



SUSTAINABLE COLD-CHAIN STUDY IN BIHAR

INSTITUTIONAL, POLICY AND INFRASTRUCTURE LANDSCAPE



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Institutional, Policy and Infrastructure Landscape

United Nations Environment Programme (UNEP) Cool Coalition in partnership with the Alliance for an Energy Efficient Economy (AEEE), is implementing the project "Scaling-up Investment in Clean and Efficient Cold chain in India." The project aims to accelerate the development of sustainable and integrated cold chain in India and selected states. It is supporting the national government and two states, namely Bihar and Haryana, in mainstreaming energy-efficient, renewable energy-powered, and low-GWP refrigerant cold chain infrastructure and services in rural areas, particularly focusing on packhouses and reefer transport as part of an integrated cold-chain. The project is contributing to the implementation of India's Cooling Action Plan and is working to enhance rural livelihoods.

The Cool Coalition is a global multi-stakeholder network that connects a wide range of key actors from government, cities, international organizations, businesses, finance, academia, and civil society groups to facilitate knowledge exchange, advocacy and joint action towards a rapid global transition to efficient and climate-friendly cooling.

Alliance for an Energy Efficient Economy (AEEE) supports policy implementation and enables the energy efficiency market with a not-for-profit motive. AEEE promotes energy efficiency as a resource and collaborates with industry and government to transform the market for energy-efficient products and services, thereby contributing toward meeting India's goals on energy security, clean energy, and climate change.

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List of Abbreviations

ABD	Agri-Business Development
AC'S	Air Conditioners
ACA	Additional Central Assistance
AEEE	Alliance for an Energy Efficient Economy
AIF	Agriculture Infrastructure Fund
AMI	Agricultural Marketing Infrastructure
AMUL	Anand Milk Union Limited
APEDA	Agricultural & Processed Food Products Export Development Authority
APMC	Agricultural Produce Market Committees
ARM	Agriculture Road map
ASCI	Agriculture Skill Council of India
ASSOCHAM	Associated Chambers of Commerce and Industry of India
BAGRI	Bihar Agriculture Growth and Reform Initiative
BAIPP	Bihar Agricultural Investment Promotion Policy
BAPCC	Bihar Action Plan of Climate Change (BAPCC)
BAU	Bihar Agricultural University
BAVAS	Bihar Agri produce Value Addition System
BCCA	Bihar cold Chain Association
BEE	Bureau of Energy Efficiency
BHDS	Bihar Horticulture Development Society
BIADA	Bihar Industrial Area Development Authority
BISCOMAJN	Bihar State Co-operative Marketing Union
BKSK	BAGRI Kisan Sewa Kendra
BREDA	Bihar Renewable Energy Development Agency
BRLPS	Bihar Rural Livelihoods Promotion Society
CA	Controlled Atmosphere
CAGR	Compound Annual Growth Rate
CBBO	Cluster-Based Business Organisations
CCC	Clean Cooling Collaborative
CCLRC	Cold Chain Logistics Resource Centre
CDP	Cluster Development Programme
CFC	Chlorofluorocarbon
CIPHET	Central Institute of Post-Harvest Engineering and Technology
CIS	Capital Investment Scheme
CNG	Compressed Natural Gas
COMFED	Bihar State Milk Cooperative Federation Limited
DAC&FW	Department of Agriculture, Cooperation & Farmer's Welfare
DAY-NRLM	Deendaya! Antodaya Yojana – National Rural Livelihoods Mission
DFI	Doubling Farmer's Income
DFID	Department for International Development
DG sets	Diesel Generator sets
DISCOMs	Distribution Company
DMI	Directorate of Marketing & Inspection
DPR	Detailed Project Report
e-NAM	National Agriculture Market
EC	Energy Conservation
ECBC	Energy Conservation Building Code
EESL	Energy Efficiency Services Limited
ESCerts	Energy Saving Certificates
ESCO	Energy Service Company
F&V	Fruits and Vegetables
FAO	Food Agriculture Organization
FCAOI	Federation of Cold Storage Associations of India
FDI	Foreign Direct Investment
FL	Food Losses
FPC	Farmer Producer Companies
FPCL	Farmer Producer Corporation Limited
FPO	Farmer Producer Organisations
GC	General Council
GCCA	Global Cold-chain Alliance
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information System
GoB	Government of Bihar
Gol	Government of India

GrAMs	Gramin Agricultural Markets
GSDP	Gross State Domestic Product
GWh	Gigawatt hour
GWP	Global Warming Potential
Ha	Hectare
HCFC	Hydrochlorofluorocarbons
HFC'S	Hydrofluorocarbons
HMNEH	Horticulture Mission for North-East & Himalayan States
HPMP	Hydrochlorofluorocarbons Phase-out Management Plan
HVAC	Heating, Ventilating, Air Conditioning
ICAP	India Cooling Action Plan
ICAR	Indian Council of Agricultural Research
ICC	Integrated Cold-chain
ICDP	Integrated Cooperative Development Project
ICIMOD	International Centre for Integrated Mountain Development
ICT	Information and Communications Technology
IL&FS	Infrastructure Leasing & Financial Services Limited
INR	Indian Rupee
IOT	Internet of Things
IQF	Individual Quick Freezing
ISAM	Integrated Scheme for Agricultural Marketing
ISHRAE	Indian Society for Heating Refrigeration and Air conditioning Engineers
ITDP	Integrated Tribal Development Programme
JV	Joint Venture
K-CEP	Kigali Cooling Efficiency Program
KVA	Kilovolt Ampere
KVK	Krishi Vigyan Kendras
KW	Kilowatt Hour
LED	Light Emitting Diode
LLP	Limited Liability Partnership
LPG	Liquefied Petroleum Gas
MA	Modified Atmosphere
MBBL	Model Building Bye-Laws
MEPS	Minimum Energy Performance Standards
MFD'S	Multi-Function Design
MIDH	Mission for Integrated Development of Horticulture
MNRE	Ministry of New and Renewable Energy
MoA&FW	Ministry of Agriculture and Farmer's Welfare
MoCI	Ministry of Commerce and Industry
MoE&FCC	Ministry of Environment, Forest and Climate Change
MoFPI	Ministry of Food Processing Industries
MoP	Ministry of Power
MOP	Meeting of the Parties
MoRD	Ministry of Rural Development
MRIN	Marketing Information and Research Network
MSDE	Ministry of Skill Development & Entrepreneurship
MT	Metric Tonnes
NABARD	National Bank for Agriculture and Rural Development
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAFED	National Agricultural Cooperative Marketing Federation of India Ltd.
NAPCC	National Action plan for climate change
NARS	National Agricultural Research System
NCCD	National Centre for Cold-chain Development
NCCRC	National Cold Chain Resource Centre
NCCVMRC	National Cold Chain & Vaccine Management Resource Center
NCDC	National Cooperative Development Corporation
NDC	Nationally Determined Contributions
NDDB	National Dairy Development Board
NFDB	National Fisheries Development Board
NGO	Non-Government Organizations
NHB	National Horticulture Board
NHM	National Horticulture Mission
NIAM	National Institute of Agriculture Marketing
NISE	National Institute of Solar Energy
NITI Ayog	National Institution for Transforming India Ayog
NSM	National Solar Mission
ODOP	One District One Product
PACS	Primary Agricultural Credit Societies
PAT	Perform, Achieve, Trade

PAU	Punjab Agricultural University
PCS	Primary Cooperative Society
PDF	Project Development Facility
PDS	Public Distribution System
PHM	Post-Harvest Management
PLC	Programmable Logic Controller
PLC	Programmable Logic Controller
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan
PMKSY	Pradhan Mantri Kisan SAMPADA Yojana
PPP	Public Private Partnership
PVCs	Primary Vegetable Cooperative Societies
PwC	Pricewaterhousecoopers
R&D	Research and Development
RAC	Refrigeration and Air Conditioning
RAMA	Refrigeration and Air-conditioning Manufacturers Association
RBI	Reserve Bank of India
RKVY	Rashtriya Krishi Vikas Yojana
RKVY- RAFTAAR	Rashtriya Krishi Vikas Yojana- Remunerative Approaches for Agriculture and Allied sector Rejuvenation
RTC	Ready to Cook
RTE	Ready to Eat
S&L	Standards and Labelling
S&T	Scientific and Technological
SACEP	South Asia Co-operative Environment Programme
SAGF	Strengthening of Agmark Grading Facilities
SAPCC	State Action Plan for Climate Change
SDA	State Designated Agency
SDG	Sustainable Development Goals
SFAC	Small Farmers Agri-business Consortium
SHB	State Horticulture Board
SHGs	Self Help Groups
SHMs	State Horticulture Missions
SPV	Solar Photo Voltaic
TSG	Technical Support Groups
TWh	Terawatt hour
ULB	Urban Local Body
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USD	United States Dollar
UTs	Union Territory
VCA	Venture Capital Assistance
VEGFED	Vegetable Federation
VFDs	Variable Frequency Drives
VPOs	Village Producer Organizations

1 Introduction

1.1 Background

India is an agrarian economy, where 54.6% of the total workforce is engaged in agricultural and allied sector activities.¹ The country, which was once produce-deficit, has emerged as the largest producer of spices, pulses, milk, tea, cashew, mango, banana and jute, and the second-largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton and oilseeds. The country is also a net exporter of agriculture and produces more than one billion tonnes of agricultural produce.² India produced 320.7 million tonnes (including 188.9 million tonnes of vegetables and 102 million tonnes of fruits) of horticulture produce in 2019-20.³ The total horticulture production was highest in Uttar Pradesh (39.2 million MT), followed by West Bengal (32.4 million MT), Madhya Pradesh (26.5 million MT), Maharashtra (24.5 million MT), Andhra Pradesh (24.6 million MT) and Bihar (21.1 million MT). Even though India has reached production self-sufficiency (in terms of agricultural produce), the country faces food insecurity and malnutrition, a significant consequence of uncurbed food loss⁴ and food waste⁵ in India. Moreover, the government can better utilise the export potential of the horticulture produce as only 1% of the produce was exported in 2017-18.⁶ The nation's malnutrition and food insecurity challenges and untapped export potential indicate that though India has made several advancements in agriculture production, the country is yet to create cold-chain infrastructure (such as appropriate packhouses, refrigerated transport vehicles and ripening chambers) that can support affordable post-production and easy access to markets for farmers.

In the food journey from farm to table, maintaining the produce quality and its nutritional value is very important, wherein cold-chain plays a significant role. Cold-chain refers to all the logistical processes applied to maintain multiple parameters (such as temperature and moisture content) during preconditioning, handling, transport, storage, and retail perishable products. Cold-chain helps in extending the marketable life of fresh farm produce. The lack of cold-chain infrastructure has led to considerable post-harvest losses. Several organisations have estimated the post-harvest losses — such as the Indian Council of Agricultural Research (ICAR) reported in 2016 that about 5.8% to 18.1% of fruits and 6.9% to 13% of vegetables were lost during post-harvesting activities due to poor handling and improper storage (excluding loss in transportation).⁷ Whereas the Doubling Farmer Income (Volume III) (DFI) report estimated losses in fruits and vegetables as 34 and 44.6 per cent, respectively⁸. The loss due to the lack of farm-to-market link, whether we consider the lower range reported by ICAR or, the higher range reported by the DFI committee, is an irrevocable loss to farmers' already low incomes and a missed opportunity for alleviating food insecurity. The Central Institute of Post-Harvest Engineering and Technology (CIPHET) has highlighted a total post-harvest loss of around 14 Billion USD annually (as per

¹ Department of Agriculture, Cooperation & Farmers' Welfare Ministry of Agriculture & Farmers' Welfare Government of India. 2020. ANNUAL REPORT 2020-21. [online] Available at:

<https://agricoop.nic.in/sites/default/files/Web%20copy%20of%20AR%20%28Eng%29_7.pdf>

² NITI Aayog. 2020. Volume 2 – Agriculture: Evaluation of Centrally Sponsored Schemes in Package I - Agriculture, Animal Husbandry and Fisheries Sector.

³ Ministry of Agriculture & Farmers Welfare. 2021. Release of Final Estimates of 2019-20 and First Advance Estimates of 2020-21 of Area and Production of Horticultural Crops. [online] Available at: <<https://pib.gov.in/PressReleasePage.aspx?PRID=1703196>>

⁴ Food loss is understood to occur when the food produced for human consumption is discarded or suffers a reduction in quantity, or is diverted for non-food purpose. The cause is primarily the miscarriage in post-harvest connectivity to markets, i.e., failure in the handling and connecting of food produced to consumption points (DFI Volume III).

⁵ Food waste is understood as the waste that occurs in the hands of consumers, conscious or unconscious due to habitual excesses or other rejection factors, i.e., food discarded at consumer-end, after monetisation of the farmers' produce (DFI Volume III).

⁶ Department of Agriculture, Cooperation & Farmers' Welfare Horticulture Statistics Division. 2018. Horticulture Statistics at a Glance. [online] Available at: <<https://agricoop.nic.in/sites/default/files/Horticulture%20Statistics%20at%20a%20Glance-2018.pdf>>

⁷ Jha, S, Vishwakarma, R, Ahmad, T and Rai, A. 2016. Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops/Commodities in India. ICAR.

⁸ Committee for Doubling Farmers' Income. 2015. DFI (Volume III): Post-production Agri-logistics: maximising gains for farmers

their report published in 2019).⁹ Such a magnitude of monetary loss primarily impacts smallholder and marginal farmers involved in horticulture crop production.

Smallholder farmers—those with less than two hectares of land—account for 86% of all farmers in India at around 126 million and own about half of the arable land¹⁰. Bihar, West Bengal, Uttar Pradesh, Odisha and Tamil Nadu have a high share of small-holder farmers, over 90 per cent.¹¹ Bihar is also one of the poorest states in India, with fragmented production at the backend, limited power availability, inadequate roads and enabling infrastructure impacting quality and health of fresh and processed food products and rendering a substantial population of farmers economically vulnerable. Bihar thus is the focus of this study which aims to understand the state’s cold-chain scenario. The following section discusses Bihar horticulture and cold-chain background briefly.

1.1.1 Horticulture landscape in Bihar

Bihar, located in eastern India, is the third-largest state by population and the twelfth-largest by territory (area of 94,163 km²). The state is primarily an agricultural state, with around 80% of the rural population—much higher than the national average—engaged in agriculture. It is endowed with fertile agricultural land, a subtropical climate, and vast potential to grow horticultural crops. Based on soil characterisation, rainfall, temperature, and terrain, there are four main agro-climatic zones in Bihar (Figure 1), namely, North Alluvial Plain (Zone 1), North East Alluvial Plain (Zone II), South East Alluvial Plain (Zone-III A), and South-West Alluvial Plain (Zone-III B), each with its unique prospects.



Figure 1: Bihar districts falling within different agro-climatic zones

The entire agricultural operation in Bihar is divided into two seasons –Kharif and Rabi. The Kharif season (crops sown at the beginning of the rainy season) starts from the end of May and lasts till the end of October, followed by the Rabi season (crops sown at the end of monsoon or at the beginning of winter season), which starts around early November and ends around mid-May.

⁹ Central Institute of Post-Harvest Engineering and Technology. 2019. Annual Report 2018-19. Ludhiana: ICAR.

¹⁰Ministry of Agriculture & Farmers Welfare, Government of India. 2019. Agriculture Census 2015-16 (Phase-I): All India Report on Number and Area of Operational Holdings”. New Delhi. [online] Available at: <http://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf>

¹¹Ministry of Agriculture & Farmers Welfare, Government of India (2019). “Agriculture Census 2015-16 (Phase-I): All India Report on Number and Area of Operational Holdings”. New Delhi. [online] Available at: <http://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf>

Many tropical and subtropical fruits, vegetables, tuber crops, medicinal and aromatic plants, flowers, spices, and plantation crops are grown commercially in the state. In 2018, Bihar had 2.96 million hectares of area under fruit production and 8.24 million hectares of area under vegetable production. The agricultural sector in the state is growing at a CAGR of 13.8%, contributing to ~19% of the gross state domestic product (GSDP). Bihar is the fourth largest vegetable producer (Okra, Cabbage, Potato, Brinjal, Cauliflower and Onion) and the eighth largest fruit producer (Mango, Guava, Litchi and Banana) in India^{12,13}. In addition to the horticulture crops, Bihar is a leading producer of Makhana (also known as Gorgon nut or Fox nut), accounting for more than 85% of the total production of India. Makhana attracts moisture and may require special climate-controlled rooms. It is also a very light product that will require a lot of space/volume to store, making its storage very expensive. The state is also one of the leading producers of rice, wheat, maize, gram, red gram, sugarcane and spices, for which there is good demand in domestic and foreign markets.¹⁴

The horticulture produce is dispersed over several districts in Bihar (Figure 2), with significant vegetable growing districts including Patna, Vaishali, Muzaffarpur, W. Champaran, E. Champaran. The Muzaffarpur district remains the focal point of Litchi production in the country, with other major fruit producing districts including Bhagalpur and Vaishali for Banana, and Darbhanga, Muzaffarpur, Samastipur, East and West Champaran, and Bhagalpur for Mangoes. Furthermore, the cold storage association representative in Bihar highlighted that Purnia district is one of the major producers of Makhana and Maize and has planned its expansion in Bananas. Other major Makhana producing districts include Madhubani, Darbhanga, Sitamarhi, Saharsa, Katihar, Supaul, Kishanganj, and Araria in the state.



Figure 2: Major horticulture producing districts in Bihar¹⁵

As seen in Figure 2, the state is a major fruits and vegetable producer; however, the state cannot leverage the full potential of its produce. There are several reasons for the unrealised agriculture potential of the state, including poorly developed road infrastructure that limits market access, failing to earn adequate revenue from its produce. Furthermore, the farmers in the state face frequent flood and drought conditions

¹² Department of Agriculture, Bihar. Creating an Enabling Ecosystem for Agri Investors. [online] Available at: <http://horticulture.bihar.gov.in/HORTMIS/BAIPP/Downloads/BAIPP_Brochures.PDF>

¹³ Horticulture Statistics Division, Ministry of Agriculture & Farmers' Welfare, 2018. Horticultural Statistics at a Glance 2018.

¹⁴ From stakeholder consultations

¹⁵ Department of Agriculture and Cooperation Horticulture Area Production Information System. [online] Available at: <<https://aps.dac.gov.in/Login.aspx>>

impacting their produce, with no mitigation measures in place. The state also faces unreliable power supply, poor marketing infrastructure, inadequate processing facilities, inadequate research and extension support and more importantly, a lack of post-harvest management infrastructure. These factors have led to rural poverty, insufficient nutrition, and labour migration across the state. Per the Associated Chambers of Commerce and Industry of India (ASSOCHAM), Bihar incurs a post-harvest loss of over INR 10,700 crores annually in fruits and vegetables.¹⁶ Moreover, 90 per cent of the farmers in the state are marginal/small-holders, holding approximately 57% of the total operational landholdings (of the total agricultural land, an area where actual farming is done). These farmers have low incomes and depend on daily sales of their produce for their income and hence may be forced to accept a lower price immediately, rather than to store their produce in anticipation of a higher price. Therefore, they hardly invest in farm-level and post-harvest management facilities, adversely affecting horticulture crops' overall production and quality. These practices further contribute to greater post-harvest loss and result in a missed opportunity to enhance farmers' livelihood.

