establish export-oriented value chain clusters tailored to specific crops (e.g., pomegranates, bananas, mangoes) that integrate logistics, R&D, testing laboratories, and closed-loop systems. These clusters should prioritize the inclusion of smallholder farmers by promoting Farmer-Producer Organizations (FPOs) or cooperatives, modelled after India's successful dairy sector.
- iv. FPOs will facilitate collective access to shared infrastructure, advanced technologies, cold storage facilities, and centralized quality control mechanisms, enhancing market competitiveness for smallholders. Policy frameworks must ensure equitable participation and benefit-sharing within agricultural clusters, preventing marginalization and fostering integration to build a robust, inclusive, and globally competitive agricultural ecosystem.
- v. **Promote High-Value Products and Develop a Strategic Export Plan for 25 Key Agricultural Commodities:** To maximize export revenue and competitiveness, India should transition from bulk exports of low-value commodities (e.g., sugar, rice) to high-value, niche agricultural products. This includes processed foods, organic produce, and exotic fresh fruits and vegetables, which align with evolving market demands and offer premium pricing potential. An action plan should target 25 key products with high export potential over the next five years, focusing on India's distinctive offerings like Kalanamak rice, Basmati rice, and exotic crops such as mangoes. By strategically aligning export volumes and values with market positioning, India can create premium market segments, enhance economic returns, and establish a stronger competitive edge in global trade.
- vi. **Strengthen Quality Standards for Domestic and Global Markets:** Enhance export competitiveness and market access by ensuring adherence to both international and domestic quality standards. Train farmers and producer organizations to comply with global certifications such as Global GAP and residue-free production practices, enabling access to high-demand markets like the EU and US. Focus on consumer trends toward organic and food-safe products by providing financial incentives and technical

assistance to support compliance. Simultaneously, enforce FSSAI quality assurance protocols within the domestic market to maintain consistent product quality. Align processed food products with internationally recognized certifications and standards to improve credibility and market accessibility. This integrated approach will boost consumer confidence, ensure seamless compliance with trade requirements, and solidify India's reputation as a reliable global supplier.

- vii. **Shift Logistics from Air to Sea Freight for Cost-Effective and Sustainable Exports:** Switching from air freight to sea freight offers significant advantages in terms of cost-effectiveness and environmental sustainability. Sea freight provides a more economical option for transporting large volumes of goods over long distances, reducing shipping costs per unit. Additionally, it has a lower carbon footprint compared to air freight, aligning with global efforts to minimize environmental impacts and promote sustainable supply chain practices.
- viii. **Develop State-Specific Export Strategies and Incentive Frameworks:** Formulate state-specific export action plans that align with overarching national export objectives. Design and implement targeted incentive mechanisms to promote the export of high-value and value-added processed products.
- ix. **Enhance Policies to Boost Processed Food Export Growth:** Strengthen policies to promote the export of processed food products, with a particular focus on categories such as dairy, starch-based goods, and frozen items. Harmonize regulatory frameworks to facilitate domestic production that meets international quality and compliance standards.
- x. **Adopt Sustainable and Climate-Resilient Agricultural Practices for Exports:** To address environmental and economic challenges in agricultural exports, adopt sustainable practices by prioritizing the diversification of crops with lower water requirements and promoting water-saving technologies to enhance water-use efficiency. This is particularly critical for reducing the ecological impact of exporting water-intensive crops like sugar and non-basmati rice. Simultaneously, focus on developing high-yielding, climate-resilient seed varieties to boost productivity and ensure adaptability to changing climatic conditions. Strengthening agricultural research by fostering collaboration between public and private sector stakeholders, enabling the integration of advanced technologies and innovative practices.
- xi. **Utilize Agricultural By-Products for Sustainable Value Creation:** Advocate for the adoption of a circular economy model by developing secondary products derived from agricultural by-products, such as utilizing peels, seeds, and fibers for energy generation, water purification, or organic fertilizer production. This approach fosters the efficient use of agricultural residues, contributing to resource recovery, waste reduction, and the promotion of sustainable agricultural practices.

5.2 Develop Transportation Strategies

- i. **Invest in Rural Infrastructure for Improved Farm-to-Market Connectivity:** Invest in the development and upgrading of all-season rural road networks to facilitate efficient and reliable transportation of agricultural produce, thereby improving the connectivity between rural farming areas and market centres. This initiative aims to reduce transit time, enhance supply chain efficiency, and mitigate weather-related disruptions to agricultural logistics.

