All India Cold-chain Infrastructure Capacity Assessment of Status & Gap

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All India Cold-chain Infrastructure Capacity (Assessment of Status & Gap)

National Centre for Cold-chain Development (NCCD)

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NABCONS Team

New Delhi
14 August 2015

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Abbreviations

Acronym	Full form
AHMCE	Average Item Wise Household Monthly Consumption Expenditure
APEDA	Agricultural & Processed Food Products Export Development Authority
APMC	Agricultural Produce Market Committee
ASI	Annual Survey of Industries
CAGR	Compound Annual Growth Rate
CONCOR	Container Corporation of India
CV	Coefficient of Variation
DAC	Department of Agriculture & Cooperation, Ministry of Agriculture
DI	Direct Interview
DMI	Directorate of Marketing & Inspection, MoA
EXIM	Export Import
FGD	Focus Group Discussion
FPO	Farmer Producer Organization
HH	Household
HMNEH	Horticulture Mission for North Eastern and Himalayan States (part of MIDH)
IQF	Individual Quick Freezing
ISAM	Integrated Scheme for Agricultural Marketing
IWAI	Inland Waterways Authority of India
Km	Kilometre
MIDH	Mission for Integrated Development of Horticulture, MoA
MoA	Ministry of Agriculture
MoFPI	Ministry of Food Processing Industries
MoRTH	Ministry of Road Transport & Highways
MPEDA	Marine Products Export Development Authority
MR	Merchandise Retailer
MT	Metric Tonne or Tons
NCCD	National Centre for Cold-chain Development
NHB	National Horticulture Board (part of MIDH)
NHM	National Horticulture Mission (part of MIDH)
NMFP	National Mission on Food Processing, MoFPI
NSS	National Sample Survey
NSSO	National Sample Survey Organization
PCME	Per-capita Monthly Consumption Expenditure
QSR	Quick Service Restaurant
Reefer	Refrigerated Transport
TFCP	Task Force on Cold-chain Projects, GOI, 2014
ToR	Terms of Reference
UT	Union Territory

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DEFINITIONS USED

The definitions and terminology used for the purpose of this study are given as under:

1. **Cold-chain:** An environment controlled logistics chain, ensuring uninterrupted care from source-to-user, consisting only of storage and distribution related activities in which the inventory is maintained within predetermined ambient parameters. Cold-chain does not alter the essential characteristics of the produce or product handled.

2. **Pack-House:** A modern infrastructure with facilities for conveyer belt system for sorting, grading, washing, drying, weighing, packaging, pre-cooling and staging. Modern pack-houses are the first step in organised post-harvest management for horticulture, and are in effect the first mile sourcing points for this sector. A modern integrated pack-house unit enables small lot sourcing of horticulture produce, and should be built close to farm-gate.

3. **Refrigerated Transport:** The refrigerated transport system, with an insulated carrier and equipped with active refrigeration, designed for temperature controlled carriage of perishable products. This can include refrigerated trucks (reefer trucks), vans, rail, containers and ships for transporting perishable products.

4. **Storage:** Static infrastructure designed with insulated and refrigerated chambers for long term or transient storage of whole fresh, ready-to-retail, or processed forms of perishable products.

5. **Pre-Cooling Unit:** A specialized cooling system designed to rapidly remove field heat from freshly harvested produce and thereby prepares the cargo for subsequent travel in the cold-chain. A Precooling unit can be in the form of forced-air cooling, hydro cooling, vacuum cooling, room cooling, icing, etc. Precooling or post-harvest cooling is the heart of a modern pack-house and is one of the key steps in preparing fruits and vegetables for the extended cold-chain.

6. **Sorting:** The activity at source when produce is assorted into target lots basis qualitative criteria viz. as non-edible, as reject or dump, by quality, by shelf-life, by market value, etc. It is the first stage categorisation of received produce and separates them into differentiated value-based flow towards an ascertained and useful end-use. Thus, the process of sorting is key to direct the flow of collected produce into existing and multiple value-based productive use.

7. **Grading**: The activity at source for physical segregation of goods into optimal packing lots, after undergoing initial sorting. It is a pre-cursor to effective packaging, performed such that the space in a unit package can be maximised for safe carriage, and leads to efficient shelf space utilisation and graded shelf presentation.

8. **Cold Room (Staging):** An insulated and refrigerated chamber which serves as a transient staging space, and is a necessary attachment to a Pre-Cooling Unit. Appended to pre-coolers, a staging cold room frees the pre-cooler space for the sequential batch of incoming freshly harvested produce. This component is typically installed at farm-gate as part of a modern pack house, and temporarily stores preconditioned fresh produce, awaiting transport link to a distribution point (a cold store close to market).

9. **Cold Storage (Bulk):** Environment controlled warehousing space with multiple chambers intended for the bulk storage of perishable produce. It is designed for long duration storage of produce so as to build an inventory buffer which will serve to smoothen the episodic production by stabilising & sustaining the supply lines. These are normally constructed in areas close to producing areas (farm-gate) to facilitate quick access to producers for a selective set of crops only.

10. **Cold Storage (Hubs):** Environment controlled warehousing space with multiple temperature zones for functioning as a distribution hub. It is designed for short term handling of products so as to serve as a distribution logistics platform for market ready packaged produce and ready to retail products. Cold storage (Hubs) are key to effective distribution of perishable foods and essentially at the front end of the cold-chain, constructed close to consuming centres.

11. **Reefer Vehicles:** Road transport vehicles with a fixed insulated body equipped with active refrigeration designed for environment controlled carriage of products. These are effectively cold rooms on wheels – or mobile cold stores. The refrigeration on long haul trucks is powered through integrated diesel driven motors, independent of the main truck engine. In case of small vehicles, the use of direct drive systems linked to the vehicle engine or battery powered refrigeration is the norm. Normally Reefer trucks incorporate GPS based location tracking system and are installed with data logging temperature and humidity sensors.

12. **Reefer Container:** A multi-modal insulated container with integrated refrigeration equipment. Unlike fixed body reefer trucks, reefer containers can be released from the truck trailer chassis and handled as an independent unit load. This allows the prime mover and/or trailer to be utilized for other hauling operations. Reefer containers are normally used for multi-modal activities where rail-road-sea-air movements are involved in the logistics chain. The equipment is designed to source electric power from a separate generator (power-pack) which is independent of the reefer container. These can also be positioned on site for use as a temporary temperature controlled store utilising external electric power.

13. **Ripening Unit:** A front-end facility in the cold-chain, designed to function for controlled and hygienic ripening of certain fresh produce. Modern ripening units contain multiple ripening chambers and these are used extensively for ripening bananas and other fruits like mangoes, avocadoes, kiwis, tomatoes, pears, etc.

14. **CA enabled cold store (Controlled Atmosphere Technology):** This refers to a cold store fitted with technology to actively alter the atmospheric gaseous contents, in addition to controlling the temperature. This is effected by utilising specialised equipment, generally involving molecular sieves (mechanical or chemical) to change the molecular composition of air. Used to purge the natural air in a cold storage space, an active and rapid change to atmospheric composition is done to maximise advantage of physiological slow down and for other benefits for specific fresh produce. Basically, in all cold stores there manifests a slow, passive, self-induced modification (from normal respiration and physiological activity) to atmospheric contents. In CA based cold stores, the atmospheric composition is heightened by active intervention. Globally, this add-on technology is commercially used in cold stores for long term storage of suitable quality of Apples, Kiwi and Pears. This technology is also used in certain transport modes.

15. **Batch Load:** A capacity measurement utilised when the infrastructure is used to sequentially throughput goods after a time based activity or procedure. Usually used for pack-houses where the pre-coolers operate to cool a few tons of produce at a time, in multiple runs or batches per day. For example, a pre-cooler with holding volume of 5 tons can output 15 tons of conditioned vegetables if operated every 6 hours for three times in a day. The batch load in this case would compute to 5 tons/batch in 3 batches/day, or 15 tons per day. Similarly, in case of sorting and grading lines, the batch load is assessed in the volumetric throughput – or tons per hour or per day.

16. **Holding cycle:** The period of time a specific good is held in a storage or transport chamber. Also called inventory turnover, it is a long period in case of products like potato, apples and few days in case of tomato, milk, litchi, etc. The handling capacity of a space is in multiples of its size and the holding cycle or rotation of the inventory held.

17. **Storage Size:** The volumetric size of the holding space of a transport or storage chamber (stated in tons or cubic metres). This storage size is a static measure of the space created and is also termed holding capacity. The mass to volume ratio of goods held in cold-chain varies depending on the density of the produce, the packaging used, the storage/stacking system used, space design, etc. For purpose of this report, uniform ton to volume ratios as defined in MIDH Guidelines is used. The storage size of a cold store is a factor of the total volumetric capacity handled by a cold store.

18. **Storage Capacity:** The handling capacity or the throughput measure of the goods that pass through a holding space over a specific period of time. This is also called the useful capacity of a space, and assessed on the basis of storage size and the product holding cycle. In case of a weekly holding cycle, the handling capacity of a space is "storage size x 52 weeks" or a 52x multiple of its holding size. The handling capacity of a storage unit depends on the product type being handled and is the proper characterisation of the capability of a unit. The storage capacity of a cold store is a multiple of the space or storage size created.

19. **Front-end-merchandising:** Front-end merchandising refers to the practise of managing products at the last mile selling point to end-use customer. Merchandising involves the display and care at retail end and includes temperature controlled cabinets, street vending carts and other retail platforms.

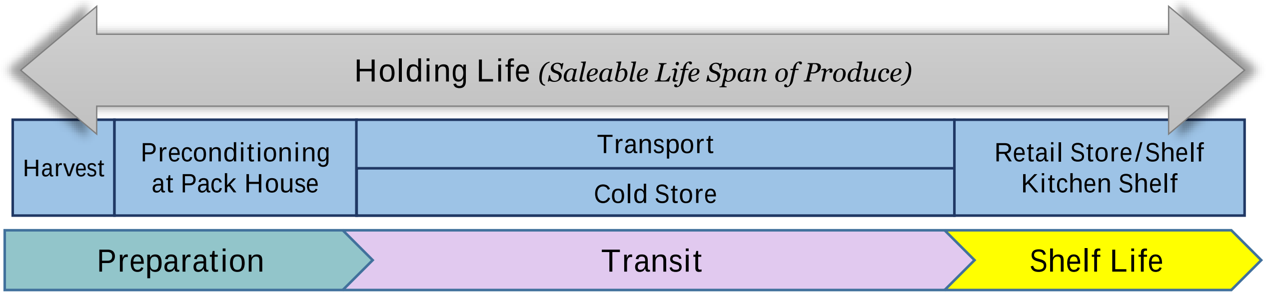
20. **Retail Shelf / Cabinet:** These shelves/cabinets are temperature and/or humidity controlled merchandising units, used for holding of temperature sensitive goods and used to safeguard the on-shelf quality of the food items. These can be designed for fresh foods and processed items.

21. **Fresh Food (Produce):** A produce of nature that is harvested by farmers and where the essential and natural attributes have not been altered. This includes all whole food that is a produce of nature and not a product of industrial process. The harvest may undergo cleaned, sorting, grading, trimming, de-sapping, fumigation, washing, waxing, packaging but does not undergo any process that modifies its natural characteristics. E.g., all fresh fruits and vegetables, raw milk, eggs, fresh fish, etc.

22. **Processed Food (Product):** A food product manufactured by transformative processes that may involve mincing or macerating, liquefaction, emulsification, cooking (such as boiling, broiling, frying, baking or grilling), dicing or slicing, pickling,

preservation, canning or jarring, freezing or drying, refining, grinding, etc. – the natural attributes are altered, or ingredients added where the produce is transformed from its natural physical or chemical forms into a new product. E.g., pickles, flakes, ketchup, canned vegetables, juices, pulp, deep frozen goods, chocolates, beverages, etc. Processing industry may also use refrigeration technology (IQF, Blast freezers, etc), such specialised production plants and product lines forming part of manufacturing equipment/components.

23. **Holding Life:** Also called Product Life, refers to the Saleable Life Span of a product. In case of Fresh produce, this commences at harvest and extends until the produce perishes. In case of processed food products, this is initiated after the manufacturing process and extends upto the predetermined expiry date. Holding life is divided into time spent in each activity in the supply chain, with Shelf Life being the time spent in the front end, on shelf.



The holding life of produce is extended with cold-chain, creating more opportunity to producers by expanding the range and accessibility to markets. The Holding Cycle in a space, should always a small part of the total Holding Life of a product.

24. **LIFO (Last-In, First-Out):** It is a method of storing and retrieving goods where inventory is rotated as a part of logistical procedure. This is usually employed where the storage space or warehouse capacity is limited or physical access to the inventory is restricted. In cold-chain, this is most commonly used when following the "stuffing" principle in transport. A staging area is used for preparing goods for LIFO loading onto large transport. This method is not otherwise used when handling perishables.

25. **FIFO (First-In, First-Out):** It is a method of storing and retrieving goods where goods can be throughput in a simple pass-through method. For example, a conveyor belt or where inventory storage period is so short, that applying any other logic is superfluous. FIFO can also be used in cold stores if holding goods of identical nature.

26. **FEFO (First-Expire, First-Out):** It is a method used exclusively to handle perishable goods. This involves intelligent stock keeping and storing so that inventory items that are expected to expire first are the ones to be picked and brought into use. This inventory handling method is most critical to value realisation of perishable goods. In case of fresh food, where no expiry labels are uses, a mix of FIFO and FEFO is used. FEFO requires a closer understanding of the life cycle of individual batches of perishable goods, including integration of information from source points.

27. **Data logger:** Is an electronic device that records data over time or in relation to location captured via instruments and sensors. Temperature and humidity levels are

commonly recorded in case of handling fruits and vegetables. Other measures can include position, gas composition, impact or shock, sunlight, etc.

28. **Dock levellers:** It applies to an adjustable metal ramp designed to bridge the gap between the cargo bed of a transport vehicle and the loading platform of a cold-store**.** It is used for ensuring smooth transfer of goods into and out of cold storages and facilitate the effective operation during loading and unloading

29. **Stacking system:** Broadly represents the storage method such as racks, bins and pallets for holding cargo in storage and transport. The use of modern stacking systems promotes standardisation in load handling and brings storage space in synergy with modern packaging systems.

30. **Blast freezer:** Special equipment or rooms designed for rapid freezing of product that requires frozen storage at less than -18 °C temperatures, like fish, meat, ice cream, etc. Used in frozen foods industry and not to be confused with pre-cooler which cool in only in the positive temperature ranges for fresh fruits and vegetables.

31. **Cost-Plus Model:** A business model that relies on a pricing strategy that applies an absolute or percentile mark-up on the cost of the product/service & delivery, to determine fixed market price and profits. This model pursues growth through raising quantum of revenue, by increasing its geographic range and associated supply chain, thereby increasing its margins and returns. This model promotes supply side collaboration and places demand on greater market linked cooperation in the supply chain for arbitrage across geographies.

32. **Time-Arbitrage Model:** A business model that relies on holding inventory for timed opportunistic trade, where its margins are assessed on the asset's future demand and on risk premium, on the basis of a number of macro-economic factors. This strategy pursues profits through timing or controlling transactions, by lowering its procurement cost, taking advantage of poor production and the limitations of supply chain. Such a model promotes inventory based arbitration on market demand (hoarding), and can have little interest in sustained long term growth of supply side.

33. **Geographical Arbitrage Model:** A business model where higher price realisation is achieved by bridging distances between production locations and demand centres, facilitating faster cash flows and actively expanding the customer base. This model can minimise static inventory, promote demand for greater production and productivity.

34. **Reverse logistic**: The return of a transport system to first point of origin. When reverse logistics is planned so as to carry other goods for use at point of origin (reverse haulage), the trade achieves greater economic sustainability through optimisation of resources.

35. **Last mile:** Refers to the front end activities and assets in the overall value chain system. This includes merchandising platforms, delivery vehicles and the cold stores used as distribution hubs.

36. **Cross Docking:** Refers to deconsolidating and dispatching or received products with little or minimal period spent in storage between the two activities.

EXECUTIVE SUMMARY

The main objective of this study titled, **"All India Cold-chain Infrastructure Capacity (Assessment of Status & Gap)",** is a comprehensive evaluation of the pan-India consumption of perishable food items, to assess the demand, current status and gaps in cold-chain infrastructure so as to provide significant assessments for future policy development and intervention.

2. Unlike previous attempts to estimate the requirement for cold-chain, the present study **follows an inverse approach**, with primary reference to existing domestic demand for food products. This study evaluated the consumer driven demand for food items, the infrastructure required to link such consumption backwards to production points, and holistic infrastructure required at source points.

3. **The scope of the study** is to assess the requirements predominantly for fruits and vegetables and other products in the chill, mild-chill and frozen categories of cold-chain[1]. Milk distribution has a well-proven logistics network and as its core logistics needs are different from other solid food products, it was not included in this study. However, high value dairy products like ice-cream is included under frozen category in this study. Since no consumption statistics are available for floriculture, the same was not considered in this study. Spices production has less share under horticulture, and hence all spices were not accounted. However, dried chillies being an important user-base of bulk cold stores are included in the study.

4. **Primary focus** was to evaluate available information, from agencies, analysed by adopting standard statistical tools and techniques. The demand analysis was carried out based on evaluating previous 10 years per-capita consumption data of NSSO, procured from Ministry of Statistics and Programme Implementation (MoSPI). The derived consumption trends & population growth was applied to the most recent NSSO data (68th Round) to arrive at a realistic 2014-15 consumption for urban populations.

5. The consumption of major fresh fruits and vegetables is the main determinant for assessing development needs of cold-chain infrastructure in the country. Tables and maps were prepared to provide insights into the consumption patterns across states and selected items in the country.

6. To assess existing cold-chain infrastructure in India, data-on-records was taken from various stakeholders viz. Ministries, agencies and departments which are supporting cold-chain infrastructure creation in the country. Field level interactions were carried out in different zones of India by structured & semi-structured questionnaires for the cold-chain units, users of cold-chain facilities including Farmer Producer Organizations, street hawkers, vendors, traders and transport service providers.

[1] Fig 2.4, Page 10

7. Nine major consumption centres/cities viz. Mumbai, Delhi, Kolkata, Ahmedabad, Jaipur, Chennai, Bengaluru, Hyderabad and Guwahati have been considered as sample cities to determine the requirement of cold-chain infrastructure in India. The cities were selected on basis of zonal representation and consumption demand for perishable items viz. apple, grapes, orange, kiwi, strawberry, mango, banana, papaya, okra, cauliflower, cabbage, tomato, carrot, potato, onion and other processed food products.[2]

8. To assess the gap in cold-chain infrastructure, following steps were carried:

- The products were segmented on the basis of their holding life, namely those suitable for long term bulk storage and those for short transitory holding.
- The products were categorised by temperature requirements (under frozen, chill, mild-chill, and normal).
- Cold stores were segmented into Hubs for distribution purposes and Bulk stores for holding at farm-gate, in considering relevant produce protocols.
- The distance from urban consumption centres to producing areas was used to arrive at a time-distance matrix, cross tabbed with production.
- The study has used monthly consumption volumes to evaluate throughput of each product category before translating into the relevant infrastructure.

9. The study brings forth the following cold-chain infrastructure requirements[3] in order to manage better the existing consumption volumes in the country in 2014-15;

Type of Infrastructure	All India Requirement
Pack-house	**70,080 nos.**
Cold Storage (Bulk) #	**341,64,411 MT**
Cold Storage (Hub) #	**9,36,251 MT**
Reefer Vehicles	**61,826 nos.**
Ripening Chamber	**9,131 nos.**

 # For Cold Storage (Bulk) and Cold Storage (Hub), the figure in MT (metric tonnes) indicates static storage size. For rest of components, the figures indicate the number of units.

1o. The study has estimated the requirement for cold storage (Bulk) as 341,64,411 MT, for long term holding of fresh produce like potato, dried chillies, apple, etc.

11. The study has estimated the requirement for cold storage (hub) as 9,36,251 MT segregated by temperature ranges, i.e. chilled, mild chilled and frozen. The breakup of the estimated requirement of cold storage (hub) is as under;

[2] Table 2.2 and 2.3, Page 14
[3] Table 7.1, Page 88

- Cold storage (hub) requirement at consumption point for chilled category products (such as apple, grape, orange, strawberry, kiwi, tomato, cauliflower, okra, cabbage, carrot) is estimated to be 6,16,896 MT.
- Cold storage (hub) requirement at consumption hub for mild chilled category products (such as mango, banana, papaya) is 2,41,353 MT.
- Frozen storage space requirement at consumption hub for frozen goods (such as meats and ice-cream) is 78,002 MT. It may be noted that front-end storage of frozen goods is also necessary at retail end and an equal capacity in that format is indicative.

12. **The handling capacity** (throughput of goods handled during a year) of each cold storage type is calculated. The storage size of existing cold storages as per available statistics has been placed in this report.

- The handling capacity of a storage unit, in case of single commodity bulk stores is considered equal to the holding size (storage size or static space created). Example, in case of potato the inventory is held for extended period of 8 to 10 months before the storage space is prepared for next harvest. Hence, the handling capacity is equal to the space created. In actual practise, some partial space may be used for holding of other products like eggs, dry fruit, etc.
- The handling capacity of a cold store hub, modern pack-houses, transport, etc. is calculated as a multiple of their fixed storage space and the weekly/monthly throughput cycle of the product handled.

13. **Cold-chain Infrastructure Gap**: As per recorded data (31.3.2014), the country has created 31.82 million tons of cold storage space. This evaluates into a current gap of **3.28 million tons** in cold storage space (Bulk & Hub). The gap for other types of infrastructure is based on available information of existing assets from the line departments and market estimates.

Type of Infrastructure	Infrastructure Requirement (*A*)	Infrastructure Created (*B*)	All India Gap (*A-B*)
Pack-house	70,080 nos.	249 nos.	**69,831 nos.**
Cold Storage (Bulk)	341,64,411 MT	318,23,700 MT	**32,76,962 MT**
Cold Storage (Hub)	9,36,251 MT		
Reefer Vehicles	61,826 nos.	9,000 nos.	**52,826 nos.**
Ripening Chamber	9,131 nos.	812 nos.	**8,319 nos.**

A baseline survey conducted by NHB (December 2014), estimates that a total of 5367 cold stores of size 26.85 million tons remain in operation. Considering this, the total gap in cold storage space can be assessed to be 8.25 million tons. However, it is presumed that some of the non-functional cold stores could be upgraded and/or modernised instead of creating anew.

Besides cold stores, a good distribution system is required to address the missing/weak links in terms of other cold-chain infrastructure components at farm level like modern pack-houses and transportation through reefer vehicles, so as to integrate the cold-chain, to expand reach to markets and thereby minimise the loss to perishable products. A higher requirement in terms of modern pack-houses, refrigerated transport units and ripening chambers is evidenced in this study.

Key findings of the study for future cold-chain infrastructure creation are as under (see Chapter 8 and 9 for **Recommendations** and **Conclusions**):

i. Cold-chain development efforts in India were earlier mainly focussed on building storage capacity basis the sole hypothesis of cross seasonal carry-through of produce. This resulted in development of single commodity bulk storage, at production end for specific crop types (eg. Potato, dried chillies). The larger basket of perishable horticulture requires other infrastructure components to avail of cold-chain as a market linked intervention.

ii. Earlier, Government subsidy schemes supported development of cold storages in clusters, and lacked appropriate scale of development for associated farm-gate pre-cooling in form of modern pack-houses. This could be attributed to the fact that earlier cold-chain was thought synonymous to cold stores in isolation, nor integrated or aligned with consumer demographics.

iii. Cold-chain is now understood as a logistics conduit, linking producing points with consumption centres. The major components that need to be developed for effective integration of the cold-chain sector, are:

- **Static Infrastructure** – immobile infrastructure at farm-gate (modern pack-houses with pre-coolers, value adding units), term based storage (Bulk cold warehouses), and Cold distribution Hubs (Cold stores for last mile access to markets).
- **Mobile Infrastructure** – transport units for connecting the static infrastructure - designed for logistical load factors (small volume transit and long haul transits). Additionally, cold-chain extends to last mile retail or point of sale at merchandising platforms.
- **Standards & Protocols** – to define a common glossary and procedures for handling a wide array of raw produce and finished products.
- **Skilled Resources** – human resources to implement all above aspects.

Success of any cold-chain relies on how effectively it can serve as a conduit for products that are sensitive to their holding environment from the place of Origin to their Destination (OD pair). Cold-chain can be treated as part of the second green revolution, to be approached as end-to-end logistics from farm to markets. This report includes definitions of the terms used in cold-chain, to be referred by the industry and policy makers.

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CHAPTER – 1: INTRODUCTION TO THE STUDY

1.0 Introduction

India over the years witnessed a marked increase in production of perishable high nutrition products like fruits, vegetables, meat and poultry products etc. but development of cold-chain infrastructure was not strategically directed, for safe handling and to convey these perishable products to markets, except in the dairy sector. A resultant demand supply mismatch emerged across these agricultural commodities, frequently contributing to wide spread price fluctuations and inflation.

The inadequacy of scientific farm-to-market logistics, also contributed to high food losses in case of perishable foods, further adding to inflationary pressures. These inflationary trends are evaluated to be mainly due to ineffective post-harvest logistics on domestic front, which was unable to cope with increased demand and the associated increase in production. In order to reduce post-harvest loss of fruits and vegetables a number of schemes were launched by different Ministries of GoI.

Ministry of Agriculture launched a "Mission for Integrated Development of Horticulture" in 2014, under which cold-chain development is the thrust area, so that all other inputs in way of enhancing horticultural yields can have suitable recourse to reach gainful end-use. This Mission subsumes all previous major programmes for horticulture (namely NHM, HMNEH, NHB, CDB, NBM, CIH) of the Department of Agriculture & Cooperation. Cold-chain is considered an important tool for farmers of perishable produce, to connect with markets and to realise meaningful productivity.

Ministry of Food Processing Industries (MoFPI), GoI is operating a "Scheme on cold chain, value addition and preservation infrastructure" dedicated for cold-chain in addition to other programs that develop processing units. Ministry of Commerce is operating a scheme to enhance exports, which includes necessary export oriented cold-chain components. All these centrally sponsored initiatives by the Government have contributed a great extent for the creation of new cold storage capacity and a few other components of cold-chain.

Strategically, holistic development of integrated cold-chain holds the key for reducing post-harvest losses, ensuring uninterrupted supply and thereby minimising food inflation. A number of studies on cold-chain sector, were conducted earlier by different agencies to assess the infrastructure demand of this sector and the outcome of these studies is briefly discussed as under:

- According to a study conducted by **National Stock Exchange Limited (NSEL)** in December 2010, the country needed 61.13 million MT cold storage capacity against the then available 24.29 million MT. A gap of 36.83 million MT was evaluated. The assessment was made on the basis of peak season production of fruits & vegetables and their highest market arrival in a month.
- As per **Emerson Climate Technologies**, in 2013 report titled "The Food Wastage & Cold Storage Infrastructure Relationship in India" there were

about 6,300 cold storage facilities with an installed capacity of 30.11 million tons. The report carried forward the earlier assessment that India needs to double its cold storage space, to reach a total of 61.13 million tons of cold storage capacity in order to minimise food wastage.

- **The Associated Chambers of Commerce and Industry of India (ASSOCHAM)** in a study with TechSci Research, titled "Opportunities in Cold Chain-emerging Trends and Market Challenges", estimated the cold chain industry to register a compound annual growth rate of 25.8%, to reach a value of Rs.640 billion by 2017. The report referred to existing 30.11 million MT of cold storages in 2012, and of the need to create an additional 36.83 million MT in cold stores. The report states that the shift in demand towards horticulture products in India is expected to generate significant demand for temperature-controlled warehouses. The study also reported the concentration of cold stores in certain states as a failing.
- Recently in 2014, **YES Bank** conducted a study titled "Cold Chain-Opportunities in India". According to the report, the market share in cold-chain was divided into 88-90% with cold stores and 10-12% with refrigerated transport. This report also referred to the earlier assessment of 61 million metric tons required in form of cold storage and projected the need to create another 30.98 million tons nationwide in storage capacity. It observed a shift in trend for use of multipurpose cold storages and end-to-end services. The report also analysed that the top 5 producing states alone suffered a capacity deficit of 23.5 million tons in cold stores.

