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Refrigerated Transportation and Cold-chain Logistics in India – Current Status and Future Prospects

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ABSTRACT

Reefer transportation has become an integral part of supply chain management for the shipment of temperature-sensitive goods. In a country as large and geographically diverse as India, refrigerated road transport is crucial for the safe circulation of fresh and frozen perishables. The need for reliable and efficient cooling technology for urban deliveries increases rapidly. In India, reefer transportation is mainly used to ship milk and dairy products. In addition to refrigeration transport, cold storage facilities are essential for storing perishable products, such as dairy and meat products, fruits and vegetables, medicines, and pharmaceutical products. Currently, Indian cold storage industries are at their nascent stage. A great deal of potential is available for the cold storage infrastructure in India, as a significant increase in the food market is expected in the next five years. This article discusses statistics on refrigeration transport, its various types, and their share in the Indian refrigeration transport market. Furthermore, available cold chain storage facilities, based on number and capacities in major states of India, are discussed. The benefits of cold storage, challenges in the installation of cold storage, and strategies to overcome them are presented in this paper.
Keywords: Refrigerated Transport, Cold storage, Cold Chain Logistics, Perishable Products

INTRODUCTION

Refrigerated transportation (reefer container) allows perishable products needing temperature-controlled transportation to be moved from their farm/store to consumers quicker and more efficiently. It has become an integral part of supply chain management for the shipment of perishable products. It keeps products from deteriorating and getting wasted during transport. In a geographically diverse country like India, refrigerated transport is crucial for the safe circulation of fresh and frozen perishables. The need for reliable and efficient cooling technology for urban deliveries increases rapidly. However, the lack of logistical support, cost structure, and regulations are key challenges for reefer transportation.

Mainly agriculture and pharma industries use refrigerated transportation. It is estimated that about 104 million metric tons of perishable products are transported between cities in India annually. In India, around 80% of the reefer transportation is used for milk and dairy products. Products such as processed foods, pharmaceuticals, flowers, ice creams, fruits, and vegetables are now being transported in refrigerated trucks, which add to product quality and shelf life. Refrigerated trucks are primarily equipped with a mechanical refrigeration system containing dry ice, which is inefficient and leads to a waste of approximately $15 billion.

Refrigerated Transport Market in the Indian Perspectives

Indian refrigerated transport market was $3.70 billion in 2021 and is expected to reach $6.17 billion by 2028 with a compound annual growth rate (CAGR) of 7.63% over the forecast period. According to National Investment Promotion & Facilitation Agency (NIPFA), logistics and transportation account for a share of 15% of India's GDP. Strong market growth has been mainly due to the growing food industry

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and the improvement of the transport infrastructure in India. Perishable products, such as vegetables, fruits, meat, and sausages, are transported by trucks. These vehicles have an insulated, refrigerated superstructure to maintain coolness and the quality of the goods being transported. Refrigeration units installed in vehicles or refrigerated vehicles need constant maintenance and repair to remain operational, which comes at a cost. Thus, the high repair and maintenance costs of refrigerated vehicles are expected to hinder the market growth. Constantly evolving refrigeration technologies for transport offer new growth opportunities.

An overview of the Indian refrigerated transport market in 2022 and for the forecast period is provided in Table 1, which is subcategorized based on various parameters.

Table 1: An overview of Indian refrigeration transport market: current (2022) and for the forecast period (2028)