- ii. **Enhance Internal Logistics for Cost Reduction in Northeast and Southeast Asia Trade Routes:** Enhance internal logistics systems to mitigate the elevated transportation costs associated with the movement of goods from remote regions, such as the Northeastern states of India, and along trade routes to Southeast Asia. This involves optimizing supply chain processes, leveraging technology, and identifying cost-effective modes of transportation to streamline operations and reduce logistical overhead.
- iii. **Implement GPS and IoT for Real-Time Produce Transport Monitoring:** Implement GPS-integrated vehicle tracking systems coupled with Internet of Things (IoT) solutions to enable continuous, real-time monitoring of agricultural produce throughout the transportation process. This approach ensures precise tracking and condition assessment during transit, optimizing logistics and ensuring product integrity.
- iv. **Establish Advanced Agri-Logistics Hubs and Terminal Market Infrastructure:** Establish integrated Agri-logistics hubs and terminal markets designed with state-of-the-art infrastructure, including advanced sorting, grading, and pre-cooling facilities, to enhance post-harvest management and streamline supply chain operations for agricultural products.
- v. **Develop Specialized Agri-Export and Freight Corridors:** Develop and implement specialized export and freight corridors tailored for agricultural and horticultural products, linking key production zones to ports, airports, and logistical hubs. These corridors should include dedicated road freight infrastructure designed to minimize transportation delays and reduce spoilage, ensuring efficient and timely export of produce.
- vi. **Modernize Fleet and Integrate Advanced Transportation Technologies:** Implement incentive programs to encourage fleet operators to integrate GPS-enabled vehicles within their fleets, enabling optimized route planning, enhanced operational efficiency, and minimized transit durations.

5.3 Develop Awareness, Capabilities and Technology Adoption

- i. **Establish Rural Training Infrastructure for Agricultural Productivity and Global Market Access:** Establish rural training centres to provide farmers with comprehensive education on post-harvest handling techniques, advanced storage methodologies, and cold chain management systems. Emphasize strategies to optimize productivity at the farm level, alongside improving sorting and grading protocols to ensure product consistency and quality.
- ii. **Integrate Digital Technologies for Supply Chain Optimization and Transparency:** To enhance supply chain efficiency and reduce post-harvest losses, integrate digital technologies such as blockchain, artificial intelligence (AI), Internet of Things (IoT) devices, and advanced data analytics tools. Implement blockchain and AI-driven solutions to optimize cold chain logistics, improving traceability, security, and operational transparency while ensuring real-time monitoring and data integrity across the supply network.
- iii. Additionally, develop technology-driven aggregation platforms that support crop diversification strategies and align with dynamic market demands, offering critical insights for decision-making. To accelerate the adoption of these technologies, provide targeted financial incentives for stakeholders to integrate advanced tools like blockchain, barcoding, and digital inventory management systems, which will streamline operations, enhance supply chain transparency, and improve overall efficiency.

- iv. **Assess and Bridge Cold Chain Infrastructure Gaps:** Undertake an assessment to identify current gaps in cold chain infrastructure and the corresponding requirements across specific districts and product categories. These studies should focus on evaluating the current state of cold chain systems, pinpointing deficiencies, and recommending tailored infrastructure enhancements to optimize the storage, transportation, and distribution of temperature-sensitive products.

5.4 Develop an Integrated Supply Chain and Cold Chain Infrastructure

- i. **Modernize Agricultural Markets through APMC Infrastructure Enhancement:** Modernization of Agricultural Produce Market Committees (APMCs) through infrastructure upgrades, including the implementation of digital auction platforms, state-of-the-art storage solutions, integrated cold chain systems, and optimized transportation networks, aimed at improving market operational efficiency and minimizing post-harvest losses.
- ii. **Develop Integrated Cold Chain and Agri-Logistics Solutions:** Develop a network of advanced cold chain logistics hubs near key agricultural production zones to optimize the transportation, storage, and distribution of perishable goods. Equip these hubs with modern sorting, grading, and pre-cooling facilities, alongside energy-efficient technologies such as photovoltaic solar systems and phase change materials (PCMs) to reduce costs and enhance sustainability.
- iii. Introduce portable cold storage systems for small-scale farmers and retrofit existing facilities with IoT-based real-time monitoring systems to track environmental parameters, optimize inventory management, and improve operational efficiency. Ensure precise temperature control throughout the cold chain to mitigate spoilage risks, enhance product quality, and improve supply chain reliability.
- iv. **Standardize Cold Chain Protocols for Export Compliance:** Establish standardized protocols for cold chain management, encompassing temperature control, handling procedures, and packaging specifications, to ensure alignment with international export compliance standards.
- v. **Expand Cold Storage Capacity in Underserved Regions:** Address Cold Storage Capacity Deficiency: Enhance cold storage infrastructure by establishing an additional 3.28 million tons of capacity in regions with limited storage facilities, thereby improving the supply chain and reducing post-harvest losses.