The physical loss of produce in Bihar and across other states in India can be averted if the produce reaches the consumer timely, consequently saving the monetary losses associated with the post-harvest loss. Therefore, it is important to ensure the development of supporting infrastructure for post-production management (including cold-chain) and improved physical connectivity linking farmers/producers with the markets. Furthermore, this supporting infrastructure creation will demand higher energy consumption. It is important to note that now is a critical window of opportunity to cost-effectively incorporate energy-efficient and environmentally friendly technologies, innovative thermal management, and new energy systems in the cold-chain sector, focusing on optimising its existing energy consumption and reducing emissions. India Cooling Action Plan (2019) highlights that cold-chain offers an excellent opportunity to reduce cooling demand, refrigerant requirement, and energy consumption through improved designs, including proper insulation and the use of energy-efficient cooling equipment. This step will be vital to develop an integrated and low-energy cold-chain that is central to advancing farmers' economic well-being (supporting Doubling of Farmers' Income initiative by the Government of India) and carries other vital co-benefits such as mitigating food losses and alleviating hunger. These benefits can further contribute towards several of the Sustainable Development Goals (SDGs).

1.2 Objective and Context

1.2.1 Objective and scope of the study

This study brings to light Bihar's horticulture cold-chain scenario, describing the policy and institutional landscape, discussing the present status of cold-chain infrastructure in Bihar, estimating the GHG emissions due to lack of post-harvest infrastructure in the state, identifying gaps in cold-chain development and proposing recommendations to strengthen the cold-chain development in the state. The study's outcomes are captured in this report which begins with a brief overview of the need for cold-chain in the state, providing a background on the nation's and state's major produce and the impact of fragmented cold-chain on the produce and livelihoods of farmers. Further, the report discusses the institutional landscape that proposes, funds, supports and implements cold-chain infrastructure development. Next, the report summarises the significant government initiatives contributing to the current horticulture cold-chain infrastructure development and the implementation uptake of these initiatives in Bihar. Then, the report provides a consolidated status of the cold-chain infrastructure in Bihar, indicating the environmental impact of the food loss due to the lack of post-harvest infrastructure. Finally, the report summarises the barriers to cold-chain development in Bihar, including observations from various stakeholders consulted during the report's development, and proposes recommendations to overcome these barriers. The observations, findings, and recommendations based on our study presented

¹⁶Business-standard (2013), TN post-harvest losses at Rs 8,100 crore: ASSOCHAM. [online] Available at: <https://www.business-standard.com/article/economy-policy/tn-post-harvest-losses-at-rs-8-100-crore-asso-cham-114071401246_1.html>

in this report will advance cold-chain development in Bihar. They will be helpful to the state agencies, national actors and global agencies to develop an understanding of the need for an integrated cold-chain in Bihar and replicate similar studies for other states and regions.

Cold-chain sector serves diverse needs ranging from horticulture, dairy, fishery, vaccines, etc., and the infrastructure development for these would entail cross-sectoral and cross-ministerial effort exploring the logistical needs of different produce types. However, the focus of this report is limited to the horticulture cold-chain and the relevant actors related to developing a sustainable cold-chain through the use of affordable and energy-efficient technologies.

While a complete targeted study in itself, the report also serves as a starting-point for an overarching project that is focused on scaling up low-climate impact cold-chain in India.

1.2.2 The Overarching Context

The United Nations Environment Programme (UNEP) and Alliance for an Energy Efficient Economy (AEEE), in consultation with the Ministry of Environment, Forest and Climate Change (MoEF&CC) and with support from Energy Efficiency Services Limited (EESL), have initiated a project on "Scaling up Investment in Clean and Efficient Cold-chain in India" with funding support from the Clean Cooling Collaborative (formerly the Kigali Cooling Efficiency Program).

This project will support the implementation of the Indian Cooling Action Plan (ICAP) and contribute to government efforts on Doubling of Farmers' Income, reducing greenhouse gas emissions in line with the Paris agreement, support the objective of the Kigali amendment to the Montreal protocol, and reduce food loss and waste in support of the Sustainable Development Goals. The project aligns with the objective of Cool Coalition – a global multi-stakeholder network that connects a wide range of key actors from government, cities, international organisations, businesses, finance, academia, and civil society groups. It facilitates knowledge exchange, advocacy and joint action towards a rapid global transition to efficient and climate-friendly cooling.

As part of this project, two pilot states will be selected for in-depth support on cold-chain over three years on technology, policy, capacity building, finance, and potential investment support from EESL. Given the various aspects of cold-chain in India and the need for focused support, the project will predominantly focus on horticulture cold-chain, especially underdeveloped elements such as pack-houses. Bihar has been selected as the first pilot state considering the critical cold-chain infrastructure gap, strong state government support to sustainability and the existing framework of support from UNEP to the state of Bihar on climate change mitigation and adaptation planning.

Ultimately, the project will support pilot states to expand integrated, efficient cold-chain infrastructure using renewable energy and low-GWP refrigerants. The emphasis will be on reducing food loss and corresponding environmental impacts of the food system, increasing farmer incomes, and improving rural livelihoods and resilience.

1.3 Overall approach

The overall approach adopted for this study (shown in Figure 3) included, primarily, three components, literature review, stakeholder consultation and site visits to understand: Institutional and policy landscape of cold-chain development at the national level and in the state of Bihar, the status of cold-chain infrastructure at the national level and in Bihar and estimate GHG emissions due to post-harvest loss.

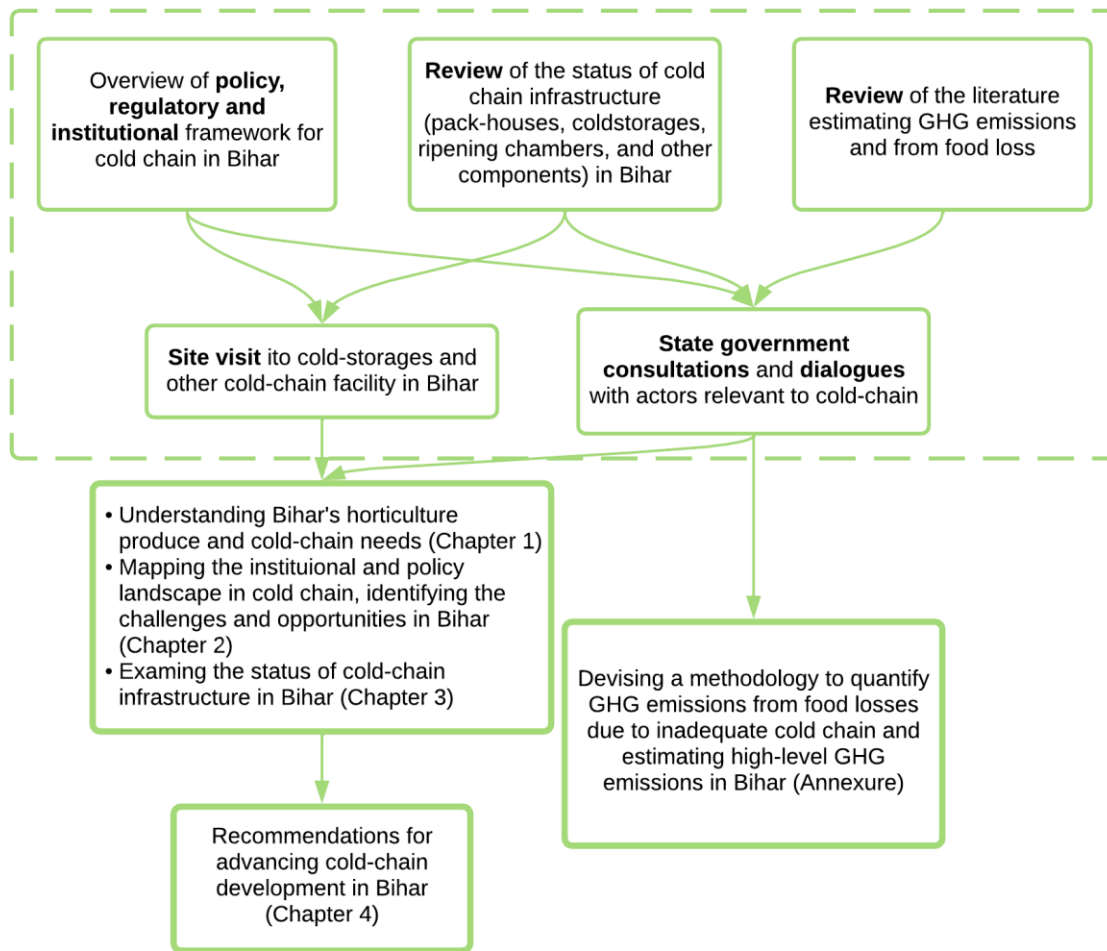


Figure 3: Overall approach adopted in this study

Literature Review: AEEE team reviewed relevant documents available in the form of data collected from various sources like Agriculture Censuses, government publications, internal records of the organization, reports, books, journal articles and websites and national infrastructure status reports. These studies helped identify the key institutions and their role in cold-chain development, major policies that facilitate cold chain development to identify opportunities to integrate energy-efficiency in the cold-chain, understand the present energy usage status in the cold-chain sector.

Some of the key publications reviewed included (but were not limited to):

- Ozone Cell (2019). India Cooling Action Plan. New Delhi: Ministry of Environment, Forest and Climate Change, Government of India.
- NCCD. (2015). All India cold-chain infrastructure capacity - Assessment of status and gap.
- NCCD. (2015). Guidelines & Minimum System Standards for Implementation in Cold-chain Components
- Committee for Doubling Farmers' Income. (2015). DFI (Volume III): Post-production Agri-logistics: maximising gains for farmers
- Committee for Doubling Farmers' Income. (2015). DFI (Volume IV): Post-production interventions: Agricultural Marketing.
- Cooling India. (2017). Role of Refrigeration in Dairy Industry.

- Committee for Doubling Farmers' Income. (2018). DFI (Volume IX): Farm linked Activities and Secondary Agriculture
- Committee for Doubling Farmers' Income. (2017). DFI (Volume XI): Empowering the Farmers through Extension
- Ashok, A., Brison, M., & LeTallec, Y. (2017). Improving cold chain systems: Challenges and solutions. *Vaccine*, 35(17), 2217-2223. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0264410X16307307>
- Committee for Doubling Farmers' Income. (2017). DFI (Volume VI): Strategies for Sustainability in Agriculture
- University of Birmingham (2017). India's Third Agricultural Revolution: Doubling farmers' incomes through clean cold chains.
- AEEE (2021). Enabling Cold-chain Infrastructure Development in India: Evolution and Assessment of Policies and Institutional Mapping
- AEEE (2021). Analysis of Cold Storage infrastructure in West Bengal- Retrofitting opportunities in the ESCO model; AEEE
- Kachhawa, S., Khurana, K., Garg, T., and George, G. (2021). Technology and Policy Roadmap for Energy Efficient Cold Storages in India. European Council for an Energy Efficient Economy Summer Study proceedings.
- Garg, T., Kachhawa, S. and George, G. (2020). Energy efficiency in post-harvest management in India. *Energy 2020: Energy Innovation for a Sustainable Economy*

Stakeholder Engagement: In collaboration with the UNEP team, the AEEE team engaged with diverse stakeholders, from government departments to financial institutions to cold storage owners to academic institutions (between mid-August to early October), providing a well-rounded view of the state's present status of the cold-chain infrastructure, their perspective on the cold-chain scenario in Bihar, their role in the cold-chain development, existing challenges and potential opportunities. The team conducted fourteen consultations with stakeholders indicated in Figure 4.

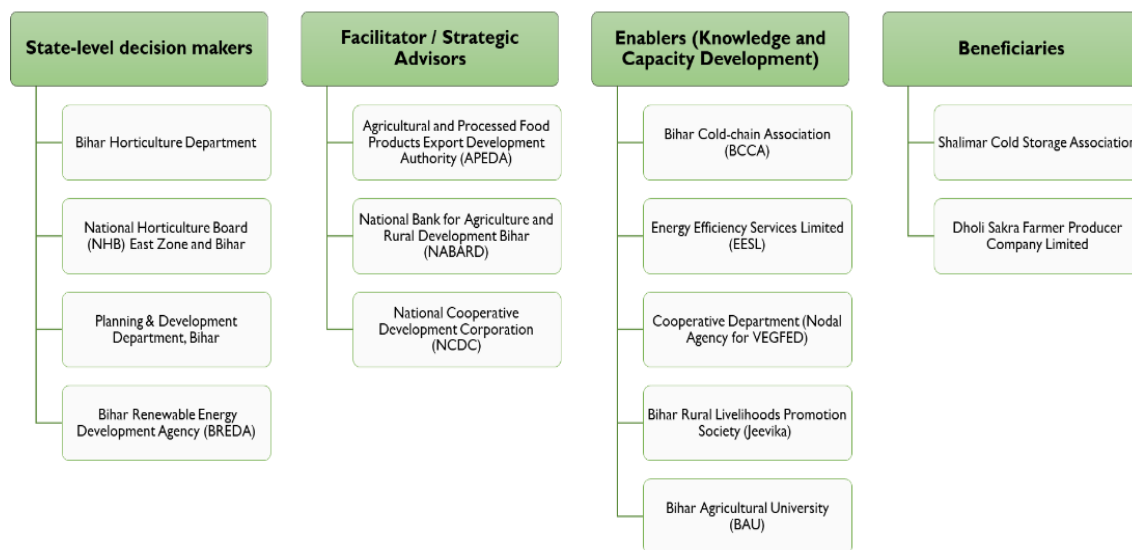


Figure 4: AEEE and UNEP team interacted with these fourteen stakeholders

Site visits: AEEE team visited the state in October 2021, met important stakeholders, including the Director of Horticulture, and visited cold storage in Vaishali District. The team followed a participatory approach with interactive interviews to gauge the challenges related to cold-chain infrastructure and identify opportunities to integrate energy efficiency in the existing cold-chain infrastructure. The site

visits also provided the local context to the major challenges observed through desktop research and consultations.

2 Mapping of Institutional and Policy Landscape

The cold-chain sector is directly related to various other sectors like food, commerce and health, and hence these aspects are under the aegis of multiple ministries. This chapter briefly elaborates on the key actors involved in sustainable cold-chain development and the important policies that have shaped the cold-chain sector at the national level and in Bihar.

India complies with a three-tier governance structure, ideating, supporting and implementing various schemes and initiatives. Within each of these tiers, multiple agencies – both government and non-government – play a role as presented in Figure 5:

- **Ideate:** Central-level organisations responsible for devising policies, schemes and initiatives related to cold-chain infrastructure development, integrating new schemes with existing policies and initiatives and developing standards in sectors.
- **Support:** Organisations (including autonomous bodies) that conduct research in framing policies, schemes, and initiatives, facilitate rolling out by developing the needed strategies and assist the government entities in properly enforcing policies schemes in states.
- **Implement:** Ground-level actors that implement schemes at the state and district-level, launch campaigns to create awareness about these policies and provide the necessary technology and human capacity to build cold-chain infrastructure. In this study, since the focus is Bihar, the state-level actors are mentioned for Bihar.

Figure 5 also highlights the end-users and beneficiaries of a well-developed cold-chain.

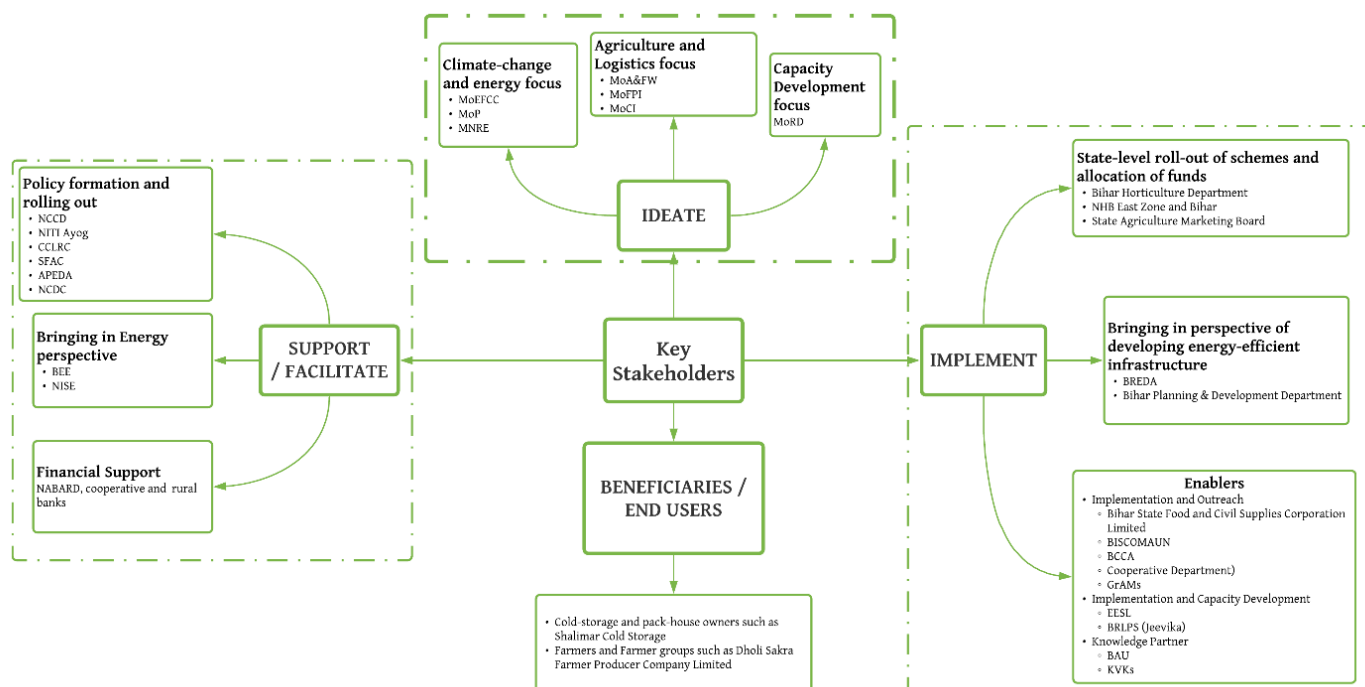


Figure 5: Key actors in the cold-chain sector.

2.1 Institutional and policy landscape: National level

This section discusses the role of actors and policies at the national level that can shape the cold-chain development.

2.1.1 Institutional framework governing cold-chain in India

In advancing sustainable cold-chain infrastructure in India, multiple aspects related to policy development, the strategic roll-out of schemes, facilitating and financing initiatives, capacity building and integration with energy efficiency and employing renewable energy opportunities are considered at the national level. These actors are crucial in providing an institutional and financial push for sustainable cold-chain development.

Table 1 briefly summarises the roles and responsibilities of the institutions at the national level, including central government institutes and autonomous bodies and their contribution to horticulture cold-chain development. These institutions are categorised into the following heads:

Policy-level Decision-Making Bodies (focusing on Agriculture and Logistics): Ministry of Agriculture & Farmers' Welfare (MoA&FW), Ministry of Food Processing Industries (MoFPI) and Ministry of Commerce and Industry (MoCI) can play a crucial role at the central level in framing comprehensive policies/strategies that can help develop sustainable cold-chain infrastructure, linking food-energy-climate-change nexus with farmers' livelihood.

Knowledge Partner/Strategic Advisory bodies: Continuous research is needed in developing sustainable cold-chain infrastructure, identifying the challenges with the existing infrastructure, policies and initiatives, and exploring opportunities to overcome these challenges. Further, developing strategies for rolling out these policies and conducting consultations with industry partners providing cold-chain solutions is essential for drafting comprehensive policies, schemes, or initiatives. Institutions such as National Centre for cold-chain Development (NCCD) and Niti Ayog, which have rich experience in co-drafting national policies, can provide their technical support in developing action plans at the national level for building a sustainable cold-chain in India.