Parameter	2021	2028
India Refrigerated Transport Market	Value: USD 3.70 Billion	Value: USD 6.17 Billion
CAGR (2022 – 2028)	Value: 7.63%	
by Application ($ bn)	Chilled Food Products: 2.02 Frozen Food Products: 1.68	Chilled Food Products: 3.47 Frozen Food Products: 2.70
by Transport ($ bn)	Refrigerated Road Transport: 1.32 Refrigerated Sea Transport: 0.68 Refrigerated Rail Transport: 0.94 Refrigerated Air Transport: 0.77	Refrigerated Road Transport: 2.30 Refrigerated Sea Transport: 1.04 Refrigerated Rail Transport: 1.57 Refrigerated Air Transport: 1.26
by Technology ($ bn)	Vapor Compression Systems: 0.75 Air-blown Evaporators: 1.78 Eutectic Devices: 1.18	Vapor Compression Systems: 1.19 Air-blown Evaporators: 2.93 Eutectic Devices: 2.05
by Temperature ($ bn)	Single temperature: 1.09 Multi-temperature: 2.62	Single temperature: 1.72 Multi-temperature: 4.44

2.1. India Refrigerated Transport Market by Transport

The Indian refrigerated transport market is classified into refrigerated transport by road, sea, rail, and air, based on transport. The refrigerated road transport segment holds the largest market share in the Indian refrigerated transport market, as shown in Figure 1.

The revenue generated by the refrigerated road transport segment was $1.32 billion in 2021 and is projected to reach $2.30 billion in 2028, with a CAGR of 8.31%. The demand for refrigerated road transport is high because road transportation provides door-to-door service, rapid speed, short-distance delivery, and services in rural areas, reducing costs and improving flexibility. The current state of logistics in the food and beverage sector is highly skewed toward refrigerated road transport. The development of road infrastructure and the consequent improvement in delivery time performance and less damage in transit are the main reasons for the high growth of refrigerated road transport.

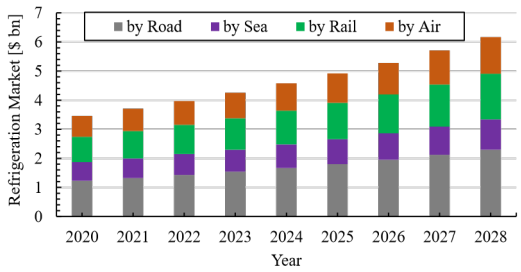

Figure 1: India refrigerated transport marker by temperature (revenue % share)

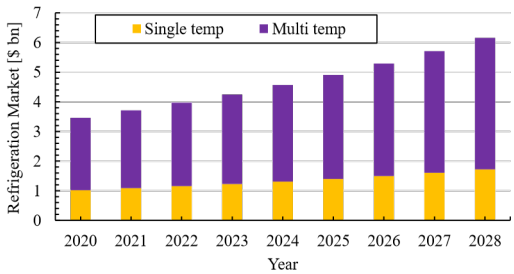

Figure 2: India refrigerated transport market by transport, 2021–2028 (revenue % share)

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2.2. India Refrigerated Transport Market by Temperature

According to the temperature requirements, the Indian refrigerated transport market is divided into single-temperature and multi-temperature. Among these, multitemperature refrigerated transport is expected to grow at a faster CAGR during the forecast period due to the increased utilization (refer to Figure 2).

The multi-temperature segment shared 70.84% of the market value in 2022. It is expected to increase to 72.04% in 2028, with a CAGR of 7.93%. Multi-evaporator refrigeration systems are used for cooling and heating purposes at the same time in different zones of the containers. These systems have a thermal accumulator in the first zone (Kopecka et al. (2015)). It includes a phase change material to absorb thermal energy from one zone in the interior space while transforming to a second zone. Factors such as fuel savings, low noise level, and superior temperature control ability are expected to enhance the segment's growth. It can control the temperature of the two parts separately; thus, frozen and fresh products are efficiently transported together. This characteristic of multi-temperature sectors makes the system more reasonable and precise in refrigerated transport. Furthermore, India's rapidly developing pharmaceutical and food industry will increase its share of multi-temperature refrigerated transport.

2.3 India Refrigerated Transport Market by Technology

Based on technology, the Indian refrigerated transport market is classified as Vapor compression systems, Air-blown evaporators (ABE), and Eutectic devices. Due to the increased utilization, the eutectic devices segment is growing at a higher CAGR during the forecast period, as presented in Figure 3.