5.5 Development and Investment in Warehouse Infrastructure

- i. **Establish Advanced Scientific Warehousing for Post-Harvest Management:** Prioritize the establishment of state-of-the-art warehousing infrastructure equipped with climate-controlled environments to minimize post-harvest losses due to spoilage. Incorporate mechanized storage systems tailored for the efficient handling and preservation of agricultural commodities such as grains, pulses, and oilseeds.
- ii. **Expand Warehousing Infrastructure with Technology Integration:** Develop and expand modern, integrated warehousing facilities by increasing warehouse registration, implementing digital solutions such as IoT-enabled inventory management and warehouse receipt systems, and promoting private sector participation through Public-

Private Partnerships (PPP) to establish advanced storage solutions, particularly in high-production areas, for seamless and efficient supply chain management.

- iii. **Invest in Export-Oriented Warehousing Facilities:** Prioritize targeted capital allocation towards the development of advanced warehousing facilities and pack houses specifically tailored to meet the requirements of export-oriented clusters, ensuring compliance with international standards and optimizing supply chain efficiency.

5.6 Expand and Modernize Pack-House Infrastructure

- i. **Develop Pack-Houses in High-Production Areas for Efficient Handling:** Extensive Development of Pack-House Facilities: Establish a comprehensive network of pack-houses in high-yield regions to optimize the grading, sorting, and minimal processing of produce, ensuring efficiency and standardization in post-harvest handling.
- ii. **Standardize Pack-House Design and Implement Technological Advancements:** Implement automation within pack-houses by incorporating conveyor belt systems, advanced electronic sorting and grading machines, and precision-controlled temperature regulation units to enhance operational efficiency and maintain product quality.

5.7 Strengthen and Modernize Reefer Vehicle Infrastructure

- i. **Expand Reefer Vehicle Fleet with Financial Incentives:** Implement financial incentives, including subsidies and access to financing, to stimulate private sector investment in refrigerated vehicle acquisition, with the objective of addressing the current fleet capacity shortfall.
- ii. **Develop a Centralized Digital Reefer Vehicle Booking System:** Design and implement a digital platform that facilitates the centralized reservation of reefer vehicles, aimed at minimizing visibility gaps within logistics planning and optimizing resource allocation for temperature-sensitive cargo transportation. This system will enable real-time tracking, improve operational efficiency, and enhance coordination across the logistics network.
- iii. **Promote Energy-Efficient Refrigerated Transport Solutions:** Promote the adoption of hybrid or electric refrigerated vehicles to optimize operational efficiency by lowering fuel consumption and reducing carbon emissions associated with refrigeration transport. Implementing these energy-efficient alternatives will significantly contribute to sustainability goals and operational cost reduction in the logistics and cold-chain sectors.

5.8 Strengthen and Optimize Reefer Container Infrastructure for Agricultural and Seafood Exports

- i. **Scale Domestic Reefer Container Manufacturing Capacity:** Establish and scale domestic production infrastructure for refrigerated containers (reefer containers) to mitigate reliance on imports and strengthen self-sufficiency in the national supply chain.

- ii. **Optimize Port Operations for Reefer Container Efficiency:** Enhance operational efficiency at ports by implementing streamlined processes and advanced logistics solutions to minimize the turnaround time for reefer containers.
- iii. **Develop Dedicated Cold-Chain Export Hubs for Agriculture and Seafood:** Develop and operationalize specialized export cold-chain hubs at key maritime ports to facilitate the efficient handling, storage, and transportation of agricultural and seafood products, ensuring optimal temperature-controlled logistics to maintain product quality and meet international export standards.

5.9 Development and Invest in Warehouse Infrastructure

- i. **Establish Advanced Scientific Warehousing for Post-Harvest Management:** Develop and establish advanced ripening chambers equipped with energy-efficient technologies and eco-friendly ripening agents, such as ethylene, to enable precise and controlled ripening processes while minimizing environmental impact.
- ii. **Expand Warehousing Infrastructure with Technology Integration:** Prioritize the development of modern ripening chamber facilities in major fruit-producing regions to enhance post-harvest management, minimize losses, and ensure the availability of quality produce.