Capacity Development: Ministry of Rural Development (MoRD), Agriculture Skill Council of India (ASCI), along with other agencies such as MoA&FW and NCCD, can help create and build human capacity that can be employed in the existing and upcoming cold-chain infrastructure. Further, organisations such as SFAC can help reach out to larger farmer interest groups to create awareness about the government schemes and initiatives.

Integrating Energy-efficiency aspects in cold-chain development: At present, extensive work needs to be done in cold-chain development; it is essential to scope out the limitations of the existing policies and schemes and opportunities to integrate energy-efficiency aspects in the cold-chain sector. Organisations such as the Ministry of New and Renewable Energy (MNRE) and the Ministry of Power (MoP) can support MoA&FW in integrating energy-efficiency aspects with existing cold-chain interventions. Moreover, climate change is an important aspect that has to be integrated with advancing cold-chain development. Therefore, organisations such as the Ministry of Environment, Forest and Climate Change (MoEF&CC) and Bureau of Energy Efficiency (BEE) can guide this development.

Table 1: Institutions and their role in cold-chain development¹⁷

Organization	Aim/Objective	Current role in cold-chain
Policy-level Decision-Making Bodies (focusing on Agriculture and Logistics)		
Ministry of Agriculture and Farmer's Welfare (MoA&FW)	The central role of MoA&FW is to formulate policies and regulations for the agriculture sector in India. The Department of Agriculture, Cooperation & Farmer's Welfare (DAC&FW) works directly for the wellbeing of farmers and implementation programs formulated by the ministry. To reach the objective, the ministry has launched major initiatives like Mission for Integrated Development of Horticulture (MIDH), Rashtriya Krishi Vikas Yojana (RKVY), Integrated Scheme for Agricultural Marketing (ISAM), etc.	The initiatives such as MIDH and ISAM aim to create a path for holistic growth of the agriculture sector, including providing an adequate storage facility and ensuring the product's quality; hence, the ministry has a significant role in developing cold-chain infrastructure.
Ministry of Food Processing Industries (MoFPI)	MoFPI monitors and governs the aspects of food processing and post-harvest agriculture produce management. The major initiatives being run by MoFPI are the Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters, i.e. Pradhan Mantri Kisan SAMPADA Yojana.	MoFPI is one of the key agencies involved in the development of cold-chain infrastructure as major schemes launched by MoFPI such as Pradhan Mantri Kisan SAMPADA Yojana aims to enhance the food processing efficiency of agriculture and minimise food waste at the processing stage by providing adequate infrastructure for storage, transportation, and processing of agro-food produce.
Ministry of Commerce and Industry (MoCI)	MoCI aims to promote export and ensure quality products, including agriculture and allied activities. The Department of Commerce is responsible for formulating trade policies that provide strategies and guidelines to be followed for export and trade. MoCI direct Agricultural & Processed Food Products Export Development Authority (APEDA), which is a critical agency in the trading of agriculture products.	The MoCI is indirectly related to the development of the cold-chain sector as it creates demand for high-quality agriculture produce for export. It creates a demand for the cold-chain to maintain the quality of perishable produce. Agencies such as APEDA are involved in developing an integrated packhouse facility to ensure quality for exporting fresh fruits and vegetables.
Knowledge Partner/Strategic Advisory bodies		
National Centre for Cold-chain Development (NCCD)	NCCD is registered as a society to function in an autonomous manner as a think-tank on cold-chain and to operate under public-private-partnership mode at no cost to the government. The initial capital was provided by the	NCCD is one of the key organisations for promoting and developing the integrated cold-chain in India. It plays its role by creating standards for cold-chain infrastructure, suggesting strategies for human resource development and recommending a policy framework to the

¹⁷ Gupta, K., Garg, T., Kumari, A., & Kumar, S. 2021. Enabling Cold-chain Infrastructure Development in India: Evolution and Assessment of Policies and Institutional Mapping. New Delhi: Alliance for an Energy Efficient Economy.

Organization	Aim/Objective	Current role in cold-chain
	<p>government and the objectives of NCCD are to recommend, suggest, assess, undertake & coordinate, facilitate and foster as below:</p> <ul style="list-style-type: none"> ● To recommend standards and protocols for cold-chain infrastructure/building including post-harvest management so as to harmonize with international standards and best practices and suggest a mechanism for benchmarking and certification of infrastructure /building, process and services provided by cold-chain industry. ● To suggest indicative guidelines for the preparation of project reports for potential investors/entrepreneurs. ● To assess and develop appropriate IT-based management information systems for cold-chain infrastructure. ● To undertake and coordinate Research and Development (R&D) work required for the development of cold-chain industry in consultation with stakeholders. ● To undertake and coordinate the task of Human Resource Development (HRD) and capacity building. It may also conduct in-house training, short-term/long courses relevant for cold-chain development. ● To launch a publicity campaign to educate the stakeholders, including awareness building about the benefits of integrated cold-chain. ● To recommend appropriate policy framework relating to the development of cold-chain. ● To facilitate and foster the development of multi- modal transportation facilities for perishable agricultural, horticultural and allied commodities and establishment of a National Green Grid for Perishable Commodities. 	<p>government.</p> <p>NCCD operational guidelines and minimum system standards define different cold-chain components and specify the admissible costs for providing Govt assistance for setting up integrated cold-chain infrastructures like packhouse, refrigerated transport, cold store, and ripening chamber, and add-on components like alternate technologies (Vapour absorption, solar, hybrids), PLC, modernization of refrigeration and insulation etc.</p>
<p>National Cooperative Development Corporation (NCDC)</p>	<p>NCDC is a statutory corporation under the Ministry of Agriculture & Farmers Welfare with the objective: To plan, promote and finance interventions to boost agricultural production, marketing, storage, export, etc. To be the nodal agency of Gol for implementing schemes of various ministries and provides loan assistance at the appealing interest rate for creation of Cold-chain facilities and dovetail the same with the grant-in-aid assistance from the</p>	<p>NCDC provides financial assistance for developing infrastructures like processing units, adequate storage facilities and a marketing place. Providing financial assistance for a storage facility becomes one of the main entities directly linked with the development of cold-chain infrastructure. NCDC can provide loan assistance at an attractive rate of interest for the creation of Cold Chain facilities and dovetail the same with the grant-in-aid assistance from the Government of India. In addition to assisting the cooperatives in setting up of Cold Chain</p>

Organization	Aim/Objective	Current role in cold-chain
	Government of India. NCDC provides assistance to primary, district and state level cooperatives.	infrastructure/ components as per the pattern of assistance given above, NCDC also provides working capital assistance for undertaking business operations by the cooperative assisted for Cold Chain facilities. NCDC loan will be dovetailed with the Grant-in-aid assistance available from different sources viz. through Central Sector Integrated Scheme on Agricultural Cooperation (CSISAC) and through Mission for Integrated Development of Horticulture (MIDH) / National Horticulture Board (NHB) / National Horticulture Mission (NHM).
National Institution for Transforming India Ayog	<p>National Institution for Transforming India Ayog (NITI Ayog) is the state-of-the-art resource centre and policy think tank responsible for assisting the governments and various institutions with a consolidated approach to multiple aspects from urban development to agriculture to rural development. It serves as a think tank and knowledge and innovation hub, facilitating the collaborative community of national and international experts, practitioners and partners.</p> <p>It is responsible for designing a policy and programme framework with a holistic approach keeping in mind all the stakeholders.</p> <p>It also monitors and evaluates the various projects and regulations in place to better its implementation.</p> <p>One of its major responsibilities includes fostering the idea of Cooperative federalism.</p>	<p>NITI Ayog has a vertical that focuses on agriculture and allied sectors. The Vertical aims to transform Indian agriculture, led by innovation, for improved nutrition and income of farmers, through sustainable and inclusive growth. The vertical conducts in-house research studies and partners with research institutes and academia. These studies analyse emerging issues, such as problems faced by farmers, food security, and the impact of various policies and developmental programmes.</p> <p>Further, the apex think tank is working on an Agriculture Transformation Index, which will measure the performance of States across six pillars: inputs, sustainability, productivity and diversification, policy, preservation, processing and exports, and farmers' income and welfare. The index aims to capture the new policy paradigm in agriculture, which is sustainable intensification and increasing farmers' income.</p>
Central Institute of Post-Harvest Engineering and Technology (CIPHET)	Established on 3 rd October 1989 at the PAU Campus, Ludhiana, Punjab, India, as a nodal institute to undertake lead research in the Post-Harvest Engineering and Technology appropriate to agricultural production catchment and agro-industries.	<p>Research on post-harvest processing, preservation, storage and value addition of agricultural commodities. Human resource and entrepreneurship development in post-harvest engineering and technology.</p> <p>It could be helpful in cold chain setup to minimize post-harvest losses</p>
Indian Council of Agricultural Research (ICAR)	Established on 16 th July 1929, an autonomous body responsible for coordinating agricultural education and research in India. It reports to the Department of Agricultural Research and Education, Ministry of Agriculture.	Into technical space in the agriculture sector. No direct involvement in the cold-chain specific industry.
Cold Chain	The Cold Chain Logistics Resource Centre is setup under	CCLRC has come up with commodity specific post-harvest protocols

Organization	Aim/Objective	Current role in cold-chain
Logistics Resource Centre	CII's food and agriculture Center of Excellence. It will support and catalyse the development of integrated cold chain networks across the country, aligned with the overall objectives of reducing food loss, maximizing energy efficiency and optimizing time and cost in the cold-chain networks.	<p>and technical design specifications for cold-chain infrastructure. The resource centre will support and strengthen the existing charter of agencies operating in cold chain like National Centre on Cold-chain Development (NCCD), National Cold Chain & Vaccine Management Resource Centre (NCCVMRC), National Cold Chain Resource Centre (NCCRC), MIDH (National Horticulture Board (NHB), NHM, HMNEH), National Cooperative Development Corporation (NCDC), National Fisheries Development Board (NFDB), NDDDB. The Centre will focus on the following areas:</p> <ul style="list-style-type: none"> ● Development of Cold Chain Database ● Investment Promotion in Cold-Chain Services. ● Support Efficient Utilization of Existing Cold Chain Infrastructure ● Promote Environmentally Sustainable Cold Chain Solutions ● Training and Capacity Building
National Agricultural Cooperative Marketing Federation of India Ltd. (NAFED)	NAFED is registered under the multi-state cooperative societies act. NAFED was set up to promote cooperative marketing of agricultural produce to benefit the farmers. Agricultural farmers are the prominent members of NAFED, who have the authority to say in the form of members of the General Body in the working of NAFED.	<p>NAFED owns several cold-chain facilities such as cold storages, serving as Industrial Units, some of these units are for NAFED's own use, while others are leased out to generate additional revenues.</p> <p>During the year 2020-21, as per the directions of the Ministry of Consumer Affairs, Food and Public Distribution, NAFED procured over one Lakh MT onions valuing INR 105.97 crore, for creating buffer stock under Price Stabilization fund (PSF) of Government of India.¹⁸</p> <p>NAFED also plans to create infrastructure for an end to end supply chain in Jammu & Kashmir (J&K). This will include pre-conditioning, Controlled Atmosphere CA storage, onion storage, processing facilities, ripening chambers, refrigerated transport and dry warehouses.¹⁹</p>

Capacity Development

¹⁸ National Agricultural Cooperative Marketing Federation of India Ltd. (2021). *Annual Report 2020-2021*. Retrieved from <https://www.nafed-india.com/documents/AR.pdf>

¹⁹ National Agricultural Cooperative Marketing Federation of India Ltd. (2021). *NAFED News*. Retrieved from <https://www.nafed-india.com/documents/Newsletters/NL20210621162655.pdf>

Organization	Aim/Objective	Current role in cold-chain
Ministry of Rural Development	<p>The Ministry of Rural Development is the most crucial ministry in the government, catering to the rural population's development and welfare. It is responsible for the sustainable and inclusive growth of rural India.</p> <p>The ministry assists in providing livelihood opportunities to the rural poor and consequently assists them in constructing a social safety net. The Ministry also looks after the infrastructure development such as all-weather roads, housing, schools etc. Moreover, the ministry is also responsible for capacity development and training of rural development functionaries.</p>	<p>MoRD has launched the Deendayal Antodaya Yojana – National Rural Livelihoods Mission (DAY-NRLM) in 2011 to construct sustainable community institutions for the rural poor to eradicate poverty. In the sphere of cold chain development, the Mission has also supported the development of 7028 custom hiring centre/community-managed tool banks across multiple states. These hiring centres enable small and marginal farmers to hire farm equipment and services such as soil testing, cold chain management etc., at nominal rates.</p>
Small Farmers Agri-business Consortium (SFAC)	<p>SFAC is a society promoted by the Ministry of Agriculture and Farmers' Welfare to increase incomes of small and marginal farmers and pioneered Farmer Producer Organizations (FPOs)/ Farmer Producer Companies (FPCs).</p>	<p>SFAC focuses on the growth of farmers and aims towards the increased income of farmers. The objective is to increase agribusiness and increase price recovery for agricultural produce, indirectly related to the cold-chain sector.</p> <p>SFAC has pioneered the formation and growth of Farmer Producer Organizations/Farmer Producer Companies. SFAC also implements the National Agriculture Market Electronic Trading (e-Nam) platform. The purpose is to provide a single unified market for agricultural products with better price discovery for farmers.</p>
Agriculture Skill Council of India (ASCI)	<p>Not-for-profit organization working under the Ministry of Skill Development & Entrepreneurship (MSDE) aegis. ASCI work towards the capacity building by bridging gaps and upgrading the skills of farmers, wage workers, self-employed & extension workers engaged in organized / unorganized Agriculture & Allied Sectors segments.</p> <p>ASCI is contributing to nation-building through Skill Development in Agriculture.</p>	<p>Presently, ASCI work on skill development and has no active involvement in cold-chain capacity building. It could potentially serve as a helping hand in imparting soft skills required for operationally running cold chain solutions</p>
Integrating Energy-efficiency aspects in cold-chain development		
Ministry of Environment, Forest & Climate Change (MoEFCC)	<p>Ministry of Environment, Forest & Climate Change is the central ministry responsible for planning, promoting, coordinating, and overseeing India's environmental and forestry policies and programmes. It serves as a point of coordination for the United Nations Environment</p>	<p>ICAP report- The Ozone Cell under MoEF&CC has published ICAP in 2019, a flagship initiative. It includes a long-term integrated 20-year (2017-18 to 2037-38) outlook across all sectors regarding India's cooling demand, technology options, refrigerant use, and energy consumption. One of the ICAP objectives is to map alternative</p>

Organization	Aim/Objective	Current role in cold-chain
	<p>Programme (UNEP), South Asia Co-operative Environment Programme (SACEP), International Centre for Integrated Mountain Development (ICIMOD) and for the follow-up of the United Nations Conference on Environment and Development (UNCED).</p>	<p>technologies that can cater to the nation's cooling requirements. It also sets a target of a 25-30% reduction in refrigerant demand. Most importantly, under the space cooling in buildings, ICAP recommends the development of MEPS for evaporative air coolers</p>
<p>Ministry of Power (MoP)</p>	<p>The Ministry of Power designs formulates and implements a general policy in the field of energy. It deals with the general policy on the electric power sector and coordinates its advancement and efficient implementation.</p> <p>The area of hydro thermal power and electric power generation and the proper transmission and distribution system networks lies in the hands of the Ministry of Power. It also extends to the research, development and technical assistance to the states and UTs.</p> <p>MoP administers the various Acts formulated within the ambit of the power sector like the Electricity Act, Damodar Valley Corporation Act etc.</p> <p>It also manages and assists the Central Electricity Authority, Central Electricity Board and Central Electricity Regulatory Commission.</p>	<p>MoP drafted the National Electricity Policy that states that electricity should be readily available, accessible and affordable to everyone, with a lot of importance attached to rural electrification. And rural electrification is essential for cold chain infrastructure development. With the majority of our agricultural produce originating from rural areas, this would ensure an uninterrupted electricity supply to sustain the cold chain infrastructure.</p>
<p>Ministry of New and Renewable Energy (MNRE)</p>	<p>The Ministry's primary goal is to develop and deploy new and renewable energy to supplement the country's energy needs.</p> <p>MNRE is visionary about developing new and renewable energy technologies, processes, materials, components, sub-systems, products & services that meet international specifications, standards, and performance parameters to turn the country into a net foreign exchange earner in the sector and deploy such indigenously developed and/or manufactured products and services in support of the national goal of energy security. The mission of the ministry includes:</p> <ul style="list-style-type: none"> ● Energy Security ● Increase in the share of clean Power ● Energy availability and Access ● Energy Affordability 	<p>Some notable ongoing schemes include:</p> <ul style="list-style-type: none"> ● Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM) is one of the world's largest efforts to solarize agriculture pumps and supply renewable energy to more than one 3.5 million farmers. ● Solar Parks- The Ministry launched the Solar Parks initiative to make it easier for solar project developers to set up projects using a plug-and-play paradigm. The MNRE currently focuses on using renewable energy sources for pre-harvest activities such as irrigation facilities (Bihar Renewable Energy Department Authority also indicated this).

Organization	Aim/Objective	Current role in cold-chain
	Energy Equity	
Bureau of Energy Efficiency	<p>The mission of the Bureau of Energy Efficiency is to develop policy and strategies with a thrust on self- regulation and market principles within the overall framework of the Energy Conservation Act, 2001 (EC Act) with the primary objective of reducing the energy intensity of the Indian economy. This will be achieved with the active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors of the economy. The major functions of the BEE include developing energy consumption and process standards, MEPS & labels for various appliances, and specific EC building codes, identifying designated consumers, and creating awareness, along with dissemination of information related to energy efficiency and conservation.</p>	<p>BEE has been active in integrating energy-efficiency in existing cold-chain infrastructure and has formed a technical committee on cold-chain with major actors in the cold-chain sector. BEE is also developing guidelines for energy-efficient packhouses and has recently floated a request for proposal on demonstrating energy efficiency opportunities in pack-houses to address the challenges and opportunities in installing the energy efficient pack-houses.</p>
National Institute of Solar Energy (NISE),	<p>National Institute of Solar Energy (NISE), an autonomous institution under the Ministry of New and Renewable (MNRE), focuses on Research and Development (R&D) in the field of Solar Energy. NISE supports the MNRE in implementing the National Solar Mission (NSM). Additionally, NISE carries out R&D activities in the field of Hydrogen energy and hosts various skill development programmes in solar energy.</p> <p>NISE maintains a NABL accredited solar photovoltaic module testing laboratory, battery testing facility, solar water pumping system test rig, and outdoor test facilities. The Institute also has a fully developed testing facility for small and large size solar thermal systems and solar resource assessment.</p>	<p>Research and development projects being carried out at NISE include:</p> <ul style="list-style-type: none"> • Design Improvements and Deployment of Solar Photo Voltaic (SPV) cold Storage with Thermal Storage. • Solar Dryer cum Space Heating System is an in-house project for drying agricultural products and or space heating during winters. • Solar Powered Bulk Milk <p>NISE has implemented three pilot installations of Solar Cold Storage for Horticulture Research Centre, Agartala. Agricultural Department Komalpur, in Dhalai and Krishak Bandhu Centre, Gomti Udaipur in Tripura state.</p>

The following discussion focuses on understanding the present initiatives of different ministries to ensure sustainable and climate-friendly development of cold-chain infrastructure.