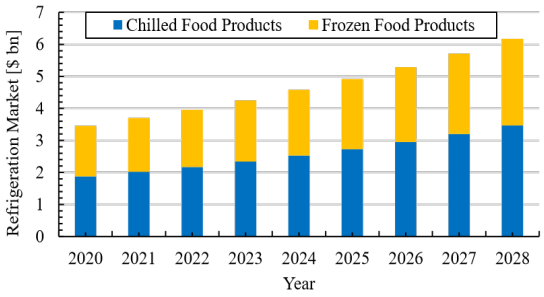

Figure 3: India refrigerated transport marker by application (revenue % share)

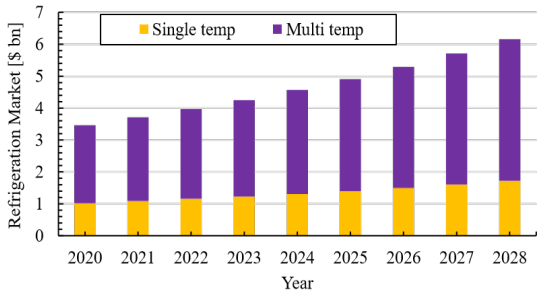

Figure 4: India refrigerated transport market by technology, 2021–2028 (revenue % share)

Air-blown evaporators generated revenue of $1.78 billion in 2022 (approximately 48% of the market share). It is projected to increase to $2.93 billion in 2028, with a CAGR of 7.47%. It works by coupling the evaporation power to cool the temperatures inside the vehicles. In the Air-blown evaporators, a fresh air is passed through the evaporator coils of the refrigeration system, where the evaporator takes the heat from the air and cools down the air temperature between 2 – 10°C. The cold air directed into the vehicle cabin. The major factors influencing the segment's growth are energy-efficient, climate control, and cost efficiency.

The eutectic devices segment accounts for about 32% of the market share in 2022, which is expected to grow at a CAGR of 8.36% until 2028. A eutectic device is installed inside a reefer container or truck to transport the products. A cryogen is provided to a circuit of the device, which is connected to a transport unit. Then the cryogen is circulated through the circuit, exchanging heat from the eutectic. The cryogen is frozen by the eutectic medium, which is used to cool a cargo space. A comparison of air-blown evaporators and eutectic devices is mentioned in Table 2.

2.4 India Refrigerated Transport Market by Application

The Indian refrigerated transport market is classified into chilled and frozen food products according to application. Among the two, the chilled food products segment shares the most significant market revenue in the Indian refrigerated transport market, as displayed in Figure 4.

The revenue from the chilled food products segment was $2.02 billion in 2021. It is projected to reach $3.47 billion in 2028, growing with a CAGR of 8.12%. The typical temperature for chilled food storage is below 5◦C. Fruit and vegetables, meat, and dairy products fall into the chilled foods category. A complicated product range, such as ready meals, is included in this large category, and each component

has unique qualities that influence consumer demand. The market for chilled meals is substantial and expanding rapidly due to the wide variety of food types it offers.

Table 2: A comparison of Air-blown evaporators and eutectic devices for refrigerated transport.

Eutectic Refrigeration System	Air-blown Refrigeration System
Zero-emission	High carbon emissions
Zero-noise operation	High level of noise
Low operating cost	High operating cost
No fuel or energy is required for refrigeration during delivery	Runs on the vehicle engine or auxiliary engine
No connection to vehicle engine	Runs on vehicle engine or auxiliary engine
Maintenance-free	High maintenance
Skilled labor not required for maintenance	Skilled labor required for maintenance
Merchandise is preserved in case of vehicle failure	Vehicle failure may cause product safety issues

COLD STORAGE AND COLD-CHAIN LOGISTICS

The Indian agriculture sector moved from conventional agriculture in the 1950s to a highly capital-intensive sector that transformed Indian agriculture from a food grain deficient economy to a food grain surplus economy. Nowadays, the Indian agriculture sector is not restricted to crops but has expanded to horticulture, medicine, and other allied activities. Agriculture plays a crucial role in the Indian economy, as approximately 60% of the Indian land area (157.35 million hectares) is agricultural land. As per published reports (Baruah and Handique (2016)), over 58% of rural households depend on agriculture as their primary source of livelihood. The share of agriculture and allied market, including fisheries and forestry, is estimated to be 20.4% of the gross value added (GVA) during 2016-17. India is a leading producer of a variety of agricultural products.