Similarly there were other research outputs that principally enumerated the need and/or large gap of cold storage capacity in the country, based on estimations on production surpluses. The reports suggest the need for integration but did not elucidate on any of the associated infrastructure. These reports are perceived to be predominantly supply driven, staying focused on cold stores alone, incomplete on the concept of cold-chain. The need of a holistic demand driven study was therefore felt.

NCCD mooted the concept of cold-chain as a custodian of value, harvested or produced, requiring to function as an end-to-end logistics chain, from point of production to consumer. In case of fresh fruits and vegetables, by delaying the inherent perishability of the produce the cold-chain offers scope for uninterrupted transfer of that value from farms to distant geographies. Cold-chain thereby empowers farms to reach out to more consumers by expanding their market reach.

To do so, creating cold storage facilities is not considered sufficient, without the associated and appropriate cold-chain links that integrate the farm-to-fork logistics. Various other infrastructure components that together empower cold-chain integration and market connectivity needed to be understood and developed in a holistic manner. Moreover, optimally, the need assessments required to be linked to market demand for better planning of assets to be developed for cold-chain.

Therefore, the need was felt that cold-chain infrastructure gap assessments be conducted with an inverse approach, i.e. be demand driven, based on consumption. The present study, commissioned under the overall guidance of National Centre for Cold-chain Development (NCCD), starts with an assessment of consumption data at select urban centres of fresh horticulture produce and other food products using cold-chain. The consumption by urban population was evaluated and formed the basis to arrive at the infrastructure required to effectually cater to such demand. The study is delinked form earlier ones which assessed requirements on the basis of production (supply side) alone. Information about existing infrastructure components is then used to assess the gap against the assessed requirement.

1.1 Objective of the Study

The main objective of the study is to conduct a demand based comprehensive pan-India evaluation of the requirement, capacity created and existing gaps in key cold-chain components so as to provide relevant assessment for future development of cold-chain infrastructure. The terms of reference is appended in **Annexure-I**.

1.2 Output of the Study

The study tabulates and enumerates the required infrastructure components, as per volumetric flow of goods on basis of per capita consumption at population centres, linked to distance from identified producing districts, categorised by temperature ranges (under frozen, chill, mild chill) and segmented by bulk long term storage or short transitory supply chain.

This was calculated on the basis of data-on-records of the existing infrastructure made available, per capita consumption data from NSSO and production figures published under MIDH. The key points of the output are as listed under:

i. Size and/or capacity of existing cold-chain infrastructure components.
ii. Cold storage required capacity cross tabbed by application (mild chill, chill and frozen) and regions.
iii. Reefer transport requirement and gap, basis existing consumption demand.
iv. Pack-houses requirement and gap, basis produce and consumption demand.
v. Ripening chambers requirement and gap basis consumption demand.
vi. Matrix to assess infrastructure needs on the basis of existing market demand linked to existing production and growth trends as possible.

1.3 Approach to Study

An inverse approach is applied to assess infrastructure components needed under the farm-to-fork model for end-to-end and uninterrupted cold-chain, thereby linking capacity required on basis of current consumption, backwards to point of production.

The figure below highlights the approach followed for the study.

Fig 1. 1 Approach to Study

Analysis of Consumption data from NSSO

↓

Collation and estimation of Population figures from Census 2011

↓

Collation of production data, major district-wise

↓

Collation & analysis of existing cold-chain infrastructure data

↓

Primary survey (*field visits*) to selected consumption centres across India

↓

Cross-tabbing distance and consumption figures

↓

Development of a matrix to deduce infrastructure requirement

↓

Cold-chain Infrastructure Gap assessment

The detailed approach and methodology of the study is explained in **Annexure - II**.

Further, a detailed list of stakeholders contacted for existing infrastructure data is presented in **Annexure – III.**

In regards the primary survey, the information gathered and views expressed by the respondents are captured in a tabulated form and is appended in **Annexure – IV**.

1.4 About this report

During the course of study, following points were considered.

i. Cold-chain infrastructure sector is fragmented in many ways. Multiple agencies/departments are supporting cold-chain development through various schemes. Data pertaining to existing cold-chain infrastructure was sought from them. In some instances, the information is not received whereas in other cases, the information was received in disconnected formats. A standardisation in data was attempted by providing of structured data formats for relevant responses within time frame allowed for the study.

ii. An exhaustive and comprehensive district-wise production data is not available for most of the fruits & vegetables.

iii. A consolidated database of existing numbers and typed of reefer vehicles in India is not available. There is no records of registration under this category.

iv. Reefer transport estimation is done for fruits & vegetables volumes only as modern vehicles have cross-utilisation for frozen and other products.

v. Latest NSSO per-capita consumption data used (2011-12, 68th NSSO Round), along with previous data to assess consumption/demand in 2014-15. The district-wise production data is available for the year 2012-13 with a few exceptions wherein data for 2011-12 was used.

vi. NSSO consumption data does not cover all the products selected for this study. In such cases, the demand was estimated by evaluating the data of import figures, existing literature and primary survey.

vii. The entire fruits & vegetables basket of India is not covered under the study, rather a selection of fruits and vegetables currently consumed and capable of being handled in cold-chain are considered for primary assessment.

viii. Since the selected produce/products as detailed in the report have multiple producing regions, the districts that produce more than 5% of state level production have been referred to only.

ix. Fruits like Kiwi and Strawberry, though currently imported in low quantities, are indigenously produced in India including in the north-eastern states. Since these are high value produce and a demand for exists as validated through imports, it warranted that the cold-chain infrastructure requirement for these also be considered in this study.

x. In case Dairy products, milk movement is not considered as it is already well-established and studies with demand and supply assessments exist. Additionally, the cold-chain needs in case of milk differ from requirements when handling solid food products. However, high value dairy products like ice-cream, butter is considered for this study.

xi. The need to establish Food Processing Units is not assessed. The refrigeration components where used by food production facilities are industrial production lines and part of food processing industry and as an industry these are already well covered under the aegis of Ministry of Food Processing Industries. However, the logistics movement of final product to market in the cold-chain, where needed, is taken into account for calculating requirement of cold distribution hubs at the front end.

xii. Some industrial projects have captive cold-chain assets, like for pharmaceutical ingredients and for on-site storage in food processing factories. Such captive storage requirement is not considered in the study.

xiii. Regarding floriculture, there is no definitive consumption statistics available to assess domestic demand. The majority of existing export oriented floriculture units have captive on-site pack-house pre-cooling and storage facilities apart from reefer vans for transporting flowers to the nearest airport. Therefore, this was not considered under this study.

xiv. In case of spices and plantation crops, the percentage share of production is 8.3% (2014-15 advance estimates), of total 280.4 million tons of horticulture production. Furthermore, where required, these crops have cross functional utility in existing capacity, therefore plantation crops, aromatics and spices are not considered in this study. However, the storage requirement for dry chillies is assessed.

xv. The demand for merchandising equipment at front-end consumption centres is not specifically calculated. The physical merchandising units are dynamic and seen in multiple sizes, locations and with varied throughput capacity. However, Retail shelf/cabinets and modern street vending carts are supported under Ministry of Agriculture capital subsidy scheme.

xvi. A glossary of standard terms used in cold-chain sector is developed[4]. It may be suitably referred when going through various sections of the report.

xvii. The study relies extensively on multiple information collated from different Ministries/Departments/Agencies.

[4] Definitions Used, Page ix to xiii

CHAPTER – 2: FRAMEWORK OF THE STUDY

2.0 Cold-chain Flow

A cold-chain is an environmentally controlled chain of logistics activities, which conditions and maintains the goods (produce or product) within a stipulated range of parameters that include temperature, humidity, atmosphere, packaging and other conditions. Importantly, cold-chain is all about end-to-end connectivity and hence, above all, be market linked.

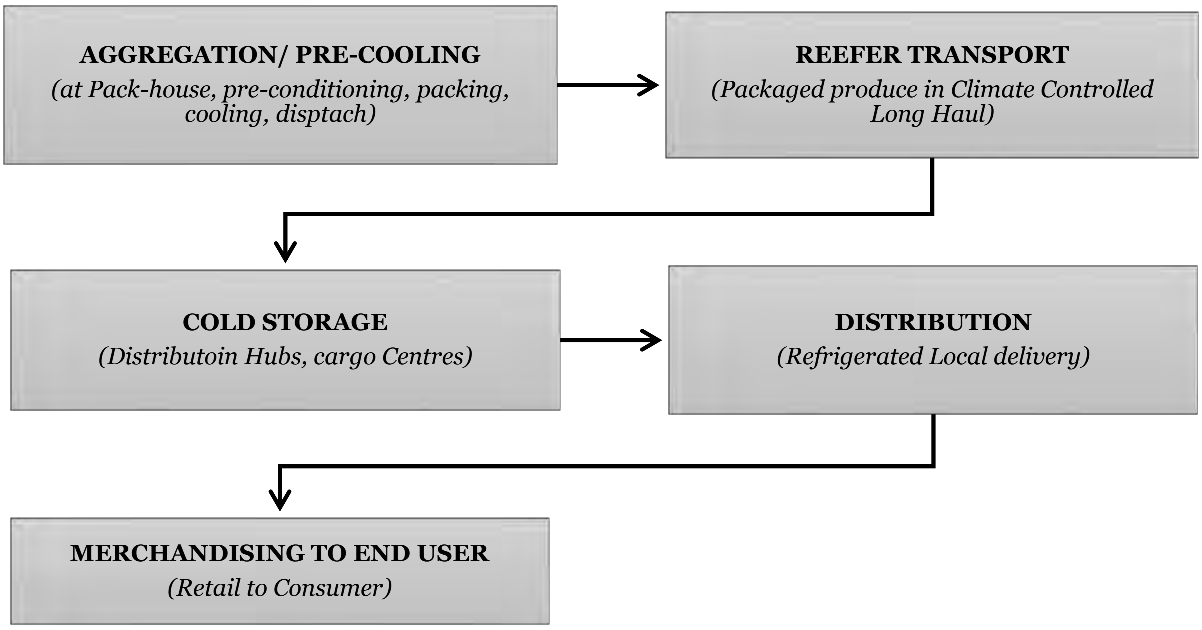
Depending upon the handling requirements, a typical cold-chain flow may be understood separately for harvested fresh horticultural produce (fruits & vegetables) and processed products (manufactured food items). The holding life of majority of the fresh horticultural & floriculture produce, even when in the cold-chain, ranges from just a few days to a few weeks only. The temporary extension in life, allows the product to remain in a consumable state for a longer period.

In the cold-chain, the essential characteristics of agricultural produce remains un-altered as prime activity of preconditioning at a pack-house does not transform the produce but safe-guards the value and makes it more marketable.

The key benefit derived from cold-chain is in fact, empowering the direct linkage of farm-gate value with consumers. By enhancing the holding life and transportability of the produce, cold-chain allows the scope to reach and capture more markets.

A typical flow diagram from farm to end-customer is illustrated in Fig. 2.1.

Fig 2. 1 Logistics Flow for Fresh Horticultural & Floriculture Produce

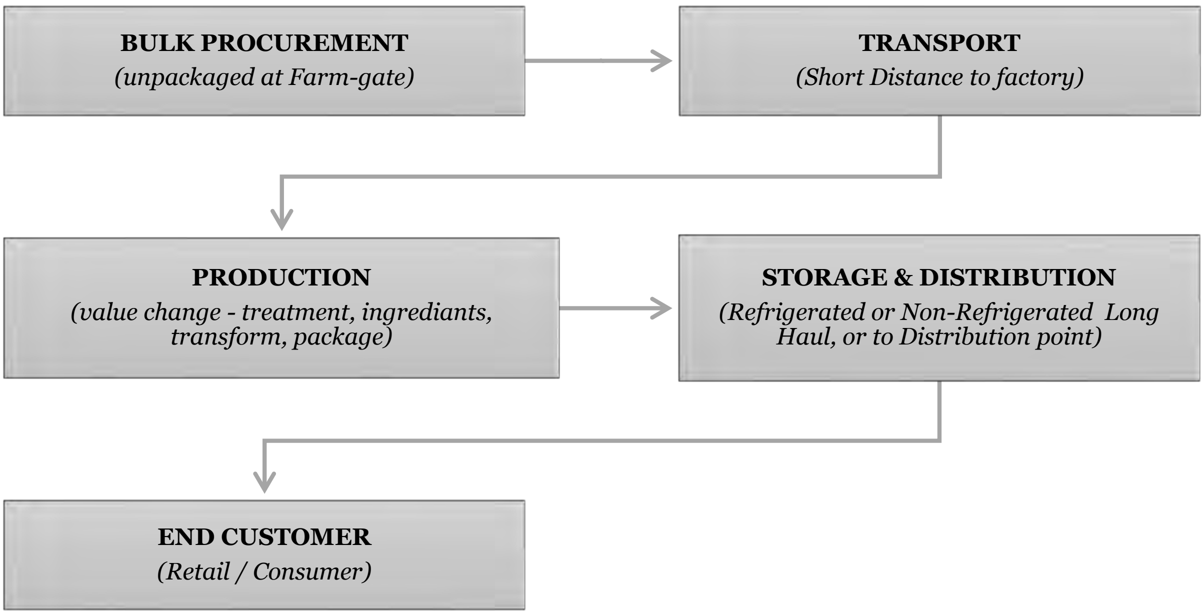


In case of whole produce like fresh fruits and vegetables, their perishable nature necessitates use of uninterrupted cold-chain to connect and expand market footprint, maintain quality and to avoid food loss.

On the other hand, food processing involves transforming the produce (a specialised cultivar sourced in bulk or culled material) through activities wherein, by addition of other ingredients, preservatives, or industrial processes, the natural characteristics of agricultural produce is altered into a manufactured food product. Depending on the process, the processing plant may be delinked from the cold-chain - if the finished product does not require a temperature controlled mode of logistics. Yet, processing units benefit from linking with multiple pack-houses as the material that is culled as low grade or unsuitable for fresh market, can optimally be used as the raw material for the processor. Therefore, food processing is an appropriate option to maximise on harvested value and serves to optimise the overall cold-chain.

The processor, will normally procure suitable raw material, for onward processing activities like IQF, Pulping, Juicing, Pickling, Drying, Cooking, etc. Through transforming processes, a new product or value item is created for onwards retail. The raw material sourced is not necessarily in packaged form as a final product and package is prepared after processing. For the farmer, value realisation on produce closes at this stage, the processing unit being a consumer and in consequence the producer/owner of new product. A typical flow from farm to end-customer is illustrated in Fig. 2.2.

Fig 2. 2 Logistics Flow for Processed Food Items



Many of the processed food products do not need the cold-chain as a logistics service. However, refrigeration is necessary for preparation and/or distribution of fresh milk & dairy products, most frozen meat and sea food products, frozen or cut fruits & vegetables and for semi-processed pulps. In cases where other techniques are used for processing viz. curing, adding preservatives, aseptic packaging, drying and flaking, etc., normal logistics can be used (pickles, tetra-packed products, corn flakes, sauces, jams, biscuits, mixes, breads, etc.)

2.1 Product Segmentation

The various goods which require cold-chain facilities were segmented into broad product segments, listed in Fig 2.3:

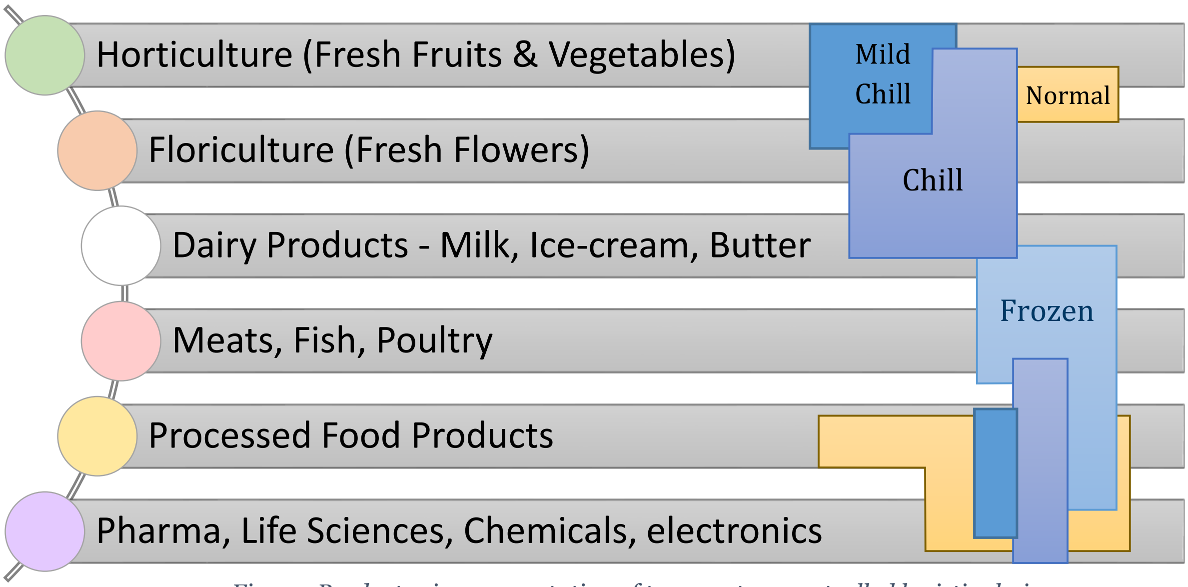


Fig 2. 3 Product-wise segmentation of temperature controlled logistic chain

The above listed product segments, have varied holding times, depending on time-temperature combinations and cold-chain infrastructure facilities.

The first 3 in the list mostly have a short holding life and the last 3 have a long holding life of many months or even years. Accordingly, the cold-chain facilities play a differentiated role which may be summarized as under:

- For fresh horticulture and floriculture produce, the cold-chain enhances the life cycle of the produce thereby extending its saleable life and time span to reach the end-consumers across geographies. Due to shortage of time, quick logistics connectivity is the driving force.
- For transformed or processed food, the cold-chain protects the status of the manufactured goods till it is consumed. Due to long term holding ability, low cost procurement and a managed product inventory takes precedence.

In both cases, the cold-chain protects value of goods under its care, and the primary benefit of cold-chain goes to the producer/owners of this value, namely the farmers, growers, producer organisations, as well the traders and food processors.

It is also noted that there is scope for synergistic use of infrastructure, between the different user or product segments. In utilising logistics assets, cross utilisation and improved capacity utilisation can be effected if the initial design and planning is in accordance. The most commonly used component between segments is the reefer transport and these are designed to handle in a wide range of conditions.

2.2 Cold-chain Categories Based on Storage Temperature

Based on product storage temperature, the using commodities can be broadly classified into 4 categories depicted in Fig.2.4.

Fig 2. 4 Cold-chain segmentation based on storage temperature

Chill (0ºC to 10ºC)	• Fresh Fruits like apple, pears, oranges, etc. • Fresh Vegetables potato, carrot, cauliflower, etc. • Raw/ Pasteurized Milk • Butter, Eggs • Dry Fruits/ Nuts • Dry Chillies
Mild Chill (10ºC to 20ºC)	• Sub-tropical fruits like mango, banana, papaya, etc. • Dairy products like Milk Powder • Chocolate • Seeds
Frozen (below minus-18ºC)	• Frozen vegetables, fruit pulp, pineapple slices, etc. • Other items like - ice-cream, butter, fish and meat products.
Normal (>20ºC)	• Whole Onion • Dehydrated foods • Roasted foods • Sun-dried products • Pickle, Jams & Jellies • Ready-To-Eat (RTE) foods • Oils and extracts

2.2.1 Chill

"Chill" refers to produce and products which are stored within the temperature range of **0ºC to 10ºC.** The cold storages with chambers capable of maintaining the chill range of temperature are used for storage of produce in this category. The majority of fruits and vegetables, fresh meats, fish, dairy and pharmaceutical goods fall in this category.

2.2.2 Mild Chill

"Mild-Chill" refers to produce and products which are stored at an ambient temperature range of **10ºC to 20ºC**.

The cold storages with chambers capable of maintaining mild-chill range of temperature are used for storage of sub-tropical fruits like mango, banana and papaya of the fruits and other products in category.

The "Mild-Chill" and "Chill" cold storages may further be categorized depending upon the business model of the facility and location, as follows:

i. Cold Room (Staging) – attached to pack-houses for temporary storage of produce, pending dispatch. Inventory will normally not be retained for longer than 2 or 3 days.

ii. Cold Storage (Bulk) – for storing of long-term holding crops like potato or spices. These are located close to producing region (farm-gate infrastructure), and designed to hold inventory for long periods until next harvest season.

iii. Cold Storage (Hubs) – modern cold store facilities, to serve as a platform for distribution access to market. Located close to consumption centres (front-end infrastructure), and designed for regular receipt and dispatch of multiple products and produce to retail end.

For specific produce, Controlled Atmosphere (CA) technology enabled cold storages are used which involves careful control of not only temperature and humidity, but also the oxygen and atmospheric contents to further affect the maturing process.

Globally, use of this technology has been commercially established for apples, kiwi and pears and supported for these specific crops only. To achieve the best storage quality, growing and harvesting techniques including timing of harvest is critical. Apples picked too early will not store well under Controlled Atmosphere technology, nor will those that are past the proper stage of maturity.

It is to be noted that not all cultivars of the same fruit type are suitable for such storage. The harvested crop should be not only be suitable for CA enabled atmospheres, but care to be taken that they are not from senile or first bearing trees. CA enabled cold stores are built at farm-gate for long term storage and to feed market demand for the remaining period.

2.2.3 Frozen

"Frozen" refers to products which are required to be stored at extreme cold ambient, at **below -18^{o}C.** The food products are output from processing factories and IQF/blast freezers can be used to achieve rapid freezing or a crystallisation stage of the product. Deep freezing protects from natural microbial and enzymatic activities. Equipment for blast freezing or IQF is part of a production facility. There are a number of products which are so processed and kept in deep frozen state for preservation purposes. Cold-chain comes into use on final dispatch of finished product to market.

2.2.4 Normal

"Normal" refers to uncontrolled ambient conditions or those non cold-chain products which are stored at a temperature of **higher than 20^{o}C.** The normal storage is largely used for storing those produce types and ancillary materials which are not prepared for cold-chain usage or do not necessarily require cold-chain facilities, for example – Onion.

2.3 Product Holding Life

Holding life of a product can be understood as the summation of the time spent by a product during preparatory cycle (pack-house, cold storage bulk), transport cycle (reefer vehicles), storage cycle (cold storage hub) and shelf cycle (retail point-of-sale). Accordingly, based on the holding life, two main categories are discussed:

1. Long-term Holding Life
2. Short-term Holding Life

2.3.1 Long-term holding life

For products with "long-term" holding life, the focus is towards holding inventory so as to make available fresh supply in lean months of production and/or non-production months. This segment maintains a strategic buffer near farms or at production centres, pending dispatch to markets as demand fluctuates. The storage period for "long-term" is considered **3 to 10 months or longer**. The long-term bulk storage must be discouraged from hoarding activity.

Fig 2. 5 Cold-chain segmentation based on holding life

Long-term holding life (3 months to 10 months)

- Apple, Pear; Orange; Kiwi
- Carrot; Cabbage; Potato
- Onion, dry chillies
- Frozen Meats, Fish, Processed foods

Short holding life (7 days to 6 weeks)

- Mango; Litchi ; Pineapple; Peach; Plum; Grape; Banana; Cherry; Strawberry
- Tomato; Brinjal; Okra; Cauliflower; all Green leafy vegetables

2.3.2 Short-term Storage

For products with "short-term" holding life, the focus is to develop fast connectivity and for transactions across geographical limitations. The connectivity is essentially seen to originate from farm-gate infrastructure (pack-houses, etc.) to Wholesalers/Mandis (APMC) and retailers through reefer transport. The storage period for "short-term" is considered from **1 week to 4 weeks**. It is noted that the fresh produce requiring short-term storage is sold and consumed much before expiry of their full life cycle. This is where cold-chain finds meaningful application.

2.4 Major Cold-chain Infrastructure Components

The study has identified major cold-chain infrastructure components and their desirable location of establishment. Based on primary survey of major consumption centres, production centres and available data on records with various departments/ ministries, an assessment of current usage is listed as per Table 2.1 below.

Table 2. 1 Major Cold-chain Infrastructure Components

#	Infrastructure Component	Desirable Set-up Location	Current Usage
1	Modern Pack-house (**PH**)	At farm gate for fresh produce preconditioning	For exporters mostly
2	Long Haul Transport (**T**)	From pack-house to Mandi/ wholesale buyer	Across the country
3	Cold Storage Hubs (**CH**)	Close to consumption/ distribution centre	Across the country
4	Cold Storage Bulk (**CS**)	At farm gate/food processing premises	At farm gate/ food processing premises
5	Ripening Chamber (**RC**)	Close to consumption/ distribution centre	Near to Consumption centre
6	Last mile Transport (**t**)	Within distribution city	Major cities
7	Retail/ Front-end (**FE**)	Last mile merchandising	Front end
8	Food Processing Unit (**PU**)	Factory dispatch of food product as source point	Cluster parks, production zones

The above considered infrastructure components are assessed for need by developing a matrix as per volumetric flow of selected high value fresh farm produce. The volumetric flow of the selected produce estimated on basis of per capita consumption at major consumption centres, linked to distance from identified producing districts for the purpose of developing the cold-chain infrastructure matrix.

2.5 Products Selected for Study

The study has focussed primarily on the high value produce / product segments categorized by temperature ranges. Across the temperature ranges, the produce/products segments have been identified on the basis of analysis of the unit level NSSO consumption data using NSSTAR browser and STATA software.

The principle objective of the study is to identify the existing status and possible weak links in the infrastructure requirement in for food distribution domain. Furthermore, there are certain well established and demand driven models in the food manufacturing and dairy sectors.

However, the fresh food sector, known as the uninterrupted farm to fork model, which falls directly under cold-chain user base, that requires to be developed. Hence the study has predominantly concentrated on fruits and vegetables which are readily consumed in the country.

Table 2. 2 List of Products Selected

Category (Temperature Range)	Produce/ Products Considered	
Chill (0^0C to 10^0C)	**Fresh Fruits:** 1. Apple 2. Grapes 3. Orange 4. Strawberry 5. Kiwi	**Fresh Vegetables:** 6. Potato 7. Tomato 8. Cauliflower 9. Okra 10. Carrot 11. Cabbage
Mild-Chill (10^0C to 20^0C)	**Fresh Fruits:** 12. Mango 13. Banana 14. Papaya	
Frozen (below -18^0C)	**Other Food Products:** 15. Processed Products 16. Meat & Meat Products (*Livestock, Poultry, Fish*) 17. Dairy products (Ice-Cream, Butter)	
Normal (20^oC to 30^oC)	18. Onion	

The criteria of selection is described under the section 1.4.

2.6 Consumption Centres Selected for Study

Based on the selection of products under study from NSS data, consumption volume was estimated for cities and major cities from each of the zones of the country. These were identified on the basis of ranking of the cities in terms of the consumption demand for the selected products. A list of 9 cities identified for the study is tabulated below.

Table 2. 3 List of Consumption Centres Selected

Zone	Cluster of Cities	Selected Major Consumption Centres/ Cities
North	Delhi	1. Delhi
South	Bengaluru, Chennai & Hyderabad	2. Bengaluru 3. Hyderabad 4. Chennai
East	Kolkata, North-24 Pragana	5. Kolkata
West	Mumbai, Thane, Ahmedabad, Pune, Jaipur, Surat	6. Mumbai 7. Ahmedabad 8. Jaipur
North- East	North Eastern States	9. Guwahati

Following criteria was followed in selection of the cities:

As the study was primarily targeted to assess the demand driven need for cold-chain infrastructure, cities were selected purposefully to estimate requirements, based broadly on two factors viz. (a) Quantity of consumption (b) Consumption pattern as per the regional and cultural demographic variations. Hence, following criteria was used to select the cities for analysis.