2.1.2 Central government schemes for cold-chain development

This section provides an overview of the missions, schemes and initiatives that support the development of an integrated farm-to-consumer cold chain. The section doesn't aim to provide a comprehensive treatment of every applicable agricultural scheme and initiative; instead touches upon the aspects of government schemes relevant to the current study, which focuses on energy efficiency. Moreover, the section also reviews the Government of India's environmental policies, schemes and initiatives that may guide the elements of the cold chain that require cooling – specifically, those related to refrigerant policy and regulation. This will also help identify the initiatives that may need integration and alignment with reference to cold-chain planning at national and state levels. The section summarises the central policies, indicating their objective, the support offered, key stakeholders, latest funds allocated (wherever available). The section also indicates implementation in Bihar (wherever possible) and opportunities to integrate energy-efficiency measures in these schemes.

2.1.2.1 Rashtriya Krishi Vikas Yojana- Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RKVY-RAFTAAR)

Objective: The RKVY scheme was initiated in 2007 to ensure the holistic development of agriculture and allied sectors by allowing states to choose their own agriculture and allied sector development activities per the district/state agriculture plan. Under the RKVY infrastructure & assets stream, projects can be funded for functional infrastructure for collection, sorting, grading, cold storage, precooling, refrigerated vans, ripening chambers and primary processing units. The scheme aims to make farming a remunerative economic activity by strengthening the farmers' efforts, risk mitigation, and promoting agri-business entrepreneurship.

The main objectives of the scheme are:

- To strengthen the farmers' efforts by building the required pre and post-harvest agri-infrastructure that increases access to quality inputs, storage, market facilities etc. and enables farmers to make informed choices.
- To provide autonomy flexibility to States to plan and execute schemes as per local/ farmers' needs.
- To promote value chain addition linked production models that will help farmers increase their income as well as encourage production/productivity
- To mitigate the risk of farmers, focusing on additional income generation activities - like integrated farming, mushroom cultivation, bee keeping, aromatic plant cultivation, floriculture, etc.
- To empower youth through skill development, innovation and agri- entrepreneurship based agribusiness models that attract them to agriculture.

Support Provided & Key target stakeholders: Until 2013-14, the scheme was implemented as Additional Central Assistance (ACA) to the state plan scheme with 100% central assistance. It was converted into a centrally sponsored scheme in 2014-15 with 100% central assistance. Since 2015-16, the funding pattern of the scheme has been altered to the ratio of 60:40 between Central and State governments (90:10 for the North Eastern States and the Himalayan States). For Union Territories, the funding is through a 100% central grant.

The DAC & FW (The Department of Agriculture Cooperation & Farmers Welfare) is responsible for the issue of guidelines for implementation of RKVY, providing a framework for the preparation of the State Agriculture Plan and release of funds to the State. The Agriculture Department of the State shall be the nodal department for implementing the scheme. The States shall do sectoral and district-wise allocation of projects under RKVY-RAFTAAR. The state may devolve funds to Panchayat bodies as per projects

allocated for implementation. For administrative convenience and ease of implementation, State governments may identify or create an exclusive agency for implementing the scheme on a fast-track basis. Beneficiaries for this initiative include individuals and farmer interest groups.

Opportunities for integrating climate-friendly interventions: There is a need to bring sustainability and improved energy management in advancing cold-chain infrastructure. At present, RKVY's focus is meeting the existing and needed cold-chain infrastructure gap. However, the interventions mentioned within RKVY does not include energy efficiency or improved energy use. It is essential to understand that the energy requirement of the proposed cold-chain infrastructure will be massive, and therefore integrating the subsidies and incentives under this mission push for improved energy management of the existing and proposed cold-chain infrastructure will be crucial.

2.1.2.2 The Mission for Integrated Development of Horticulture (MIDH)

Objective: Launched by the Ministry of Agriculture and Farmers Welfare in 2014, the Mission for Integrated Development of Horticulture (MIDH) aims for the holistic growth of the horticulture sector, covering fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. Moreover, the mission supports skill development and create employment generation opportunities for rural youth in horticulture and post-harvest management, especially in the cold-chain sector, through promoting R&D technologies for cultivation, production, post-harvest management and processing with a particular focus on cold-chain infrastructure for extending the shelf life of perishables. MIDH also supports capacity buildings of farmers and technicians for adopting improved technologies through existing institutions like State Agriculture Universities, Krishi Vigyan Kendras and Institutes with the Department of Horticulture in States.

Support provided and key stakeholders: The central government contributes 85% of the total fund for developmental programmes in all the states except the states in the North East and the Himalayas; 15% share is contributed by state governments. In the case of the North-Eastern States and the Himalayan States, GoI's contribution is 100%. In terms of the support flow available for pack-houses under MIDH, the financial assistance is first released to the State Horticulture Missions (SHMs)/state-level implementing agencies. They, in turn, make the funds available to the district implementing agency. Beneficiaries receive the funds from the district implementing agency at the state level.

At National Level, the mission will have a General Council (GC) under the Chairmanship of the Union Agriculture Minister. The Horticulture Division in DAC will provide the necessary support to GC. At State Level, the directorate of horticulture will be the implementation agency supported by Technical Support Groups (TSG), which would comprise personnel at different levels (having knowledge in horticulture and agro-forestry) providing technical services experience. The state horticulture will also work with district panchayats, district planning committee and Panchayati raj institutions to successfully implement the scheme. These actors will provide assistance in identifying crops/species and beneficiaries based on their expertise. The targeted beneficiaries may include individuals, farmer groups, Registered Farmer Producer Organisations (FPOs), firms, Non-Government Organizations (NGOs), Self Help Groups (SHGs) and Cooperatives.

The Ministry of Agriculture and Farmers Welfare has allocated INR 2250 Crore for 2021-22 for 'Mission for Integrated Development of Horticulture' (MIDH).

Opportunities for integrating climate-friendly interventions: There is a need to bring sustainability and improved energy management in advancing cold-chain infrastructure. At present, MIDH's focus is building cold-chain infrastructure and has proposed a few strategies to integrate energy efficiency in cold-chain as part of its intervention in the integrated post-harvest management during XII Plan for NHM and HMNEH sub schemes through:²⁰

²⁰ [http://midh.gov.in/PDF/MIDH_Guidelines\(final\).pdf](http://midh.gov.in/PDF/MIDH_Guidelines(final).pdf)

- Expansion, modernisation and construction of cold storages
- Integrating Pack Houses with facilities for conveyer belt, sorting, grading units, washing drying and weighing
- Mobile pre-cooling units
- Technology Induction and modernisation of cold chain
- Evaporative/ low energy cool chamber
- Low cost onion storage structure
- Pusa zero energy cool chamber

It is essential to understand that the energy and emissions footprint of the proposed cold-chain infrastructure will be massive. MIDH can further promote the development of efficient cold-chain infrastructure by:

- Using MIDH funds to support the training and sensitization workshops of farmers and farmer groups around the need for cold-chain infrastructure.
- Hold capacity building sessions for skill-building around operating low-cost technology solutions that can be used for refrigeration

In the long run, modifications/alterations should be made in the MIDH provisions, integrating energy-efficiency interventions. Such provisions can be framed in consultation with the MNRE, BEE and MoP.

2.1.2.3 Guidelines & Minimum System Standards for Implementation in Cold-chain Components by NCCD

Objective: National Centre for Cold Chain Development (in 2015) published the operational guidelines that define and describe the cold-chain components and specify the minimum investment required to develop and set up of cold-chain components like integrated packhouse with the pre-cooling unit and cold rooms (staging), refrigerated transport, ripening chamber etc. The guidelines set out the possible options focusing on materials, lighting, cooling, and automation. This document defines and describes the concept and application of cold chain components supported under MIDH and allied agencies and provides remarks and recommendations for the users.

Key stakeholders: These guidelines are helpful for the cold chain component manufacturers, cold chain users, members who are directly related to the supply and installation of technology-based equipment, companies/firms, various governmental departments and ministries of centre and states, Government constituted committees and task force, Authorities of standard setting, technical specifications, testing laboratory and product specification etc.

Opportunities for climate-friendly interventions: The NCCD operational guidelines already defines and describes energy efficient and renewable energy technologies for cold-chain development, and can be expanded/updated to capture new technologies and related energy efficiency measures. It is further possible to include operation and maintenance protocols in the guidelines to enable energy savings. It specifies the need for innovation that combines using an alternate source of energy/ hybrid energy solutions in mitigating energy load of the cold chain for futuristic gains that entail opportunities to be a long-term leader in sustainable cold-chain development.

2.1.2.4 Integrated Scheme for Agricultural Marketing (ISAM)

Objective: Initiated by the Department of Agriculture and Cooperation (under MoA&FW) in 2014, the primary objectives of ISAM are to promote agricultural marketing infrastructure, create scientific storage space, promote pledge financing to increase farmers' income, catalyse private investment, and facilitate training, research, and development. The ISAM is an umbrella scheme consisting of the following five elements:

- Agricultural Marketing Infrastructure (AMI)

- Marketing Information and Research Network (MRIN)
- Agmark Grading Facilities (SAGF)
- Agri-Business Development (ABD) via Venture Capital Assistance (VCA) and Project Development Facility (PDF)
- Choudhary Charan Singh National Institute of Agriculture Marketing (NIAM)

The scheme focuses on the following:

- Enhancing the creation of agricultural marketing infrastructure by providing backend support to State, cooperative and private sector investments
- Developing storage capacity and promoting pledge financing to boost the farmer's income
- Promoting integrated value chains to provide vertical integration of farmers with primary processors
- Using Information and Communications Technology (ICT) as a vehicle extension to sensitise and orient farmers to respond to new challenges in agricultural marketing
- Establishing a nationwide information network system for speedy collection and dissemination of market information and data on arrivals and prices for efficient and timely utilisation by farmers and other stakeholders
- Supporting the framing of grade standards and quality certification of agricultural commodities to assist farmers in receiving profitable prices for their graded produce
- Catalysing private investment to set up agribusiness projects and thereby provide an assured market to producers and strengthen backward linkages of agriculture projects with producers and their groups
- Undertaking and promoting training, research, education, extension and consultancy in the agricultural marketing sector

Subsidies provided and Key stakeholders: The Marketing Division in the Department of Agriculture is overall in charge of policy formulation for the agricultural marketing sector. The Directorate of Marketing & Inspection (DMI), an attached office of the Department, implements the three sub-schemes, which are Agricultural Marketing Infrastructure (AMI), Marketing Research and Information Network (MRIN) and Strengthening of Agmark Grading Facilities (SAGF).

Small Farmers Agribusiness Consortium (SFAC), an autonomous organisation, implement the sub-scheme of Agribusiness Development (ABD) through Venture Capital Assistance (VCA) and Project Development Facility (PDF). Chaudhary Charan Singh National Institute of Agriculture Marketing (NIAM), also an autonomous organisation under the Department, will provide training, research and consultancy to stakeholders in the agri marketing sector.

The beneficiaries under this scheme may include individuals, farmer groups, registered Farmer Producer Organisations (FPOs), firms, Non-Government Organizations (NGOs), Self Help Groups (SHGs), Cooperative Marketing Federations, Government bodies, Local Bodies, Panchayats and the State agencies.

The overall budgetary allocation for ISAM is INR 4,548 Crores during the XII Plan. Sub scheme-wise break-down of the budget allocated is INR 4000 Crores for AMI, INR 12 Crores for MRIN, INR 6 Crores for SAGF, INR 500 Crores for ABD and INR 30 Crores for NIAM.

Opportunities for integrating climate-friendly interventions: The various sub-schemes of ISAM focuses on catering to a holistic demand for marketing the produce, thereby making the markets more accessible to farmers. However, the sector lacks marketing and storage infrastructure and lower utilization of digital portals such as e-NAM. The performance of the e-NAM component is lagging as there is limited focus on directly connecting farmers and consumers; lack of quality testing and grading labs adversely impacts price realization. Moreover, post-harvest infrastructure for collecting and storing produce such as pack-houses, reefer vehicles and ripening chambers is also inadequate. Therefore, it is crucial to develop adequate post-harvest facilities. Further, with advancing cold-chain infrastructure

development comes an opportunity to build more energy-efficient cold-chain infrastructure using low-cost solutions.

2.1.2.5 Pradhan Mantri Kisan Sampada Yojana (PMKSY)

Objective: Launched by the Ministry of Food Processing Industries in 2017, the Pradhan Mantri Kisan SAMPADA Yojana aims to create a modern and efficient supply chain to directly connect the farm gate with the retail outlet. The scheme seeks to supplement agriculture, modernize processing and reduce Agri-Waste. The comprehensive package offered would potentially create modern infrastructure with efficient supply chain management from the farm gate to the retail outlet. Apart from boosting the growth of the food processing sectors in the country, it would provide the farmers with improved returns, even doubling their income. It creates vast employment opportunities in rural locales, reduces wastage of agricultural produce, increases the processing level and enhances the export of the foods so processed.

Subsidies provided and key stakeholders: PMSKY allocated INR 6,000 crore for the period 2016-20. The mission was supposed to leverage investment of INR 31,400 crore to handle 334 lakh MT agri-produce valued at INR 1,04,125 crore, benefiting 20 lakh farmers and generating 5,30,500 direct/indirect employment in the country by the year 2019-20. The various sub-schemes within PMKSY are briefly mentioned in Figure 6 with the kind of support offered by these sub-schemes.

Mega Food Parks	•Capital grant @ 50% in general areas and @ 75% in Hilly areas
Integrated Cold Chain and Value Addition Infrastructure	•For storage infrastructure including pack-house and pre-cooling unit, ripening chamber and transport infrastructure, grant-in-aid @ 35% for General Areas and @ 50% for North Eastern States, Himalayan States, ITDP Areas & Islands
Creation/ Expansion of Food Processing/ Preservation	•Grants-in-aid @ 35% in general areas and @ 50% in the North Eastern States including Sikkim and Himalayan States
Infrastructure for Agro-processing Clusters	•Grants-in-aid @ 35% in general areas and @ 50% in the North Eastern States including Sikkim and Himalayan States
Creation of Backward and Forward Linkages	•Grants-in-aid @35% in general areas and @ 50% in the North Eastern States, including Sikkim and Himalayan States
Food Safety and Quality Assurance Infrastructure	•Grants-in-aid @ 35% in general areas and @ 50% in the North Eastern States, including Sikkim and Himalayan States
Human Resources and Institutions	•Financial assistance to undertake demand-driven research & development work, promotional activities, skill development (178 lakh persons by the year 2022) and strengthening of institutions
Operation Greens	•Grant-in-aid @ 50% of the eligible project cost in all areas, subject to a maximum of INR 50 crore per project.

Figure 6: Sub-schemes of PMKSY (Source: MOA&FW)

The projects under PMKSY have been approved across several states, including Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh. In the State of Bihar, nine projects have been approved under PMKSY, out of which one project under the Integrated Cold-chain and Value Addition Infrastructure (ICC) scheme is located in the Gopalganj district in Bihar.

Opportunities for integrating climate-friendly interventions: Similar to MIDH and ISAM, advancing cold-chain infrastructure will require the adoption of technologies/appliances, etc., that support better energy management of cold-storages, pack-houses and other cold-chain components (which are energy-intensive). PMKSY scheme focuses on developing supporting infrastructure for post-harvest management. It will require integration with schemes/policies that include energy-efficiency measures

such as ICAP and other initiatives/programmes discussed in the next section. These initiatives will need modifications/alterations/additions to integrate energy-efficiency measures. Such provisions can be framed in consultation with MoEFCC, MoP, MNRE, NCCD and BEE.

2.1.2.6 APEDA (Agricultural & Processed Food Products Export Development Authority) Assistance

Objective: The Agricultural and Processed Food Products Export Development Authority (APEDA) was established by the Government of India under the Agricultural and Processed Food Products Export Development Authority Act passed by the Parliament in December 1985, with the objectives:

- To develop optimum flexible consumer packages for selected dehydrated food products that would extend their shelf-life and retain their quality of freshness. This would help the processors/packers market the products for a longer period, distribute them to distant places, and export them.
- To develop a transport pack for suitable consumer packs and draw the specifications.
- To develop a direct bulk packaging system for selected dehydrated/freeze-dried products and draw specifications.

Subsidies provided and key stakeholders: For the development of export infrastructure, APEDA assistance is available for the establishment of post-harvest infrastructure for fresh horticulture produce, as shown in Table 2. Key features of the APEDA scheme are mentioned below:

- The financial assistance is provided to the exporters for setting up pack-house facilities with packing and grading lines, pre-cooling units with cold storage and refrigerated transportation, cable system for handling crops like banana, pre-shipment treatment facilities such as irradiation, etc.
- For integrated pack-houses, the proposals should meet the technical standards notified by the Central Government under the Schemes from time to time
- 75% of the assistance shall be released after submission of final claim documents, and the balance 25% of the total eligible assistance shall be released after registration of the pack-house as per the APEDA pack-house registration scheme.

Table 2: Pattern of Assistance from APEDA

Component	Pattern of Assistance
1. Integrated Pack House and processing facilities for addressing missing gaps Facilities include equipment for collection, cleaning, washing, sorting/grading, pre-cooling, packing, cold storage, Hand held Near-infrared Spectroscopy (NIR) instrument (on pre-harvesting quality evaluation of Mango Fruits), Hot water dip treatment etc. and processing facilities for addressing missing gaps.	The assistance will be upto 40% subject to a ceiling of Rs 200 lakhs
2. Purchase of insulated, reefer transport/mobile pre-cooling units, including a special vehicle for livestock carriers	The assistance will be up to 40% of the total cost, subject to a ceiling of Rs. 200 lakhs
3. Cable handling system for banana and other crops	The assistance will be up to 40% of the total cost, subject to a ceiling of Rs. 200 lakhs
4. Food processing facilities for addressing missing gaps required for enhancing productivity/efficiency or quality for value added products which may include	The assistance shall be up to 40% of the total cost subject to a ceiling of Rs. 200 lakhs

facilities like x-ray, Screening equipments, Sortex, IQF, cooking/blanching line, filth/metal detector, sensors, vibrators or any new technology or equipment for food safety and quality requirements.	
5. Up-gradation of facilities mentioned at (1) to (4) above	The assistance will be upto 40% of the total cost subject to a ceiling of Rs. 200 lakhs per beneficiary per location
6. Common infrastructure facilities such as Integrated Pack houses, Processing Units, Laboratories etc. to be set up by Central and State government institutions	The assistance will be up to 90% of the approved cost subject to a ceiling of Rs. 600 lakhs. The funds shall be released against a bank guarantee.

Opportunities for integrating climate-friendly interventions: APEDA's current focus is building integrated cold-chain infrastructure. However, there is no emphasis on better energy management. As mentioned for earlier initiatives, APEDA schemes will require incorporating energy-efficiency measures to build integrated cold-chain infrastructure that uses energy-efficient appliances and guidelines. Moreover, APEDA, while providing accreditation to the cold-chain infrastructure, may ensure compliance with energy efficiency measures, in conjunction with NCCD operational guidelines, if and when operation and maintenance protocols are included to enable energy savings.

2.1.2.7 Other Initiatives and Schemes

Several other initiatives have played an important role in cold-chain development, briefly discussed in Table 3, indicating the organisation launching the initiative, the initiative's primary objective, and the implementing agency within the state (in this case, Bihar).