The research focus in this sector has now shifted to maximizing returns to the farmers by improving resource use and input management and providing easy and affordable access to the large population. In the past 30 years, approximately 95% of research studies have been focused on increasing productivity. While only 5% are directed toward reducing losses (Kader (2005)). Efficient management in the post-harvest stage is necessary to maximize farmers' returns and ensure food security. The Food and Agriculture Organization (FAO) of the United Nations has estimated that about 1.3 billion tons of food are globally wasted annually (Gustavsson et al. (2011)). Food losses are not only a threat to human consumption and farmers' income but can also adversely affect the environment. Food losses are estimated to generate 6-10% of greenhouse gas emissions (Gustavsson et al. (2011)) due to methane gas production during waste food decomposition (Planning Commission (2012)). Therefore, global food loss and waste produce 4.4 billion tons of CO2e emissions per year (Singhal and Saksena (2017)).

A cold chain is a temperature-controlled supply chain of cold storage and transportation (refer to Figure 5), where agricultural products are preserved fresh, and shelf life is extended for a long period. With a significant increase in food demand and changing lifestyles, the cold chain has become the focal point for the government and investors. The required temperatures of various food items are mentioned in Table 3. Table 4 shows the shelf lives of different food items at their optimum temperature and elevated temperature of 10°C and 30°C from their optimum temperature. The table indicates that an increase in store temperature may significantly reduce the shelf life of these food items. Therefore, it is essential to maintain the store temperature according to the optimum temperature.

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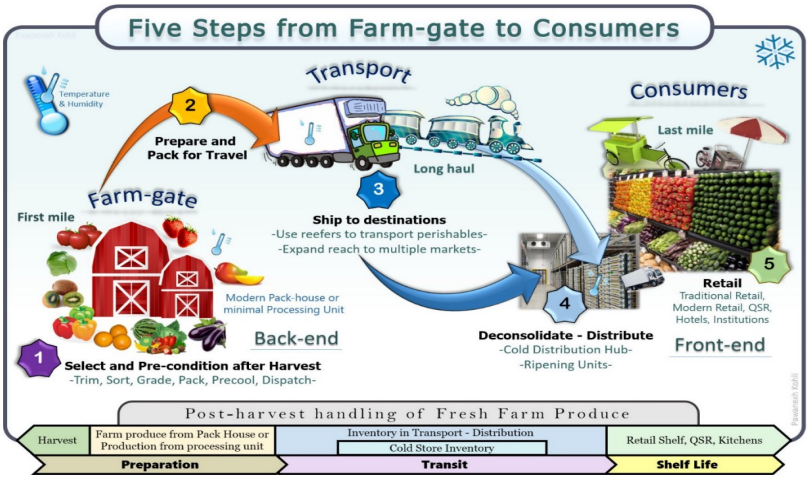

Figure 5: Various steps involved in supplying products to retail customers from farm produce. Source: National Cold Chain Development (NCCD)

Indian cold chain is still in a developing stage. India produces many perishables and dairy products, but the cold chain potential remains limited. Possible reasons are the high share of cold storage for single commodities, the high initial investment, lack of basic infrastructure, such as roads, water and power supply, and drainage, and lack of awareness of handling perishable products. A significant loss, ranging from Rs 52,000 to Rs 95,000 crores per year from the agriculture sector, occurs due to the fledgling cold supply chain (Jani (2020)). The inadequate cold chain infrastructure hampers India's food exports as well. Many countries have stringent guidelines for the import of agricultural and processed food products.