- All the cities were ranked according to the Household Monthly Consumption quantity of each of the selected fruits and vegetables items.
- The cities holding ranks across the maximum number of fruits and vegetable items were filtered.
- The leading cities were also stratified to represent the regional variations. All of the cities with high consumption of fruits and vegetables from each of the zones such as South, North, East, West and North-East were finally selected for cold-chain infra gap study.

2.7 Tools for Data Analysis and Research

NSSO household unit level data is extracted using statistical software and analysed using standard statistical methods like mean, growth rate, extrapolation, graphs /charts, etc. Coefficient of variation is used to trace the variations in consumption across the items of fruits and vegetables and for a single product across the states.

Further, following steps were followed to estimate per-capita consumption of fruits and vegetables for the year 2014-15:

- ❖ Step-I: Extracting Unit level Household consumption Data

Unit level per household per month consumption expenditure of selected commodities was accessed from NSO data base for all the districts across rural and urban sectors from NSSTAR explorer and exported to STATA for a disaggregated analysis. The unit level household monthly consumption in quantity was accessed from the NSSO data set through NESSTAR explorers. The monthly household consumption data for the fruit products apple, grape, orange, mango and banana and vegetable products - okra, carrot, tomato, cabbage, potato, cauliflower, and onion, were exported to STATA software for analysis. The average household level monthly consumption expenditure for each of the fruits and vegetable products across the selected districts (sample cities) was arrived by considering the average household consumption across all the household units' data available in a particular city for a selected fruit or vegetable product. The average Monthly household consumption in quantity on a selected product was divided with the household size of the respective city/district to compute the per-capita monthly consumption in quantity.

- ❖ Step-II: Computation of Average Item Wise Household Monthly Consumption in Quantity (AHMCQ)

Average per-household consumption per month for each of the selected items was estimated by taking the sample households covered by NSSO in each of the districts:

Average per Household consumption in quantity per Month in a district= **∑Qih/n,** where, Qih= consumption in quantity for i^{th} item for the h^{th} household and 'n' (n = **∑h** represents total number of sample households covered under NSSO survey report in the district).

- Step-III: Estimation of per-capita monthly consumption in Quantity (PCMCQ)

PCMCQ is derived from Average Monthly Household Consumption expenditure (AHMCQ).

PCME_2011-12 = AHMCQ/Average Household Size

Where, Average Household size = Total Census 2011 population of the District/No. of Census 2011 Households

- Step –IV: Extrapolation of 2011-12 PCMCQ to represent the PCMCQ for 2014-15

The above PCMCQ is based on NSSO 68^{th} round referring to the year 2011-12. In order to arrive at current level expenditure for the year 2014-15 for a particular item and for a specific district, Average PCMHC (Per-Capita Monthly Household Consumption) growth rate of the All India for an item during 2009-10 and 2011-12 is factored with PCMCQ of the same to estimate consumption quantity for the year 2014-15.

The all India PCMCQ growth rates (CAGR) for (PCMCQGi) for i^{th} item for rural and urban sectors are separately taken as the proxy for growth of rural and urban segments consumption of State/district/consumption centre.

The PCMCQ for i^{th} Item for a segment (rural/urban) of the state/district/consumption centre in the year 2012-13 = **PCMCQ_2011-12 for i_{th} item for a state/district/consumption centre *(1+ PCMCQGi**)

The PCMCQ for i^{th} Item for a segment (rural/urban) of the state/district/consumption centre in the year 2013-14 = **PCMCQ_2012-13 for i_{th} item for a state/district/consumption centre *(1+ PCMCQGi**)

The PCMCQ for i^{th} Item for a segment (rural/urban) of the state/district/consumption centre in the year 2014-15 = **PCMCQ_2013-14 for i_{th} item for a state/district/consumption centre *(1+ PCMCQGi**)

Where j represent the state of location of district/consumption centre

- Step-V: Estimation of State/District/Consumption Centre wise Total consumption in quantity per Item for the year 2014-15

The state/city/district wise population figures are accessed from 2001 and 2011 census reports. Based on annual growth rate of population of the sample cities during 2001 and 2011, population for the sample cities for the year 2014-15 has been estimated. The projected population of the year 2014-15 has been multiplied with the above estimated **PCMCQ_2014-15** to arrive at the total consumption of a particular item for the year 2014-15.

For Assessing Demand upto the year 2020 following technique is used for estimation:

Further, the demand projection of cold-chain infrastructure for the coming years would depend on increase in the per-capita consumption demand in urban areas and increase in the urban population. Accordingly, the projected growth rate for cold chain infrastructure would be a combination of per-capita growth in consumption and urban population growth rate.

For estimating the projected growth rate of per-capita demand for commodities under consideration for any year 't', following technique is used in this study:

- Projected growth rate of per-capita consumption demand is the CAGR of per-capita consumption between the recent 02 periods of NSSO data (66^{th} & 68^{th} round).
- Projected growth rate of consumption per-capita = ((Consumption per-capita in the year 2011-12/ Consumption per-capita in the year 2004-05)^ $^{(1/\text{No. of years})}$ -1)*100
- Projected growth rate of urban population= ((Urban population 2011 census/ Urban population 2001 census)^ $^{(1/\text{No. of years})}$ -1)*100

For the estimation of projected growth rate of production, wherever necessary, log-lin trend method has been used:

- Y (Production) of selected items = a + log bt, Lin-log trend projected growth rate (g_p) = ((Antilog of estimated **b**)-1)*100

Finally, the combined projected growth rate for cold-chain infrastructure has been taken as a summation of the factors viz. per-capita consumption, urban population growth and urbanization

2.7.1 Consumption Estimation for Products not covered in NSSO Data

The disaggregated unit level data for frozen products like frozen fruits and vegetables and dairy product like ice-cream was not available in the NSSO survey.

The fruits like kiwi and strawberry are either imported or produced in very small quantities. These fruits are marketed mainly in metro and major cities and it is assumed that 80 per cent of production of these fruits is consumed in the selected cities. Accordingly, per capita consumption was estimated dividing the quantity by the total population of all the cities.

Since all of these products are under the category of processing and is taken care by Ministry of Food Processing Industries, the available literature was considered accurate. At the same time, food processing industry is demand driven and therefore 100% of the production capacity is considered as consumption. To ascertain per capita consumption data for such products, secondary sources[5] is used.

2.7.2 Assumptions for Consumption Data Analysis

Following assumptions are considered for analysis of the consumption data.

- Growth rate for the consumption demand is computed from 66th and 68th round NSSO reports – 10 years data.
- The quantity of per-capita consumption of 2011-12, has been used to estimate the total consumption demand for the year 2014-15.
- A regional consumption trend was evaluated for projecting current consumption in the regions for 2014-15. Where necessary, the all India consumption trend is used.
- The population growth rates across the cities during 2001 census and 2011 census has been used for the estimation of population for the year 2014-15.
- Per-capita monthly consumption growth percentage for a state has been used as a proxy growth percentage for the city belonging to the particular state.
- If consumption quantity for certain fruits like, Banana and Orange is available in numbers only, a conversion factor (9 bananas = 1 kg, and 6 oranges = 1 kg) is used to bring uniformity in unit of measurement.

2.8 Method for Estimation of Infrastructure

Multiple infrastructure components are required to complete the cold-chain. Therefore, differentiated methodology was required to integrate the various infrastructure components to facilitate a streamlined flow of perishable goods through them. The following methodology is adopted in the study to estimate the requirement of various cold-chain infrastructure components.

A. Population Factor & Consumption Factor

i. Population factor is used by assessing the percentage share of population of the nine selected cities with the total urban population of India. A multiple of 5.15 is applied to arrive at the infrastructure assessment for current urban population of 41.3 crores.

[5] Per Capita Consumption figure for the following food products is considered as follows:
- Ice-cream (mL/month) = 33.34; Source: www.indiaretailing.com/FoodGrocer/7/42/46/9718
- Frozen food (gm/month) = 344.0; Source: Analysis from NSSO data and other Sources

ii. Consumption factor is calculated by assessing the share of selected products in the total basket of the perishable produce consumed by the total urban population of the country. A multiple of 1.0 to 1.5 is applied where required.

iii. Similarly to evaluate pack-house and reefer transport numbers, in the first instance the requirement has been analysed for the selected cities and then extrapolated for the urban population of the country.

B. Estimation of Cold Storage (Bulk) capacity

Step-1: The available production data (as provided for 2012-13) has been used for major producing states/ districts.

Step-2: Consumption of a product in any particular state/ district is calculated by taking into account the per capita consumption of the product and population figures of that state/ district.

Step-3: State/ district requirement of cold storage (bulk) is arrived by assuming that a certain percentage of the production of products is available for storage and subsequent distribution to markets. To exemplify, the production percentage considered for products which require bulk/ long-term storage are - Apple (75%), Potato (75%), Kiwi (100%), Carrot (75%), Cabbage (50%) and Dry Chillies (75%). For volumetric assessment, 1 MT is equivalent to 3.4 cubic metres.

C. Estimation of Cold Storage (Hub) capacity

Step-1: Consumption of products at a particular centre/ city is calculated by multiplying per capita consumption and population.

Step-2: To estimate the cold storage (hub) requirement, the throughput (holding cycle) is applied to the consumption as assessed above. The holding cycle of the products, at front end Hubs, considered is mentioned below:

Category	Holding Cycle (in days)
Fruits	7
Vegetables	7
Frozen products	15

Actual holding times will vary for specific produce and as per supply chain dynamics.
In most cases as supply chain develops, the holding periods can be shorter.

Step-3: To assess national requirement of cold storage (hub) at front end (city level), the population factor and consumption factor as described in A (i) & (ii) above is applied. For volumetric capacity, 1 MT is equivalent to 3.4 cubic metres.

D. Estimation of Ripening Units

Step-1: Monthly consumption of a fruit at a particular centre/ city is calculated by multiplying per capita consumption and population.

Step-2: An average four days ripening cycle has been assumed for all fruits to arrive at the required size of ripening units. Each unit is assumed of a size of 40 MT which will therefore have a daily throughput of 10 MT.

E. Estimation of Pack-house

Step-1: Consumption of horticulture produce at a particular centre/ city is used to estimate the required number of pack houses. For each consumption centre, a source/ production point at a distance of greater than 300 km is considered for cold-chain intervention in the form of a pack-house.

Step-2: For pack-house, it is assumed that it will be operational only during the production season for a particular crop. A unit handling capacity of 16 MT is assumed for each pack-house. Multiples of this unit capacity can be set up in regions.

F. Estimation of Reefer Transport Unit Vehicles

Consumption of horticulture produce at a particular centre/ city and pack-house numbers required to meet this consumption is used to estimate the required number of reefer vehicles.

Step-1: It is assumed that each reefer unit carrying capacity is 8 MT and maximum running per day is 450 km (with an average speed of 30 km/ hr for 15 hr in a day).

Step-2: Entire round trip distance has been considered to evaluate reefer vehicle requirement. As such, the reefer vehicle numbers are estimated so that where a round trip distance from source point i.e. pack-house to consumption centre is greater than 450 km, a multiplying factor of 2 is considered.

It may be noted that a reefer transport unit can be in the form of reefer trucks, reefer containers of varying holding sizes.

An empty reverse load has been considered, though market dynamics and operator networking, will attempt to optimise the carriage. This optimisation will reflect in higher number of vehicles, which has not been factored.

It may be noted that for selected products, the distance from source points to urban consumption centres has been taken as per the following mechanism:

- Apple, Grapes, Orange, Mango, Banana, Papaya, Tomato, Cauliflower, Okra, Cabbage and Onion - Districts with more than 5% share in that State's Production are used as source points for estimation of reefer vehicles.

- Carrot - All major states producing carrot are considered. In the absence of district level production data, the state capital is assumed as the source point for estimation of reefer vehicles.
- Strawberry, Kiwi – All producing districts are linked to selected cities for estimation of reefer vehicles.
- Dry Chillies / Onion / Potato – are not used for estimation of reefer vehicles.

G. Other Assumptions

To calculate infrastructure requirements for selected fruits and vegetables, certain factors like the product seasonality and availability of produce for markets after production is considered based on market inputs and practices for calculation purpose, as listed below:

- Tomato, Cauliflower, Okra - 50% of total consumption as derived from NSSO data
- Carrot - 75% of total consumption as derived from NSSO data
- Grapes, Orange, Banana, Papaya - 100% of total consumption as derived from NSSO data
- Mango - 70% consumption of Hyderabad, Bengaluru and Chennai and 100% for remaining 6 cities
- Strawberry, Kiwi - 100% production (Entire production is assumed to be consumed in 9 selected cities)

H. Development of Matrix

Finally, after calculating above infrastructure requirements, a matrix that correlates time-consumption-distance between source of produce and consumption centres has been created.

This model matrix is replicable for assessing the demand at any city of given population size, using per capita consumption and other input data.

The matrix inputs a target population and per capita consumption of a selected product/produce. The distance from source is also an input along with the minimum required inventory holding period at the front end storage (Hub).

The matrix[6] then provides the throughput required from source point (i.e. from pack-house or production facility), the number of reefer vehicles needed to maintain a daily supply to front-end storage, the physical buffer space required at this front end cold store, and an indication of the merchandising platform space required.

[6] Fig 7.1, Page 90

2.9 Post-Harvest Infrastructure Protocols

Prior to arriving at a requirement of relevant cold-chain infrastructure, the post-harvest handling protocols for perishable produce and other food items needed to be identified. The necessary components are identified on the basis of the individual product life cycle, globally established practices for operation of technically feasible supply chains.

Multiple infrastructure components are listed, basis post-harvest protocols deployed:

Table 2. 4 Post-Harvest Infrastructure Protocols for Selected Products

#	Products	**Logistics Flow** (to-be read in order of component listed)
1	Apple	CS – PH – T – CH - t - FE
2	Kiwi	CS – PH – T – CH - t - FE
3	Grapes	PH – T – CH - t - FE
4	Orange	PH – T – CH - t - FE
5	Strawberry	PH – T – CH - t - FE
6	Potato	CS – Ts – FE
7	Onion	SS - Ts – FE
8	Tomato	PH – T – CH - t - FE
9	Cauliflower	PH – T – CH - t - FE
10	Okra	PH – T – CH - t - FE
11	Carrot	CS – PH – T – CH - t - FE
12	Cabbage	CS – PH – T – CH - t - FE
13	Mango	PH – T – CH – RC - t - FE
14	Banana	PH – T – CH – RC - t - FE
15	Papaya	PH – T – CH – RC - t - FE
16	Processed food products	PU – T – CH - t - FE
17	Meat & meat products	PU – T – CH - t - FE
18	Dairy products (Ice-cream, Butter)	PU – T – CH - t - FE

LEGEND:
PH - Pack-house; T - Long Haul Reefer Transport; Ts – Non-reefer Transport; CS - Cold Storage Bulk; CH - Cold Storage Hub; RC - Ripening Chamber; FE - Front-end merchandising; SS – Storage Structure; PU - Food Processing Unit or Allied; t – last mile Transport

Table 2.4 highlights the standard protocols for the selected products under study and relevant component definition is presented in initial sections of this report.[7]

An integrated cold-chain, uninterrupted farm-to-market model, requires access to various infrastructure at multiple locations and across states. This type of market

[7] From NCCD literature

linked revenue model is dependent on volume based growth, with improved produce quality and minimises demand-supply fluctuations.

As a next step, the above listed infrastructure components are assumed in modular unit sizes derived on the basis of market demand and then linked to available production figures. This information will assist developers to target specific regions and markets and thereby develop appropriate business models with suitable infrastructure. The study does not directly refer to specific business models or existing utilisation.

2.9.1 Assumptions on Modular Unit Sizes of Infrastructure

The cold-chain protocols for selected commodities discussed in previous section are needed for end-to-end uninterrupted cold-chain, under the farm-to-fork supply chain concept. Accordingly a mathematical matrix[8] is developed to deduce the requirement of cold-chain infrastructure as per product segment and categorization, cross tabbed with consumption volumes and distance from production areas. In order to assess the infrastructure requirement for handling the produce following assumptions were made to standardise the parameters for each component of cold-chain protocol.

2.9.1.1 Modern Pack-House (PH)

A modern infrastructure with facilities for conveyer belt system for sorting, grading, washing, drying, weighing, packaging, precooling and staging. Pack-houses are the first step in organised post-harvest management for horticulture and are effectively first mile production units for this sector. A modern integrated pack-house unit enables small lot of sourcing and aggregation of horticulture produce, and should be built close to farm-gate. For fresh horticultural produce, a modern pack-house initiates the cold-chain wherein the raw harvest is sorted and aggregated. The output, a packaged, pre-cooled load is then directed to distinct last mile markets. The assumption taken into consideration is as under:

- An integrated pack-house, handling 16 MT per day, with a 2 MT/hour sorting grading line, a pre-cooler and staging cold room of holding size 30 MT.
- Depending on produce, a pack-house will function on perennial basis (eg. banana) or for only 90 days per annum (eg. Mango, Litchi)
- Each pack-house is provided reefer transport unit to handle its daily throughput.

2.9.1.2 Cold Store Bulk (CS)

It is an environment controlled warehousing space with multiple chambers intended for bulk storage of perishable produce. The space is designed for long duration storage of a specific produce so as to build an inventory buffer which will serve to smoothen the episodic production by stabilising & sustaining the supply lines. These

[8] Fig 7.1, Page 90

are normally constructed in areas close to producing areas (farm-gate) to facilitate quick access to farmers, for a selective set of crops only.

- A bulk cold storage unit of volumetric size equal to 5000 MT holding capacity.
- If the identified product is has one harvest a year, the annual throughput or handling capacity of such a cold storage unit will be equal to its holding size.
- If the identified product is has two harvests a year, such a cold storage unit will be capable of handling capacity equal to two times its holding size.
- For unit conversion, 1 MT of space is taken as equivalent to 3.4 cubic metres of volumetric capacity for all products uniformly.

2.9.1.3 Cold Store Hub (CH)

It is an environment controlled warehousing space functioning as a distribution hub. It is designed for short-term handling of produce so as to serve as a distribution logistics platform for marketable packaged produce and ready to retail produce. Cold storage (Hubs) are key to effective distribution of perishable produce and are essential for maintaining the integrity of the cold-chain. These are normally constructed close to consumption centres, built at the front-end linked to source points with refrigerated transport. Through the mathematical matrix, cold storage hub capacity at a particular consumption centre is derived which is a function of following variables:

- Per capita monthly consumption of multi-commodities at a particular consumption centre, based on NSSO unit level data [NSS – 68th Round]
- Population figures of a particular consumption centre, based on 2011 Census data
- Total throughput capacity is assessed basis holding periods of selected products
- For unit conversion, 1 MT of space is taken as equivalent to 3.4 cubic metres of volumetric capacity for all products uniformly.
- Multiple commodities (temperature zones) for fresh horticulture and frozen goods has been totalled to arrive at this capacity.

2.9.1.4 Ripening chamber (RC)

A last mile facility in the cold-chain, designed to function for controlled and hygienic ripening of certain fresh produce. Modern ripening units contain multiple ripening chambers and are used extensively for ripening bananas but are also used to ripen other fruits like mangoes, avocadoes, kiwis, tomatoes, pears, etc.

Ripening chambers can be designed for multi-tiered pallet based storing or structures for basic storage. It is important cold-chain component to promote as unsafe ripening practices can cause various health complications to end consumer.

- One ripening chamber unit is assumed of 10 MT per day throughput capacity i.e. 10 tons a day is one unit output with 4 days of ripening time
- The static size of such a unit would be 40 MT
- For unit conversion, 1 MT of space is taken as equivalent to 11.0 cubic metres of volumetric capacity.

2.9.1.5 Transport (T /Ts/ t)

The material transportation from farm to fork takes place by following different modes:

- Long haul reefer vehicles (T) from farm to consumption centre
- Short haul reefer vehicles (t) from distribution hubs to front-end retail points
- Non-refrigerated trucks (Ts) are used for produce like onion, potato, etc.

- The number of reefer road transport units will depend on the turnaround time i.e. distance from source to market.
- Reefer vehicle is assumed with carrying capacity of 8 MT with an average road speed of 30 km per hour for 15 hours a day.
- Distance covered by reefer vehicle is assumed as 450 kms per day.

As there are no regular refrigerated rail movements for domestic produce, therefore only road transport is considered. However, developing refrigerated reefer container for rail and waterway transport will reduce the total number of road vehicles required.

The above assumptions are used while arriving at the cold-chain infrastructure required for products selected for study from producing areas to consumption markets and is explained further in subsequent sections.

2.10 Domestic Consumption and Import Profiles

The estimation of cold-chain infrastructure requirement at the consumption level is linked to quantity of production and import. Therefore, it is imperative to study the production, growth rate, import, major producing area, etc. of the product handled under the cold-chain.

A brief diagrammatic description regarding product profiles of a few fruits and vegetables is presented in **Annexure – XVI**. The different time-temperature-humidity combinations for storage and transport of various food products are presented in **Annexure – XVII**.

CHAPTER - 3: COLD-CHAIN IN INDIA

3.0 Understanding Cold-chain

With a milk production of 138 million tonnes annually and fruit and vegetable production of approximately 280.4 million MT/annum, India ranks first in milk production and second in fruits and vegetables production in the world. India also has a significant production in meat and meat products. However, the post-harvest losses in perishable products have remained a cause of concern. As per a recent study by CIPHET in 2015, the post-harvest loss among food products is the higher (4.58% to 15.88%) in case of selected fruit and vegetables. This study did not differentiate between losses within or without the cold-chain. An attempt is made to have an understanding of cold-chain in Indian context in this chapter.

Cold-chain is not just about the "cold" but it refers to all logistical procedures applied, to maintain multiple parameters of finished produce during the pre-conditioning, handling, transport, storage and retail of products. The cold-chain includes varied aspects of packaging, atmospheric gases, biology, injury, humidity, traceability, infrastructure, people & product flow, besides temperature. In fact, temperature control can only work with all others in synch.[9]

Cold-chain as an Enabler[10]

Commonly understood as climate controlled warehousing and transport where the temperature, humidity, air composition and packaging play an important role in food delivery. The cold-chain offers many opportunities, two basic aspects are as follows:

A. **Preserving a product's quality.** This is best exemplified in case where cold-chain technology is deployed to primarily protect goods from inclement natural or ambient conditions. In this function, the cold-chain has a more of a preservative effect on the cargo it protects – there is no extension of products' storage life, only a function of preserving its state by maintaining predetermined ambient parameters. These product types are ice cream, meats, most processed foods, vaccines, many chemicals and plastics, electronic goods, etc. These product segments have a clear-cut product expiry period, linked to the ingredients added and the production or manufacturing process. The 'expiry-date' or 'sell-by-date' is maintained by subjecting the package to predefined temperature parameters; whereby the predetermined product quality is secured by the cold-chain to great accuracy. The price discovery is pre-ascertained and product is labelled accordingly.

   In such cases, the production unit or factory is the origin of the cold-chain and the new value that is created at point of origin is preserved for market realisation by cold-chain services. Here, cold warehousing and transport

[9] Excerpts from NCCD Newsletter: ISSN 2395-4515, Issue 3

[10] NCCD. 2014. *Guidelines & minimum System Standards for Implementation in Cold-chain*, developed by National Centre for Cold-chain Development for Ministry of Agriculture

ensures or preserves the goods in a state of pre-determined expiry, with the value and selling date of each package having been defined during the production process.

B. **Enhancing the produce's life cycle.** When we consider cold-chain for fruits and vegetables in fresh form, primarily living perishables, the cargo under care benefits from an enhanced life cycle. The cold-chain when applied correctly, effectively extends the produce's living cycle and safeguards nutrient quality. Though the produce trends on a perpetual, downward biological life cycle, the ageing process is retarded, buying time to reach consumers. Such cargoes are sold fresh and the value impact is not merely because of the temperature control, but also due to many other aspects, which are akin to biological care. When handling farm fresh produce, the cold-chain services need to be more accurate in all its practises, as these are not packaged products but packaged freshness; cold-chain has to manage humidity and microbial conditions, requires to maintain oxygen levels at breathable limits, monitor & control degenerative gases, segregate to avoid tainting between living tissues, and all the while continuing to maintain precise temperatures.

   Excess cooling is harmful and a couple of degrees warmer means faster product demise; any parameter disruption will impact the product longevity and price realisation, both of which are variable. An accurate measure of the produce life cycle is not always possible as it is dependant to pre-harvest conditions too. The cold-chain is merely utilised to retard physiological changes and buy some time. The produce is subject to more dynamic price discovery mechanisms, basis demand, market access and freshness.

   In such cases, the cold-chain is used primarily to derive benefit from the temporary enhancement of life cycle, by using this period to connect with more consumers and to balance episodic harvest periods. The pack-house, transport and cold stores system involve superior skills in their operations with knowledge about the produce under care. This is well understood in case of fresh milk, fresh mangoes, fresh grapes, etc. and the sensitivity of these value chains is frequently evidenced. The product being handled is not a product manufactured under controlled processes, but harvested produce with its originating quality being subject to vagaries of nature. Cold-chain should therefore not procrastinate, but hasten the farm to consumer cycle.

The concepts A and B are two ends of a spectrum – one is a preservative function, the other serves to delay senescence and enhance saleable life. The use of either function depends on the product and produce types. A combination thereof of these underlying principles are also seen in use (potatoes, spices, pulses and select apples are examples).

Understanding the principle involved helps users devise suitable designs and networks. Nevertheless, cold-chain is a specialised logistics system that serves as a conduit to carry and safeguard value, which was either manufactured or harvested, from source to end-consumers.

Agriculture-Industry connect

Cold-chain is a logistics application that has extended itself from a merely protective role into a life enhancing solution for the fresh food sector only recently. Yet globally, the latter and this ability to link fresh foods with markets across vast distance has become its main function. Cold-chains have become the prime link between a long existing production base (the farms) and urban consumption centres.

In case of horticulture, though the farming base is low cost, it can benefit the most from the cold-chain. When handling fresh horticulture produce, the modern pack-house is the key post-harvest point, which prepares the fresh produce to enter the cold-chain conduit. After being conditioned for the cold-chain, the majority of the produce enters the transit phase to markets. This transit requires reefer transport and close to market cold storages. At these cold stores, designed as distribution centres, the produce is deconsolidated into demand based lots for distribution to retail outlets for consumers to access.

Each handling component, the pre-conditioning stage, transitory storage and transport, close-to-market storage for distribution and retail, requires special care, besides basic temperature control, as explained earlier. The cold-chain is not essential for the farmers to produce, but is necessary to reach far away markets – it empowers them with the ability to capture a larger buyer base and helps to bring their harvest to more valuable end use. Conversely, an ice cream factory for example, can exist only with the assurance of a temperature enabled supply link.

Pack-house Origins

Pre-conditioning of the produce after harvest is of primary importance. As a part of this activity, produce is first assorted by value and designated into market lots, even before the energy application phase of cold-chain. The fresh produce that can realise value in the immediate vicinity is not subject to further energy inputs. This implies that the modern pack-house, as the start-point of the cold-chain, also becomes the originator of other supply links which may not require temperature control. Fresh Produce that can be sold locally is routed accordingly, that which can be processed into a product goes to the local processing factory, and that which needs to link to distant markets enters the temperature conditioning phase for onward travel.

Pack-house is the point of origin and is the key decision maker for routing of perishable agriculture produce

Hence, a pack-house initiates multiple market routing or value realisation options. If the routing requires long travel, then packaging for safe transport is the next necessary step. Packaging lines can be used and the package designs are specific for fresh produce. After packaging, the precooling stage is entered so as to bring both the produce and its package to optimal temperatures so as to retard senescence. Thereafter, the packaged fresh produce is kept in a transitory staging cold room, pending onwards transport to faraway markets. Pre-conditioning is the preparatory activity for travel to market, the first phase in the farm to fork trip.