5.10 Enhance Transportation and Logistics Efficiency

5.10.1 Upgrade Port and Air Cargo Handling

- i. **Modernize Port Infrastructure with Specialized Cargo Handling:** Upgrade major ports with advanced cargo-handling systems to reduce vessel turnaround times and enhance operational efficiency. Develop specialized infrastructure, including cold storage facilities and refrigerated ports, to handle perishable commodities. Establish dedicated terminals tailored for specific cargo types to optimize capacity utilization, ensure product integrity, and improve overall throughput across the supply chain.
- ii. **Strengthen Domestic Container Manufacturing for Reduced Import Dependency:** Allocate and promote investments to scale up the manufacturing capabilities for refrigerated containers, with a strategic focus on diminishing the reliance on Chinese imports. This initiative aims to bolster local production, ensuring greater supply chain resilience and self-sufficiency in the refrigerated container sector.

5.10.2 Expand Air Transport for Agricultural Exports

- i. **Augment Air Cargo Capacity for Agricultural Exports:** Augment freight handling capabilities at strategic airports, such as Varanasi, to bolster the export of agricultural products, with a specific focus on increasing support for the agricultural sector in Eastern Uttar Pradesh.

- ii. **Increase International Air Connectivity for Cargo Operations:** Implement strategic incentives for airlines to augment international cargo flight operations, while facilitating the establishment of transshipment bond arrangements to streamline logistics and enhance cargo throughput.
- iii. **Facilitate Horticultural Exports with Temperature-Controlled Infrastructure:** Implement temperature-regulated storage systems and establish specialized handling infrastructure at airports to support the efficient management and transport of high-volume, low-weight horticultural exports, ensuring optimal preservation and minimizing spoilage during transit.

5.11 Technological Advancement in Seafood Processing and Aquaculture

- i. **Automate Seafood Processing:** Allocate capital investment by the Government towards the establishment of automated seafood processing facilities, aimed at decreasing reliance on manual labour and optimizing operational efficiency. Formulate policies which will attract private investment in such infrastructure.
- ii. **Promote Sustainable Aquaculture Practices:** Focus on the development of eco-friendly, chemical-free aquaculture systems to cater to high-value organic and premium seafood segments, such as the U.S. market.

5.12 Strengthening Specialized Meat Supply Chains and Quality Enhancement

- i. **Develop Specialized Meat Production Supply Chains:** Develop dedicated supply chains for the exclusive purpose of raising buffaloes for meat production, distinct from the dairy sector, to optimize operational efficiency and production quality. Stop harassment by criminal elements during transportation of animals and meat. Ensure that halal certification is provided by credible agencies. Stop demonization of such certification in the domestic market also. Municipal slaughterhouses also need to be modernized to improve the supply chain of meat and scientifically handling the by-products.
- ii. **Enhance Quality Assurance and Capacity Building Initiatives:** Introduce comprehensive training programs and capacity-building frameworks aimed at equipping farmers and meat processors with the skills and knowledge required to adhere to international standards and best practices in meat production.

5.13 Build a Comprehensive Ecosystem for Millet

- i. **Develop Robust Millet Ecosystem:** Invest in the development of advanced processing facilities, implementation of product standardization protocols, and the establishment of dedicated research and development (R&D) initiatives to foster a sustainable and scalable millet production ecosystem.

- ii. **Implement Strategic Dual Market Approach:** Facilitate the promotion of millets as an important solution for addressing domestic nutritional challenges while simultaneously positioning the product for export markets targeting health-conscious consumer segments.

5.14 Improve Export Competitiveness in Processed Food

- i. **Drive Market-Driven Product Innovation:** Customize products to meet the specific demands of targeted export markets, while investing in advanced packaging solutions, brand development, and continuous product innovation to strengthen global competitive positioning.

5.15 Expand Market and Value Creation including Plantation Crops

- i. **Foster Value Addition and Diversification:** Foster investment in downstream activities, including value-added processing and brand development. Promote the integration of high-value crops such as pepper and avocados to diversify agricultural output.
- ii. **Implement Global Certifications:** Implement internationally recognized certifications, such as Rainforest Alliance, to enhance market access, improve product credibility, and strengthen customer confidence.
- iii. **Explore Allied Ventures:** Investigate and pursue synergistic business opportunities, such as plantation-based tourism and hospitality, to expand revenue channels and reduce dependency on traditional agricultural outputs.