Table 3: Optimum temperature of various food products to store for maximum shelf life.

Temp (°C)	Example
Frozen (-18)	Ice cream, frozen meats (fish, poultry, livestock), frozen ingredients, some frozen processed commodities.
Chilled (0-10)	Fresh fruits & vegetables, fresh meats, milk, butter, confectionery, some pharmaceuticals
Mild Chilled (10-20)	Fresh fruits & vegetables, chocolates, and seeds and some milk products
Normal (20)	Whole onion, dehydrated foods, pickles, jams, and oils and extracts

Table 4: Shelf life of different food items at their optimum and elevated temperatures.

Food product	At opt cold temp	opt temp + 10°C	Opt temp + 30°C
Fresh fish	10 days, 0°C	4-5 days, 10°C	few hours, 30°C
Milk	2 weeks, 0°C	7 days, 10°C	few hours, 30°C
vegetables	1 months, 0°C	2 weeks, 10°C	< 2 days, 30°C
Potatoes	5 - 6 months, 4-12°C	< 2 months, 22°C	< 2 weeks, 42°C
Mangoes	2-3 weeks, 13°C	1 weeks, 23°C	2 days, 43°C
Apples	3-6 months, -1°C	2 months, 10°C	few weeks, 30°C

3.1. Benefits of the cold chain supply

- Better product quality in terms of nutritional value, color, and texture.

- No bacteria forms due to proper cold storage conditions.
- Longer storage of product/extension of Shelf life.
- Development of the packaging industry.
- Better handling and hygiene practices.
- Inventory management and automation.
- The growth of the refrigerated transport industry.

A significant amount of food losses has been reported in India according to World Food India, 2017, as tabulated in Table 5 due to a lack of cold storage facilities. Table 6 indicates about a 90% gap between the required and currently operating cold storage facilities in India. Therefore, enormous potential is available for investment in cold chain logistics.

Table 5: Estimated food losses in different types of food products

Food Type	estimated losses
Fruits and vegetables	4.6 to 15.9%
Inland fish	5.2%
Marine fish	10.5%
Meat	2.7%
Poultry meat	6.7%

Table 6: The available and required cold storage facilities across India. Source: NCCD

Cold-chain Component	Required (MT)	Created (MT)	Gap
Pack-house	11,21,274	3,984	97%
Cold house (Bulk)	3,41,64,411	3,18,23,700	9%
Cold House (Hub)	9,36,251		
Reefer Transport	4,94,608	72,000	85%
Ripping Chamber	91,306	8,120	91%

A great deal of interest has focused on building infrastructure for warehousing and cold stores to extend the shelf life of horticultural and perishable products. Although significant efforts have been made to develop cold chain infrastructure, it is still at a nascent stage. Reports on the post-harvesting sector and its allies to economic development emphasize the importance and cost-effectiveness of cold chain management (Kader (2005), International (2009)). Currently, the Mission for Integrated Development for Horticulture (MIDH) of the agriculture ministry and Pradhan Mantri Krishi Sampada Yojana (PMKSY) from the Ministry of Food Processing Industries are two prime schemes that provide financial assistance to set up cold storage facilities in the country (Chakraborty (2020)). MIDH assisted a total of 1104 cold storage facilities with a combined capacity of 48.34 lakh MT from 2014-15. At the same time, 208 cold chain and value-addition infrastructure facilities with a capacity of 5.3 lakh tons have been built under PMKSY till 2019. In addition, investment in the cold chain in India is also opened under the automatic route for 100% FDI participation.