Making the connect

Transport is the next link in this chain. For transport, unitised cargo lots are preferred to facilitate safe as well as speedy handling. Globally, the pallet is the common unit load used. The uniformly sized unit loads, are loaded onto carriers – the reefer trucks or larger unit loads like the reefer container. Reefer containers allow the use of rail, road and waterways without multiple handling of the primary goods (fresh produce).

Uniformity in the load units also allow for harmonisation of the handling equipment and promotes standardisation of operations in the cold-chain.

Handle with care

Palletisation of a load facilitates safe multi-modal handling, whilst transporting and when in cold stores. Pallet handling is best done by mechanised means, which ensures quick & easy operations, reducing the loss that occurs due to mishandling. Cold stores are preferred when they are equipped to handle pallet based cargoes, i.e. Fork lift types, roll-on/roll-off ramps, pallet based put away racks, etc.

Modern cold stores, especially those that serve as distribution centres, increasingly use high reach storage systems and deploy dock shelters, ramps and high reach handling equipment. This also assists in better land area utilisation.

At the last mile, retail shops also need strengthening to handle cold-chain routed fresh produce. In all, the complete chain enhances the produces' usable life, retards loss of freshness, sustains nutritional value to the maximum and contributes enormously by extending the value chain system beyond traditional regions and limitations. The most phenomenal gain is drastic reduction in physical loss, through organised practices, when compared to the traditional multi-layered logistics chain.

Energising the chain

There is an energy cost to achieve such value gain. The cold-chain is energy intensive, primarily due to the added need to regulate temperatures at desired levels. The other major energy use is at the need for speedy transportation. However, the direct conveyance of farm fresh value to urban centres can be expected to be a continued key role for cold-chains and various solutions to minimise energy use are available.

Good planning, insulation, automation, and utilising alternate sources of energy or hybrid energy solutions is a way to mitigate the energy load of a cold-chain. Innovations that combine individual energy solutions may seem futuristic, but have become a common stance globally. India's cold-chain needs to have opportunity to align with futuristic trends and be long term leaders in the 'greening' of the cold-chain.

Cold warehousing

Some of the crops produced in India can take advantage of long term storage, so as to continue trade even in lean periods. These are mostly those that have a single season harvest across the entire country and are compatible for extended storage periods. Such crop types spend most of their life span inside cold stores, pending optimal demand or price from markets. Such product types enter into cold storages soon after harvest, in bulk and in sufficient quantity to feed the consumer for the most part of the year. Fresh potato and apples are ready examples in India.

Cold stores intended for long term holding of produce are designed close to production areas. They will source produce during harvest season and store in bulk, without undertaking any retail packaging. During off season periods, the chambers are periodically opened and product released to market. Much before the start of the next harvest season, the chambers start to empty out and finally the entire store is emptied and readied for the next harvest. These cold stores can have sorting, grading infrastructure. Packaging lines may also be installed, for use when produce exits term storage phase, for subsequent dispatch to market. Such cold stores can be termed as farm-gate facilities as they effectively are scaled up aggregation centres at source, with large term storage chambers and other appropriate technology options.

The other cold store type is that at the front end of the cold supply chain. It will be designed for transient storage and enabled for cross-docking (fast distribution) operations. Pre-conditioned and packed produce enters this store, having already flowed in the cold-chain – the goods would have originated at a pack-house or from a processing unit. Since goods already arrive in packaged form for retail, there is no need for a pack-house type unit to this infrastructure. In some cases, a large infrastructure which doubles as an aggregation unit for raw produce, will design a pre-conditioning facility for preparing local produce for cross regional travel.

The front end cold stores are distribution centres or hubs, and are a perpetual hub of activity, receiving and dispatching cargo at a daily or frequent basis and are critical infrastructure to serve connectivity to the market. The ante-room, also known as a staging area, is large in size to allow for multiple activities and movements inside such a cold store. These cold distribution hubs are located close to consumption centres, metros and other steady demand centres such as ports and airports so as to serve as a feeding centre.

Standardisation of handling, packaging and equipment is critical to smooth operations and to minimise operational wastage with the storage aspect taking a back seat. The operational needs of the two main type of cold stores differ, as does the associated technical design and sizing of infrastructure.

Ripe for consumption

Ripening chambers are a unique component of the cold-chain and used only in the fresh produce segment. In this segment, whereas the cold-chain operates to extend life by slowing the normal metabolism, the ripening chambers do the opposite and advances the physiological activity. Depending on market demand, ripening chambers are used to manipulate the life extension brought on by the cold-chain, by adjusting or tweaking the maturity cycle of the produce.

The produce that enters a ripening facility exits the cold store well within its extended life cycle, and the ripening process is triggered. Climacteric fruits like bananas, mangoes and papayas are normally ripened on demand, to meet market requirements. Normally, the produce would otherwise ripen naturally towards the end of their life span. Ripening chambers can also be used by a non-climacteric fruits like for de-greening of citrus fruit.

Ripening chambers are designed to maintain mild-chill temperatures and dose the fruit with ethylene, which is a natural ripening trigger. Air circulation ensures that the dosing is even inside the chamber and allows for a clean look to the ripened product. A ripening cycle of 4 to 5 days is the typical norm. At the end of each cycle, the ripened produce moves out for retail. The shelf life of ripened produce is minimal and thus, ripening chambers need to be built at the last mile of the cold-supply-chain, close to the consumption base. Ripened produce cannot last long and should not be dispatched for long distant travel.

Cold-chain keeps custody of value[11]- The approach to cold-chain needs orienting towards a supply chain business, one where the chain of custody is key to its success. From the moment temperature-sensitive goods leave source point (manufacturer or harvester), it is a race against time and inclement conditions to bring it to the consumers in usable state. Poor practice by anyone in custody of goods, can have an incremental and damaging impact on final value realisation.

3.1 Evolution of Cold-chain in India

The cold-chain in India is traditionally conceived as setting up of cold storage unit. NCCD has defined Cold-chain as an environment controlled supply chain, consisting of storage and distribution activities which maintains a product in stipulated ambient range of conditions. It involves a series of activities and procedures that perishable goods are subject to, from source of raw material to a production facility or to an end consumer. Cold-chain is not merely refrigerated storage and transport but as a supply chain, it must include a point of origin – a production unit such as horticultural pack-house, an ice cream factory, and an abattoir or vaccine manufacturing facility.[12]

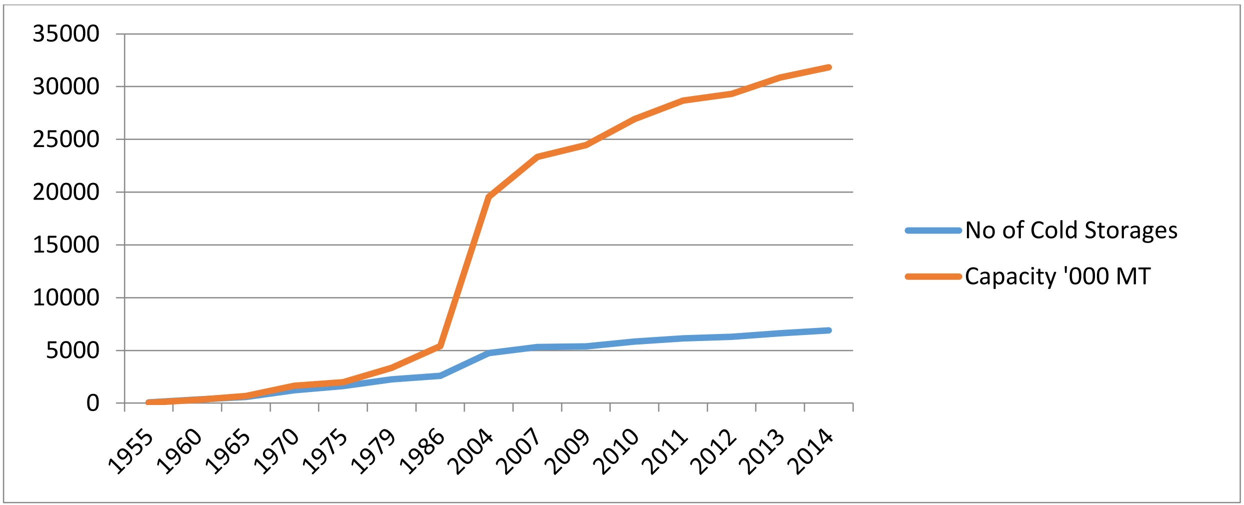
The birth of cold-chain in India could be traced back to setting up of the first cold storage units in Kolkata in 1892. However, the development of the industry in a scientific manner was initiated post-independence with the "Cold Storage Order, 1964" coming in effect under the Section 3 of Essential Commodities Act, 1955. The Act was applicable all over India.

[11] NCCD News Letter (ISSN 2395-4515), Issue No.12, February 2015
[12] NCCD News Letter (ISSN 2395-4515), Issue No.2, April 2014

Subsequently States like West Bengal, Uttar Pradesh, Haryana, Punjab etc. enacted their own acts after promulgation of a cold storage order known as Central Cold Storage Order 1980. Directorate of Marketing & Inspection (DMI), Ministry of Agriculture, Government of India, enforced the Central Cold Storage Order 1980. Till then, there had been a controlled growth of this sector. Government of India modified the Central Cold Storage Order during May 1997 in line with the policy of liberalization.

After deregulation in 1997, there has been a spurt growth in establishment of cold storages in India (Fig 3.1).

Fig 3. 1 Growth of Cold-Storage in India



The first step to accelerate the growth of cold-chain was taken by Govt. of India by appointing a High Level Expert Committee (HLEC) in November 1998 under the Chairmanship of Shri J N L Srivastava, former Secretary, Ministry of Agriculture and Cooperation for improving the cold storage/other storages in the country. The committee recommended creation of cold storage capacity of 12 lakh MT during 9th Five Year Plan and a capital investment subsidy for construction/expansion/modernisation of cold storage and storages for horticulture produce was launched by National Horticulture Board, implemented through NABARD and DMI. The scheme gave impetus for growth of standalone cold storages all over the country. Further, the capacity grew at much faster rate than the number of units indicating establishment of bigger units after 1998. As on 31 March 2014, there were 6891 cold storage units created with a total storage size of 31.82 million tonnes[13]. The integrated cold-chain development was lacking and need for a scheme to promote the same was felt.

In 2005-06, a mission mode approach to developing horticulture was initiated with the launch of National Horticulture Mission (NHM) in addition to the existing Horticulture Mission for North Eastern and Himalayan States. In 2013, all existing arms under DAC involved in horticulture development were subsumed under the

[13] Report of the Task Force on Cold Chain Projects (TFCP), MoFPI/ DMI. DAC., GoI

Mission for Integrated Development of Horticulture (MIDH). Post-harvest infrastructure development is a thrust area under MIDH.

In October 2014 a report by the Task Force on Cold Chain Projects recommended creation of additional 7.5 million MT cold-chain capacity in the next 5 years under the joint responsibility of the Ministry of Agriculture and the Ministry of Food Processing Industries. Out of 7.5 million MT, DAC can take up 5 million MT under MIDH and MoFPI can take up 2.5 million MT. The capacity needs to be planned to adopt an "end-to-end" approach so as to connect farm-gate to the consumers in a seamless manner.

The base line survey of cold stores, conducted by M/s. Hansa Research for National Horticulture Board[14] under DAC in 2013-14, indicates the segment wise share in number of cold storage is shown in Fig. 3.2.

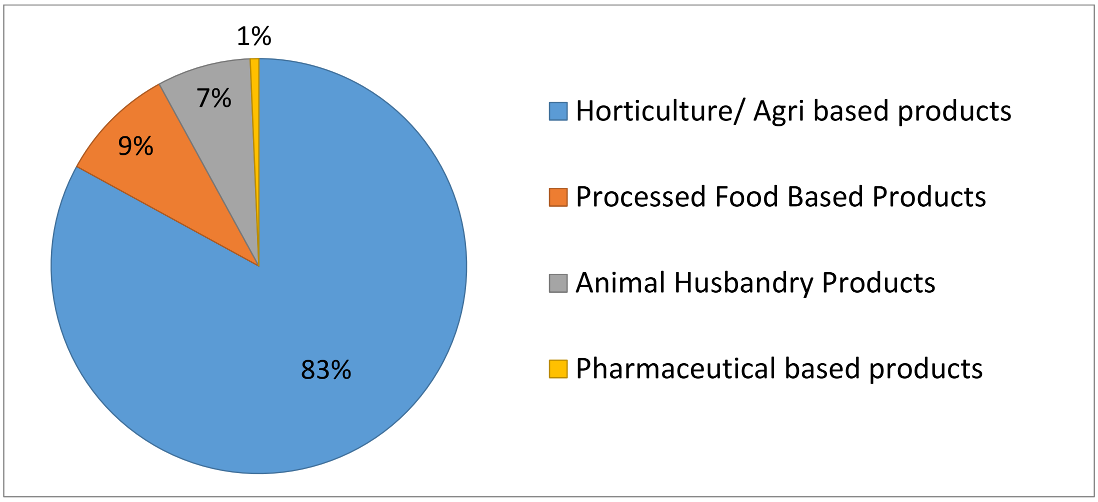


Fig 3. 2 Segment-wise Segregation of Cold Storages

It is observed that this information on segment wise share is collated from the respondents' answers to the census/survey and is uncorroborated. The segmentation is derived from statements of respondents and cold stores built at farm-gate may have also responded as multi-commodity storage types.

As per this survey, 1219 cold stores are permanently closed/not available and the total number of functional cold stores is 5367 amounting to a total storage size of 26.85 million tons. The survey also indicates that although most of the cold storages facilitate transportation of commodities, 79% don't own any transportation facility and there are very few modern pack-houses to originate produce into cold-chain.

It is observed that India had made steady progress in standalone cold storages but required to develop other associated infrastructure components in the cold-chain. This study evaluates and reveals the infrastructure requirements to meet current consumption of urban population in India, from domestic production. It is felt this requires greater attention to modern pack-houses and refrigerated transport to link

[14] All India Cold storage Capacity and Technology Baseline Survey, NHB 2015

producers to markets. To make headway in integrated cold-chain infrastructure, holistic approach to such development is required.

NCCD had earlier estimated on a broad level that for every cold store (Hub) of size 5000MT, to handle a weekly throughput of 2000MT of fresh fruits and vegetables, there needed to be integrated development of 16 pack-house units, connected with an associated number of reefer vehicles. In effect the investment needed to shift more towards pack-houses and refrigerated transport as cold storage accounted for only about 18% of the investment in this chain.[15]

Refrigerated transport is still in nascent stage in India. In comparison, France which is reported to have 5 million tons in cold storage space, has about 1,40,000 reefer vehicles and the UK reports using about 80,000 reefer vehicles. In U.S.A. reports indicate that 80-85% of fresh fruits and vegetables movement is through cold-chain. India has negligible reefer transportation for its domestic movement of perishables.

China is also reported to suffer a deficit of reefer transport with estimated 66,000 reefer vehicles.[16] In comparison, in India it is estimated that there are less than 10,000 actively refrigerated transport vehicles and no domestic reefer rail options. Most of the cold-chain providers are private players and only few operators can offer end-to-end cold-chain solutions.

In India, because of renewed focus on developing the rural areas, especially due to the PMGSY (Pradhan Mantri Gram Sadak Yojna), the rural road infrastructure network is fast turning into a reality. This should add impetus to the need and obvious benefits to be derived from connecting rural output with buying markets. Developing reefer trucks or transport units that can carry farm produce closer to last mile value realisation, will be a vital factor for more inclusive wealth creation.

In case of perishables, the reefer trucks require source handling points, which brings across the need to have pack-houses that prepare and precondition the goods for travel to market. In this chain, wherever a buffer inventory is required, the cold stores are necessitated to secure seamless delivery of food. Overall, the operational processes and supply chain systems, will bring stability in supply, prices and reduce losses that are otherwise incurred. Additionally, every handling centre, especially the pack-houses, can have value addition in form of food processing units, ensuring maximum gain from what is harvested.

[15] NCCD News Letter (ISSN 2395-4515), Issue No.7, September 2014
[16] Cold Chains and the Demographic Dividend, Dearman Report, April 2015

CHAPTER - 4: EXISTING COLD-CHAIN INFRASTRUCTURE

4.0 Cold-chain Infrastructure

Cold-chain infrastructure creation is promoted under various schemes implemented by ministries/departments. In addition to this, presence of private players makes it difficult to assess current status of cold-chain infrastructure by activity component. However, the available set of data-on-records is essential to ascertain the existing ecosystem and arriving at the gap in infrastructure. The section will highlight the summary of component-wise existing infrastructure as per the available information.

4.1 Existing Infrastructure

This section presents the component-wise status of infrastructure in India created under different schemes of various departments.

Table 4. 1 Existing Cold-chain Infrastructure in India

#	Infrastructure Component	Numbers	Avg Size or capacity (MT)	Remarks
1	Modern Pack-house (**PH**)	249	NA	Study of secondary data and estimates
2	Cold Storage Hubs (**CH**)	5367	5003	Baseline Survey (DAC)
3	Cold Storage Bulk (**CS**)			Baseline Survey (DAC)
4	Ripening Chamber (**RC**)	812	NA	Study of secondary data and estimates
5	Reefer Transport (**T**)	9,000	6 to 15 tons	Market estimate
6	Last mile Transport (**t**)		< 4 tons	Market estimate
7	Retail/ Front-end (**FE**)	1.968 million outlets	NA	Market estimate

The Task Force on Cold-chain Projects (TFCP-2014) reports that a total of 31.82 million metric tons of cold stores have been created (**Annexure - VI**) in the country. Of these, a total of 10.58 million tons in cold storage size were created in the last 7 years (*from 2007 to 2014*), through Central Government Assistance:

- Under MoFPI: total 0.19 million tons capacity is created.
- Under MIDH (*NHM/HMNEH/NHB*): total 10.39 million tons is created.

As per information from various government departments and agencies, 6891 cold storages have been created of size 31.82 million tons, see **Annexure – VI.** This information is not further segregated into Cold Storage (Bulk) or Cold Storage (Hub).

To assess the existing operating throughput capability of each infrastructure component, the handling capacity is calculated by applying the holding size with holding period. Two cases are discussed for understanding.

Case 1 – Bulk storage of single season harvest crop, farm-gate

Throughput Capability of Cold Storage – Bulk (Potato, Apple, Dried Chilly, etc.)		
A	Holding cycle of product	8-10 months
B	Rotation in Storage Space in a year	1 time
C	Static Size of Cold storage created	25 mill tons
D	Throughput Capability	25 mill tons

Note:

Since these stores are used to cycle a single crop, harvested in one season, the storage space, effectively handles one rotation of inventory in a year, with a few months of non-usage of the space. In potato, it is observed that the empty period of approximately 2-3 months is used to prepare the space for the next harvest. In effect, the static size of the cold store is equal to the throughput capacity – 1 cycle per year.

Case 2 – Cold Storage Hub, storage of multiple commodities, front-end

In a similar manner, the throughput capability of cold storage (hub) to store other food products is estimated on the basis of holding cycle listed in the table below.

Table 4. 9 Assumptions for Calculating Throughput Capability of Cold Storage (Hub)

Product Category (by temperature)	Product Types	Holding cycle (number of days)
Chill (0°C to 10°C)	Fruits	7
	Vegetables	7
Mild-Chill (10°C to 20°C)	Fruits	7
Frozen (<-18°C)	Processed food, Dairy products, Meat products	15

In case of assumed holding period of 1 week (7 days) for fruits and vegetables, the Annual throughput capacity = Storage size in tons x 52 weeks

In case of assumed holding period of 2 weeks (15 days) for frozen goods, the Annual throughput capacity = Storage size in tons x 26 weeks

Note: Clear differentiation of operational capability of cold stores (Bulk and Hub), in correlation to the positioning of the cold stores in the supply chain system, was not possible from the summary available of the baseline survey by NHB or other data. This differentiation between cold store uses, as mooted in this study has also not been attempted before and is needed for clear understanding and developing of integrated cold-chains.

A study to validate the operational usage of cold stores, that are in proximity to large consumption centres and their capacity to function as distribution hubs will be needed. This will help to confirm the actual number of distribution hubs, which can serve as part of the integrated supply chain of perishables.

Apart from cold storages, a good distribution system is required to address the missing or weak links in terms of other cold-chain infrastructure components at farm level like modern pack-houses and transportation through reefer vehicles and merchandising units thereby minimising the wastage of the products.

Product specific turnarounds are an important consideration when assessing capacity for cold-chain assets, including cold stores (Hubs) and merchandising retail units. Empirical observations show that fresh milk has very high throughputs and can have twice a day replenishments. This is noted especially at milk booths, retail end and at household level. The storage requirement is more at the "shelf level" with cold store only acting as an interim cross dock facility. In fact, fresh milk is also moved directly in insulated tankers, which do not require a cold store interface. Tetra-packaged milk bypasses cold-chain use and stored in home refrigerators.

Similarly, in case of fresh meats and fish, the maximum time spent by the inventory is in transit or held at frontend retail units and households. Very fast throughputs are observed in this segment, as also with high perishable milk based products.

In case of deep frozen meats and fish products, including frozen processed foods, the inventory is preferably moved to retail cabinets (deep freezers) and the cold storage (Hub) spaces come into use to buffer such movement - on exiting the processing plant, reefer transport is a core necessity. Though in this study, a 15 day cycle at distribution hubs is assumed for these product types, this period may vary in practice once more holding capacity is developed in the form of frozen display cabinets.

Processed food items where raw produce availability is highly seasonal, have production lines being fed when in season (eg. Peas). The finished product is then stored at the production site or captive stores (eg. cold stores linked to IQF lines). Basis individual pricing strategies and market demand, the food processor then uses the service of cold-chain to move this product inventory to consumers. In such cases, when the product exits producer's storage end, the demand for cold-chain is generated in form of reefer transport units, cold distribution hubs and frozen retail cabinets.

CHAPTER - 5: DEMAND ANALYSIS OF FOOD PRODUCTS

5.0 Consumption-led Demand

The cold-chain system integrates consumption with production, hence assessing both supply and demand for any product (passing through the cold-chain system) is important for estimating the requirements of cold-chain infrastructure.

To have market linked and viable development, consumption demand analysis is a key part of the need assessment for cold-chain infrastructure. All food that is produced has consumption as its end-use and hence any infrastructure deployed that is not linked to consumption, will eventually be constrained in fulfilling the benefits expected from such infrastructure. With this is mind, the primary driver in assessing infrastructure requirements is the demand, and not merely the supply. In fact, the supply or production would get attuned to demand, or aim to reach where demand exists by using infrastructure as a tool to carry the inventory produced to many more demand centres.

This study aims to provide strategic direction to develop appropriate "demand based" infrastructure, so as to ensure smooth supply of perishable products from production centres to consumption centres. This infrastructure should be created in such a manner that it can be utilised effectively as a tool to ensure uninterrupted delivery of food at reasonable cost to the consumer at one hand, and on the other hand ensuring extended market reach and remunerative price to the producers.

Cold-chain is considered a logistics conduit that protects and moves value once it is created (after harvest or after processing). Therefore, source point for cold-chain is primarily the point where agricultural produce (farm-gate) or final product (factory-gate) is first handled or for onward linkage with demand centres. The production based activities of farming and/or processing are value creating activities, such value thereafter being handed over to cold-chain for its market connectivity and delivery.

As mandated under the study, extensive analysis has been undertaken to understand the pattern of consumption of fresh fruit and vegetable items and other food products that can benefit by passing through the cold-chain system. Also undertaken was assessing the regional variation of consumption of such items.

The consumption patterns are presented in the form of charts and graphics. The features pertaining to quantity of consumption of the food products emerging from data compiled from NSSO survey reports is highlighted in subsequent pages.

5.1 Consumption Profile of Fruits and Vegetables

In the subsequent pages, the consumption maps of selected fruits and vegetables is presented with zone-wise statistics and state-wise classification when compared with national consumption average figures.

Per-Capita Consumption Profile of Apple

Per Capita Monthly Consumption (PCMC) of Apple in Kg.

State	PCMC
Andhra Pradesh	0.16
Arunachal Pradesh	0.32
Assam	0.07
Bihar	0.13
Chhattisgarh	0.08
Delhi	0.35
Goa	0.48

State	PCMC
Gujarat	0.21
Haryana	0.51
Himachal Pradesh	0.44
J & K	0.70
Jharkhand	0.14
Karnataka	0.23
Kerala	0.25

State	PCMC
Madhya Pradesh	0.10
Maharashtra	0.32
Manipur	0.07
Meghalaya	0.04
Mizoram	0.02
Nagaland	0.18
Odisha	0.09
Punjab	0.40
Rajasthan	0.16

State	PCMC
Sikkim	0.15
Tamil Nadu	0.23
Tripura	0.07
Uttar Pradesh	0.14
Uttarakhand	0.30
West Bengal	0.14
All India	0.19

1. The state J & K has the highest per-capita monthly consumption of apple (0.7 Kg.) and followed by the states Haryana and Himachal Pradesh.
2. Per-capita monthly consumption of apples is lower in the North-eastern states (Except the state Arunachal Pradesh) as compare to other parts of the country
3. Out of the listed 29 states of India, in14 states of India, average per-capita consumption of apple is higher than all India average.
4. Based on unit level HH monthly Consumption data, among the sample cities, Mumbai has the highest per capita consumption of apple followed by Bangalore, Ahmedabad and Chennai.

Per-Capita Consumption Profile of Mango

Per Capita Monthly Consumption (PCMC) of Mango in Kg.

State	PCMC
Andhra Pradesh	0.66
Arunachal Pradesh	0.06
Assam	0.30
Bihar	0.55
Chhattisgarh	0.37
Delhi	0.33
Goa	0.44

State	PCMC
Gujarat	0.53
Haryana	0.82
Himachal Pradesh	0.62
J & K	0.26
Jharkhand	0.48
Karnataka	0.41
Kerala	0.34
Madhya Pradesh	0.39

State	PCMC
Maharashtra	0.43
Manipur	0.09
Meghalaya	0.15
Mizoram	0.29
Nagaland	0.10
Odisha	0.57
Punjab	0.54
Rajasthan	0.46

State	PCMC
Sikkim	0.16
Tamil Nadu	0.38
Tripura	0.66
Uttar Pradesh	0.57
Uttarakhand	0.33
West Bengal	0.46
All India	0.49

1. The state Haryana has the highest per-capita monthly consumption of Mango (0.82 Kg.) and followed by the states Andhra Pradesh, Tripura, Himachal Pradesh, Uttar Pradesh, Bihar & Gujarat.
2. Per-capita monthly consumption of Mango is lower in the North-eastern states (Except the state Tripura) as compare to other parts of the country
3. Out of the listed 29 states of India, in 09 states of India, average per-capita consumption of Mango is higher than all India average (0.49 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, higher monthly per-capita consumption of Mango is traced in Bangalore and followed by Chennai and Hyderabad.

Per-Capita Consumption Profile of Orange

Per Capita Monthly Consumption (PCMC) of Orange in Kg.

State	PCMC
Andhra Pradesh	0.212
Arunachal Pradesh	0.796
Assam	0.157
Bihar	0.044
Chhattisgarh	0.070
Delhi	0.463
Goa	0.246

State	PCMC
Gujarat	0.082
Haryana	0.390
Himachal Pradesh	0.302
J & K	0.416
Jharkhand	0.052
Karnataka	0.166
Kerala	0.472
Madhya Pradesh	0.075

State	PCMC
Maharashtra	0.155
Manipur	0.054
Meghalaya	0.264
Mizoram	0.159
Nagaland	0.278
Odisha	0.036
Punjab	0.327
Rajasthan	0.172

State	PCMC
Sikkim	0.317
Tamil Nadu	0.124
Tripura	0.189
Uttar Pradesh	0.067
Uttarakhand	0.244
West Bengal	0.266
All India	0.153

1. The North-east state Arunachal Pradesh has the highest per-capita monthly consumption of Orange (0.796 Kg.) and followed by the states Kerala, Delhi, J & K, Haryana, Punjab, Sikkim & HP.
2. Per-capita monthly consumption of Orange is lower in the states Odisha, Bihar and Jharkhand as compare to other parts of the country
3. Out of the listed 29 states of India, in 20 states of India, average per-capita consumption of Orange is higher than all India average (0.153 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of orange is traced in Jaipur and followed by Mumbai – Mumbai sub urban and Kolkata.