Table 3: Central Initiatives on Horticulture Cold-chain Development²¹

Initiatives/Policies	Overview of the initiative in the cold-chain context	Implementing Agency in the state
NABARD Warehouse/Cold Storage Scheme	<p>Considering the success of the special window under Rural Infrastructure Development Fund (RIDF) during 2011- 12, an increased allocation of Rs. 5,000 crore under the special window under RIDF (Tranche XVIII) was made by GoI during 2012- 13 for financing State Governments and State-owned agencies to increase the scientific food grain storage requirements towards food and nutritional security.</p> <p>GoI allocated further amounts of Rs. 5,000 crore each during 2013- 14 and 2014- 15 through a separate dedicated corpus (outside allocation under RIDF) for providing affordable credit to the public as well as private sectors to facilitate augmentation of the existing agricultural warehousing infrastructure in the country. This allocation was constituted as Warehouse Infrastructure Fund (WIF).²²</p> <p>Under this scheme, loans are provided for projects involving:</p> <ul style="list-style-type: none"> • Creation of storage infrastructure, with a minimum capacity of 5,000 MT, for agricultural and allied produce, including the construction of Warehouses, Silos, Cold storage, Controlled Atmosphere (CA) stores, other cold-chain activities like reefer vans, bulk coolers, etc. • Modernization/improvement of the existing storage infrastructure projects. 	National Bank for Agriculture and Rural Development
Cold Storage and Fruits & Vegetables Development Program	<p>Under this scheme, NCDC:</p> <ul style="list-style-type: none"> • Provides financial assistance to the extent of 90% of the block cost to the State Governments for setting up/modernization/ expansion/ rehabilitation of cold storage and Ice plants by cooperatives. • Has dovetailed its cold storage programme with National Horticulture Board (NHB). In such cases, the quantum of assistance provided by NCDC is reduced by the subsidy available under the Capital Investment Scheme (CIS) of NHB. 	National Cooperative Development Corporation
Integrated Cooperative Development	<p>One of the critical Schemes of the NCDC is the “Integrated Cooperative Development Project (ICDP) Scheme”, which was introduced in the year 1985-86 and aims at:</p> <ul style="list-style-type: none"> • Development of Primary Agricultural Credit Societies as multi-purpose self-reliant entities; • Development of allied sector cooperatives; and 	National Cooperative Development Corporation

²¹ Gupta, K., Garg, T., Kumari, A., & Kumar, S. 2021. Enabling Cold-chain Infrastructure Development in India: Evolution and Assessment of Policies and Institutional Mapping. New Delhi: Alliance for an Energy Efficient Economy.

²² NABARD - National Bank for Agriculture and Rural Development. (2022). Retrieved from <https://www.nabard.org/content.aspx?id=57> | <https://www.nabard.org/content.aspx?id=571>

Initiatives/Policies	Overview of the initiative in the cold-chain context	Implementing Agency in the state
Project (ICDP) Scheme	<ul style="list-style-type: none"> Development of viable, functional linkages among cooperatives. <p>Under the scheme, an integrated area-based approach is adopted to develop cooperatives in a selected district. The Scheme promotes various economic activities through cooperatives in agriculture, agro-based industries, cottage and household industries and agro-allied sectors like fishery, dairy and livestock, handloom, horticulture, rural industries in a selected district. Assistance under notified services is provided for tourism, transport, education, rural housing, hospitals, health care, generation & distribution of power by new and non-conventional renewable sources of energy and cooperatives banking. A Macro Plan for the selected district is prepared, keeping the local resources and needs in view. Assistance is in a package form and includes –infrastructural needs, funds for business development and HRD aspects.</p> <p>NCDC funds the ICD Projects through State Government. The project funding is under two heads (i) Loan and (ii) Subsidy. The loan is for the creation of infrastructure facilities such as godowns, banking counters, transport vehicles, small processing units, etc. and strengthening of share capital / providing margin money for augmenting the business of the societies. The subsidy is provided for the development of cooperatives (as per developed, under-developed and least developed state categories) and for project implementation, manpower development and training, monitoring and incentives.²³</p>	
Mega Food Park Scheme	<p>Launched by the Ministry of Food Processing in 2008, this scheme aims to establish a "direct linkage from farm to processing and then to consumer markets" through a network of collection centres and primary processing centres. This scheme provides:</p> <ul style="list-style-type: none"> A capital grant at the rate of 50% of the eligible project cost in general areas (which excludes North Eastern regions such as Sikkim, Himachal Pradesh, Jammu & Kashmir and Uttarakhand) is subject to a maximum of USD 7 million per project. Supports infrastructural facilities for food processing & allied industries along with the value chain from the farm to market, including creating infrastructure near the farm, transportation, logistics, and centralised processing centres. As of June-2020, there are 19 operational Mega Food Parks.²⁴ The centre has approved two mega food parks in Bihar; one at Khagaria is under implementation, while the other in the Motipur block of Muzaffarpur district is under approval. 	Bihar Industrial Area Development Authority (BIADA)

²³ NCDC Regional Directorate, 2021. Highlights of the programmes assisted and other relevant achievements/ issues during the last 5 years (2016-17 to 2020-21) in Bihar. [online] Available at: <<https://www.ncdc.in/index.jsp?page=icdp=en>>

²⁴ Savills India (2021). On an Upward Trajectory: Cold-chain Logistics in India. [online] Available at: <<https://pdf.savills.asia/asia-pacific-research/india-research/on-an-upward-trajectory-cold-chain-logistics-india.pdf>>

Initiatives/Policies	Overview of the initiative in the cold-chain context	Implementing Agency in the state
Agriculture Infrastructure Fund	<p>The Hon'ble Finance Minister announced on 15.05.2020 Rs 1 lakh crore Agri Infrastructure Fund for farm-gate infrastructure for farmers. A financing facility of INR1,00,000 crore will be provided for funding Agriculture Infrastructure Projects at farm-gate & aggregation points (Primary Agricultural Cooperative Societies, Farmers Producer Organizations, Agriculture entrepreneurs, Start-ups, etc.). AIF aims to provide:</p> <ul style="list-style-type: none"> • Medium - long term debt financing facility for investment in viable projects for post-harvest management Infrastructure and community farming assets. • For setting up cold stores and chains, warehousing, grading and packaging units, e-marketing points linked to e-trading platforms, and PPP projects for crop aggregation sponsored by central/state/local bodies. 	<p>PMU, PM-KISAN²⁵ For Bihar, INR 3980 Crores has been set aside to develop post-harvest management facilities under this scheme.</p>
Venture Capital	<p>SFAC extends venture capital assistance in the form of equity to agribusiness projects. The quantum of SFAC support is 26% of the promoter's equity or Rs.50 lakhs in the general area and 40% of the promoter equity or Rs.50 lakhs in projects located in the North-East Region and Hilly states. This venture capital is repayable to SFAC after the term loan repayment.</p>	<p>Small Farmer Agri-Business Consortium (SFAC)</p>
Cluster Development initiative	<p>MoA&FW has established a new Horticulture Cluster Development in 2021 with the initiative to boost the Indian horticulture sector's worldwide competitiveness. The National Horticulture Board has been recognised as the Nodal Agency to execute the Cluster Development Programme, which is a component of the NHB's Central Sector Scheme.</p> <p>The Cluster Growth Programme (CDP) is intended to capitalise on the geographical specialisation of horticultural clusters and encourage integrated and market-led development of pre-production, production, post-harvest, logistics, branding, and marketing activities.</p> <p>The programme will be implemented in 12 horticulture clusters out of the 53 selected for the pilot phase.</p>	<p>There are no clusters that are identified in the state of Bihar.</p>
One District One Product	<p>ODOP programme was first started by the Uttar Pradesh Government in 2018, later MoFPI launched the One District One Product (ODOP) scheme to reap the benefit of scale in procurement of inputs, availing common services and marketing of products at the national level. ODOP for the scheme will provide the framework for value chain development and alignment of support infrastructure. There may be more than one cluster of ODOP products in one district. There may be a cluster of ODOP products consisting of more than one adjacent district in a State. Under the ODOP scheme, MoFPI will support agricultural products for their processing and efforts to reduce wastage, proper assaying, and storage and marketing.</p> <p>Under the ODOP scheme, Bihar has identified 38 districts producing Makhana, Banana, Litchi,</p>	<p>Concerned State horticulture department with assistance from MoFPI.</p>

²⁵PMU, PM-KISAN is a project management unit for PM-KISAN at state level. Under the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme, a financial benefit of Rs 6,000 per year is provided to the eligible farmer families, payable in three equal installments of Rs 2,000. The money is transferred directly to the bank account of the beneficiaries.

Initiatives/Policies	Overview of the initiative in the cold-chain context	Implementing Agency in the state
	<p>Mangoes, etc.²⁶ It is essential to highlight that there are two other schemes focused on cluster development, one by the Department of Commerce focusing on agriculture crops on a cluster approach for support for exports under the Agriculture Export Policy, and the other from the Ministry of Agriculture focusing on a cluster approach for the development of specific agriproducts in districts having a comparative advantage. The ODOP approach of the scheme would lead to easing in providing common facilities and other support services.</p>	
<p>National Investment and Infrastructure Fund (NIIF)</p>	<p>NIIF, launched by the GoI in 2015, is a collaborative investment platform for international and Indian investors, investing across Infrastructure and Growth Equity. The NIIF fund managers believe in generating attractive risk-adjusted returns by efficiently operating the investments through economic cycles, while staying committed to sustainable investing principles.</p> <p>NIIF manages over USD 4.3 billion assets under management through their funds: Master Fund, Fund of Funds and Strategic Opportunities Fund. It aims to ensure a strong governance framework and best-in-class ESG practices for the organisations, portfolio companies and funds.</p> <p>National Investment and Infrastructure Fund (NIIF) and Global trade enabler DP World have signed an MoU to develop the logistics sector in India with the aim of preventing the loss of agricultural produce through adequate marine and warehousing infrastructure including cold storage as well as development of inland waterways, reducing logistics costs at the same time.</p>	
<p>National Infrastructure Pipeline(NIP)</p>	<p>Launched in August 2020, the National Infrastructure Pipeline (NIP) is a first-of-its-kind, whole-of-government exercise to provide world-class infrastructure across India, and improve the quality of life for all citizens. It aims to showcase investment opportunities in India's infrastructure sector, improve project preparation and attracting investments into India.</p> <p>NIP aims to capture key greenfield and brownfield projects for investments across all economic and social infrastructure sub-sectors on a best-effort basis.</p> <p>Under NIP, 8 projects worth INR 4533 crores will be implemented under cold chain infrastructure category described below:²⁷</p> <ul style="list-style-type: none"> • Ministry of Agriculture & Farmer's Welfare has come up with 30 Cold Chain Demonstration Centres Construction Project with a ticket size of 1500 INR Crores. • Ministry of Agriculture & Farmer's Welfare has come up with Cold Chain Facilities at 12 Major Ports Buildings with a ticket size of 1000 INR Crores. • Ministry of Agriculture & Farmer's Welfare has come up with Reefer Container Handling Facility Project with a ticket size of 1000 INR Crores. • Ministry of Agriculture & Farmer's Welfare has come up with Refrigerated Transport Vehicles for Perishable Produce Procurement Project with a ticket size of 500 INR Crores 	<p>Top Promoters -</p> <ol style="list-style-type: none"> 1) Tamil Nadu State Agricultural Marketing Board. 2) Ministry of Agriculture and Farmer's Welfare. 3) Government of West Bengal. 4) Government of Andhra Pradesh.

²⁶ MoFPI. 2021. Approved list of ODOP. [online] Available at: https://mofpi.nic.in/sites/default/files/odop_list_of_35_states_and_uts.pdf

²⁷ Investment in India: Best Opportunities to Invest in India | IIG. (2022). Retrieved from <https://indiainvestmentgrid.gov.in> <https://indiainvestmentgrid.gov.in/opportunities/nip-projects/cold-chain?sector=32>

Initiatives/Policies	Overview of the initiative in the cold-chain context	Implementing Agency in the state
	<ul style="list-style-type: none"> • Horticulture Department, Government of Mizoram. has come up with The Mega Cold Chain Park with a ticket size of 200.24 INR Crores. This project in Cold Chain sub-sector involves Development of Cold Chain Storage. • Govt. of West Bengal has come up with Storages in 10 Districts Construction Project with a ticket size of 200 INR Crores. • Govt. of West Bengal has come up with Cold Storages, Ice Plants & Blast Freezing Facilities Construction Project with a ticket size of 117 INR Crores. • Govt. of Andhra Pradesh has come up with the Vishakhapatnam Cold Storage Establishment Project with a ticket size of 10 INR Crores. 	

It is important to note that in developing sustainable cold-chain in Bihar, other than the central scheme focusing on cold-chain development, government initiatives and schemes that focus on energy efficiency, energy transition, climate change should also be understood, a few of these initiatives and standards are discussed in the below section.

2.1.3 Energy efficiency initiatives relevant to cold-chain

This section briefly discusses some of the central government's initiatives with respect to their relevance to advancing sustainable cold-chain development in India. These initiatives include setting targets to reduce the climate change impact on the country, identifying actionable items for multiple sectors to reduce emissions, providing guidelines to build energy-efficient infrastructure, etc. The objective of each initiative is briefly described below, along with recommendations (if any) that apply to cold-chain, and the respective stakeholders for framing and implementing these recommendations.

2.1.3.1 Nationally Determined Contributions (NDCs)

Objective: Nationally Determined Contributions (NDC) are national climate plans highlighting climate actions, including climate-related targets, policies, and measures governments aim to implement in response to climate change and as a contribution to global climate action. In its NDC Synthesis Report, the United Nations Framework Convention on Climate Change (UNFCCC) has called for more ambitious climate action plans by the countries to achieve the Paris Agreement target of containing global temperature rise to 2°C (ideally 1.5°C) by the end of the century. NDCs are at the heart of the Paris Agreement and embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. Each NDC reflects the country's ambition, considering its domestic circumstances and capabilities.

In India's NDC, the country has focused on adaptation efforts, including a) developing sustainable habitats; b) optimizing water use efficiency; c) creating ecologically sustainable climate-resilient agricultural production systems; d) safeguarding the Himalayan glaciers and mountain ecosystem; and e) enhancing carbon sinks in sustainably managed forests and implementing adaptation measures for vulnerable species, forest-dependent communities and ecosystems. India has also set up a National Adaptation Fund with an initial allocation of INR 3,500 million (USD 55.6 million) to combat the adaptation needs in key sectors. This fund will assist national and state-level activities in meeting the cost of adaptation measures in areas that are particularly vulnerable to the adverse effects of climate change.²⁸

Recommendations for cold-chain: Though India's NDCs include high-level themes such as water, agriculture, the focus is on sustainable agriculture production and not on post-production activities, which are also responsible for GHG emissions and need to be accounted for. These emissions result from degradation of produce lost due to inadequate supply chain, including poor storage and handling techniques, lack of refrigeration, and spoilage in transport and processing. It will be essential to incorporate the adoption of more climate-friendly cooling solutions in further advancing the cold-chain infrastructure in India.

Key stakeholders (current and prospective): Some of the actors who may play an essential role in framing the new NDCs for India are MoEFCC's Ozone Cell, BEE, MoA&FW, MoFPI, UNEP, representation from some of the state actors.

2.1.3.2 India Cooling Action Plan

Objective: India Cooling Action Plan (ICAP) aims to provide sustainable cooling and thermal comfort for all while securing environmental and socio-economic benefits for society. This will also help in reducing both direct and indirect emissions. The India Cooling Action seeks to:

- Reduce cooling demand across sectors by 20% to 25% by 2037-38
- Reduce refrigerant demand by 25% to 30% by 2037-38
- Reduce cooling energy requirements by 25% to 40% by 2037-38

²⁸ PIB. 2021. Ministry of Environment, Forest and Climate Change. [online] Available at: <<https://pib.gov.in/newsite/printrelease.aspx?relid=128403>>

- Recognize “cooling and related areas” as a thrust area of research under the national S&T Programme
- Training and certification of 100,000 servicing sector technicians by 2022-23, synergizing with Skill India Mission.

Recommendations for cold-chain: India Cooling Action Plan (ICAP) provides a tool for incorporating sustainability paradigm to a primary logistics issue, in terms of technologies, energy efficiency and providing end-to-end cold through real-time monitoring technologies resulting in reduced food loss. The ICAP²⁹ proposes the development of integrated cold chain infrastructure with appropriate market linkages, supported by adequate training and up-skilling of farmers and professionals. India has a large inventory of cold storages or refrigerated warehouses. Still, the other elements that form an uninterrupted cold chain – pack-houses, reefer transport and ripening chambers – are largely missing. The co-benefits include the economic well-being of farmers in direct support of the Doubling Farmers Income (DFI) initiative, reducing food losses, strengthening food security and alleviating hunger issues, leading to healthy citizens with reach to nutritious and affordable fruits and vegetables, and a less GHG-intensive diet. The India Cooling Action Plan provides recommendations on the Cold Chain Sector, which inter-alia include:

- Encourage the development of cold chain infrastructure with the use of low-GWP refrigerant-based energy-efficient cooling systems,
- Development of safety standards for flammable and toxic refrigerants for cold storage and other segments of the cold chain,
- Develop programmes for retrofitting of existing cold storage to reduce cooling, refrigerant demand and energy consumption,
- Standardize all design, construction and associated specifications for small, medium and large cold-chain infrastructure components,
- Link the incentives to develop cold-chain infrastructure with the adoption of energy-efficient design, construction and maintenance practices and low GWP refrigerant and renewable technologies.

Key stakeholders (current and prospective): MoEF&CC has constituted a cold-chain thematic working group for operationalizing the recommendations of the India Cooling Action Plan. Some of the actors who may play an essential role in ICAP implementation will include, MoEFCC’s Ozone Cell, BEE, MoA&FW, MoFPI, NCCD, Refrigeration and Air-conditioning Manufacturers Association (RAMA), Indian Society for Heating Refrigeration and Air conditioning Engineers (ISHRAE), think tanks such as NITI Aayog.

2.1.3.3 Energy Conservation Building Code (ECBC)

Objective: The Energy Conservation Building Code was launched as a first step towards promoting energy efficiency in the building sector in India. It is applicable for large commercial buildings with a connected load of 100 kW and above or 120 kVA and above. ECBC focuses on building envelope, mechanical systems and equipment, including heating, ventilating, air conditioning (HVAC) systems, interior and exterior lighting systems, electrical systems and renewable energy, and considers the country's climates zones.

Recommendations for cold-chain: Although ECBC is applicable for buildings, certain aspects of the code like structural design, materials used (wall, roof and window) and efficiency of motors, pumps and chillers could be helpful for the design and selection of equipment for the cold-chain components such as cold-storages and pack-houses.

²⁹ MoEF&CC. 2019. India Cooling Action Plan. [online] Available at: <<http://ozonecell.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf>>.

Key stakeholders (current and prospective): Ministry of Housing and Urban Affairs (MoHUA), MoEFCC, MNRE, BEE, NCCD, ISHRAE and RAMA.

2.1.3.4 Standards and Labelling Programme

Objective: The Bureau of Energy Efficiency initiated the Standards and Labelling (S&L) programme for equipment and appliances to facilitate an informed choice by the consumer regarding energy savings and cost-saving potential of products. Energy efficiency labelling programs under BEE are intended to help reduce the energy consumption of appliances without diminishing the service they provide to consumers. S&L programme aims to:

- Achieve energy savings at the national level by promoting energy-efficient products.
- Prohibit manufacture, sale and import of such equipment that does not conform to the standards.
- Provide the consumer with an informed choice about relevant products' energy and cost-saving potential.
- Ensure that only energy-efficient equipment and appliances would be made available to the consumers.