Even with an increased number of cold storage facilities in India in the recent past, cold storage still needs to be improved as compared to the requirement, as mentioned in Table 6. India's annual production of fruits and vegetables is approximately 300 million tonnes, representing 18% of the total agricultural output, which is still rising gradually. The shortage of cold storage and cold-chain facilities is the major bottleneck in increasing agricultural production. The current cold storage facilities are mainly for a single commodity like potatoes, oranges, apples, grapes, pomegranates, and flowers, which results in poor capacity utilization. Of the 7645 cold storage in India, 68% of the capacity is used for potatoes. Only about 38% of cold storage facilities are multicommodity. The distribution of cold storage has also been highly skewed, as mentioned in Table 7. The top seven states (Uttar Pradesh, Gujarat, Punjab, Maharashtra, West Bengal, Andhra Pradesh, and Haryana) hold almost 73% of the cold storage in the country.

3.2. Market Share

Indian cold chain market is expected to increase with a CAGR of approximately 14% during the forecast period of 2020-2025 mar (2020). The main factor of the increasing cold chain market is the substantial growth in processed food, medical and pharmaceutical products, horticulture, and the high demand for

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dairy and meat products. The Indian cold chain market consists of a large number of small players. The dairy sector has the most developed cold chain among product categories. More than half of all cold storage capacities are devoted to potatoes. Therefore, a shift towards multipurpose storage and value-added services covering end-to-end requirements is required.

Table 7: Number of cold storage and required refrigerating capacities for the major states of India along with their % share. Source: Press Bureau of India A. F. W. (2020).

State	Cold Storage	% Share	Capacity (MT)	% Share
UP	2,406	29.4%	1,47,14,235	39.3%
GJ	969	11.8%	38,22,112	10.2%
PB	697	8.5%	23,15,096	6.2%
MH	619	7.6%	10,09,693	2.7%
WB	514	6.3%	59,47,311	15.9%
AP & TS	405	4.9%	15,67,664	4.2%
HR	359	4.4%	8,19,809	2.2%
BR	311	3.8%	14,79,122	4.0%
MP	302	3.7%	12,93,574	3.5%
KA	223	2.7%	6,76,832	1.8%
KL	199	2.4%	81,705	0.2%
TN	183	2.2%	3,82,683	1.0%
RJ	180	2.2%	6,11,831	1.6%
OD	179	2.2%	5,72,966	1.5%
Others	640	7.8%	21,30,464	5.7%

3.3. Challenges to cold chain supply

The key challenges to the growth of this sector are:

Sensitive links in the food chain: It has been proven that temperature fluctuations significantly affect the entire cold chain. Temperature control problems during refrigerated food at the retailer typically occur due to a lack of compliance with the temperature specifications for refrigerated foods.

Cost of energy consumption: The expected cost of cold storage per cubic foot is approximately INR 80 – 90 in India, which is about INR 40 in western countries Gubba (2021). Energy expenses account for nearly 30% of the total expenses for cold storage industries in India compared to 10% in the western countries. These factors hinder the installation of cold storage.

lack of logistical support: Indian cold chain industry is fragmented and requires heavy investment in building technology-enabled cold chain management that can cover the entire process from procurement to transportation in refrigerated trucks to retail customers.

Uneven distribution of capacity: A majority of cold storage facilities in India have been set up in Uttar Pradesh, Maharashtra, Gujarat, Punjab, West Bengal, and Uttarakhand. Furthermore, most of these facilities can only be used for a single commodity, which is a major bottleneck.

Apart from these challenges, a few other barriers that are observed in various studies are: (1) High capital costs of renewable projects; (2) outdated technology; (3) poor cold chain network; (4) lack of skilled manpower; (5) poor cold storage Infrastructure; (6) cold chain sterilization with chemicals; (7) lack of reverse logistics; (8) non-recyclable packaging; (9) lack of government support.

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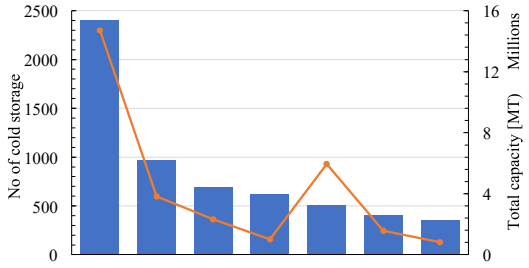

Figure 6: State wise distribution of Cold Storage in India as on 31.08.2020 A. F. W. (2020).