Per-Capita Consumption Profile of Grapes

Per Capita Monthly Consumption (PCMC) of Grapes in Kg.

State	PCMC
Andhra Pradesh	0.207
Arunachal Pradesh	0.041
Assam	0.015
Bihar	0.055
Chhattisgarh	0.048
Delhi	0.113
Goa	0.183

State	PCMC
Gujarat	0.149
Haryana	0.212
Himachal Pradesh	0.125
J & K	0.085
Jharkhand	0.043
Karnataka	0.160
Kerala	0.263

State	PCMC
Madhya Pradesh	0.148
Maharashtra	0.185
Manipur	0.006
Meghalaya	0.004
Mizoram	0.006
Nagaland	0.019
Odisha	0.042
Punjab	0.121
Rajasthan	0.108

State	PCMC
Sikkim	0.014
Tamil Nadu	0.140
Tripura	0.051
Uttar Pradesh	0.090
Uttarakhand	0.134
West Bengal	0.060
All India	0.122

1. The state Kerala has the highest per-capita monthly consumption of grapes (0.263 Kg.) and followed by the states Haryana and Andhra Pradesh.
2. Per-capita monthly consumption of grapes is lower in the North-Eastern states as compare to other parts of the country
3. Out of the listed 29 states of India, in 11 states of India, average per-capita consumption of grapes is higher than all India average (0.122 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of grapes is traced in Jaipur and followed by Bangalore.

Per-Capita Consumption Profile of Banana

Per Capita Monthly Consumption (PCMC) of Banana in Kg.

State	PCMC
Andhra Pradesh	0.98
Arunachal Pradesh	0.67
Assam	0.61
Bihar	0.52
Chhattisgarh	0.24
Delhi	0.65
Goa	1.10

State	PCMC
Gujarat	0.61
Haryana	0.84
Himachal Pradesh	0.59
J & K	0.42
Jharkhand	0.18
Karnataka	1.03
Kerala	1.24

State	PCMC
Madhya Pradesh	0.47
Maharashtra	0.98
Manipur	0.43
Meghalaya	0.33
Mizoram	0.46
Nagaland	0.99
Odisha	0.40
Punjab	0.51
Rajasthan	0.56

State	PCMC
Sikkim	0.21
Tamil Nadu	0.94
Tripura	1.00
Uttar Pradesh	0.39
Uttarakhand	0.63
West Bengal	0.45
All India	0.65

1. The state Kerala has the highest per-capita monthly consumption of banana (1.24 Kg.) and followed by the states Karnataka, Goa, Tripura, Nagaland, Maharashtra, Andhra Pradesh and Tamil Nadu.
2. Per-capita monthly consumption of banana is lower in the states Jharkhand, Sikkim and Chhattisgarh as compare to other states of the country
3. Out of the listed 29 states of India, in 11 states of India, average per-capita consumption of banana is higher than all India average (0.65 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of banana is traced in Ahmedabad and followed by Chennai and Mumbai & Mumbai suburb.

Per-Capita Consumption Profile of Okra

Per Capita Monthly Consumption (PCMC) of Okra in Kg.

State	PCMC
Andhra Pradesh	0.44
Arunachal Pradesh	0.11
Assam	0.12
Bihar	0.37
Chhattisgarh	0.29
Delhi	0.28
Goa	0.21

State	PCMC
Gujarat	0.28
Haryana	0.24
Himachal Pradesh	0.28
J & K	0.20
Jharkhand	0.31
Karnataka	0.17
Kerala	0.25
Madhya Pradesh	0.18

State	PCMC
Maharashtra	0.23
Manipur	0.06
Meghalaya	0.06
Mizoram	0.11
Nagaland	0.02
Odisha	0.18
Punjab	0.30
Rajasthan	0.20

State	PCMC
Sikkim	0.07
Tamil Nadu	0.31
Tripura	0.16
Uttar Pradesh	0.18
Uttarakhand	0.25
West Bengal	0.19
All India	0.25

1. The state Andhra Pradesh has the highest per-capita monthly consumption of okra (0.44 Kg.) and followed by the states Bihar, Jharkhand, Tamil Nadu and Punjab.
2. Per-capita monthly consumption of okra is lower in the North-Eastern states as compare to other states of the country
3. Out of the listed 29 states of India, in 09 states of India, average per-capita consumption of okra is higher than all India average (0.25 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of Okra is traced in Guwahati and followed by Kolkata, Jaipur and Mumbai & Mumbai suburb.

Per-Capita Consumption Profile of Tomato

Per Capita Monthly Consumption (PCMC) of Tomato in Kg.

State	PCMC
Andhra Pradesh	1.41
Arunachal Pradesh	0.53
Assam	0.37
Bihar	0.35
Chhattisgarh	1.66
Delhi	1.04
Goa	0.87

State	PCMC
Gujarat	0.95
Haryana	1.18
Himachal Pradesh	0.83
J & K	0.85
Jharkhand	0.81
Karnataka	1.10
Kerala	0.67
Madhya Pradesh	0.98

State	PCMC
Maharashtra	0.86
Manipur	0.21
Meghalaya	0.52
Mizoram	0.34
Nagaland	0.60
Odisha	0.85
Punjab	0.80
Rajasthan	0.92

State	PCMC
Sikkim	0.67
Tamil Nadu	1.22
Tripura	0.40
Uttar Pradesh	0.61
Uttarakhand	0.82
West Bengal	0.33
All India	0.83

1. The state Chhattisgarh has the highest per-capita monthly consumption of tomato (1.66 Kg.) and followed by the states Andhra Pradesh, Tamil Nadu, Haryana, Karnataka and Delhi.
2. Per-capita monthly consumption of tomato is lower in the North-Eastern states as compare to other states of the country
3. Out of the listed 29 states of India, in 13 states of India, average per-capita consumption of tomato is higher than all India average (0.83 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of tomato is traced in Hyderabad and followed by Chennai.

Per-Capita Consumption Profile of Carrot

Per Capita Monthly Consumption (PCMC) of Carrot in Kg.

State	PCMC
Andhra Pradesh	0.12
Arunachal Pradesh	0.03
Assam	0.05
Bihar	0.03
Chhattisgarh	0.03
Delhi	0.22
Goa	0.06

State	PCMC
Gujarat	0.06
Haryana	0.45
Himachal Pradesh	0.20
J & K	0.17
Jharkhand	0.04
Karnataka	0.18
Kerala	0.23
Madhya Pradesh	0.04

State	PCMC
Maharashtra	0.06
Manipur	0.05
Meghalaya	0.07
Mizoram	0.05
Nagaland	0.04
Odisha	0.02
Punjab	0.42
Rajasthan	0.17

State	PCMC
Sikkim	0.02
Tamil Nadu	0.28
Tripura	0.04
Uttar Pradesh	0.09
Uttarakhand	0.09
West Bengal	0.04
All India	0.10

1. The state Chhattisgarh has the highest per-capita monthly consumption of carrot (0.45 Kg.) and followed by the states Tamil Nadu, Kerala and Delhi.
2. Per-capita monthly consumption of carrot is lower in the states Odisha, Sikkim, Chhattisgarh and Arunachal Pradesh as compare to other states of the country
3. Out of the listed 29 states of India, in 10 states of India, average per-capita consumption of carrot is higher than all India average (0.10 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of carrot is traced in Jaipur and followed by Delhi.

Per-Capita Consumption Profile of Cabbage

Per Capita Monthly Consumption (PCMC) of Cabbage in Kg.

State	PCMC
Andhra Pradesh	0.18
Arunachal Pradesh	0.31
Assam	0.43
Bihar	0.27
Chhattisgarh	0.32
Delhi	0.22
Goa	0.38

State	PCMC
Gujarat	0.40
Haryana	0.17
Himachal Pradesh	0.31
J & K	0.22
Jharkhand	0.39
Karnataka	0.20
Kerala	0.23
Madhya Pradesh	0.13

State	PCMC
Maharashtra	0.29
Manipur	0.53
Meghalaya	0.46
Mizoram	0.33
Nagaland	0.52
Odisha	0.35
Punjab	0.06
Rajasthan	0.18

State	PCMC
Sikkim	0.52
Tamil Nadu	0.26
Tripura	0.36
Uttar Pradesh	0.11
Uttarakhand	0.23
West Bengal	0.41
All India	0.24

1. The state Manipur has the highest per-capita monthly consumption of cabbage (0.53 Kg.) and followed by the states Sikkim, Nagaland, Meghalaya, Assam and West Bengal.
2. Per-capita monthly consumption of cabbage is lower in the states Punjab, Uttar Pradesh and Madhya Pradesh as compare to other states of the country
3. Out of the listed 29 states of India, in 18 states of India, average per-capita consumption of cabbage is higher than all India average (0.24 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of cabbage is traced in Kolkata and followed by Guwahati.

Per-Capita Consumption Profile of Cauliflower

Per Capita Monthly Consumption (PCMC) of Cauliflower in Kg.

State	PCMC
Andhra Pradesh	0.09
Arunachal Pradesh	0.14
Assam	0.29
Bihar	0.52
Chhattisgarh	0.30
Delhi	0.55
Goa	0.24

State	PCMC
Gujarat	0.34
Haryana	0.58
Himachal Pradesh	0.56
J & K	0.46
Jharkhand	0.38
Karnataka	0.06
Kerala	0.03
Madhya Pradesh	0.26

State	PCMC
Maharashtra	0.33
Manipur	0.14
Meghalaya	0.16
Mizoram	0.13
Nagaland	0.12
Odisha	0.30
Punjab	0.59
Rajasthan	0.26

State	PCMC
Sikkim	0.35
Tamil Nadu	0.07
Tripura	0.43
Uttar Pradesh	0.32
Uttarakhand	0.55
West Bengal	0.35
All India	0.30

1. The state Punjab has the highest per-capita monthly consumption of cauliflower (0.59 Kg.) and followed by the states Haryana, Himachal Pradesh, Delhi and Uttarkhand.
2. Per-capita monthly consumption of cauliflower is lower in the states Kerala, Karnataka, Tamil Nadu and Andhra Pradesh as compare to other states of the country
3. Out of the listed 29 states of India, in 15 states of India, average per-capita consumption of cauliflower is higher than all India average (0.30 Kg).
4. Based on unit level HH monthly Consumption data, among the sample cities, Higher monthly per-capita consumption of cauliflower is traced in Kolkata and followed by Guwahati.

Per-Capita Consumption Profile of Onion

Per Capita Monthly Consumption (PCMC) of Onion in Kg.

State	PCMC
Andhra Pradesh	1.54
Arunachal Pradesh	0.57
Assam	0.71
Bihar	1.54
Chhattisgarh	1.10
Delhi	1.31
Goa	1.81

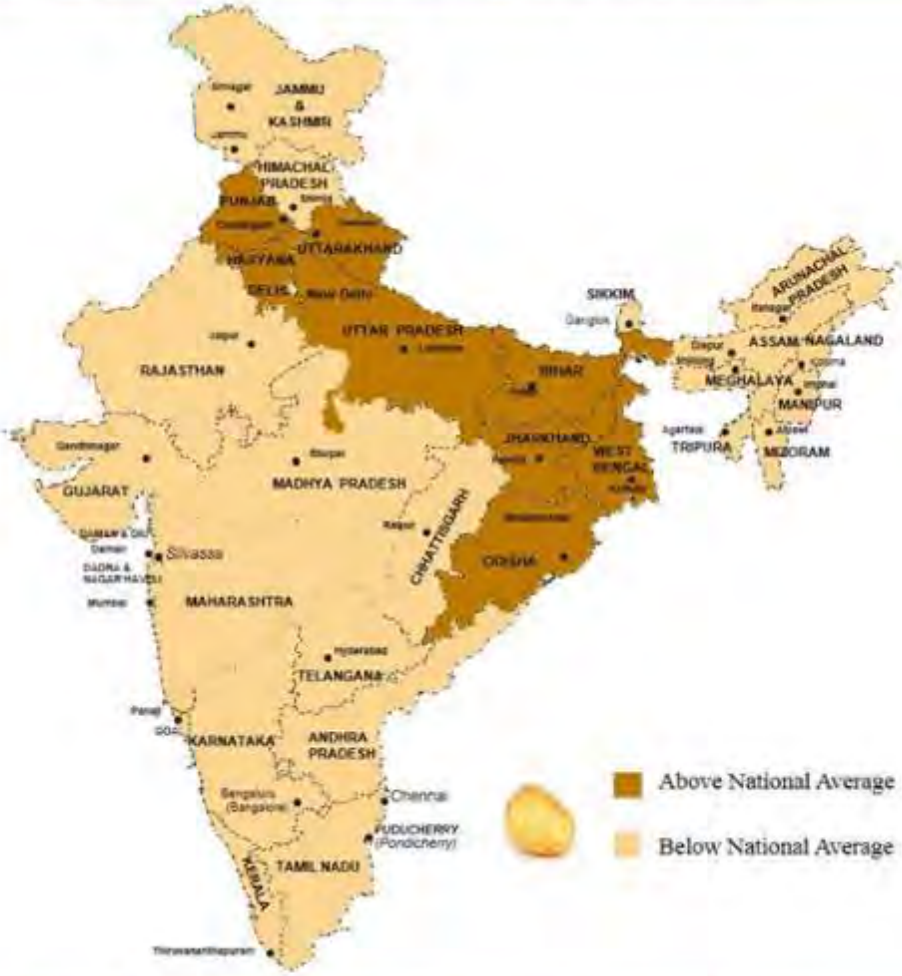
State	PCMC
Gujarat	1.11
Haryana	1.59
Himachal Pradesh	1.31
J & K	1.31
Jharkhand	1.30
Karnataka	1.32
Kerala	1.24
Madhya Pradesh	1.15

State	PCMC
Maharashtra	1.34
Manipur	0.41
Meghalaya	0.62
Mizoram	0.47
Nagaland	0.45
Odisha	1.04
Punjab	2.13
Rajasthan	1.31

State	PCMC
Sikkim	0.65
Tamil Nadu	1.35
Tripura	0.65
Uttar Pradesh	1.08
Uttarakhand	1.22
West Bengal	1.03
All India	1.26

1. The state Punjab has the highest per-capita monthly consumption of onion (2.13 Kg.) and followed by the states Goa, Haryana, Bihar and Andhra Pradesh.
2. Per-capita monthly consumption of onion is lower in the North- Eastern states as compare to other states of the country
3. Out of the listed 29 states of India, in 13 states of India, average per-capita consumption of cauliflower is higher than all India average (1.26 Kg).

Per-Capita Consumption Profile of Potato



Per Capita Monthly Consumption (PCMC) of Potato in Kg.

State	PCMC
Andhra Pradesh	0.84
Arunachal Pradesh	2.43
Assam	2.92
Bihar	5.55
Chhattisgarh	2.33
Delhi	3.00
Goa	1.03

State	PCMC
Gujarat	2.34
Haryana	3.12
Himachal Pradesh	2.44
J & K	1.93
Jharkhand	5.09
Karnataka	0.66
Kerala	0.68
Madhya Pradesh	2.32

State	PCMC
Maharashtra	1.40
Manipur	1.74
Meghalaya	2.37
Mizoram	2.44
Nagaland	2.44
Odisha	3.65
Punjab	3.18
Rajasthan	1.86

State	PCMC
Sikkim	2.65
Tamil Nadu	0.77
Tripura	2.80
Uttar Pradesh	5.01
Uttarakhand	3.15
West Bengal	6.15
All India	3.03

1. The state West Bengal has the highest per-capita monthly consumption of potato (6.15 Kg.) and followed by the states Bihar, Jharkhand and Uttar Pradesh.
2. Per-capita monthly consumption of potato is lower in the southern states as compare to other states of the country
3. Out of the listed 29 states of India, in 08 states of India, average per-capita consumption of potato is higher than all India average (3.03 Kg).

Per-Capita Consumption Profile of Ice-Cream

Per Capita Monthly Consumption (PCMC) of Ice-Cream in Rs.

State	PCMC
Andra Pradesh	0.48
Arunachal Pradesh	0.20
Assam	0.17
Bihar	0.27
Chhattisgarh	0.46
Delhi	3.04
Goa	4.43

State	PCMC
Gujarat	1.77
Haryana	0.93
Himachal Pradesh	0.09
J & K	0.67
Jharkhand	0.21
Karnataka	0.85
Kerala	1.72
Madhya Pradesh	0.38

State	PCMC
Maharashtra	1.16
Manipur	0.11
Meghalaya	0.37
Mizoram	0.51
Nagaland	0.13
Odisha	0.28
Punjab	0.66
Rajasthan	0.41

State	PCMC
Sikkim	0.02
Tamil Nadu	0.84
Tripura	0.05
Uttar Pradesh	0.47
Uttarakhand	1.06
West Bengal	0.73
All India	0.71

1. Apart from Goa, the state Delhi has the highest per-capita monthly consumption expenditure on ice-cream (Rs. 3.04) and followed by the states Gujarat, Kerala and Maharashtra.
2. Per-capita monthly consumption expenditure on ice-cream is lower in the Sikkim, Tripura, Himachal, Manipur and Nagaland states as compare to other states of the country
3. Out of the listed 29 states of India, in 10 states of India, average per-capita consumption expenditure on ice-cream is higher than all India average (Rs. 0.71).

Per-Capita Consumption Profile of Meat

Per Capita Monthly Consumption (PCMC) of Meat in Kg.

States	PCMC
Andra Pradesh	0.606
Arunachal Pradesh	0.492
Assam	0.328
Bihar	0.230
Chhattisgarh	0.253
Delhi	0.256
Goa	0.524

States	PCMC
Gujarat	0.114
Haryana	0.090
Himachal Pradesh	0.262
J & K	0.496
Jharkhand	0.315
Karnataka	0.510
Kerala	0.414
Madhya Pradesh	0.122

States	PCMC
Maharashtra	0.323
Manipur	0.204
Meghalaya	0.423
Mizoram	0.982
Nagaland	1.241
Odisha	0.134
Punjab	0.078
Rajasthan	0.086

States	PCMC
Sikkim	0.434
Tamil Nadu	0.463
Tripura	0.388
Uttar Pradesh	0.111
Uttarakhand	0.131
West Bengal	0.262
All India	0.263

1. The state Nagaland has the highest per-capita monthly consumption of Meat (1.241 Kg.) and followed by the states Mizoram, Andhra Pradesh, Goa, Karnataka, J & K, Arunachal Pradesh, Tamil Nadu, Sikkim, Meghalaya, and Kerala (Mor than 0.40 kg.).
2. Per-capita monthly consumption of Meat is lower in Punjab, Haryana and Rajasthan, states as compare to other states of the country
3. Out of the listed 29 states of India, in 15 states of India, average per-capita consumption of Meat is higher than all India average (0.263 kg.).

6.6 Overall Estimation of Cold-chain Infrastructure Requirement

Based on the tables and details in the pre-pages, the table 6.6 presented below captures the summary of overall estimation of cold-chain infrastructure requirement.

Table 6. 6 Summary of overall of cold-chain infrastructure requirement

#	Infrastructure Component	All India Requirement	
		Holding Capacity/ Storage Size	Numbers
1	Pack-house	11,21,274 MT	70,080
2	Cold Storage (Bulk)	341,64,411 MT	-
3	Cold Storage (Hub)	9,36,251 MT	-
4	Reefer Vehicles	4,94,608 MT	61,826
5	Ripening Chamber	91,306 MT	9,131
6	Onion Storage Structure	70,06,028 MT	2,80,241

Note: Cold Storage (Bulk) and Cold Storage (Hub) numbers may vary depending upon the average static holding size of each unit. It is to mention that actual size and capacities will vary depending on business model and market dynamics. The holding cycle of fruit and vegetables can be as low as one day at times at cold distribution hubs, and similar in case of fast moving processed foods like dairy products. On the other hand, this can be extended upto more than two weeks in low demand periods.

In case of bulk cold stores, though designed for holding a single crop for one cycle a year, enterprising operators can reoccupy vacated space with other goods, though this is observed to be in low volume due to occasional incompatibility of systems. Ripening units, as with Cold Hubs can also vary holding times to buffer last mile demand. In case of reefer transport, round trip times can be expected to vary depending on road infrastructure and trade involved. On the whole, the factors used provide realistic indicators on the current requirements of cold-chain infrastructure nationwide. State-wise breakup of estimated requirements are in **Annexure – XIV.**

6.7 Other Food Products

Ready to Cook (RTC) and Ready to Eat (RTE) segments of food industry are fastest growing segments due to rising demand from Modern Retail (MR) and Quick Service Restaurants (QSR). These products require specialised equipment at factory-gate like blast freezing lines and IQF processing lines. These components are designed to suit micro factors as per project's business models. The production facilities under this product segment is treated as an Industry and actively supported under the Ministry for Food Processing Industries.

In order to assess the cold-chain requirement for these products in a realistic manner, district-wise number of units and their operational capacity together with the captive infrastructure created by various private industries in the country will be required in a standardised format. As this information is not readily available, the total infrastructure need for this segment could not be estimated in the study. Nevertheless, the forward linkage in terms of distribution Cold Store (Hub) as per assessed domestic consumption has been evaluated, keeping in view the mandate of this study. Globally, the reefer transport caters to the entire range of temperature, from frozen to mild chill and has synergistic use.

The food processing industry utilises fresh farm produce as raw material by converting it into other food formats. The approach towards development of food processing units in tandem with cold-chain links of the fresh produce segment, is a generally recommended strategy to bring optimal use of resources at farm-gate and to process the produce that cannot be readily marketed. In particular cases, food processing units require specialised cultivars for a final product, and this is driven through contract farming as the cultivars may not be suitable for table use or direct marketing by farmers. However, in case of various table varieties, wherever an uninterrupted supply chain of farmer's produce to markets is not possible to develop, the food processing units form a good alternate option.

The market demand for processed foods varies with demographics worldwide and recent trends indicate greater preference for fresh foods, though in case of beverages, convenience foods, ice creams and other products requiring cooking intervention at homes, processed food items continue to increase in demand.

As modern technologies develop in food processing, it could be envisaged that in the far future, fresh harvest might no longer be the end consumers' choice and cold-chain for fresh produce no longer needed. In such a scenario, the infrastructure and associated skill requirements needed in cold-chain would also undergo change.

Demand for animal products will also vary with changes in dietary demographics. However, the source for these products in case of cold-chain, is a production facility which are already set up on the basis of market demand. The cold-chain requirements are largely in the frozen temperature segment in form of refrigerated transport, and in very large numbers in point of sale freezer cabinets.

CHAPTER – 7: GAP ASSESSMENT OF INFRASTRUCTURE

7.0 Gap Analysis of Infrastructure Components

This section highlights the gap assessed while considering the existing infrastructure already created in the country vis-à-vis the estimated requirement assessed in this report. The table 7.1 below highlights the gap analysis.

Table 7. 1 Gap Analysis of Cold-chain Infrastructure in India

Type of Infrastructure	All India Requirement (A)	All India Created (B)	All India Gap (A-B)
Pack-house	70,080 nos.	249 nos. *	**- 69,831 nos.**
Cold Storage (Bulk) #	341,64,411 MT	31823700 MT ~	**- 32,76,962 MT**
Cold Storage (Hub) #	9,36,251 MT		
Reefer Vehicles	61,826 nos.	9000 nos. ^	**- 52,826 nos.**
Ripening Chamber	9,131 nos.	812 nos. @	**- 8,319 nos.**

Notes:

For Cold Storage (Bulk) and Cold Storage (Hub), the figures in MT indicates static storage size in tons. For rest of components, the figures indicate the number of units.

* As per APEDA, there are 149 operational modern pack-houses in the country fit for export quality together with doing domestic trade. However, it is assumed that another 100 more pack-houses may exist but not necessarily recognized by APEDA. The information on pack-houses apart from APEDA is not readily available.

~ As per DMI, Department of Agriculture and Cooperation & MoFPI as of March'14 total cold storage size created in the country is 31.82 million metric tons (Annexure VI) but it is not categorized into cold stores bulk or hub. However, as per the report on All India Cold storage Capacity Survey by NHB (conducted by Hansa Research Group) dated 10-December-2014, the capacity of cold stores available in operation is 26.85 million metric tons. Therefore, the actual gap between operational cold stores and required cold stores could be higher at 8.25 million MT.

^ As per various reports and NCCD inputs, it is estimated that there are approx. 9000 reefer vehicles in the country. The information on existing registered reefer vehicles was not available with the line department viz. Ministry of Road Transport and Highways.

@ As per secondary data received from MIDH agencies (NHM & HMNEH) and CONCOR, there are 203 ripening chamber projects. The information provided was number of projects and it is assumed that each project has 4 chambers, each of 10 MT size. Data on the modern ripening chambers operational, set up nationwide independent of support from these agencies was not readily assessable for this study.

Thus, as observed from the table 7.1, the country could immediately target additional creation of the following major infrastructure components for integrated cold-chain:

- ✓ 69381 number of modern pack-houses;
- ✓ 3.27 million MT of new Cold storage aptly segregated into cold storage (bulk) and cold storage (hub);
- ✓ 52826 number of units of Refrigerated transport vehicles/containers;
- ✓ 8319 number of modern Ripening chambers.

Further, it is to mention that actual unit size and capacities will vary depending on business model, market dynamics and modular use or design of each component. On the whole, the assessment of gap analysis provides a realistic indication of the nationwide requirement of appropriate infrastructure types.

It is to note the gap assessment is on the basis of demand established from current consumption of a wide basket of products. This does not factor in the potential for future changes which are based on multiple variables. Cold-chain availability itself may act as a multiplier that can alter both consumption and production practices.