Recommendations for cold-chain: This programme focuses on integrating better energy management using energy-efficient appliances. Currently, the scheme is available for 26 equipment/appliances, including 10, for which it is mandatory (indicated in Table 4). The other appliances are presently under the voluntary labelling phase. The appliance labels relevant for cold-chain infrastructures such as cold-storages and pack-houses may include room air conditioners, tubular fluorescent lamps, LED lamps, induction motors, pump sets, ceiling fans, DG sets and chillers.

Table 4: BEE Standards and Labelling Programme³⁰

Mandatory Appliances	Voluntary Appliances
1. Room Air Conditioners	1. Induction Motors
2. Frost Free Refrigerators	2. Pump Sets
3. Tubular Florescent Lamp	3. Ceiling Fans
4. Distribution Transformer	4. LPG Stoves
5. Room Air Conditioner (Cassette, Floor Standing)	5. Washing Machine
6. Direct Cool Refrigerator	6. Computer (Notebooks/Laptops)
7. Colour TV	7. Ballast (Electronic/ Magnetic)
8. Electric Geysers (link is external)	8. Office equipment (Printer, Copier, Scanner, MFD's)
9. Variable Capacity Inverter ACs	9. Diesel Engine Driven Mono-set Pumps
10. LED Lamps	10. Solid State Inverter
	11. DG Sets
	12. Chillers
	13. Microwave Oven
	14. Solar Water heaters
	15. Light Commercial Air conditioners
	16. Deep Freezers

Key stakeholders (current and prospective) may include MoEFCC, MoP, MNRE, EESL, RAMA, ISHRAE and UNEP.

³⁰ BEE, Standards and Labeling | Bureau of Energy Efficiency. [online] Beeeindia.gov.in. Available at: <<https://beeindia.gov.in/content/standards-labeling>>.

2.1.3.5 Perform, Achieve, Trade (PAT) Scheme

Objective: The Perform, Achieve, Trade (PAT) scheme was established by the National Mission for Enhanced Energy Efficiency. It is a regulatory instrument to reduce specific energy consumption in energy-intensive industries, with an associated market-based mechanism to enhance the cost-effectiveness through certification of excess energy saving, which can be traded. The overall objective of PAT is to improve the efficiency of the production process to achieve the ultimate target of energy savings.

Recommendations for cold-chain: BEE rolled out six PAT cycles till 31st March 2020, identifying the high-energy intensive sectors such as construction, commercial buildings, railways, refineries, etc. to earn carbon credits through trading of Energy Saving Certificates (ESCerts) on the power exchanges for the industrial sector to benefit from their investments in energy efficiency. This mechanism has helped motivate the industries to adopt energy efficiency measures. Cold-chain (existing cold-storages) sector being an energy intensive sector can also benefit from such schemes.

Key stakeholders (current and prospective): MoA&FW, MoEFCC, MoFPI, BEE

2.1.3.6 Hydrochlorofluorocarbons Phase-out Management Plan (HPMP)

Objective: In September 2007, the 19th Meeting of the Parties (MOP) to the Montreal Protocol decided to accelerate the phase-out of production and consumption of HCFCs in developed and developing countries. In the HCFC phase-out management plan (HPMP), the target is to reduce 10 per cent HCFC and implement a combination of interventions such as technology transfer investments, policy and regulatory actions, technical assistance, training and capacity-building, awareness generation and monitoring in selected HCFC consuming sectors.

India is implementing the HCFC phase-out management plan (HPMP), under which the HCFCs would be phased out by 2030 except for a small portion required for servicing old equipments. The ultimate goal is to end the use of ozone-depleting substances by switching over to non-ozone depleting and environment-friendly technologies. HCFC is being used in various sectors like refrigeration and air conditioning (RAC), foam manufacturing etc. These sectors have direct linkage with other related sectors such as urban development, agriculture through the cold-chain sector and industrial development.

Recommendations for cold-chain: Presently, R-717 (natural) refrigerant is mostly used in cold storages whereas R-404A is used as the predominant refrigerant in most refrigeration systems (majorly used in pack-houses for pre-cooling and cold rooms). Other refrigerants used in refrigeration plant include hydrofluorocarbons (HFCs) like R-134a, R-32, R-407C, R-507C and hydrochlorofluorocarbons (HCFCs), namely R-22. This provides an opportunity for developing countries such as India to leapfrog to alternate refrigerants from the current use of HCFCs and HFCs. This will further help in reducing the GHG emissions. MoEFCC through HPMP is carrying out Hfc phase down, and HCFC phase out, which will also benefit the cold-chain sector to transition into natural or low GWP refrigerants in advancing new cold-chain infrastructure.

Key stakeholders (current and prospective): MoEFCC, MoA&FW, RAMA, ISHRAE, ICAR and NCCD.

2.2 Institutional and policy landscape: State level

The state government of Bihar realises that the state has abundant natural resources and favourable conditions for developing agriculture, such as fertile soil, water, and conducive weather conditions. Yet, the per-unit productivity in agriculture is lower than the average productivity found during scientific research. One of the reasons is the state has suffered from a lack of public infrastructure provisions, such as electricity and roads, hampering the overall connectivity within the state. However, in recent decades, there have been several significant investments through central and state government, which has improved the road and rail connectivity across the state, further improving the marketing of agricultural products from the more remote and disadvantaged districts.³¹ Through various agricultural and industrial schemes, both central and state actors have begun to invest in building supporting infrastructure (warehouses, cold-storages and other cold-chain components) that will help bridge the market access gap between producers and consumers. For instance, the central government also launched cold storage subsidy scheme in the 1999-2000 financial budget, which provided a greater stimulus to the rapid diffusion of cold storages, leading to a 64% increase in the number of cold storages between 2000 and 2009 from 195 to 320.³²

More recently, the state government took several important steps to develop agriculture in the state by introducing several Agriculture Roadmaps. These roadmaps aim to increase the agricultural output to ensure food and nutrition security, increase farmers' income through a boost in the agricultural sector, and increase the prospects of alternative employment opportunities, which will reduce migration to other states. It also aims to equitable agricultural growth distribution and promotes maintaining ecological balance through organic farming techniques. The first Agriculture Road Map (ARM) was introduced in the year 2008 (for the period 2008-2012), primarily focusing on the launch of several programmes like the seed extension scheme, seed gram scheme, and the thrust on bio-farming. The 2nd Agriculture Road Map (for the period 2012-2017) aimed to ensure the safety of food grains and nutrition and augment the farmers' income. These objectives were to be achieved by ensuring an adequate electricity supply to farmers, enhancing storage facilities, and promoting food processing initiatives.³³ The third ARM (for the period of 2017-2022) entailed an allocation of a sum of Rs 1.54 lakh crore for the agriculture and allied sectors, including food processing, irrigation, flood protection and dairy development projects. This roadmap has been launched to strengthen the farming community and improve the performance of the agricultural sector. The Third Agriculture Roadmap also envisages the realisation of the vision to ensure **"at least one Bihari dish on the plate of every Indian"** over the next five years. The roadmap covers the implementation of programmes by as many as 12 departments, including Agriculture, Animal Husbandry and Pisciculture, Revenue and Land Reforms, Water Resources, Power, and Food Processing. Under the implementation of this ARM, a three-layer Bihar Vegetable Processing and Distribution Cooperative system was developed, also referred to as Vegetable Federation (VEGFED, discussed in the next section).

The Bihar government also constituted the Bihar Vikas Mission (registered under the provisions of Societies Registration Act, 1860) to ensure the implementation in a mission mode in some of the priority

³¹ Minten, B., Reardon, T., Singh, K. M. & Sutradhar, R. K. 2014. The new and changing roles of cold storages in the potato supply chain in Bihar. *Econ. Polit. Wkly* 49, 98–108. [online] Available at: https://www.researchgate.net/publication/270276180_The_New_and_Changing_Roles_of_Cold_Storages_in_the_Potato_Supply_Chain_in_Bihar

³² Patnaik, G. 2005. Review of Government of India Agricultural Marketing/Processing Policies and Programs (New Delhi: Global Agri Systems). [online] Available at: https://www.researchgate.net/publication/270276180_The_New_and_Changing_Roles_of_Cold_Storages_in_the_Potato_Supply_Chain_in_Bihar

³³ Narain, G. 2017. Bihar Krishi Roadmap. National Council of Applied Economic Research. [online] Available at: <https://www.ncaer.org/uploads/photo-gallery/files/1536317300Bihar%20Krishi%20Roadmap.pdf>

areas, including agriculture, infrastructure, youth livelihood, good governance³⁴³⁵. The ARM (2017-22) is developed as part of the Agriculture sub-mission.

These governmental interventions indicate that there has been some sensitisation about the need for cold-chain development amongst the senior level actors, including the Horticulture Department, National Horticulture Board, Agricultural Universities, amongst other key actors described in the following section. However, ground-level implementation is at a very nascent stage.

2.2.1 Institutional framework governing cold chain in Bihar

Table 5 include national-level stakeholders' state-level representatives with whom the AEEE-UNEP team interacted, summarising the organisation's **aim**, its **current role/contribution** in cold-chain development, their **perspective** on cold-chain development in Bihar and their **potential role** seen in this project. The column on the stakeholders' perspective includes their understanding of cold-chain needs in the state, challenges observed, and suggestions on developing a sustainable cold-chain in Bihar.

³⁴ Government of Bihar. 2021. Bihar Vikas Mission. [online] Available at: <<https://www.bvm.bihar.gov.in/content/3753/agriculturesubmission>>

³⁵ Narain, G. 2017. Bihar Krishi Roadmap. National Council of Applied Economic Research. [online] Available at: <<https://www.ncaer.org/uploads/photo-gallery/files/1536317300Bihar%20Krishi%20Roadmap.pdf>>

Table 5: Perspective of national-level stakeholders' state representatives in cold-chain development³⁶

Organization and its aim	Current role in cold-chain	Perspective on cold-chain development	Potential role in sustainable cold-chain development at country level
<p>National Bank for Agriculture and Rural Development (NABARD) is an apex regulatory body for the overall regulation and licensing of regional rural banks and apex cooperative banks in India. It is under the jurisdiction of the Ministry of Finance, Government of India. NABARD's mission is to promote sustainable and equitable agriculture and rural development through participative financial and non-financial interventions, innovations, technology and institutional development for securing prosperity. NABARD has representation at the state and district level in each state.</p>	<p>NABARD offers post-harvest management support, which is credit and non-credit related:</p> <p>Credit-Related Support:</p> <ul style="list-style-type: none"> • Provide loans to the state governments for developing rural infrastructure and strengthening Cooperative Credit Structure • Provide loans for warehousing infrastructure (including cold-storages, pack houses and ripening chambers) to State Governments, State/ Central government Owned/ assisted entities, Cooperatives, Federation of cooperatives, FPOs, Primary Agricultural Credit Societies (PACS) or similar institutions, Corporates/ Companies, Individual entrepreneurs, etc. <p>Non-Credit Related Support:</p> <ul style="list-style-type: none"> • Provide assistance in policy formulation to Gol, RBI and State Governments on matters related to agricultural credit and rural development <p>Gol launched a program for creating 10000 FPOs in India in 2020, implemented by NABARD,</p>	<p>Understanding of the state's cold-chain need:</p> <p>NABARD officials mentioned that horticulture (or, in general, agriculture) is seen as a less enterprising opportunity by the state youth due to lack of supporting infrastructure and food processing/value-addition and manufacturing industry being at a very nascent stage in Bihar. Further, the officials described Bihar as a consumption state, indicating that the state entirely consumes the horticulture produce and, therefore, does not see a significant requirement of cold-chain development. But, the officials agreed that there is a need for cold-chain infrastructure in the state's consumption centres, i.e. districts closer to the major markets. Further, the officials added that the state is majorly a raw material provider to other states, and cold-chain development will be essential to deliver quality produce.</p> <p>Concerns: NABARD officials were keen to understand the financing of the larger Clean Cooling Collaborative (formerly K-CEP) project. Additionally, their interest was in how such initiatives will benefit the small-scale farmers as large farmers/traders/middlemen control major markets.</p> <p>Suggestions:</p> <ul style="list-style-type: none"> • NABARD officials highlighted the need to conduct a thorough need assessment identifying the surplus horticulture produce (for instance, Litchi and Makahan) that requires 	<p>With NABARD engagement with FPOs in Bihar, NABARD can help identify the right FPOs in Bihar. Further, NABKISAN can also finance these FPOs for cash credit, if needed.</p> <p>NABARD has funds for conducting a joint study on awareness creation programs and for developing a state-focused paper on cold-chain</p>

³⁶ Gupta, K., Kumari, A., Garg, T., Kachhawa, S. & Kumar, S. (2021). India's Cold-chain Policy Mapping. New Delhi: Alliance for an Energy Efficient Economy

	<p>NCDC and SFAC, focusing on creating 2 FPOs in each block. NABARD in Bihar has been promoting FPOs for the last 7-8 years. At present, 200 FPOs have been promoted by NABARD in Bihar, out of which 70-80 are doing well.</p>	<p>refrigeration to transport distant areas within and outside the state. The officials indicated that it is essential to understand how the existing cold-chain infrastructure is utilised than building new one as out of 387 cold storages, 124 are non-functional.</p> <ul style="list-style-type: none"> ● Involvement of financial institutions from the beginning in this project, such as cooperative banks. Several farmers have a business plan and DPR, yet banks are not ready to finance them due to a lack of collateral. ● Creating awareness is essential to demonstrate through lighthouse projects that benefit farmers. 	
<p>National Cooperative Development Corporation (NCDC), which is a statutory Corporation (under the Ministry of Agriculture & Farmers Welfare) set up under an Act of Indian Parliament on March 13 1963, has been assisting primary and marketing societies functioning at the village, mandi, district, regional, state and national levels for the construction of godowns of their own to create storage facility, and repair/ renovation of existing capacity of godowns under Central Sector Schemes and Corporation Sponsored Scheme. NCDC's objectives include:</p> <ul style="list-style-type: none"> ● To plan, promote and finance interventions to boost 	<p>NCDC provides financial assistance for developing infrastructures like processing units, adequate storage facilities and a marketing place. Providing financial assistance for a storage facility becomes one of the leading entities directly linked with the development of cold-chain infrastructure.</p> <p>NCDC has played a vital role in developing the cooperative storage & cold storage business in Bihar by supporting cold storages like Mahua & Barauni Cooperative Cold Storage. With the NCDC assistance under its regular schemes, 3057 rural and marketing godowns have been constructed, while 1208 godowns have been created under the ICDP Scheme. As on 31.03.2021, an assistance of</p>	<p>Understanding of the state's cold-chain need:</p> <p>The NCDC officials described Vaishali as the vegetable bowl of Bihar, including potatoes and all other vegetables, emphasising the need for a cold-chain in Vaishali. Like, NABARD, NCDC also highlighted that food processing and value-addition are missing in the state of Bihar, and cold-chain is at a very nascent stage, with a majority of successfully running cold storages being privately owned. However, they did not mention about existing pack-houses and other cold-chain components in the state.</p> <p>NCDC also informed about the VEGFED program (detailed later in the report), which aims to build an integrated packhouse in every primary cooperative with 10 MT storage and 46 refrigerated vehicles for four unions. Through VEGFED, out of 38 districts, 20-25 districts will be covered. Additionally, a food hub is planned in Patna, a big food park, with around 150-200 acres</p>	<p>NCDC can provide financial support in building cold-chain infrastructure. Moreover, NCDC is interested in supporting state Level Vegetable Federation (VEGFED), Primary Agriculture Credit Society (PACS) and district Level Sangh to create cold-chain infrastructure like pack houses, pre-cooling units, etc. to enable the cooperatives to procure, process, market, branding etc. of vegetables that can further help to nurture the State Vegetable Federation as an institution like COMFED.</p>

<p>agricultural production, marketing, storage, export, etc.</p> <ul style="list-style-type: none"> ● To be the nodal agency of Gol for implementing schemes of various ministries and provides loan assistance at the appealing interest rate for creation of cold-chain facilities and dovetail the same with the grant-in-aid assistance from the Government of India 	<p>Rs. 110.38 crore has been provided for the purpose in the State.³⁷ NCDC supported a cold chain project in Vaishali (Bihar), but the project has been stalled due to cost escalation. In this project, NCDC proposed to have 14 ripening chambers, four reefer vehicles, two integrated pack houses and 10 MT cold storage. Moreover, INR 20 crores were sanctioned for the project, but external factors (which was not elaborated by NCDC) led to the stalling of the project.</p>	<p>for which around INR 100 crores has been allocated.</p> <p>Challenges NCDC officials emphasised the importance of cooperatives in cold-chain development in the state (at the village, block and district levels) by building cold-storages (and other cold-chain components) but currently lack financial capacity require support from the state government.</p> <p>Lack of Financial Support: NCDC can support cooperatives in developing cold-chain projects. But most cooperatives do not even have the initial funding to build a cold-storage. The NCDC team highlighted that in the past, chairpersons of several Bihar cooperatives have approached NCDC for financial assistance but have returned disappointed as NCDC could not provide any financial aid (however, NCDC officials did not provide details about the same).</p> <p>Institutional Challenges: Both agriculture and cooperatives are state subjects, and therefore, support from the state government is essential to strengthening the functioning of cooperatives. However, the business-as-usual working of state departments has slowed down the execution. In this regard, NCDC mentioned that INR 3800 crores were provided from 1963 to Bihar farmers through cooperatives. However, more than 58% was provided during the last two years due to inefficiencies in institutional procedures. NCDC representatives also mentioned that there was a power problem in the state earlier. However, 90% of that problem is resolved now.</p>	
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³⁷NCDC Regional Directorate (2021). Highlights of the programmes assisted and other relevant achievements/ issues during the last 5 years (2016-17 to 2020-21) in Bihar. [online] Available: <<https://www.ncdc.in/index.jsp?page=patna=en>>