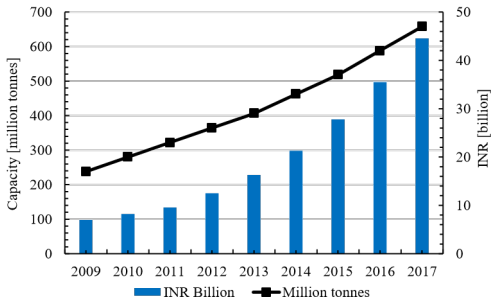

Figure 7: Indian cold storage market in terms of investment and capacities. Source: NCCD

3.4. Strategies to overcome the challenges faced by cold chain supply

- One strategy could be to ease import rules for cold-chain equipment, including refrigerated vans.
- Developing Former Producer Organizations (FPOs) and FIGs and enabling them to develop direct market links. Developing improved business models by promoting producer-owned supply chains.
- Amendments to Agricultural produce market committees (APMC) aimed at enabling direct market-driven supply chains and opening options through alternate market channels.
- Continue extant grants and subsidy schemes for cold-chain infrastructure development and extend the schemes to include the logistics and transport sectors. Develop multi-model cold-chain links through rail and highways; aimed at a fast-track green corridor for perishables.

According to the Food and Agricultural Organization (FAO), food production and availability are expected to increase by 45% by 2030, as shown in Figure 7 Jani (2020). Therefore, exploring every possible means of achieving progress is vital, particularly the reduction of post-harvest losses. The loss of perishable foods is a crucial factor in most developing countries. Significant post-harvest losses affect food security in rural economies as there is a wide gap between consumer prices and the amounts the producers are paid. It increases the product cost, making it less affordable to consumers and reducing farmers' income. Thus, it discourages farmers from producing and supplying markets. Table 4 shows the storage and temperature range for a few food products, which indicates the importance of cold chain management.

Currently, 95% of the cold storage is owned by the private sector, 3% by cooperatives, and the remaining 2% by public sector undertakings Ministry of Commerce Industry (2019). Although private sector actors are primary for developing and operating the cold chain in a vibrant agro-industry sector, governments can do much to facilitate private activity.

3.5. Future Prospects

In India, cold chain management is at its nascent stage. Restoring the cold chain sector may open up multiple opportunities for players with strong links in the agriculture value chain. Significant investment opportunities are yet to be tapped in supply chain management, cold storage, financing, retailing, and exports. There must be better linkages and ways of transportation between growers, storage, and customers. There is the absence of a single dedicated perishables gateway or fast track corridor for perishable cargo.

The consumer food retail sector is the fastest growing in the country, worth around US$15 billion; 40% of fresh produce is wasted due to lack of good handling in the supply chain. This can only be achieved by carefully designing a sustainable cold chain network by removing the barriers.

CONCLUSIONS

The Indian refrigerated transport market is projected to increase from $3.7 bn in 2021 to $6.17 bn in 2028 with a CAGR of 7.63%. The reefer market is classified according to transport, technologies,

application, and temperature. Considering the CO_2 emissions and fuel consumption, refrigerated trucks with eutectic devices are preferable over conventional refrigeration systems. Furthermore, due to fewer moving parts, the eutectic refrigeration systems require less maintenance. About 80% of refrigerated transports are utilized for transporting milk and dairy products. In India, most refrigerated trucks provide a single commodity that needs to be focused on.

It is expected that the Indian cold chain market will grow at a CAGR of about 14% from 2020 to 2025. Significantly increased demand in organized retail, processed food, medical and pharmaceutical products, and horticulture drive the growth of the Indian cold chain market. The challenges the cold chain market faces are the irregular distribution of cold storage capacity, lack of proper logistical connectivity support, and the need for high capital investment. The government of India is providing various technological and financial assistance to boost the development of the cold chain for the horticulture and agro-food products sector.

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