7.1 Infrastructure Matrix

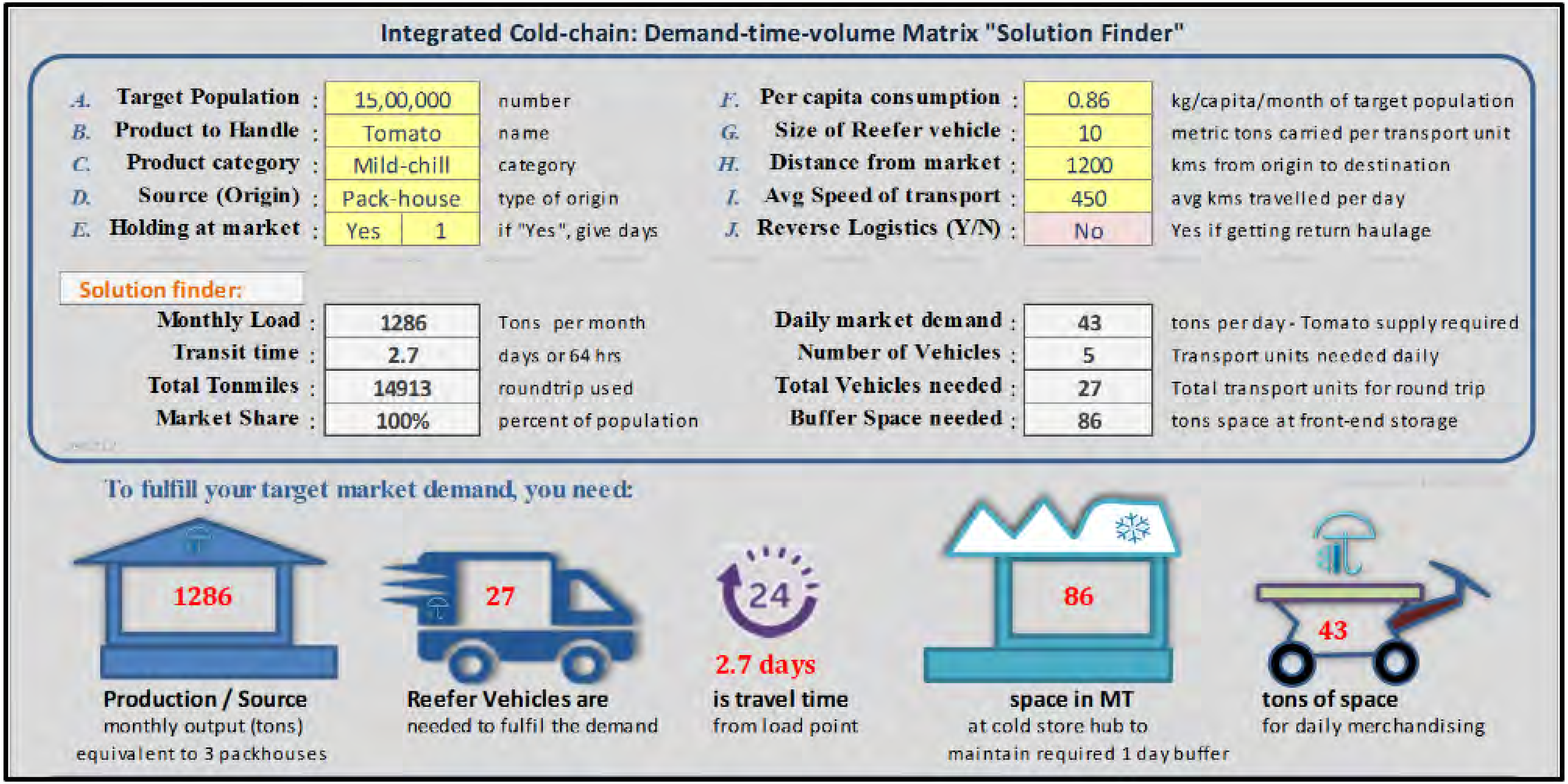
The present study provides information so as to assist policy makers and developers to target specific regions and markets and to thereby develop appropriate business models with suitable infrastructure.

In this direction, an attempt is made to develop an initial **demand-time-volume mathematical matrix** to assess infrastructure needs on the basis of existing market demand linked to existing production and growth trends.

The matrix, as illustrated in subsequent page tabulates and enumerate required infrastructure components as per volumetric flow of goods on basis of per capita consumption at population centres, linked to distance from identified producing districts, categorized by temperature ranges (under frozen, chill, mild-chill), segmented by bulk long term storage or short transitory supply chain and scope of reverse logistics. These information will act as input data for the matrix.

The output of the matrix will suggest for each product type capacity and number of units required of each cold-chain infrastructure component from origin to destination i.e. farm to market thereby ensuring seamless integration of the cold-chain components.

Fig 7. 1 Demand-Time-Volume Mathematical Matrix



This matrix is a mathematical assessment of major infrastructure components that will be needed to fulfil a targeted demand on the basis of variables such as distance, volume and holding period of goods handled.

CHAPTER – 8: STUDY RECOMMENDATIONS

8.1 Cold-chain Connectivity

India is the largest producer of fruits and second largest producer of vegetables in the world, with a high per capita production of fruits and vegetables. However, the market availability of fruits and vegetables is lagging. This may be attributed to lack of efficient supply chain mechanism and the suitable infrastructure to deliver from farm to market.

Many a times, in spite of a bumper harvest of a produce, this does not translate into smooth supply during non-harvesting periods leading to price rise and imports at high prices. As per the Task Force Report on Logistics by PHDCCI and industry estimates, approximately 104 million MT of perishable produce is transported in India each year. Of this, about 100 million MT moves via non-reefer mode and only 4 million MT is transported by reefers. Moreover, most of the refrigerated transport segment is fragmented with large number of small, unorganised/non-integrated private players focusing on select commodities or regions and even processors and the producers are increasingly outsourcing the logistics facilities rather than creating it as an integral part of their business.

Through this study a future strategy may be developed for post-harvest supply chain infrastructure in India, by the planning and policy arms of the government for a self-sustainable development of cold-chain in the country. One of the challenges is to address the development of farm-gate infrastructure like modern pack-houses at the production areas, for preconditioning the produce for market movement. These need to be linked to the front-end by actively refrigerated transport, through which efficient long distance movement of fresh horticultural produce is possible.

Thus, once relevant infrastructure, integrating the activities of preconditioning, refrigerated movement and storage is ensured, the gainful use of cold-chain connectivity will be possible. Such integrated supply lines will help to balance regional fluctuations in demand-supply gaps of fresh produce. These imbalances naturally result from concentrated production of produce in a particular location, far removed from the consumption clusters.

Further, to balance other variations in demand generated by local availability of fresh produce, a higher storage capacity at consumption centres may be targeted for buffer stocking and supply, within holding life limitations of each product type. In synergy, value is also recovered from produce which may be in excess or suffers handling damage by routing to food processing units. Modern pack-houses would benefit from attached micro small and medium scale food processing. In combination this will add to the opportunity at rural level.

It is recommended that along with pack-houses designed for cold-chain, an appropriate number of food processing units be developed. This will lead to greater value creation and higher output from rural India.

8.2 Multi-Modal Cold-chain Network

Different products need different temperature and other parameters during the handling and transportation process so as to ensure their quality, extension of product life cycle and its saleability. Any lapses in the integrated chain will lead to damage of the product and eventually it will lose market value. Apart from creating static storage capacity, which forms part of flow to market, the need of the hour is to develop and introduce Multimodal transportation of fresh horticultural produce and other food products to drive economic growth and enable efficient management of food delivery.

A **Multimodal Cold-chain Network** may be understood as the suitable physical manifestation of a nationwide market grid, for safe handling and transportation of perishable products from one place to another place, within or outside India. Such a multi-modal network would involve two or more modes of transport and facilitate a future ready farm to door delivery system. The main objective of such a network should be the reduction of time to market, increased coverage of distance and to reduce value loss to the producer/ manufacturer/exporter, thereby making the products more accessible to both the domestic and international markets.

To address the needs of cold-chain, adequate road and rail infrastructure, two major modes of transportation available in the country, need to be integrated. The developments under the Pradhan Mantri Gram Sadak Yojna (PMSGY) are direction setting and bring about such integration in road connectivity. Further, policy level changes may be initiated to include other transport modes like - inland waterways and coastal shipping. By the use of such multiple transport modes, efficiencies in operations can be brought in the chain and allow seamless linkage with other regional cold-chain grids and international networks.

A multi-modal cold-chain network would necessarily require the use of scientific handling, including palletised handling of the produce/product. This would lead to reduction in losses in the food supply chain by minimising direct handling of the products, bring modern inventory managing systems, and intelligent tracking and traceability of food items in the supply chain. The practise of organised packing, palletising, movement, delivery and marketing of food, especially in case of perishables, will lead to greater wealth creation in the agriculture sector.

A national multi-modal cold-chain network comprising five regional cold-chain grids (viz. Northern, Southern, Eastern, Western and North-Eastern) may evaluated for setting up under a competent government body. The farm produce can be transported to major consumption centres through the rail and road network. The national network will directly link the farms to consuming cities and towns. Developing associated food processing units with post-harvest pack-houses will add to greater value realisation. Each such unit will justify a large number reefer vehicles to be operated by rural youth as driver entrepreneurs.

A nationwide cold-chain network, multimodal in nature, that links farmers/ producers with consumers throughout the country will additionally mitigate seasonal and regional price variations while ensuring that the farmer/producer receives fair market prices on a regular basis.

To assist in decisions for integration of the existing assets created and future development for cold-chain, an all India virtual network of all cold-chain assets (especially pack-houses and transport, as well storages) can be developed. See **Annexure – XVIII** as per an earlier concept by NCCD titled ICAP (Integrated Cold-chain Availability Platform). Such a network will assist the fragmented asset owners to collaborate and consolidate their operations on the basis of commercial and demand based needs. This network can be for voluntary participation of the asset owners, which are mainly privately held. The information will also assist in planning capacity when linked with other IT based interventions related to production and productivity at farms.

A recent initiative by NCCD to invite calls on bottlenecks faced by reefer transporters can also be scaled up and linked under the above mentioned ICAP. Having greater understanding of physical flow of goods in the cold-chain will also help to alleviate delays that normally add to risk of perishability and to the energy used in moving good in the cold-chain.

Expanding the range and scope of physical flow of farm produce will complement the recent initiative of the National Agriculture Market (NAM). Both, the flow of information through IT systems and the flow of agricultural produce through logistics connectivity will ensure the success of NAM and translate the country into a unified market.

The ongoing improvement in rural road networks under the PMSGY serves as a precursor to such development and supports the setting up of modern pack-houses and with reefer transport for perishables, which are required to transform the rural economy of this huge sub-continent. Additionally a flow of investment into the back-end, in form of appropriate farm-gate infrastructure (modern pack-houses and/or food processing units) has associated benefits. It is recommended that all possible support in terms of fiscal and financial benefits, capacity building and through technology transfer, be extended to develop the back-end and transport as a priority.

CHAPTER – 9: CONCLUSION

9.0 Conclusion

Cold-chain is part of the agri-business logistics sector and is clearly understood as an enabling mechanism that connects producing areas with consumption centres. Logistics is regarded as the management of flow of goods between point of origin and consumption, and relates across industries. As such, the logistics sector has not been under purview of a dedicated ministry. In consequence, multiple allied ministries/departments provide support for the development of relevant infrastructure components for cold-chain. These infrastructure components are essentially the logistics tools that provide a modern conduit for produce and products, between origin and destination.

The primary consumption of goods handled in the cold-chain can be individual consumers through retail channels, or industrial facilities that create new products from the raw materials. Processed foods and health products may also require cold-chain for onwards market linkage of the secondary products. Cold-chain is also used for storing and transporting non-food products like tissue, chemicals, gases and electronics. Besides operating in a wide variety of temperatures, ranging from cryogenic, frozen, chilled and mild-chill, cold-chain also provides other categories of care in assorting, packaging, air replenishment, monitoring & maintaining humidity and other life cycle parameters, especially when used for post-harvest management.

In modern post-harvest management of fresh produce, cold-chain plays a key role. It serves two basic functions, which can result in a larger socio economic impact:

a) Cold-chain primarily functions as an environment controlled chain of activities to prepare and facilitate market reach of perishable produce, with minimal damage. Cold storages form one part in this chain in conjunction with modern pack-houses and refrigerated vehicles. The majority of fresh fruits and vegetables require this intervention to counter perishability and to retain freshness. Additionally, ripening chambers are used for certain fresh fruits as part of this chain. At the front end temperature and humidity controlled merchandising cabinets or platforms may be used depending on selling cycles and holding periods.

b) Cold storages as stand-alone units are also used for a few crops (e.g., potatoes, spices, pulses), where the produce can be stored for extended duration without any other intervention. Stand-alone cold stores are also used to store fresh produce as part of the basket of raw materials that are used in the food processing industry.

Cold-chain also plays a critical role in the logistics of certain processed foods. The needs can be varied and can have very fast turnaround cycles. Like in case of milk movement, where a daily harvest is treated or processed for onwards market linkage; the supply chain is designed to deliver as often as twice a day, with most of the storage required in transit, at retail-end and homes. In case of ice-creams and butter, logistical capacity is directly linked to market demand, installed production lines and availability of retail end freezer cabinets. The product is created regularly and duration of storage is optimally kept at a minimal, with main aim to have maximum presence in shelves or at small stores at retail end. In case processed horticulture based foods, like frozen peas, the production facility processes in harvest season and releases the frozen stock into the cold-chain conduit to suit market demand and pricing strategies. Once released from factory-gate, the main aim is to have shelf presence at frozen deep freezers at retail side. A similar system, or combination, thereof is used for fish, poultry and other meats, depending on production, adjusted to market demand and holding capability of the product.

It is to be noted that the frozen goods segment cannot do without the logistics facilitation of cold-chain - specially the requirement for reefer transport and retail side infrastructure. As stated in this report, the storage at processing units for production purpose is not assessed and this is directly linked to individual capacity of the production lines. The specialised production lines, which may use refrigeration technologies such as IQF system, are also outside purview of this study as these do not fall under logistics but are essentially processing equipment.

Cold-chain can have the greatest socio-economic impact when used as a logistics medium that empowers the farmers to directly connect with multiple markets, across geographies. Without facilitation of cold-chain, the average farmer of perishable produce has no counter to produce perishability and no other recourse but is constrained to selling off the harvested produce to the closest intermediary. The intermediary, disengages the value created by the farmer, and may further connect to nearby markets or may utilise the produce to create a new product. This in effect, disconnects farmers from scope of increased value realisation directly from consumers of fresh produce.

Cold-chain necessitates preparing and preconditioning the farm produce for long distance travel. Proper use of cold-chain allows farmers the opportunity to reach out to more buyers at greater distances, and will inevitably promote shrinking of the multi-layered value chain system. Importantly, the ability to reach out and expand the consumer base will allow for a wider range of selling options and will result in gainful productivity from farm-gate. This will add to domestic and export options.

In those few crop types, with long holding life capability (like potatoes, dried chillies, etc.), a refrigerated warehouse may be the only intervention required, which store the goods produced in one season for subsequent use. Many of the crops and products that do not have long term holding life, need the cold-chain to proactively reach to consumers, across geographies, far away from production sites. To be most effective cold-chain development requires focus on appropriate distribution connectivity between rural India and market, namely modern pack-houses and reefer transport.

The findings from this study lead to the following conclusions:

- Lack of reefer transport deters useful application of cold-chain and is a missing link. The transport occurs in multiple legs, roaming between demand points, and hence the requirement may be higher than assessed in this report.
- Transport is of no avail without relevant source and receiving points. At source, there is a shortfall of modern pack-houses. Pack-houses function as decision making centres for the purpose of directing flow of produce to relevant consumption points.
- Perishable fruits and vegetables have a limited life span in normal conditions. However, unless the selling cycle will fall within this natural period, cold-chain intervention is required to mitigate food losses and to be future ready.
- Current movement of perishable produce can bypass cold-chain intervention but results in lowered access to markets and unnecessary food loss enroute.
- Current consumption of frozen and processed goods is met by using the existing cold-chain as it cannot bypass this intervention. However, future development of capacity in processing industry will add to the cold-chain requirements evaluated in this report.
- Current consumption demands greater focus on establishing end-to-end delivery systems to connect farm-gate value directly with consumption points.
- Infrastructure creation needs to consider demand and volumetric throughputs in the component structures created to avoid unnecessary capacity overruns.
- Varied stakeholders promote cold-chain and there is need to develop a **National Policy on Cold-chain** so as to provide underlying direction for the long-term approach for holistic infrastructure creation.

The study concludes that the development and use of cold-chain is dependent on integrating the movement of goods as per protocols of each product handled. To use cold storage as stepping stones to markets, requires a matching development of **back-end infrastructure** in form of modern pack-houses with refrigerated transport attached. In case of frozen foods, to suit demand based flow, a greater capacity in form of modern retail shelves at merchandising end is indicated.

In case of perishable produce, it is recommended that alongside modern pack-houses designed for cold-chain, an appropriate number of food processing units be created. This will lead to greater value creation and higher output from rural India.

Holistic development is key to integrating the supply chain, to improve the existing domestic supply of food items, to include the complete basket of perishable foods in cold-chain, to mitigate food losses, to improve direct market connectivity for producers and for greater inclusive wealth creation in the country.

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ANNEXURES

Annexure I: Terms of Reference of the Study

The Terms of Reference (ToR) for conducting this study, is as below:

Objective:

Conduct a comprehensive pan-India study to evaluate the requirement, capacity created and existing gaps in Cold-chain infrastructure so as to provide relevant assessment for future development of cold-chain infrastructure.

Terms of Reference:

The study shall:

I. Assess cold storage status, based on the available base line information of the existing capacity.

II. Assess existing capacity of production and/or originating units (food processing units and fresh produce pack-houses) from secondary data.

III. Assess the refrigerated transportation available in cold-chain.

IV. Assess the existing throughput capability of the existing infrastructure across product (temperature) segments.

V. Assess demand for cold-chain facilities, basis production figures of raw material and market growth trends for both fresh produce and food products.

VI. To output a consolidated document with segment-wise and category-wise needs across all infrastructure components required to develop integrated cold-chains from farm/production points to market.

The detailed study and analysis on existing capacity and the gap across all infrastructure components of cold-chain should be comprehensive and highlight the region specific and product specific status. This information is to assist policy makers and developers to target specific regions and markets and to thereby develop appropriate business models with suitable infrastructure.

Information / Data to be analysed

1.1. A base line information gathering exercise of cold storage capacity has been completed by NHB (in 2014). This information to be updated and analysed for existing capacity status of cold stores.

1.2. The production capacity of food processing units to be accessed from Ministry of Food Processing Industries, NABARD, etc.

1.3. The availability of modern pack-houses for cold-chain to be accessed from State Governments, NHB, APEDA, DMI, NABARD, Licensing authorities or other sources.

1.4. The actively refrigerated transport vehicles available in the country. Information from Ministry of Road Transport and Highways, RTO, and Industry estimates to be used.

1.5. The existing container, railways and waterways capacity for domestic transport of perishable goods to be accessed from NHB, Railways (Concor) and IWAI or other sources.

1.6. The existing export and import capacity in terms of reefer containers and Perishable Cargo Centres from APEDA, Airport Authorities and Port Authorities.

The primary responsibility of collecting, collation and assessment of data shall be of the research agency (NABCONS). All sources to be tabulated in the output report.

Required output

a) Existing throughput capacity of fresh produce pack-houses with pre-coolers, cold storage, transport and food processing units.

b) Cold storage required number and capacity cross tabbed by application segment (mild chill, chill and frozen) and regions.

c) Reefer transport existing and required, categorised by carrying capacity and monthly throughput.

d) Current market demand – domestic and international and market demand trends over previous five years and for the next five years.

e) Matrix to assess infrastructure needs on the basis of existing market demand linked to existing production and growth trends.

The matrix is expected to tabulate and enumerate required infrastructure components as per volumetric flow of goods on basis of per capita consumption at population centres, linked to distance from identified producing districts, categorised by temperature ranges (under frozen, chill, mild chill) and segmented by bulk long term storage or short transitory supply chain. NCCD will supervise and coordinate the study on a regular basis at mutually agreed periods.

These terms of reference were initially shared with the TFCP and developed under consultative process with all associated stakeholders (DAC, MoFPI, NHM, APEDA, NHB). It was noted that this study was the first ever to be demand driven and the terms of reference would be used as reference in devising the final approach and methodology. The study report was shared with stakeholders, inviting comments and suggestions before finalising.

Annexure II: Approach and Methodology

As per the objectives of the study, the approach is to provide infrastructure components needed for end-to-end uninterrupted cold-chain, under the farm-to-fork model thereby linking capacity requirement on the basis of market demand to production point. The steps followed are briefed as under:

#	Major Steps	Activities Accomplished
1	Analysis of domestic consumption patterns of fresh produce and other products across urban India and evaluating regional consumption differentials.	Procurement and statistical analysis of NSSO unit level data [NSS – 68th Round – July 2011 to June 2012] on Household Consumption of Goods and Level & Pattern of Consumer Expenditure
2	Selection of high value fresh horticultural produce (fruits and vegetables), other food products and major consumption centres.	NSSO data, Import data from APEDA and MIDH data referred for selection
3	Collation of district-wise data on production of horticultural produce and other food products.	Available data with Horticulture Division, DAC and MoFPI referred for production figures
4	Computation of Monthly Per capita consumption of selected produce for each selected urban consumption centre and regional urban population.	NSSO data analysed for computation. Wherever, NSSO data not available, data from other secondary sources were used.
5	Collation of Population figures for selected urban consumption centres.	Census 2011 data referred for collation and growth trend to arrive at 2014-15 population.
6	Compilation of Definitions of Cold-chain terminology, Categorization & Segregation of Produce and other food Products.	Prepared and presented in Mid-Term Report
7	Preparation of Post-Harvest Infrastructure Protocols for identification of required infrastructure components.	Prepared and presented in Mid-Term Report
8	Carrying out Primary Research/ Survey of selected consumption and production centres by way of interaction with different stakeholders.	Primary survey carried out and observations recorded

#	Major Steps	Activities Accomplished
9	Developing a mathematical matrix to deduce requirement of cold-chain infrastructure as per demand, cross tabbed with distance from production areas.	Work initiated and detailed in Mid-Term Report. Matrix sample attached in Report.
10	Analysis of compiled information to assess against demand, holding periods, and operational throughputs	Requirement of major infrastructure components in cold-chain charted
11	Collection of data on various records regarding existing cold-chain infrastructure and compared against the deduced requirement.	Data sourced from various ministries/ departments, compilations completed, Gaps evaluated.

Thus, as evident from the above listed steps, the study uses available information and involves the mathematics of optimizing the logistics movement and throughput of consumption volumes.

Secondary Research

The secondary data with respect to status of availability of raw materials and different cold-chain infrastructure components with the identified list of stakeholders has been collected and analysed.

The data-on-records is essential to arrive at the existing infrastructure created while comparing against the deduced requirement. A detailed list of stakeholders contacted with and the status based on the interaction with officials is presented in detail in **Annexure – III.**

Primary Research

Primary research was carried out in each of nine selected consumption centres with the objective to understand the present practice of post-harvest disposal and future requirement of cold-chain facilities needed for the fresh horticulture produce.

The discussions with the respondents were conducted through direct interview (DI) method and/ or focused group discussions (FGD). The structured questionnaires were finalized jointly with NCCD, Department of Agriculture and Cooperation, GoI.

The respondent types selected from the list of MIDH scheme beneficiaries, registered FPOs list of SFAC, local APMC through NABARD and support from NCCD state nodal officers are given as under:

#	Respondent Group	Respondent Type	Total Sample Size
A & B	Users of Cold-chain Infrastructure	Farmer Producer Organizations, Street vendors, Hawkers, Grocery Stores	45
C	Service Provider	Transport service providers, Reefer Vehicle	9
D	Units under Cold-chain Infrastructure	Ripening Chamber, Pack House, Cold Storage	27
E	APMC	Traders/ Wholesalers at Fruit & Vegetable Mandi	9
		Total Sample Size for 9 Consumption Centres	**90**

Based on the field visit and discussions the information gathered and views expressed by the respondents are captured in **Annexure – IV**.

In addition, list of major QSR (Quick Service Restaurants) and MR (Modern Retail) is enclosed as **Annexure – V**.

Annexure VI: State-wise Cold Stores Created
(As of March'14)

S.No	State/UTs	Number of Cold Storages	Size in MT
1	Andaman & Nicobar (UT)	2	210
2	Andhra Pradesh	404	15,77,828
3	Arunachal Pradesh	2	5,000
4	Assam	34	1,19,652
5	Bihar	303	14,06,395
6	Chandigarh(UT)	6	12,216
7	Chattishgarh	89	4,27,766
8	Delhi	97	1,29,857
9	Goa	29	7,705
10	Gujarat	560	20,30,873
11	Haryana	295	5,88,649
12	Himachal Pradesh	32	38,557
13	Jammu & Kashmir	28	64,769
14	Jharkhand	55	2,17,280
15	Karnataka	189	5,26,752
16	Kerala	197	78,355
17	Lakshadweep(UT)	1	15
18	Madhya Pradesh	260	10,97,168
19	Maharashtra	540	7,06,302.6
20	Manipur	1	2,175
21	Meghalaya	4	8,200
22	Mizoram	3	3,931
23	Nagaland	2	6,150
24	Odisha	111	3,26,639
25	Puducherry (UT)	3	85
26	Punjab	606	20,04,778
27	Rajasthan	154	4,80,032
28	Sikkim	2	2,000
29	Tamil Nadu	163	2,95,671
30	Tripura	13	39,181
31	Uttar Pradesh	2,176	1,36,33,039
32	Uttarakhand	28	84,545
33	West Bengal	502	59,01,925
	Total	**6,891**	**3,18,23,700.6**

Source: Task force on Cold-chain Projects – MoFPI *(DMI, DAC & MoFPI)*

Annexure VII: Excerpts from Baseline Study by NHB

The base line survey involved site visits by field teams survey agency to cold stores (CS) in the country, specifically those that were open to public lease as a service. The project was not intended to cover cold storages built for captive use by industrial units or processing units, unless leasing out the capacity to others. The entire base line study involved collecting data in the form of responses from facility managers or owners to a prescribed questionnaire duly approved by NHB.

The field work was executed district after district in every state, using a readied database and applying snow balling technique. In all the survey team visited over 9,000 address locations, as against 6,100 envisaged initially. All data was collected from the owners or managers of cold stores in a face to face interview. Each visit was photographed and geotagged and information submitted online.

Item Description	No. of CSs	Average capacity	Tons
Completed full interviews	5003		25030009
Temporarily closed	61		305183
Refused & Existing 7 CA stores not covered	303		1515909
Total of above 3 – Operational CSs	**5367**	5003	**26851101**
Permanently closed including address found but CS not there	1219		6098657
Total created capacity	6596		32949758

from Base Line Survey by NHB

Mean capacity is at 5003 tons. East zone has the highest mean capacity of 8543 tons mainly contributed by WB with 11113 tons.

74% of the CSs are having brick and mortar structures with West zone CSs having comparatively more PEB structures. The mean boundary area is 4567 Sqmts while the mean covered area is 3568 Sqmts.

Nearly a third of CSs have only ground floor while 36% have four floors in their buildings. Mezzanine type of stacking is more prevalent in CSs and generally gunny nags are the smallest storage unit in the CS.

27% of the CSs had recent upgrades and the main reason for upgrade is to expand capacity. In the last three years, there is consistent average 74-75% capacity utilization of the CSs.

67% of CSs had uncovered parking space while the other 33% had covered parking space. On an average 22 vehicles can be parked in the CSs.

Transport services were not provided by 79% of the CSs. Even those facilitated the service, mostly they used hired out services. Only 4% provided reefer truck facilities and that too only half of them had their own reefer trucks.

Annexure XIV: State-wise breakup of cold-chain infrastructure requirement

State	Urban Population (2014-15)	% Share Population	Pack-house (No)	CS Bulk (MT)	CS Hub (MT)	Onion Storage (MT)	Ripening Chamber (MT)
Andhra Pradesh	18428602	4.46	3124	489195	41730	551273	4070
Arunachal	354419	0.09	60	6705	803	--	78
Assam	4774459	1.15	809	61185	10811	--	1054
Bihar	13008947	3.15	2205	5094524	29458	155936	2873
Chhattisgarh	6670958	1.61	1131	498724	15106	--	1473
Delhi	17718674	4.29	3003	--	40122	--	3913
Goa	1002786	0.24	170	--	2271	--	221
Gujarat	28523771	6.90	4835	2174886	64590	305066	6299
Haryana	9998498	2.42	1695	217754	22641	305686	2208
HP	722662	0.17	122	304511	1636	--	160
J&K	3807726	0.92	645	899220	8622	--	841
Jharkhand	8710072	2.11	1476	5228	19723	--	1923
Karnataka	25886395	6.26	4388	151695	58618	809817	5717
Kerala	19831340	4.80	3361	968	44906	--	4379
MP	21658925	5.24	3671	1818134	49045	1130550	4783
Maharashtra	54543414	13.19	9245	34200	123509	3063522	12045
Manipur	943761	0.23	160	2925	2137	--	208
Meghalaya	651738	0.16	110	17228	1476	--	144
Mizoram	623469	0.15	106	7508	1412	--	138
Nagaland	676818	0.16	115	7142	1533	--	149
Odisha	7583316	1.83	1285	288328	17172	--	1675
Punjab	11227754	2.72	1903	1667984	25424	--	2479
Rajasthan	18558887	4.49	3146	11370	42025	337343	4098
Sikkim	210234	0.05	36	2145	476	--	46
Tamil Nadu	37817826	9.15	6410	109005	85635	--	8351
Telangana	12806317	3.10	2171	248130	28999	442517	2828
Tripura	1161198	0.28	197	5925	2629	--	256
Uttar Pradesh	48414644	11.71	8206	10565506	109631	72945	10691

State	Urban Population (2014-15)	% Share Popu-lation	Pack-house (No)	CS Bulk (MT)	CS Hub (MT)	Onion Storage (MT)	Ripening Chamber (MT)
Uttarakhand	3410752	0.82	578	65208	7723	273893	753
West Bengal	31729218	7.67	5378	9409081	71848	--	7007
UT & Others			340	--	4539	--	443
All-India Urban	**413461936**		**70080**	**34164411**	**936251**	**7448545**	**91306**

- All Figures in MT indicate size in metric tonnes.
- It may be noted that this gap is assessed solely on current consumption patterns of the urban population in the country.
- The size for storage of onion at farm-gate is not considered for cold stores (bulk), though specific designs dedicated for onion cold storage in bulk in the future may be envisaged.
- The captive capacity of food processing units to assure feed to their processing lines is dependent on capacity of industrial lines installed and a factor of this assessment.