Conclusion

Strengthening agricultural infrastructure for exports requires a multifaceted approach that addresses the critical bottlenecks in storage, transportation, technology adoption, and supply chain management. The challenges mentioned above will have to be addressed if the target of 100 billion USD of exports has to be achieved.

Endnotes

- 1 PIB and Economic Survey 2023-24
- 2 <https://agriinfra.dac.gov.in/Content/DocAttachment/FINALSchemeGuidelinesAIF.pdf>
- 3 Agriculture and Allied Industries, India Brand Equity Foundation (IBEF), Feb 2020, available at <https://www.cgidubai.gov.in/docs/1588497427Agriculture-and-Allied-Industries-February-2020.pdf>
- 4 <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1909213> and <https://pib.gov.in/PressReleasePage.aspx?PRID=2034943>
- 5 <https://economictimes.indiatimes.com/news/economy/agriculture/share-of-agriculture-in-indias-gdp-declined-to-15-in-fy23-govt/articleshow/106124466.cms>
- 6 <https://igrownnews.com/agriculture-in-india-a-comprehensive-outlook/>
- 7 <https://pib.gov.in/Pressreleaseshare.px?PRID=1725891>
- 8 <https://pib.gov.in/PressReleaselframePage.aspx?PRID=2085256#:~:text=During%20the%20financial%20year%202023,gaps%20in%20the%20value%20chain.>
- 9 https://mpeda.gov.in/wp-content/uploads/2024/06/Export-performance_2023-24-approved_V5.pdf
- 10 Article on Agriculture | Siraj Hussain: Diversify the food export basket, India Today, Aug 26, 2024 available at <https://www.indiatoday.in/magazine/cover-story/story/20240826-agriculture-siraj-hussain-diversify-the-food-export-basket-2583202-2024-08-18>
- 11 PIB: <https://pib.gov.in/PressReleaselframePage.aspx?PRID=2003094> and Invest India portal: <https://www.investindia.gov.in/sector/food-processing>
- 12 <https://pib.gov.in/PressReleaselframePage.aspx?PRID=2003092>
- 13 Article: Form Local to Global: Empowering India's Food Processing Industry, India Business and Trade, 31st July 2023
- 14 India Briefing Article: India's Food Processing Industry Sees Over INR 70 billion in Investments Under PLI Scheme
December 13, 2023 available at <https://www.india-briefing.com/news/indias-food-processing-industry-sees-over-inr-70-billion-in-investments-under-pli-scheme-30535.html/#:~:text=India's%20agricultural%20and%20processed%20food,allied%20sectors%20attended%20the%20event.>
- 15 https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf

- 16 https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf
- 17 <https://www.eea.europa.eu/publications/rail-and-waterborne-transport#:~:text=A%20new%20study%20commissioned%20by,basis%20would%20support%20these%20efforts.>
- 18 <https://www.nabard.org/auth/writereaddata/tender/1201243818assessing-the-state-of-affairs-inindian-agriculture-with-a-focus-on-credit-insurance-and-storage-marketing.pdf>
- 19 CTOct23.pdf
- 20 <https://pib.gov.in/PressReleasePage.aspx?PRID=1658114>
- 21 <https://pib.gov.in/PressReleasePage.aspx?PRID=1658114>
- 22 Article on Making perishable logistics better
- 23 Shortage of reefer boxes plays havoc with India's export schedules - The Loadstar
- 24 26 & Increasing freight costs, container shortages threaten exports: GTRI | News - Business Standard
- 25 https://apeda.gov.in/apedawebsite/Announcements/APEDA_REPORT_22_Sep_16.pdf
- 26 Limited Int'l Flights Major Challenge for Agri Exporters In East Up: APEDA | Varanasi News - Times of India
- 27 <https://pib.gov.in/PressReleasePage.aspx?PRID=2003541#:~:text=According%20to%20the%20World%20Bank's,-from%2044%20in%202018%20andsixteenplacesfrom54in2014.>
- 28 https://lpi.worldbank.org/sites/default/files/2023-04/LPI_2023_report_with_layout.pdf
- 29 <https://wdra.gov.in/documents/20143/139675979/WDRA+Annual+Report+2022-23+English.pdf/dba669a3-d2d2-fae6-b2bb-83c59c50f6d7>
- 30 <https://wdra.gov.in/web/wdra/annual-reports>

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