<p>Agricultural & Processed Food Products Export Development Authority (APEDA) was established under the Ministry of Commerce & Industries. It has objectives:</p> <ul style="list-style-type: none"> • To develop the export of products • To ensure the standards of products to be exported 	<p>APEDA supports the development of integrated pack-house facilities for fresh fruits and vegetable exports from India and grants recognition to pack-houses that are found to meet infrastructure and procedural requirements by an inspection committee. As a part of the strategy, is setting up a cold-chain to develop the industries relating to the scheduled products for export. The scale of assistance is a 40% subsidy for cold-chain projects with mechanised handling systems.</p> <p>Under its XII Plan Scheme, APEDA provides a 90 per cent grant-in-aid to State Government agencies to set up cold storage facilities for common use for exports.</p> <p>Assistance to private exporters is also provided up to 40% as a subsidy with a ceiling of Rs. 7.5 lakhs to Rs. 75.00 lakhs for different components of the cold-chain.</p>	<p>Understanding of the state's cold-chain need:</p> <p>The officials described Bihar as one of the major fruits and vegetable producers, famous for its Litchi, Mango and Makhana. Further, the officials highlighted that there are 3-4 different varieties of Banana. Chiniya banana grown near Patna is one of them, which is very famous throughout the country due to its high nutritional value. Chiniya banana could be one of the produce if provided with proper preconditioning and refrigeration can be transported to the various states in India and even exported outside India.</p> <p>Challenges in Bihar:</p> <ul style="list-style-type: none"> • Huge post-harvest loss: Bihar is amongst India's major horticulture producing states. However, there is 30-40% food loss. This loss is more in the mandi than at the farm gate. However, they did not mention losses during transportation. • No monetary benefits to farmers: Even if the farmers have surplus production, they don't get additional money because there is no infrastructure from farm gate to market. • Minimum exports due to lack of cold-chain infrastructure: Bihar is landlocked, and 97% of exports go to Nepal, which is transported by regular trucks and sold at similar prices as within the state. Farmers can export in Karnataka, Tamil Nadu, Gujarat and Maharashtra since they are close to sea and vessels. But transportation is expensive. It costs INR 2- 3 lakhs for transporting by a reefer to the port. Further, exit points in Bihar is a challenge, making it critical to strengthen the airport. Moreover, only 25% of the cold-chain infrastructure is active, while 75% is non-functional. <p>There is a need to develop integrated cold-</p>	<p>APEDA can provide much-needed insights on potential markets requirement for the various produce types for export. Further, APEDA can also support in establishing the infrastructural and procedural requirements for the planned cold-chain infrastructure in Bihar. APEDA officials indicated that they would be happy to support this AEEE-UNEP initiative. However, they do not have a local presence in Bihar yet. The nearest office is in Varanasi.</p> <p>At present, APEDA is in conversation with the Jeevika programme, leading to exploring opportunities in Bihar.</p>
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		<p>chain infrastructure to increase exports and better utilize the existing cold-chain infrastructure such as cold-storages.</p> <ul style="list-style-type: none"> ● Lack of funding support: There is a vast gap between the capital needed for cold-storages and pack-houses and the type of support provided by the government. <p>Suggestion: It will be essential to keep the line ministries and the state departments informed about the larger objective of this project for its smooth execution.</p>	
<p>National Horticulture Board (NHB) was set up on the recommendation of the "Group on Perishable Agricultural Commodities," under the administrative control of the Ministry of Agriculture and Farmers Welfare. NHB aims to focus on the integrated development of the horticulture industry to promote horticulture produce, research and development, new-age technology, and awareness. NHB focuses on post-harvest management and helps in coordinating, sustaining the production and processing of fruits and vegetables to achieve the larger agenda of improving integrated development of the Horticulture industry.</p>	<p>To improve the horticulture sector, NHB's objective is to develop integrated and energy-efficient cold-chain infrastructure for fresh horticulture produce. Some of the aims relevant for cold-chain development are briefly mentioned below:</p> <ul style="list-style-type: none"> ● Promotion of field trials of newly developed PHM protocols and promotion of applied R&D programmes for commercialization of proven technology. ● Promotion of applied R & D for standardizing PHM protocols, prescribing critical storage conditions for fresh horticulture produce, bench marking technical standards for cold chain infrastructure etc. ● Transfer technology to producers/farmers and service providers such as gardeners, nurserymen, farm-level skilled workers, operators in cold storages, workforce carrying out 	<p>Understanding of the state's cold-chain need: Both officials from NHB east Zone and Bihar mentioned that the state excels in vegetable and fruits production, but there is a lack of Post-Harvest Management (PHM) activities. Sorting, grading, packaging, and precooling of produce are necessary before transporting it in a reefer vehicle and storing it in cold storage. However, the general practice followed for PHM is to harvest and put in cold storage, which leads to produce loss. This happens because of the producers' lack of awareness of sorting, grading, packaging, and precooling. The state has several cold storages, but many more are needed. Ordinary trucks are only used but not reefer vehicles. Moreover, end to end cold chain is missing in Bihar. Further, the officials highlighted that the crops such as Litchi require an end-to-end cold-chain to make them more profitable. Local bananas are much more in demand than G9 bananas from Maharashtra, which may benefit from cold-chain development such as ripening chambers. Moreover, the cold-chain development should be planned in districts such as Nalanda, Muzaffarpur, Vaishali, and East Champaran (Motihari), which forms the state's horticulture belt.</p>	<p>NHB can provide funds for awareness sessions in partnership with the Horticulture department, highlighting that they can get more than 10-15 projects on packhouses and reefer vehicles in Bihar by creating awareness. Moreover, NHB can offer free of cost training and capacity building programs for FPOs, once they get a proposal from the state government and KVKs and can support crop-specific university training for one day or two days. Additionally, NHB can support farmers via Agri Infrastructure Fund. For instance, in Uttar Pradesh, Maharashtra and Karnataka, several farmers have used this fund well. However, in Bihar, the farmers are unaware of these schemes/initiatives.</p>

	<p>post-harvest management, including the processing of fresh horticulture produce and the master trainers.</p> <ul style="list-style-type: none"> ● Promotion of consumption of horticulture produce and products. ● Promoting long-distance transport solution for bulk movement of horticulture produce through rail etc. <p>NHB provides financial assistance for cold-chain development under the MIDH scheme. Under the NHB scheme, assistance in the form of capital investment subsidy (for construction/expansion/modernization) is provided to set up cold storage (of capacity above 5,000 MT and up to 10,000 MT) for horticulture products. It is an open-ended credit linked scheme with the scale of assistance @ 40% of the capital cost in the general area.</p>	<p>Challenges in cold-chain development in Bihar</p> <ul style="list-style-type: none"> ● Cold-chain infrastructure Gap: Bihar requires post-harvest infrastructure, including cold storages, pack houses, ripening chambers and reefer vans. There is a need to build pack-houses in Muzaffarpur and Champaran for Litchi and for Mangoes in Bhagalpur and Vaishali districts. ● Technology and Skill Gap: Lack of technology providers in the state and lack of skilled labour force to use existing technology aggravates the state's cold-chain challenges. Further, there is no workforce to guide people, including engineers and consultancy services that can support cold-chain development. ● Lack of Awareness: NHB highlighted that there are a minimum number of applications received from Bihar and Jharkhand in the east zone due to lack of awareness. Moreover, the people applying for subsidies fail to produce the relevant documentation, delaying grant release from NHB's end. ● No focus on renewable energy integration: While the Board agreed that there is a need to integrate the existing pack-houses with renewable energy and clean technology, they mentioned that no energy-efficient technologies are used in the existing packhouses for Litchi. <p>Suggestions: The officials mentioned that key players to develop a sustainable cold-chain must include the banking organisations for providing financial support and APEDA for identifying the ways to increase exports.</p>	
<p>Energy Efficiency Services Limited (EESL) is a Super</p>	<p>In Bihar, EESL is working on implementing the following</p>	<p>EESL had a limited understanding of the cold-chain need in the state. However, EESL officials</p>	<p>EESL will act as an enabler in implementing the sustainable</p>

<p>Energy Service Company (ESCO), enabling consumers, industries, and governments to effectively manage their energy needs through energy-efficient technologies. EESL is implementing the world's largest energy efficiency portfolio across sectors like lighting, buildings, electric mobility, smart metering, agriculture, etc., at a scale that no organisation has been able to achieve.</p>	<p>programmes:</p> <ul style="list-style-type: none"> ● Ujala programme ● Street lighting programme with ULBs ● Smart meters programme with DISCOMs ● Buildings Energy Efficiency in railway stations in Bihar, Income Tax Building and others. <p>EESL has a good presence at ULB and district levels in the state. The core EESL team in Bihar has 20 employees. However, EESL is currently not working in the agriculture sector in Bihar.</p>	<p>discussed the critical challenges faced in implementing government schemes/programmes in Bihar:</p> <ul style="list-style-type: none"> ● Issues with coordination between various state and local agencies. For instance, at the Policy level meetings, most organizations support the initiative. But there are ground-level challenges with the structure in implementing the project. ● Ground-level actors cannot present the available data in the required form when needed. Moreover, information is not framed appropriately, and in most cases, the ground-level data is missing. In addition, there is a lack of awareness about the government schemes and programmes amongst the citizens, businesses, etc. <p>Suggestion: EESL suggested reaching out to Bihar Renewable Energy Development Agency (BREDA) to get inputs on introducing energy efficiency in cold-chain initiatives.</p>	<p>cold-chain programme in Bihar. With its experience in completing some national-level schemes in the most rural parts of the country, EESL has the potential. The AEEE-UNEP team can further develop their capacity to implement a sustainable cold-chain in Bihar.</p>
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The national-level organisations are responsible for formulating policies/guidelines and launching schemes/missions. However, their implementation is a state subject and require the active cooperation of the state and local actors. Figure 7 is a schematic representation of the state-level actors categorised with relevance to their expertise, such as state-level decision-makers, facilitators, enablers and beneficiaries.

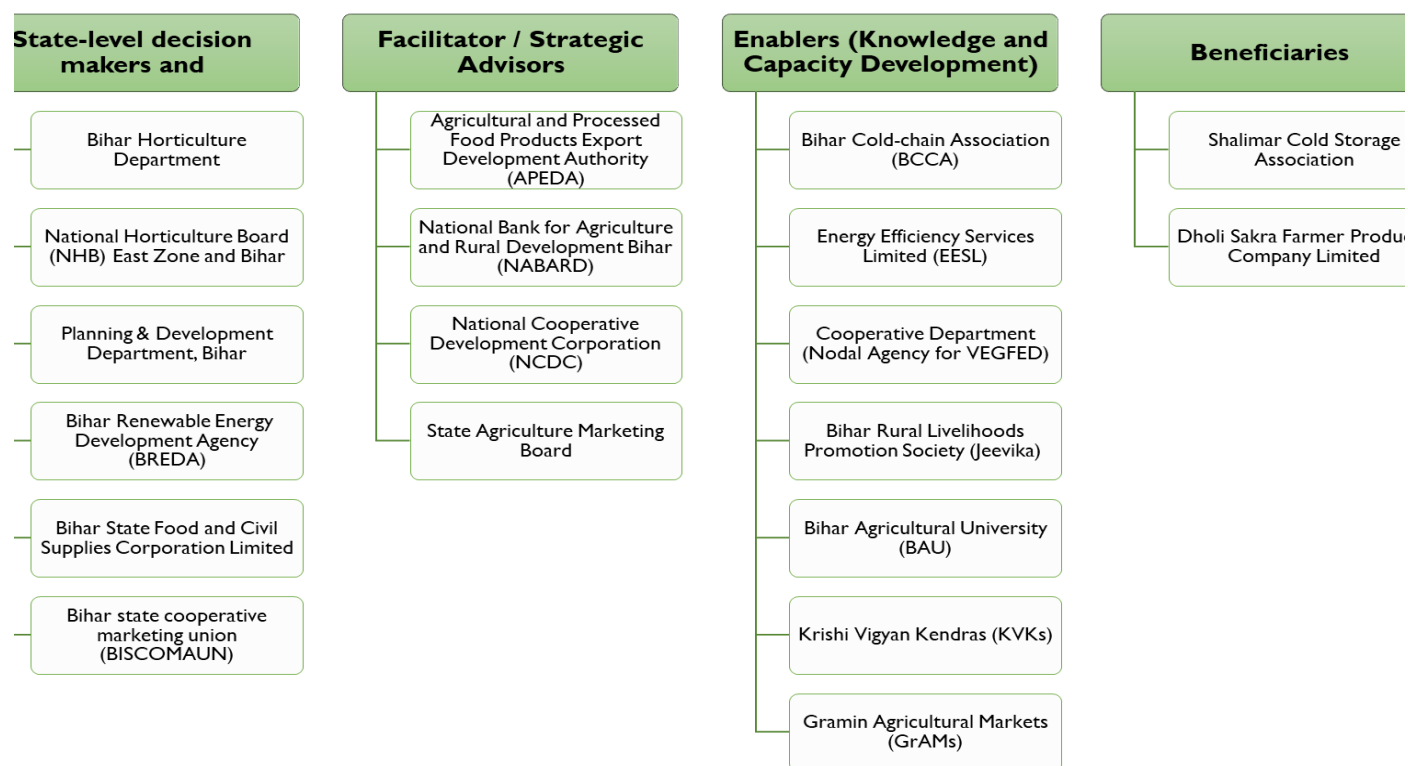


Figure 7: State-level actors in Bihar

Table 6: Perspective of state-level stakeholders' in cold-chain development

Organization and its aim	Current role in cold-chain	Perspective on cold-chain development	Potential role in sustainable cold-chain development at country level
Directorate of Horticulture, Bihar, aims to: <ul style="list-style-type: none"> Promote holistic growth of horticulture sector, including strategies focusing on research, technology promotion, extension, post- 	The Directorate of Horticulture in Bihar is responsible for implementing central schemes related to cold-chain, such as MIDH and RKRY. It supports skill development and creates employment opportunities for rural	Understanding of cold-chain need in Bihar: The Director highlighted the importance of cold-chain in Bihar, mentioning if the cold-chain infrastructure is developed, only grades 3 and 4 produce will need to be value added, while grades 1 and 2 can be sold in the market.	The Directorate of Horticulture can play a crucial role in advancing sustainable cold-chain development by bringing the key state actors together, initiating discussions on introducing energy

<p>harvest management, processing and marketing.</p> <ul style="list-style-type: none"> ● Improve productivity through quality germplasm, planting material and water use efficiency through Micro Irrigation. ● Encourage aggregation of farmers into farmer groups. ● Enhance horticulture production, augment farmers, income strengthen nutritional security. 	<p>youth in horticulture and post-harvest management, especially in the cold chain sector.</p> <p>The horticulture director mentioned that Bihar is also focusing on implementing the Solar Cool Chambers under the state plan and is providing up to 50% subsidy to the F&V FPCs and individual farmers.</p> <p>Bihar Horticulture Produce Development Scheme, another state-sponsored scheme run by the state directorate, provide up to 90% subsidy for cold-chain infrastructure.³⁸</p>	<p>Challenges: In the consultations, the directorate team mentioned some of the challenges in Bihar:</p> <ul style="list-style-type: none"> ● Sustenance of cold-storages in the state is a huge problem. In Nalanda, there are 51 cold storages, but only 20-25 are functional due non-sustainability of these cold-storages. ● Lack of awareness in improving the holding life of Litchi (in cold-chain) in terms of maintaining humidity and temperature. Only 8-10 % of Litchi produce is processed, although it has a high potential yet untapped. ● Other than Litchi, Mangoes and Banana, the state requires temperature-controlled storage space for Makhana. More than 90% of India's total production of Makhana happens in Bihar, but there are losses due to the lack of storage facilities. Such facilities are crucial for Darbhanga and Purnia, essential Makhana producing districts. Moreover, Purnia is even more important for marketing purposes with hardly any storage facilities/collection centres. <p>Suggestions:</p> <p>The team also indicated solutions for these challenges:</p> <ul style="list-style-type: none"> ● Collaborations with other departments such as Industry department, Fruits and Vegetables Corporation, Jeevika, highlighting, under BAIPP and BIIPP scheme, 50 cold storages are already developed in Begusarai district, Samastipur, Saharanpur, East Champaran, Patna and Muzaffarpur. ● Capacity Building of farmer groups, cold-storage and pack-house owners ● Awareness creation will be essential for integrating energy-efficiency 	<p>efficiency and better energy management in existing and new cold-chain infrastructure.</p> <p>With experience in implementing schemes such as MIDH and PMKSY, the directorate has a good understanding of and connections with the important stakeholders. The Directorate can act as a nodal agency for the uptake of the strategy implementation at the state level.</p>
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³⁸ But information on implementation and sanctioned funds was not shared.

<p>Cooperative Department, Government of Bihar, launched a scheme, namely, Bihar state Vegetable Processing and Marketing Scheme to establish a brand of trust in the society by marketing the vegetable produced in the state under the umbrella brand "Tarkaari". The Federation, popularly known as VEGFED, is the nodal agency implementing this project on hub and spokes model and was formed in March 2020. VEGFED's vision is Har Thali Mein Bihari Tarkaari. VEGFED follows a conventional three-tier structure like AMUL, including Primary Cooperative Society (PCS), Union and Apex body. The primary vegetable cooperative societies (PVCS) are the spokes feeding the fresh vegetables to the Union. PCS is planned to expand in 534 blocks across all districts of Bihar. But presently, it covers 250 blocks in 20 districts. Each PCS will form a union – there will be four unions in the entire state, that is, in all 38 districts.</p>	<p>The Federation (VEGFED) is the nodal agency implementing this project on hub and spokes model. It aims to:</p> <ul style="list-style-type: none"> ● Establish a farmer's vegetable supply chain network in and outside Bihar. ● Minimize the post-harvest losses by enhancing the product shelf life. ● Value addition by processing, packaging and branding the product. ● Bridge demand and supply gap of fresh & Quality vegetables. ● Increase in vegetable production and productivity in the state. ● Provide training and extension services to the vegetable growers. ● Generate employment opportunities and enhance the income of vegetable growers. ● Eliminating the intermediaries from the system. ● Establishing retail outlets for retailing of business. ● Creation of a central vegetable processing hub at the union level. ● Creation of collection centres and permanent marketing infrastructure at PVCS level. 	<p>Understanding of cold-chain needs:</p> <p>Bihar is an agrarian-based economy with most of the population residing in rural areas being indulged in agricultural activities either directly or indirectly. It is one of the largest producers of vegetables, dominated by potato, onion, eggplant & cauliflower and ranks among the top five vegetable producing states in India. However, several factors disintegrate the vegetable value chain and make it complex, such as transportation, logistics, packaging, sorting, grading, and post-harvest losses, making it difficult for farmers to sustain in these circumstances and situations.</p> <p>The officials mentioned that to address these inherent challenges and edify vegetable growers from misery and poverty, the Cooperative Department launched this scheme, elaborating about VEGFED and its role in improving horticulture in the state. In simple terms, VEGFED procures vegetables from farmers and sell them in blocks, district, the state capital and outside the state.</p> <p>VEGFED comprises mainly three unions, namely Harit union, Tirhut union and Mithila Union. Harit union is the oldest Union functional in seven districts, including Patna, Nalanda, Begusarai, Samstipur, Bhojpur, Vaishali, and Buxar. Similarly, the Tirhut union has a presence in 8 districts, i.e., east Champaran, West Champaran, Muzzafarpur, Sitamrhi, Siwan, Gopalganj, Sheohar and Saran. And the last piece in the Federation is the Mithila union comprising Dharbanga, Madhubani, Saharsa, Madhepura and Subhaul.</p> <p>VEGFED has an online portal, <u>Tarkari Mart</u>, for selling their F&V produce and are active on social media such as Linked In and Twitter.</p> <p>Challenges: The various challenges identified by the Federation include the loss of fruits and vegetables due to poor supply chain, low price</p>	<p>Cooperative departments, especially VEGFED representatives, are very motivated and active in changing the landscape of fruits and vegetable production in Bihar and can act as an essential enabler in connecting with the farmers as VEGFED has a good farmer connect.</p> <p>Further, VEGFED can provide an online presence through its social media and help in outreach activities.</p> <p>Moreover, VEGFED has accomplished market linkages with some of the significant entities for outsourcing of fresh farm vegetables and making this vegetable scheme as extensive and magnificent as a whole, including Big Bazar, Big Basket, Jio Mart, etc., which can be useful for making connections with these entities and understand their requirements to be incorporated for developing cold-chain.</p>
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		realisation by farmers for horticulture produce, the higher unemployment rate in Bihar and lack of organised fruits and vegetables business in the state.	
<p>Bihar Rural Livelihoods Promotion Society (BRLPS) is an autonomous body under the Department of Rural Development, with the below-mentioned objectives:</p> <ul style="list-style-type: none"> • Developing organizations of the rural poor and producers to enable them to access and better negotiate services, credit and assets from public and private sector agencies and financial institutions. • Investing in capacity building of public and private service providers. • Playing a catalytic role in promoting the development of microfinance and agribusiness sectors. 	<p>BRLPS is spearheading the World Bank aided Bihar Rural Livelihoods Project (BRLP), locally known as Jeevika, with the objective of social & economic empowerment of the rural poor. The BRLP objective is to enhance the social and economic empowerment of the rural poor in Bihar.</p> <p>Through Jeevika, BRLPS is also promoting an integrated value chain in agriculture and livestock in Bihar for the betterment of the producers. In this regard, BRLPS also supports FPO/C formation and promote new FPCs, where NABARD is also an important player.</p> <ul style="list-style-type: none"> • BRLPS has a reach of 10 million farmers spanning 38 districts and has engaged with around 2 million farmers, and half a million of them are engaged in livestock. • There are five functional FPCs with 40000 members under BRLPS. These farmers are engaged in growing vegetables, maize, Litchi, banana, mango and other commodities. 	<p>The officials informed the team that BRLPS is a community-based institution that has emerged as an effective vehicle for implementing various central and state government-run schemes in the past few years, directly benefitting the rural population. As of March 2020, 9.48 lakh self-help groups (SHGs) have been created.</p> <p>JEEVIKA performed the capitalisation of these SHGs from different banks. Cumulatively, 10.34 lakhs of credit linkages of SHGs have been achieved.</p> <p>JEEVIKA has worked extensively for social mobilisation, financial inclusion, livelihood promotion, health, nutrition, and sanitation. Jeevika officials highlighted two priorities for the organisation to support F&V production and improve its market access in the state and beyond,</p> <ul style="list-style-type: none"> • Setting up F&V cold chain infrastructure in Patna district, which serves as a huge F&V market for the state. • Purnea is aiming to be the banana hub for premium quality G9 variety. And Jeevika would like to support the FPOs in Purnea by building a ripening chamber. 	<p>Department of Rural Development (especially people associated with Jeevika) can help build human capacity and provide support for developing technical know-how of the farmers and people who can be employed in cold-chain infrastructure.</p> <p>The connection of Jeevika officials with farmers and grassroot workers is vast, which can help the project in outreach and awareness generation.</p> <p>Jeevika is also looking for support from institutions such as UNEP and AEEE in providing technical guidance and handholding to create pack-houses.</p>
<p>Bihar Cold-chain Association is a member of the Federation of Cold Storage Associations of India (FCAOI), which is an all India association to a) unite the cold storage industry in India under the FCAOI umbrella; b)</p>	<p>It was emphasised in the consultation that there is a huge need for cold storage facilities in India, which led to the formation of state-level associations that look after their concerns.</p>	<p>Understanding of cold-chain needs</p> <ul style="list-style-type: none"> • Most cold-storages in Bihar are potato-based, storing potatoes from mid-February to mid-November every year. Only 2% of the existing cold-storages are probably used in a year. Moreover, owing to the shortage of cold-storages, potato storage rental has increased in the last five 	<p>BCCA can again be an essential enabler, providing a greater reach to cold-storage owners in the state. Moreover, BCCA can also support in creating awareness amongst these cold-storage owners on</p>