Annexure XV: Factors Calculation

Calculation for Volume handled in Cold Hub					
Chilled			**Mild Chilled**		
Crops	**Per capita (Kg)**	**sample**	**Crops**	**Per capita (Kg)**	**sample**
Tomato	0.806	0.806	Ghee	0.050	0
Brinjal	0.358	0	Banana	0.744	0.744
Radish	0.140	0	Pineapple	0.027	0
Carrot	0.153	0.153	Papaya	0.081	0.081
Spinach	0.528	0	Mango	0.202	0.202
Green chillies	0.166	0	Dates	0.015	0
Okra	0.281	0.281	Cashew nut	0.008	0
Cauliflower	0.326	0.326	Raisins	0.009	0
Cabbage	0.271	0.271	Ginger	0.073	0
Beans	0.139	0	Garlic	0.081	0
Other vegetables	0.574	0	Cumin	0.033	0
Guava	0.091	0	Coriander Seeds	0.059	0
Orange/mousumi	0.170	0.170	Turmeric	0.046	0
Pears	0.004	0	Black pepper	0.009	0
Litchi	0.008	0	Dry chillies	0.078	0
Apple	0.191	0.191	Tamarind	0.035	0
Grapes	0.084	0.084			
Total	**4.290**	**2.282**		**1.551**	**1.027**
Factor	**1.880**			**1.510**	

Kg/per capita from NSSO data

These factors were applied to assessments from sample cities and products. In effect, a wider basket of products have been included in the storage size assessment at cold storage Hubs. Consumption volumes of other products, plus holding patterns at Hubs would create some partial variation in the assessed sizes. In case of frozen goods, a higher holding pattern was used for size assessments.

Annexure XVI: General Product Profiles

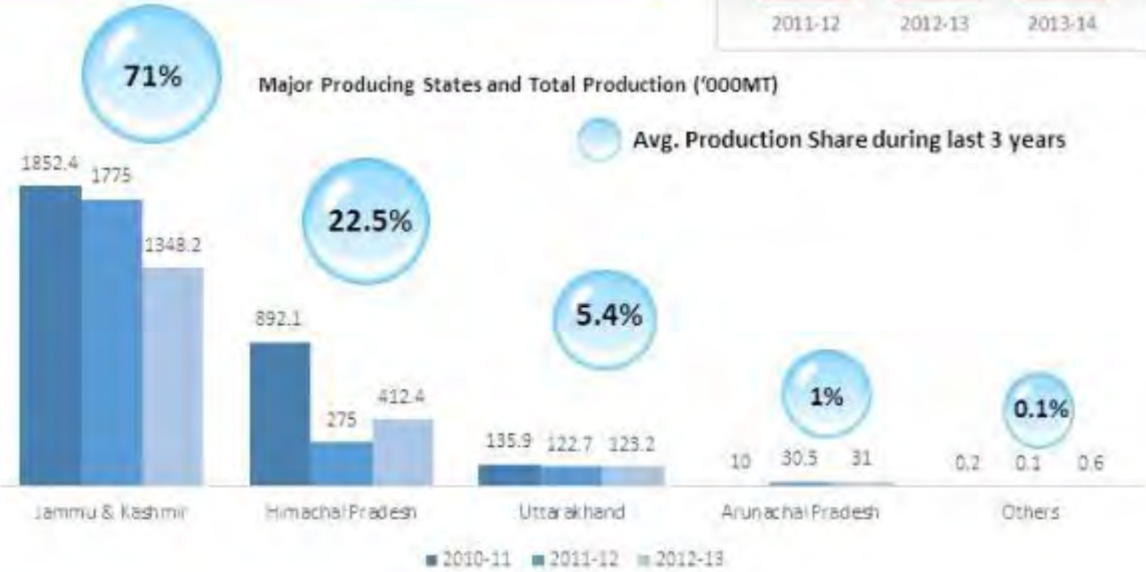
Apple

Major Producing Districts		
District	State	Production ('000 MT)
Baramulla	Jammu & Kashmir	328.0
Shimla	Himachal Pradesh	259.8
Kupwara	Jammu & Kashmir	203.7
Shopian	Jammu & Kashmir	191.5
Anantnag	Jammu & Kashmir	150.3
Kulgam	Jammu & Kashmir	120.7
Kullu	Himachal Pradesh	87.9
Budgam	Jammu & Kashmir	85.7
Pulwama	Jammu & Kashmir	85.1
Bandipora	Jammu & Kashmir	65.1
Kinnaur	Himachal Pradesh	52.0
Ganderbal	Jammu & Kashmir	51.8
Srinagar	Jammu & Kashmir	39.3

Peak and Lean Season

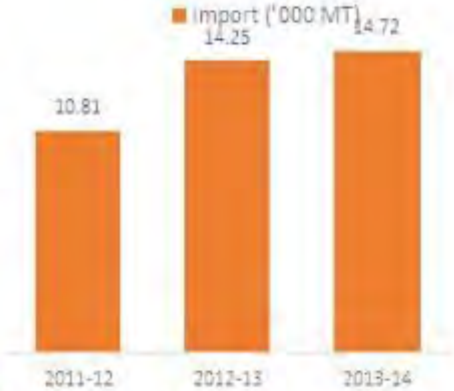
Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
J&K							Lean	Lean	Peak	Peak	Lean	
HP						Lean	Lean	Peak	Peak	Lean	Lean	
UK							Peak	Peak	Lean			
Arunachal									Lean	Peak		

Lean Season   Peak Season

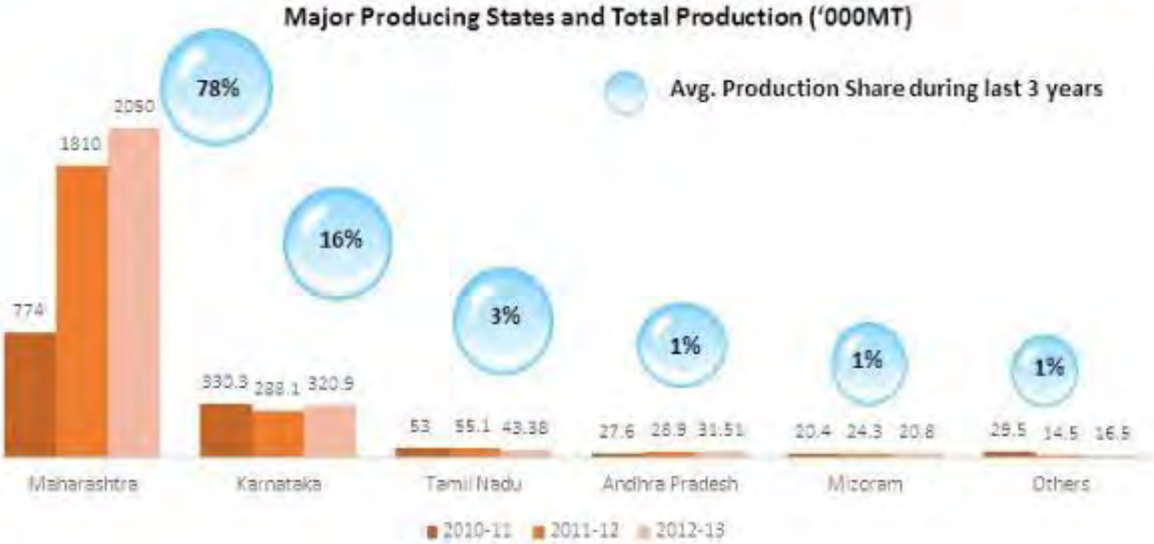


Grapes

Major Producing Districts		
District	State	Production ('000 MT)
Sangli	Maharashtra	625.4
Osmanabad	Maharashtra	108.6
Solapur	Maharashtra	105.3
Hassan	Karnataka	102.8
Chikkamagaluru	Karnataka	49.1
Mandya	Karnataka	35.8
Ballari	Karnataka	35.6
Ahmednagar	Maharashtra	30.6
Chamarajanagar	Karnataka	19.9
Haveri	Karnataka	18.3
Satara	Maharashtra	17.5



Major Producing States and Total Production ('000MT)



Orange

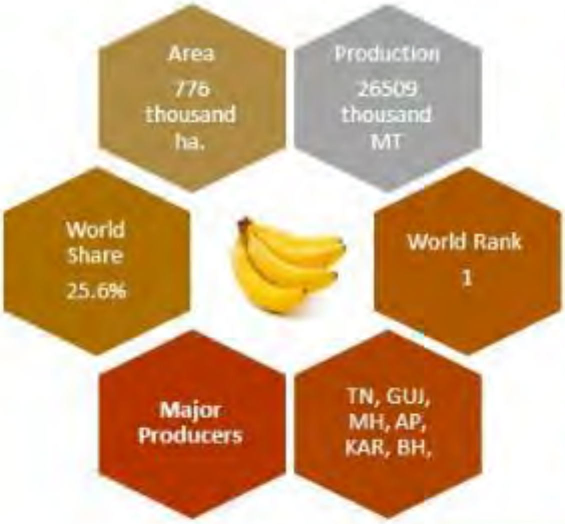
Major Producing Districts		
District	State	Production ('000 MT)
Firozpur	Punjab	564.6
Sirsa	Haryana	146.7
Hoshiarpur	Punjab	142.3
Muktsar	Punjab	127.6
Jhalawar	Rajasthan	93.1
Sri Ganganagar	Rajasthan	74.7
Bathinda	Punjab	65.1
Chamoli	Uttarakhand	42.3
Hanumangarh	Rajasthan	35.3
Almora	Uttarakhand	33.6

Peak and Lean Season

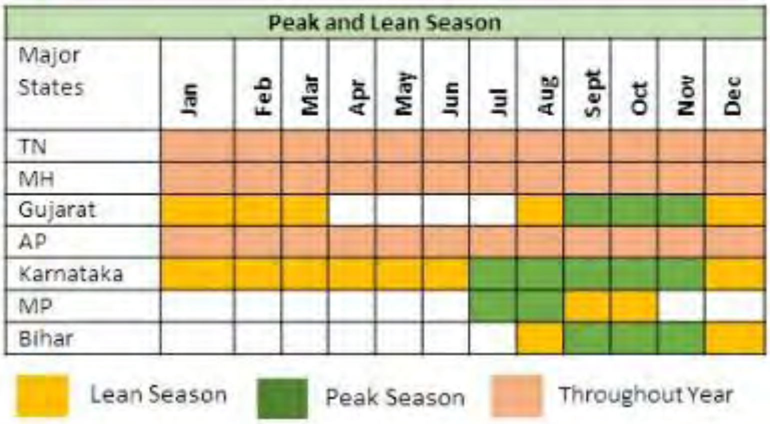
Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Punjab	Peak	Lean										Peak
MP	Peak	Peak	Peak	Lean								
MH	Lean	Lean	Lean	Peak	Lean	Lean			Lean	Lean	Lean	Lean
RJ	Peak	Peak	Lean									
Assam	Peak	Lean	Peak	Peak	Peak	Peak				Peak	Peak	Peak

Lean Season / Peak Season

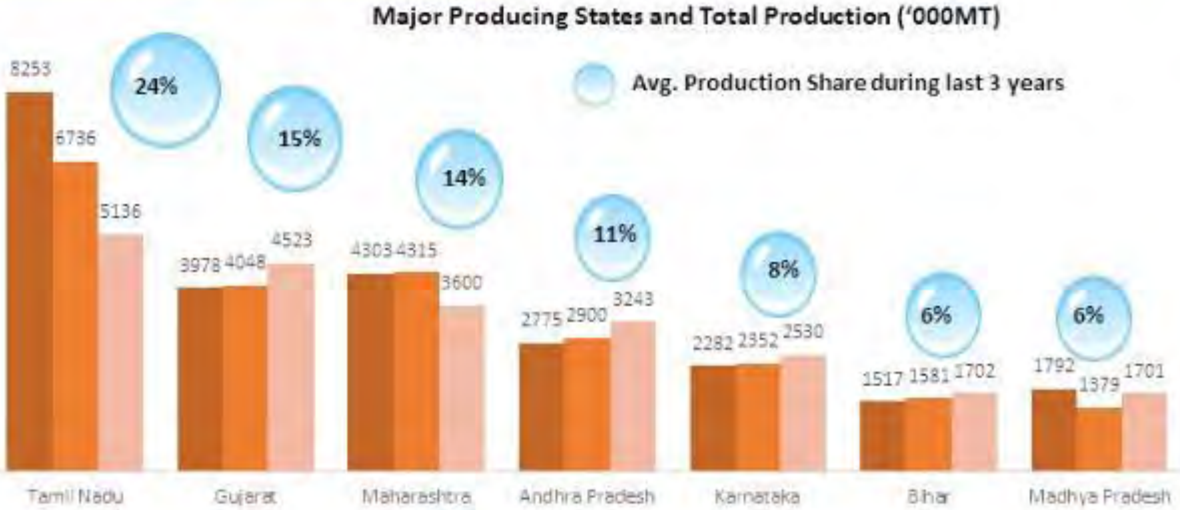
Banana



Major Producing Districts		
District	State	Production ('000 MT)
Jalgaon	Maharashtra	2880.5
Bharuch	Gujarat	1092.6
Anand	Gujarat	980.6
Surat	Gujarat	589.5
East Godavari	Andhra Pradesh	541.5
Kadapa	Andhra Pradesh	516.3
Narmada	Gujarat	514.5
Nanded	Maharashtra	480.0
Erode	Tamil Nadu	443.9
Theni	Tamil Nadu	435.4



Major Producing States and Total Production ('000MT)



Mango

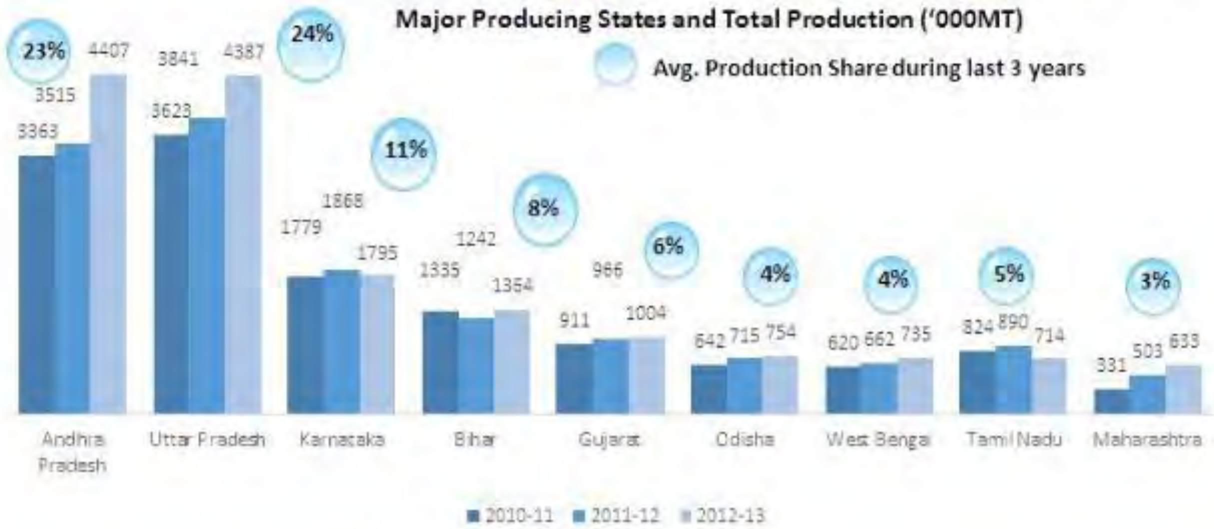
Major Producing Districts		
District	State	Production ('000 MT)
Jalna	Maharashtra	707
Chittoor	Andhra Pradesh	606
Krishna	Andhra Pradesh	539
Lucknow	Uttar Pradesh	488
Vizianagaram	Andhra Pradesh	429
Saharanpur	Uttar Pradesh	426
Khammam	Telangana	390
Kolar	Karnataka	374
Dindigul	Tamil Nadu	358
Nandurbar	Maharashtra	287
Unnao	Uttar Pradesh	273
Valsad	Gujarat	271
Warangal	Telangana	266

Source: NHB, 2012-13

Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
UP				Lean		Peak						
AP	Lean	Lean	Lean	Peak	Peak							
Karnataka				Peak	Peak	Peak	Lean					
Telangana												
Bihar						Peak	Peak	Lean				
MH			Lean	Peak	Peak	Lean						
Gujarat				Lean	Peak	Lean	Lean					

Lean Season   Peak Season



Tomato

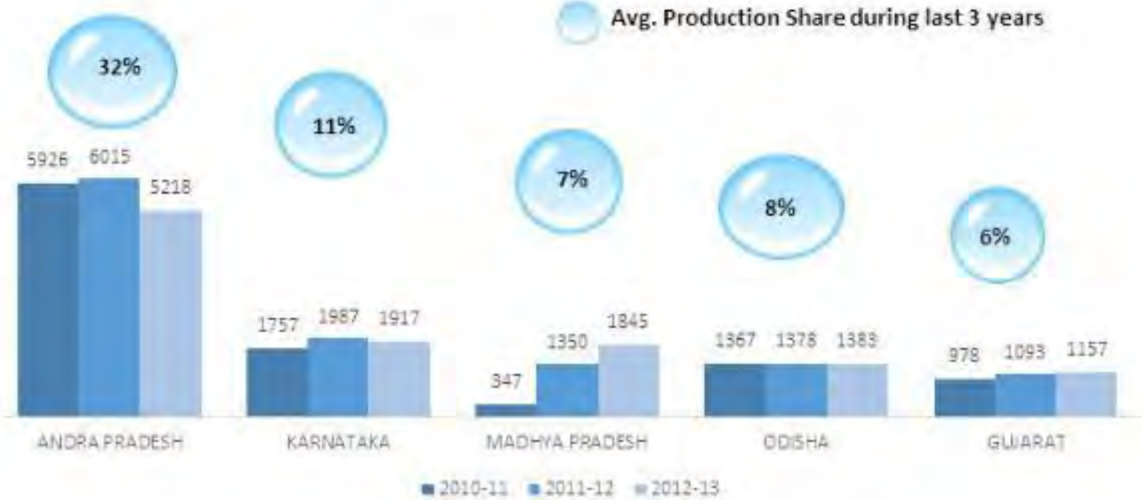
Major Producing Districts		
District	**State**	**Production ('000 MT)**
Nashik	Maharashtra	296.3
Banaskantha	Gujarat	213.4
Vadodara	Gujarat	154.8
Cooch Behar	West Bengal	148.7
Jalpaiguri	West Bengal	132.0
Anand	Gujarat	123.7
North 24 Parganas	West Bengal	107.3
Nadia	West Bengal	104.7
Mehsana	Gujarat	97.0
Durg	Chhattisgarh	94.7

Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
AP	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year	Throughout Year
KT					Peak	Peak	Peak	Lean	Lean			
MP	Peak	Peak	Lean	Lean	Lean	Lean	Lean	Lean	Lean	Peak	Lean	Peak
Odisha	Peak	Peak	Peak	Lean		Lean	Lean	Lean	Lean	Lean		Lean
Guj	Peak	Peak	Peak	Lean	Lean	Lean	Lean	Lean	Lean	Lean	Lean	Peak

Lean Season | Peak Season | Throughout Year

Major Producing States and Total Production ('000MT)



Cauliflower

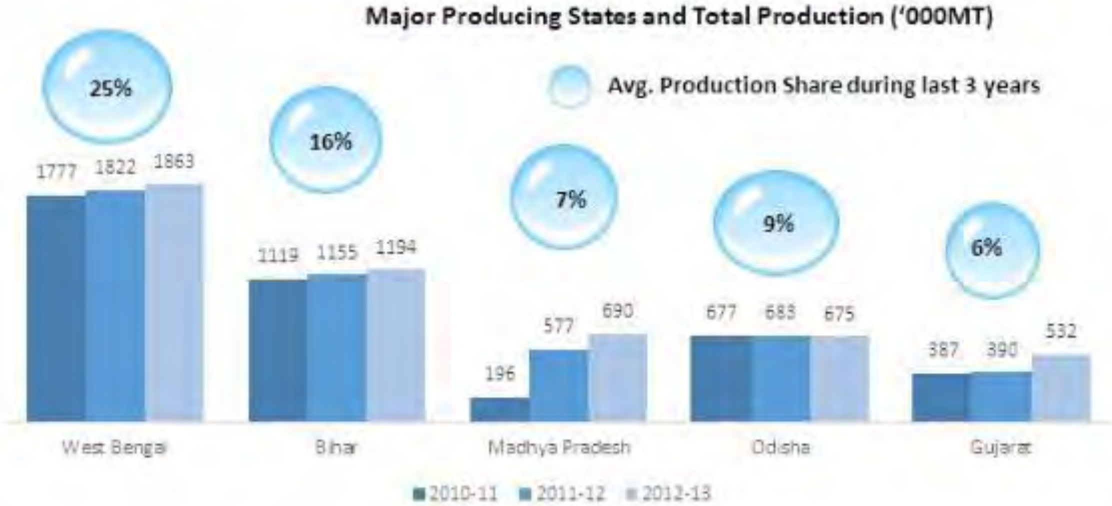
Major Producing Districts		
District	**State**	**Production ('000 MT)**
Murshidabad	West Bengal	302.5
Shahdol	Madhya Pradesh	279.0
Nadia	West Bengal	209.0
Bankura	West Bengal	153.6
North 24 Parganas	West Bengal	139.4
Cooch Behar	West Bengal	138.7
Jalpaiguri	West Bengal	112.8
Paschim Medinipur	West Bengal	111.3
Chhindwara	Madhya Pradesh	110.3
Maldah	West Bengal	109.5
South 24 Parganas	West Bengal	108.4

Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
WB	Peak	Lean								Lean	Lean	Peak
BIHAR	Peak	Peak	Lean	Lean								Peak
MH												
MP	Peak	Peak		Lean								
ODISHA	Peak	Peak	Lean							Lean	Peak	Peak
GUJARAT	Peak	Peak	Lean							Lean	Lean	Peak

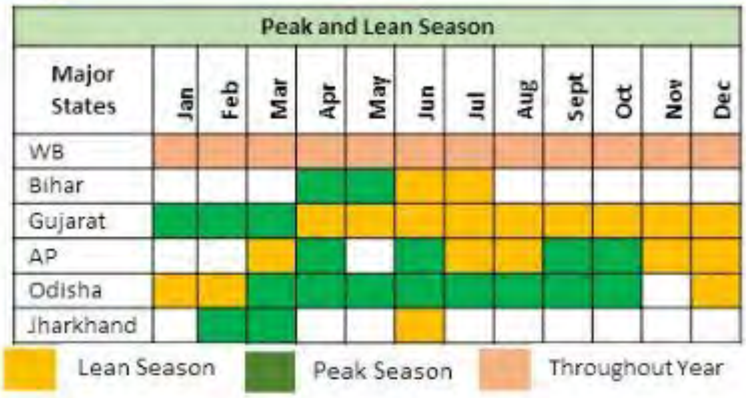
Lean Season   Peak Season

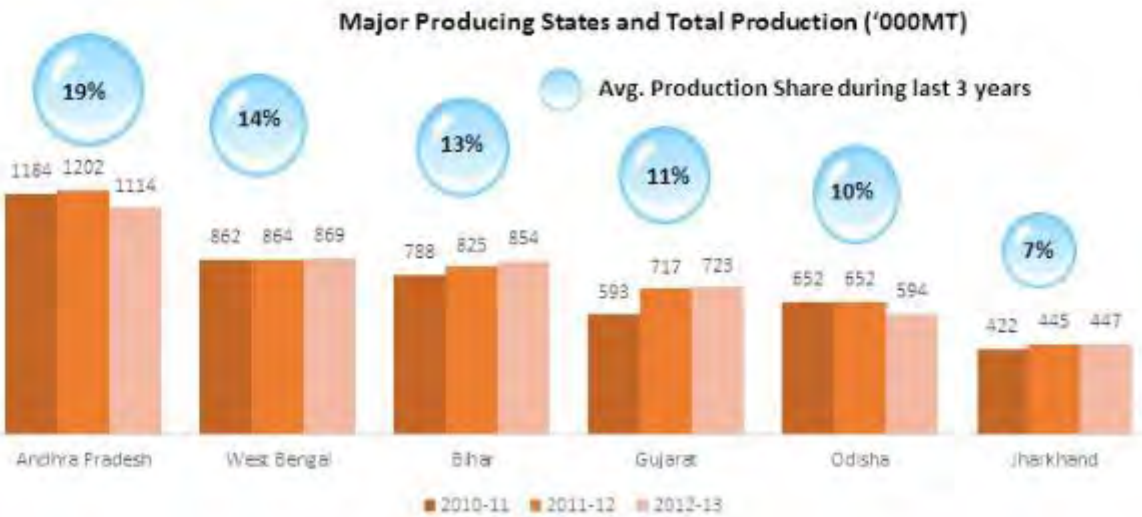
Major Producing States and Total Production ('000MT)



Okra

Major Producing Districts		
District	State	Production ('000 MT)
Surat	Gujarat	118.0
Nadia	West Bengal	115.6
Tapi	Gujarat	112.1
South 24 Parganas	West Bengal	89.1
Chittoor	Andhra Pradesh	81.3
Kadapa	Andhra Pradesh	70.7
Jalpaiguri	West Bengal	70.3
North 24 Parganas	West Bengal	69.9
Bankura	West Bengal	65.5
Navsari	Gujarat	62.1
Kurnool	Andhra Pradesh	61.3
Bardhaman	West Bengal	60.9





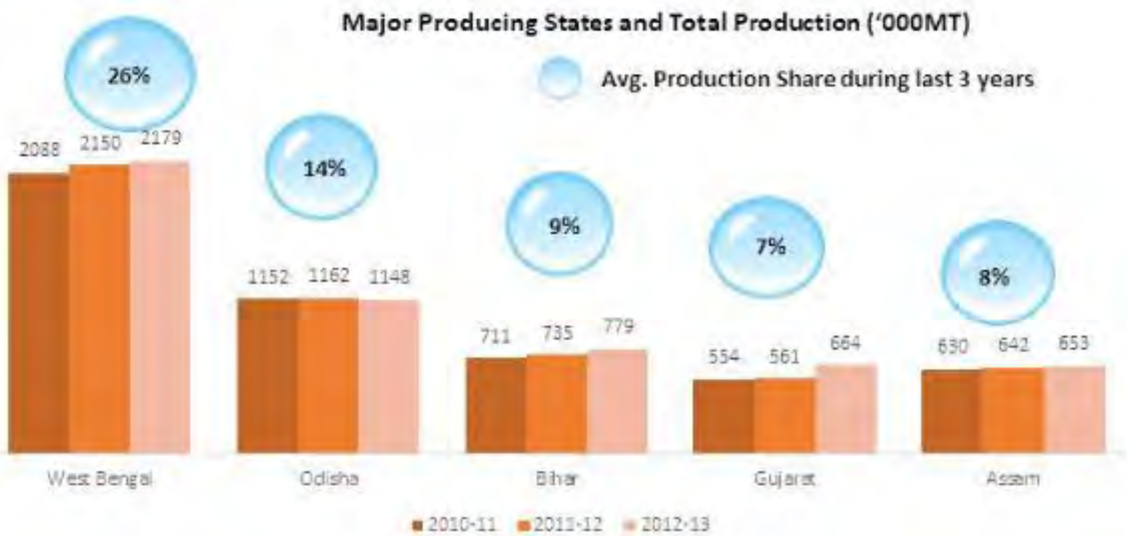
Cabbage

Major Producing Districts		
District	State	Production ('000 MT)
Murshidabad	West Bengal	316.8
Nadia	West Bengal	206.9
24 Parganas (S)	West Bengal	204.0
Sabarkantha	Gujarat	178.6
Bankura	West Bengal	169.8
Medinipur (W)	West Bengal	151.3
24 Parganas (N)	West Bengal	144.5
Cooch Behar	West Bengal	142.4
Jalpaiguri	West Bengal	133.1
Maldah	West Bengal	123.7
Dakshin Dinajpur	West Bengal	107.6

Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
WB	Peak	Peak	Lean						Lean	Lean	Peak	Peak
Odisha	Peak	Peak	Peak	Lean							Lean	Peak
Bihar	Peak	Peak	Lean	Lean							Peak	Peak
Gujarat	Peak	Peak	Lean							Lean	Lean	Peak
Assam	Peak	Peak	Lean									

Lean Season   Peak Season



Potato

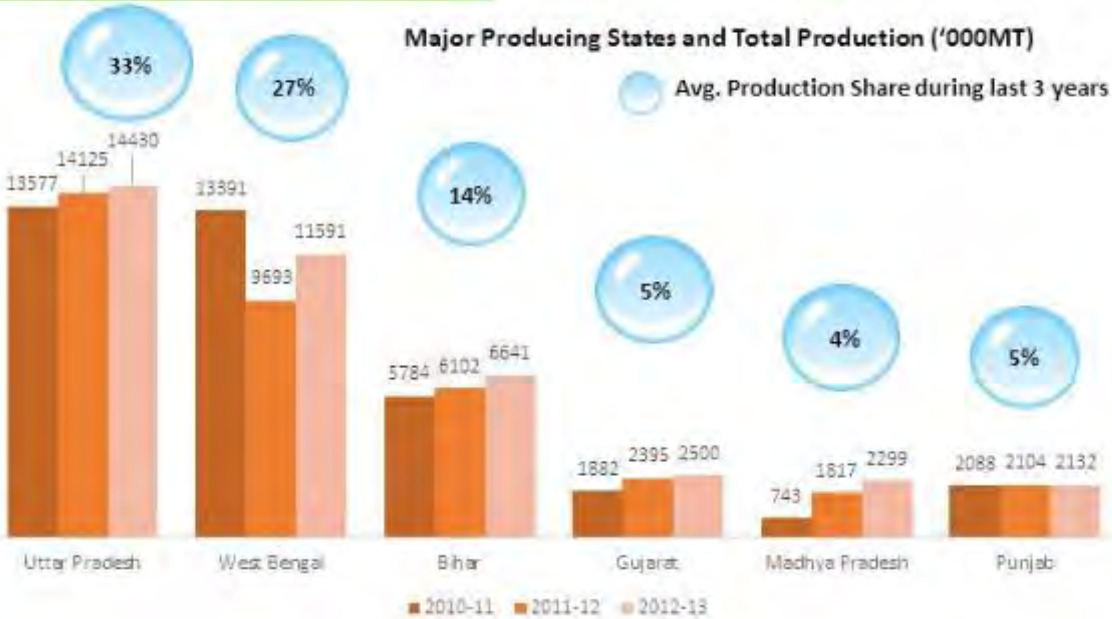
Major Producing Districts		
District	State	Production ('000 MT)
Hooghly	West Bengal	3246.4
Bardhaman	West Bengal	1854.2
Agra	Uttar Pradesh	1487.8
Paschim Medinipur	West Bengal	1463.6
Mahamaya Nagar	Uttar Pradesh	1454.1
Kannauj	Uttar Pradesh	1442.9
Firozabad	Uttar Pradesh	1398.0
Banaskantha	Gujarat	1381.4
Jalpaiguri	West Bengal	1050.2
Farrukhabad	Uttar Pradesh	877.0
Cooch Behar	West Bengal	744.3
Aligarh	Uttar Pradesh	723.9

Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
UP	Lean	Lean	Peak	Peak								
WB		Lean	Peak	Lean								
BIHAR	Peak	Peak								Lean	Lean	Lean
MP		Peak	Peak	Lean								
Guj	Peak	Lean										
Punjab	Peak	Lean										Peak

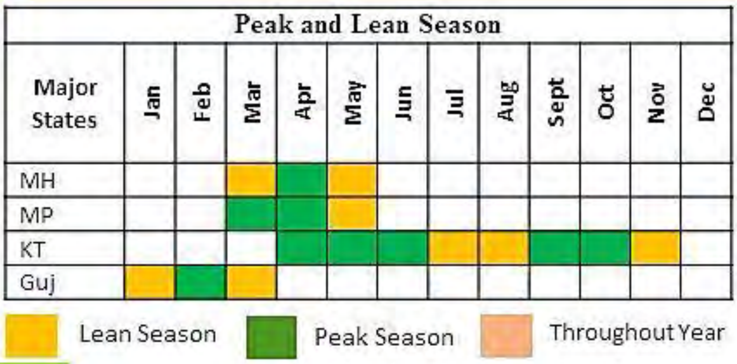
Lean Season / Peak Season

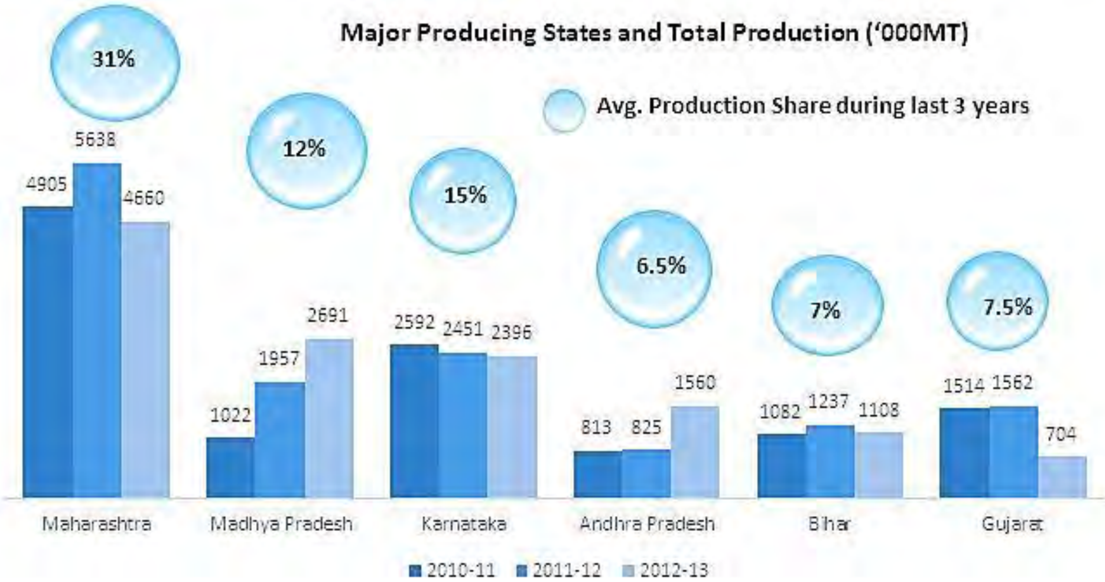
Major Producing States and Total Production ('000MT)



Onion

Major Producing Districts		
District	State	Production ('000 MT)
Nashik	Maharashtra	2233.0
Pune	Maharashtra	871.2
Shajapur	Madhya Pradesh	494.5
Aurangabad	Bihar	437.1
Sagar	Madhya Pradesh	326.8
Solapur	Maharashtra	303.9
Kurnool	Andhra Pradesh	288.9
Ujjain	Madhya Pradesh	269.2
Chitradurga	Karnataka	255.5
Khandwa	Madhya Pradesh	248.8
Dhule	Maharashtra	239.6
Gadag	Karnataka	223.0
Bagalkot	Karnataka	200.7





Annexure XVIII: Integrated Cold-chain Availability Platform (ICAP)

Concept Note for All India "Integrated Cold-chain Availability Platform (ICAP)" - a Public Services Project

Background

India is the largest producer of fruits and second largest producer of vegetables in the world. In spite of this per capita market availability of fruits and vegetables is quite low due to lack of appropriate facilities of transportation and storage. It is also frequently estimated that about 25% to 30% of produce, especially fruits and vegetables are wasted. Once originating into the cold-chain, the quality of a sizable quantity of produce also deteriorates en-route till the time it reaches the consumer.

Most of the problems relating to the supply of fruits and vegetables can be traced to insufficient availability of appropriate infrastructure that serves to control and regulate their perishability. A major segment of the horticultural produce is perishable in nature and requires specific levels of temperature and humidity to keep the produce in usable condition for longer periods.

At mild chill and chilled temperatures, perishability of produce is considerably reduced while maintaining freshness and the product's saleable life span is thereby increased. The real importance of cold-chain is its ability to maintain the appropriate conditions from source to consumption point. A cold-chain is hence a temperature & environment controlled supply chain network, with storage, transportation and distribution activities carried out in a manner such that the temperature of a product is maintained in a specified range, needed to keep it fresh and edible for a much longer period than it could under normal ambient conditions.

This facility requires high quality logistics infrastructure and appropriate technology for implementation and monitoring. Fruits, vegetables and many other commodities can be better protected or conserved by storage at low temperature & other conditions, which retard the activities that lead to senescence and product demise. This is different from the preservative techniques under processed food segments, where fresh produce is normally converted into processed food products. The cold-chain for fresh movement is not about preserving but more about protecting value.

In case of Horticulture, most of the produce has a short product life of a few weeks even within the cold-chain. During the peak harvesting season, excess produce reaches local markets close to production regions and many a times, due to lack of necessary logistics facilities, the produce is unable to reach more distant markets. This lack of proper connectivity with ready markets results in deterioration of the produce, which gets damaged and subsequently is totally wasted. Despite a local surplus, an artificial scarcity exists elsewhere and this is also exacerbated during non-harvesting periods, negatively impacting prices.

The integration of Farm-gate modern pack-houses, cold storages and reefer transportation, to be used in combination, is therefore essential for extending the usable life of the produce. The use of the extended life span is to make them available to a larger consumer base over a longer period of time. The development of cold-chain sector has therefore an important role to play in expanding market reach and by extending connectivity, thereby reducing the wastages of unconsumed perishable commodities and in turn providing better value realisation to farmers.

There is a misconception that cold storage facilities are the prime infrastructural component for all perishable commodities. To implement an integrated cold-chain, the logistics network needs to have decision taken at point of origin the farm-gate, have transport links to destination and have appropriate handling and storage facilities enroute to consumption point.

Currently, India has created about 6,500 cold storages of approximate size of over 30 million MT and about 9,000 actively refrigerated vehicles, the majority of which are operated by small cold storage and / or transport service providers. Thus, it is an extremely fragmented industry where critical data about technology used, capacity, installed or available, are either not available or of poor quality. Due to lack of shared information there is little scope of consolidation of the services offered and for integrating the activities into an effective cold-chain.

An intervention option suggested, is the provisioning of a national database that enables active linkage between multiple cold-chain assets across owners, promoting integration of use though collaboration. For collaboration, access to impartial information on capacities and movement of goods is required.

Project Rationale

The **three most important pillars** of any cold supply chain network are:

Static Infrastructure- i.e., the pack-houses and cold storages with varying capacities and using different technologies catering to different produce and products. These are primarily used for aggregating & storing the readied goods, for onwards logistics connectivity. Such aggregation brings economy of scale for the logistics operations as well as for efficient utilisation of connecting links;

Mobile Infrastructure- i.e., Refrigerated / Reefer Transport as connecting links for post-production and pre-market stages. These are designed to logistical load factors (small volume transit and long haul transits). Additionally cold-chain extends to last mile retail or point of sale involving merchandising infrastructure; and

Information Flow- i.e., Regular and dynamic information about ready capacity and the accessibility of above infrastructure; Such information has heightened impact during variables of frequent demand & supply fluctuations which occur due to changes in production yield, weather and other factors.

The success of any cold-chain relies on how efficiently it can serve as a conduit for products that are sensitive to their holding environment (air composition, temperature, microbial load, etc), from the place of origin to their destination with full integrity.

As all the produce that is handled in a cold supply chain has a predetermined useful life, accurate and timely information about availability of a static and mobile infrastructure, therefore, timely information is absolutely critical for success of the cold-chain network.

Currently, there is no system in the country which will tell a farmer, a logistics service provider or a food retailer how much of storage and transport capacity is available for perishables products at a given point in time and within reasonable reach.

Lack of such information disallows scientific planning and limits their market development activities. Furthermore, such information gap does not promote the integrated working of the nation's cold-chain infrastructure, as they have developed in silos and through individual non-collaborative ownerships.

This information gap also directly impacts the scope of interventions that can be devised to safe guard farmer's productivity, especially in times of bumper yields. Currently, better than average productivity at farm level results in an inverse negative return to farmers and leads to immediate wastage of food items.

This project is with the aim to fill such critical information gap.

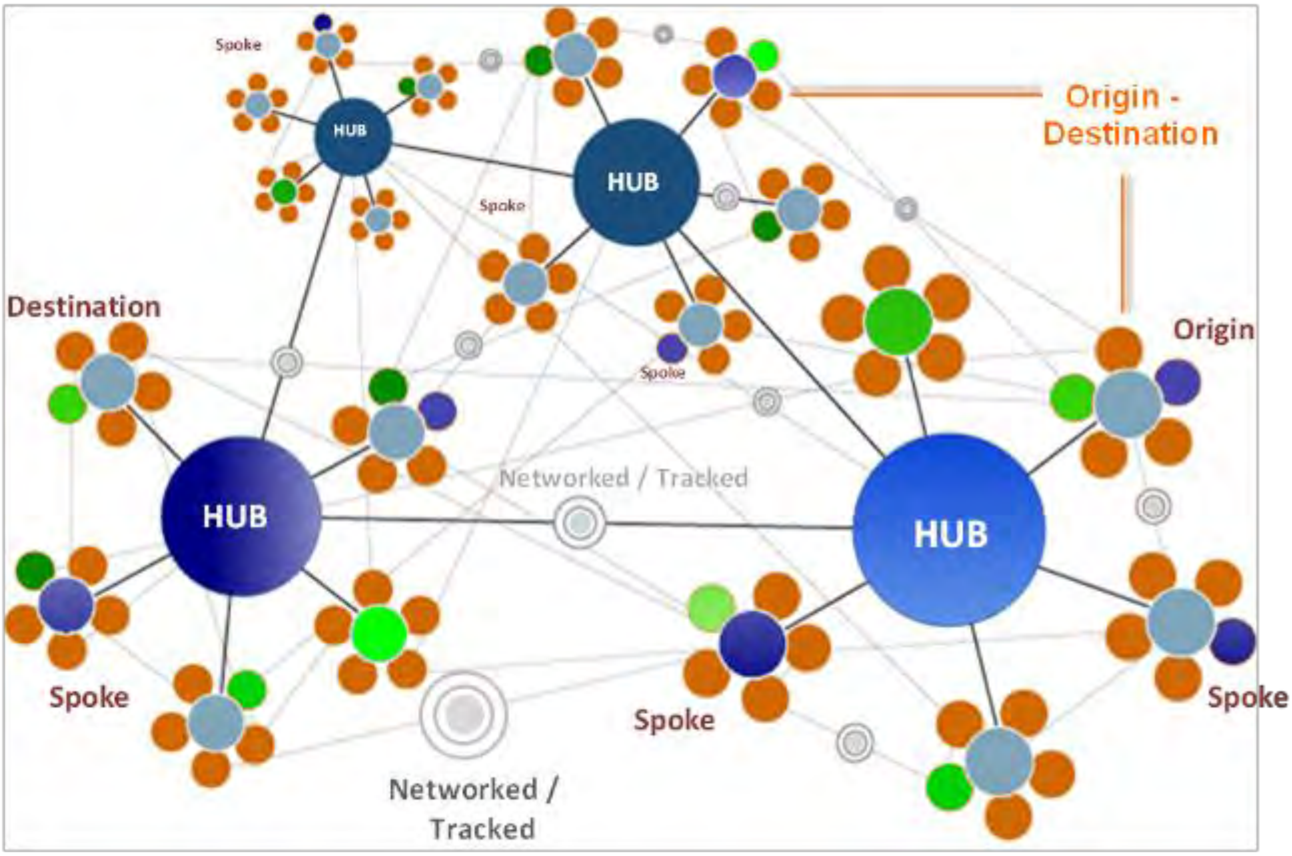
Project Concept

Just the presence or location of cold-chain infrastructure will not be sufficient. The availability of its capacity and range of utility shall make the information more functional and meaningful.

The concept is to use information about available capacity to create a **virtual network of cold-chain assets** in the country. The information on spare capacity would be provided by cold-chain asset owners and this would be piped into public domain for users to access and for government agencies to assess and evaluate further development direction.

The project can be voluntary or linked (time bound) to incentive schemes.

The information will provide users (Farm producers, processors, retailers) information and the ability to network-design a cold-chain to target and channel specific movement into markets nationwide. This will facilitate integration in the chain and bring infrastructure into optimal use.



Cold-chain Network

Impact and Benefits

ICAP (Integrated Cold-chain Availability Platform) is conceived to result in following benefits-

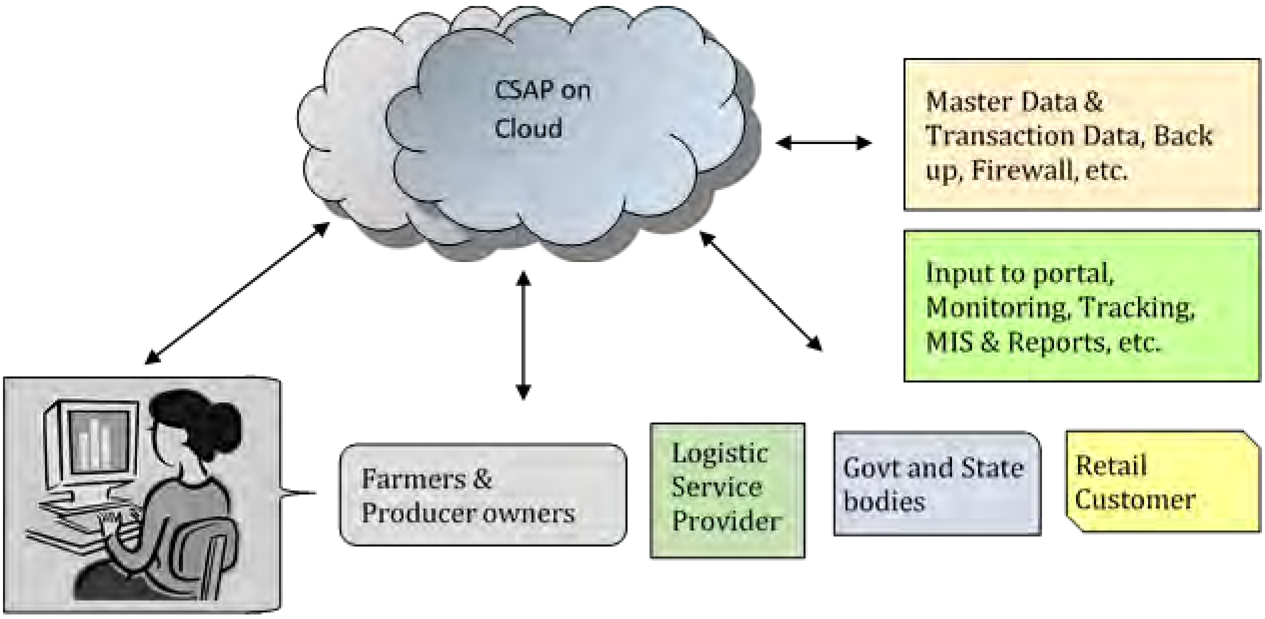
1. Direct access to nationwide capacity created.
2. Information to users and regulators on operational availability.
3. Will promote linking and integrating activities of cold-chain assets.
4. Will allow Farmer producer organizations to plan perishable movement across country.
5. Will provide information to agriculture ministry on trade impact in cold-chain sector.
6. Will empower government to plan viable public procurement mechanisms basis available cold-chain infrastructure.
7. Will bring traceability to food supply chain in perishables sector.
8. Will serve as space selling platform for asset owners.
9. Will promote buy-sell transactions of perishable goods that are in transit in the chain.

10. Will allow alignment of cold storages with marketing act by getting considered as transaction platforms, without the physical diversion of produce to non-cold-chain yards.
11. Will add transparency to cold-chain development, to regional availability and about trade lanes for perishables.
12. Will provide updated information on energy consumptions and its monitoring in cold-chain.
13. Will allow for improved demand-supply gap analysis and guide future cold-chain development.

Project Approach

Project ICAP should be developed and implemented in two phases, viz., the first phase to map the Cold Storage Capacity Availability, initially launched as **CSAP (Cold-storage Availability Platform)** wherein the storage capacity shall be determined and kept updated with associated information on suitability per product type basis associated temperature range.

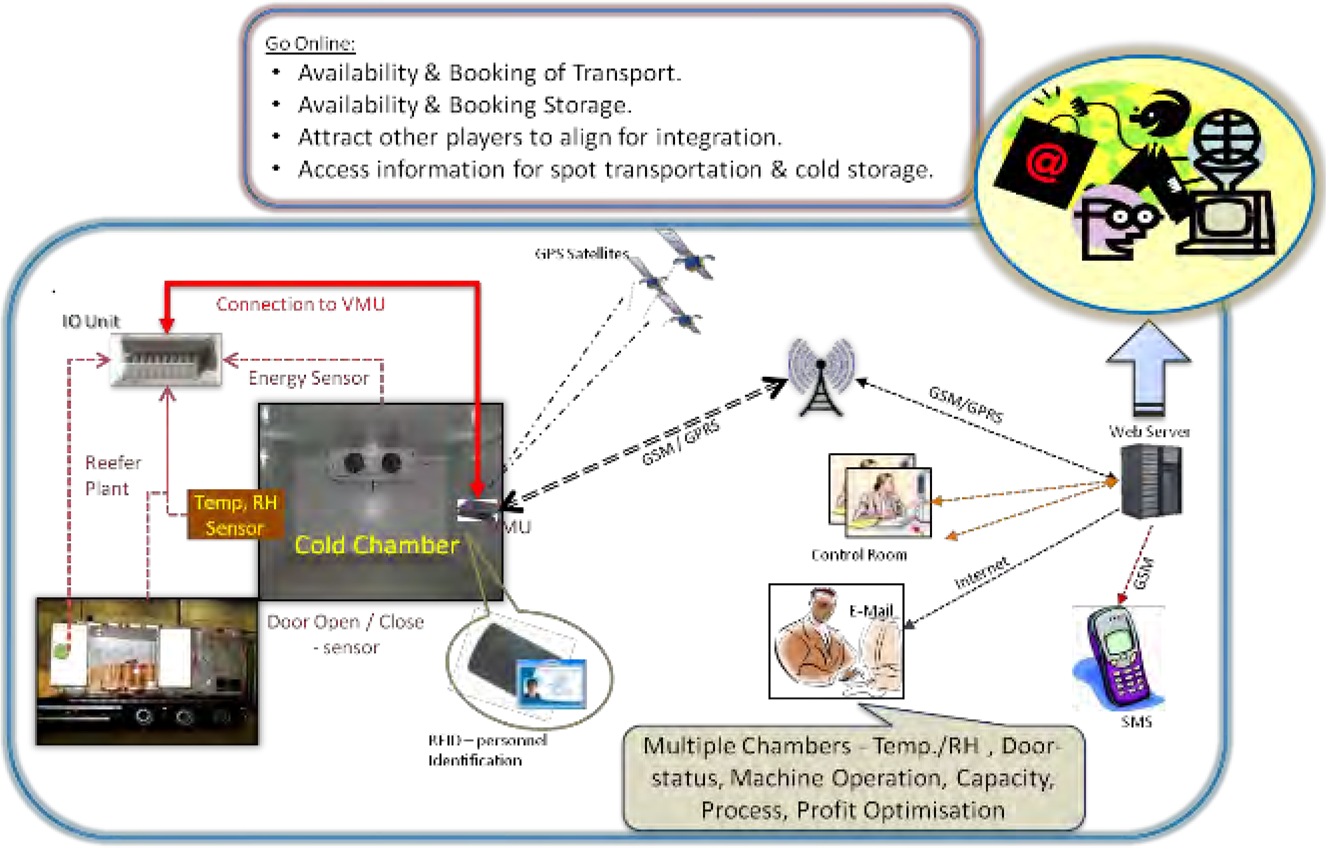
CSA Platform – Overview



It is suggested that first a pilot project be developed, keeping in mind the overall objectives and tested in a particular geographic area / state(s) with high concentration of cold stores and feedback taken from all the stake holders. The model can then be suitably modified, if required and implemented on a pan India basis.

The **second phase** shall involve the initiating of the **Reefer Transport Capacity Availability (RTAP)** on an all India basis.

RTA platform - Overview



The long-term aim of Project CSAP & RTAP shall be to develop the combined all India **Integrated Cold Chain Availability Platform (ICAP)**, an information access system that would be cloud based and accessible to end-users and stakeholders.

As necessary, NIC and/or Private IT industry can partner with implementing department under guidance of NCCD to develop the project & deploy the IT solution.

The consolidated information on key cold-chain information shall be made available to all segments of cold-chain users – horticulture, livestock, processed food and pharmaceuticals.

The information of the capacity of these two critical links of the cold-chain shall empower users to plan for integrated use of infrastructure and result in lowered wastage, lowered risk, increased value realization and more equitable sharing of such value. Asset owners should be able to advertise capacity availability and opt for improved utilisation patterns.

ICAP Features & Functionalities

1. Operational Requirements
    a. Flexible system with proper controls in place
    b. Available as web portal to registered users

c. Accessible from standard mobile devices
d. Capable of Geo tagging infrastructure with physical address on a map
e. 24 x 7 Tracking of Mobile assets with user defined alerts
f. User defined standard as well as exception reports
g. Total solution on Cloud preferably on 'pay per use' or Software as Service (SAAS) model.

2. Technical Requirements
    a. Web enabled, Windows and web services based protocols to enable working with a standard Internet connection
    b. System to be provide on line help with indexing & search capability
    c. System to be able to maintain both testing and production environment
    d. Data security & firewall protocols
    e. System hosting infrastructure should be certified for trustworthy computing i.e., ISO 27001:2005 and / or SAS 70 Type I and II attestations in public cloud infrastructure
    f. System to support easy data transfer, in and out
    g. Proper backup and archival & retrieval management
    h. System to support messaging based integration, XML, EDI

This project can be developed under aegis of Ministry of Agriculture and Ministry of food Processing Industries as these are two major stakeholders that utilise the subject infrastructure assets for movement of fresh produce and finished products.

NOTES

This report should be cited as:

NCCD. 2015. *All India Cold-chain Infrastructure Capacity (Assessment of Status & Gap),* Delhi. (www.nccd.gov.in)

This document is intended to provide domain specific insights into the current status and gap of cold-chain infrastructure in India. The study was completed in July 2015 after incorporating feedback from various stakeholder ministries/departments. The report compilation was released for print in August 2015.

The document is for reference use by academicians, students, planners and policy makers. The findings of this document are not individual to specific projects and in reading the contents, project promoters should apply location/market/product specific business considerations.

Print copies can be requested from National Centre for Cold-chain Development (NCCD).

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