<p>exchange and share the latest cold storage technology among member federations within the country and outside India; c) organise conferences, meetings to plan and execute strategies of FCAOI; arranging the visits of various industry experts; and to provide, make available and publish knowledge and information on different laws and legislation that impacts the cold storage industry. Bihar cold storage association is also a member of Bihar Industries Association and Bihar chamber of commerce.</p>		<p>years (did not mention by how much).</p> <ul style="list-style-type: none"> ● New vegetables can be grown here and transported to other states with suitable climates and soil. However, there is limited or no availability of pack-houses in Bihar, and generally, vegetable transportation is done in ordinary trucks (i.e. with no refrigeration facility). ● It is essential to emphasize the need for multi-commodity cold-chains. Awareness should be created on this aspect so that cold storages can be more effectively utilized throughout the year. ● There are more than 300 FPOs registered in the state. Most FPOs are set up by the Cluster-Based Business Organisations (CBBO) and NABARD. In addition, cooperatives also play an essential role in supporting FPOs in cold-chain development and strengthening cold-chain infrastructure in the state. ● Bihar has a good presence of private companies, including, Haldiram set up a food processing unit in Gaya, Sona chips, Big basket, and Reliance also have plans to start their operations in Bihar. <p>Challenges:</p> <ul style="list-style-type: none"> ● Lack of information: The biggest challenge in the state is the lack of knowledge amongst farmer groups and cold-storage owners. There is a need to educate them about the new technologies and financial models. Additionally, the state and central government have not disseminated information on the schemes and initiatives to the farmer groups. ● Institutional Challenges: Several cold-chain interventions are planned through cooperatives in the districts such as Motihari, East Champaran, and Vaishali. However, the realization of these interventions did not happen owing to a lack of capacity with the cooperatives to execute these interventions. It was also highlighted that around 	<p>better energy management of their cold-storages.</p>
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		<p>INR 1000 crores was allocated in Bihar for horticulture development but was not fully unutilised and sent back to the centre. The state agencies' business-as-usual process is prolonged, delaying the implementation of any schemes.</p> <ul style="list-style-type: none"> ● Minimal investment in Technology: A majority of the private investment has been done in the potato cold-storages and not for other horticulture produce because of the lack of processing plants in the state. Additionally, a lack of access to the proper technology for refrigeration has resulted in a lower export of potatoes and other produce. <p>Suggestions</p> <ul style="list-style-type: none"> ● For sustainable cold-chain development in Bihar, it is crucial to introduce new technology and financing mechanism for cold-chain projects. In addition, a focused approach to establishing forward and backward linkages for farmers for better market reach should be prioritised. ● There is a need to set up packhouses in districts such as Vaishali, Samastipur, Muzaffarpur, Nalanda and Patna to ensure better market linkages and nutritional quality of the produce. 	
<p>Bihar Renewable Energy Development Agency (BREDA) has been established to promote the development of schemes on non-conventional energy sources. It has been nominated as a nodal agency to carry out the remote village electrification program. The State Govt. provides plan funds to BREDA for expenditure on subsidies for the schemes and spending on the establishment. BREDA is one of the premier organizations working in renewable energy development and energy conservation and is</p>	<p>BREDA works as a catalyst for change by utilising the best renewable energy technology to cater to the ever-growing growth potential of Bihar by conducting research to identify the resources to support energy generation through renewable options, supporting the state government in formulating the policy regarding renewable energy sources and information dissemination and public awareness through training programs, publication, exhibition, seminar & conference.</p> <p>At present, the focus is on solar. All</p>	<p>BREDA has a limited understanding of cold-chain development.</p>	<p>BREDA can play a significant role in integrating renewable energy and sustainability concepts in cold-chain development.</p> <p>Moreover, the officials indicated that BREDA could work in the refrigeration systems and integrate solar in the cold-chain sector.</p>

<p>registered under the society registration 1860 act in 1987.</p>	<p>the government offices, residential buildings and other buildings such as Primary Health Centres, Panchayat Rajs, Circuit houses, schools, and others need to have solar rooftops. However, there are no incentives for private buildings. BREDA promotes schemes through jingles on FM, newspapers, etc. BREDA is not currently implementing any project on cold-chain.</p>		
<p>Bihar Agricultural University (BAU) was established to improve the quality of life of people of the state, especially farmers constituting more than two-thirds of the population. Having set the ultimate goal of benefitting society at large, the university intends to achieve it by imparting world-class need-based agricultural education, research, extension and public service. The university has six colleges (5 Agriculture and 1 Horticulture) and 12 research stations spread in 3 agro-ecological zones of Bihar.</p>	<p>BAU has 21 Krishi Vigyan Kendras (KVK) established in 20 of the 25 districts falling under the university's jurisdiction. The university also organises trainings in KVKs for farmers and supports incubation centres. At present, there are 110 working FPOs in Bihar. BAU gets technology from other universities in the USA and UK. For instance, BAU partnered with the American universities for super bags to store grains and a university in the UK for a net-zero energy cold storage facility.</p>	<p>Understanding of cold-chain needs: The BAU team highlighted several upcoming cold-chain projects in Bihar, such as Food Park in Khagaria, which will be essential to improve market access to the farmers. However, transportation is still a challenge in the state. Moreover, Darbhanga airport is functional now, and for the first time, Mango and Litchi were sent abroad with APEDA's help. Cold-chain development is essential in the key districts such as Nalanda, Gaya, Patna, Vaishali, Samastipur and East Champaran.</p> <p>Challenges:</p> <ul style="list-style-type: none"> ● Lack of cold-chain infrastructure: BAU mentioned that cold storages are present only in the potato belt. Moreover, Litchi requires packhouses in Muzaffarpur. Many cold storages are not functioning in Bihar. There is a need to share the good practices from other states where the cold storages are running fine such as Maharashtra, Gujarat, Punjab and Haryana. ● Lack of Skilled labour Capacity: Bihar's vegetable production can be made more profitable; however, the state lacks a skilled labour force. BAU can create awareness about the post-harvest management practices amongst farmers. ● Minimal Engagement between Farmers and 	<p>BAU can act as a knowledge partner for this project and help identify innovative solutions and conduct training programmes.</p>

		<p>Market players: Farmers have few opportunities to engage with the retail outlets and companies purchasing the produce as intermediaries play an active role in Bihar. Since this sector is majorly informal, no single agency engages directly with every other entity in the value chain.</p>	
<p>Farmer Producer Organizations (FPOs), also referred to as Farmer Producer Corporation Limited (FPCL), are autonomous self-help organisations controlled by farmer members. They are formed to mobilise and develop the capacity of farmers to leverage market strength. The team interacted with two FPCLs, Dholi Sakra and Muraul FPCL.</p>	<p>FPOs act as the first node to assess market demand and are an essential stakeholder that indirectly impacts the cold-chain development in their jurisdiction area.</p> <p>Dholi Sakra FPCL and Muraul FPCL were created under the Bihar Agriculture Growth and Reform Initiative (BAGRI) project³⁹ facilitating market linkages for vegetables such as Cauliflower and Brinjal to be sent to other states such as West Bengal. The main mandi for the two FPCLs is the Motipur mandi between Muzzafarpur and Samastipur. Dholi Sakra FPCL has 450 members, whereas only 300 farmers are presently active, including nine panchayats growing vegetables.</p> <p>Muraul FPCL was formed for Litchi produce.</p>	<p>Understanding of cold-chain need in Bihar, indicating challenges faced: In consultation with Dholi Sakra FPCL and Muraul FPCL, the representatives agreed that cold-chain infrastructure could help establish better market linkages increase their geographic reach. Further, the representatives discussed their experience with the state government. Muraul FPCL tied up with the Department of Horticulture and Postal Service Department to online sell and deliver Litchi (and some other vegetables) in Muzaffarpur and Patna. The FPCL was running this business successfully even during the pandemic. There was a good demand for online Litchi business. However, the FPCL failed to fulfil this demand due to the inefficiencies with the post office to deliver Litchi. FPCL also arranged additional vehicles and delivered the produce for some time but could not continue as the model was not sustainable, and the FPCL started incurring losses. The FPCL representatives were unhappy about partnering with the government department as their objective of developing the market linkages for the farmers could not be realized.</p> <p>Moreover, Dholi Sakra FPCL indicated that lack of technology providers and skill gap is plaguing the cold-chain development in Bihar. The FPCL had a cold room (10 by 12 feet) deployed by CoolCrop in the Sakra mandi (Muzaffarpur district), though it's non-functional. The CoolCrop's cold room ran on electricity and functioned well for the initial 3-4</p>	<p>FPOs will be the end-users and beneficiaries of the cold-chain infrastructure. Their role will be vital in understanding their requirements and accordingly plan the cold-chain infrastructure. Further, FPOs can also act as outreach and promotion agents to create awareness on the benefits of cold-chain amongst farmers, associations and other end-users.</p>

³⁹ Discussed in the section on state initiatives.

		<p>months, and farmers used to store vegetables at 50 paise per kilo. The cold room mainly was used for the summer months, while it was non-functional for the winter months. Then they faced challenges with its operation and maintenance and had to shut it down, which included:</p> <ul style="list-style-type: none"> • Cold room was monitored from Gujarat, and the technical issues could not be addressed locally, leading to vegetable spoilage due to temperature fluctuations. • Huge electricity bill and rent associated with the cold room that was paid under the BAGRI Project (during the project's duration, which varied from INR 1500 to INR 10000). After the project ended (in 2020), the FPO couldn't afford the rent and the electricity bill payment. <p>Suggestions:</p> <ul style="list-style-type: none"> • Training people in Bihar so that technical issues can be resolved in a timely manner. <p>Promoting low-cost refrigeration solutions for the farmers.</p>	
<p>Shalimar Cold-storage: Shalimar cold-storage was established in 1977. Shalimar is one of the leading warehouses in Bihar situated in Patna with proximity to NH-30 that is easily accessible from states such as Bihar, Jharkhand, Uttar Pradesh, etc. Traders and less by the farmers majorly use cold storage. It offers more than 5000 metric tons of refrigerated warehousing in one place. The cold storage used Frick India machinery.</p>	<p>The existing cold-storage:</p> <ul style="list-style-type: none"> • It has a 150000ft³ space available to store frozen food and is used year-round 24*7 • It is a multi-temperature, multi-compartment and can store poultry, meat, cut flowers, cabbage, tamarind and so on in 1 – 50C temperature. Further, the booster facility can maintain a temperature range from -18 to -220C, storing green peas, frozen chicken, frozen vegetables, french fries, ice cream and fresh cream. 	<p>Understanding cold-chain need in Bihar: Cold storage is used mainly by traders and less by the farmers.</p> <p>Challenges: Cold-chain Infrastructure: In Bihar, 90% of cold-storages are for potatoes, and there are no big packhouses in Bihar. Further, the second generation is not taking up the cold storage business. Most cold storages use slow speed compressors, an outdated insulating material such as sawdust between wall and panel and use primitive way of storing material. Most cold-storages are 80%-90% shut down from October end, open again from mid-February or March, and remain unused.</p> <p>Institutional Challenges: The ground reality in</p>	<p>Private cold-storage owners are the potential beneficiaries and should be reached to conduct the need assessment.</p>

		<p>Bihar is that the business-as-usual process of the government agencies and other organisations delays the execution of any project. Elaborating on his experience, Mr Minhaj mentioned that in 2016-2017, Shalimar applied for subsidy through IL&FS. In 2016-17, IL&FS was the in-charge of project mapping, and PwC was also associated with the industries department in Bihar. Since nothing moved at the state level, Mr Minhaj approached MoFPI directly, which approved their project report without much hassle and sanctioned a 35% subsidy (of the project cost).</p> <p>Land Acquisition: The major challenge in Bihar is land availability. If one can procure land, the government will convert it into the required land use and provide incentives. However, the government cannot provide land.</p> <p>Suggestions: State government should develop new cold-chain infrastructure but should provide support to the existing cold-storage owners to retrofit their old cold-storages.</p>	
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Some other state actors with whom the AEEE and UNEP team (mentioned in Table 7) could not engage but will keep making connections to include their perspective on cold-chain development in the state. These can play an instrumental role in sustainable cold-chain development in the state. For instance, organizations such as State Agriculture Marketing Boards, GrAMs, Bihar State Food and Civil Supplies Corporation Limited and Bihar state cooperative marketing union can act as an intermediary connect between farmers and state government; UNEP-AEEE-EESL team to advance sustainable cold-chain in the state. Further, KVKs frequently interact with farmers, FPOs and other informal farmer groups and can play a major role in improving the livelihood of farmers by educating farmers on advancement in agriculture, especially post-harvest management. And Planning department can support the team with the design guidelines for cold-chain infrastructure.

Table 7: State-level organisations and their role in cold-chain development

Organisation and its aim	Current role in Cold-chain Implementation
State Agriculture Marketing Boards are statutory boards established in respective states to develop and coordinate the growth of the agricultural marketing system. It has two primary objectives:	State Agriculture Marketing Boards provide a platform for trading agriculture produce to farmers. They are directly linked to the supply chain of agriculture and allied activities related to cold-chain infrastructure.

<ul style="list-style-type: none"> • To undertake state-level planning of the development of the agriculture markets • To make necessary arrangements for publicity related to the marketing matters 	
<p>Gramin Agricultural Markets (GrAMs) are the retail agricultural markets in close proximity of the farm gate, that promote and service a more efficient transaction of the farmers’ produce across the agricultural sub-sectors by enabling both direct sales, between the producer and consumer, and aggregation of small produce-lots for the subsequent transaction, both of which can occur either physically or online”.</p> <p>Gramin Agricultural Markets belong to the lowest in the hierarchy of market usually located at the village level established to initiate service transactions at terminal destinations. Its objectives are:</p> <ul style="list-style-type: none"> • To create a linkage between the supply side and demand side at the local level • To be an intermediary between primary, secondary and tertiary sectors <p>The Union Budget 2018-19 made an important announcement to the effect that 22,000 GrAMs shall be set up to facilitate retail agricultural marketing in the country.</p>	<p>Gramin Agricultural Markets acts as a first, and the last mile in the supply chain of agricultural produces and hence creates demand for a full-fledged infrastructure of the cold-chain. As part of the development of Off-Market infrastructure of the GrAMs, efficient road and transport infrastructure, and cold transport systems like reefer vehicles, more significant investments will be necessary for setting up the preliminary pre-conditioning facilities at the GrAMs. This can support to:</p> <ol style="list-style-type: none"> Reduce the cost of first-mile transportation by providing farmers with a marketing platform close to their farm gates. Reduce transaction costs by allowing direct sales — both in-person and online. Provide small farmers with the tools they need to target direct sales at marketplaces on their own terms by offering market linkage services. Increase opportunities for farmer mobilisation through structures such as farmer producer organisations (FPOs), cooperatives, businesses, and Village Producer Organizations (VPOs). Provide an integrated platform for the purchasing of agricultural inputs as well as consumer and white goods. Act as a hub for the spread of innovative agricultural and life-related information and knowledge.
<p>Bihar State Food and Civil Supplies Corporation Limited is a State Government company involved in manufacturing grain mill products, starches and starch products, and prepared animal feeds. It is a nodal agency for distribution of Public Distribution System (PDS) commodities is implementing the state-of-the-art e-PDS system to introduce transparency and accountability in the entire system and arrest leakages and diversions in the supply chain, which is defeating the noble cause and scheme of the Government.</p>	<p>Its role in the cold-chain includes carrying the business:</p> <ol style="list-style-type: none"> As vegetable and fruit merchants, cold storage proprietors, vegetable and fruit growers and to buy, sell, prepare for market manipulate export, import and deal in vegetables and fruits of all kinds. For cold storage, refrigerating, cooling, dehydrating, preserving, canning of any products on Company’s own account or as contractors for any authorities, companies or individuals.
<p>Bihar state cooperative marketing union (BISCOMAUN) is an apex cooperative marketing society whose aim is to ensure timely supply of good quality agri-inputs, fair price to farmers by marketing their agri-produce and adding value to it by providing a platform of multipurpose godowns, cold storage and processing facilities.</p>	<p>BISCOMAUN has several cold storages in various districts of Bihar. It currently does not operate them but leases to third parties on rent.</p> <p>In 2017, there were 13 cold storage under BISCOMAUN Cold Storage; all are cooperative and potato-based. However, out of these 12 cold-storage, 3 are non-functioning.⁴⁰</p>

⁴⁰Directorate of Horticulture. 2017. Cold Storages of Bihar. [online] Available: <http://horticulture.bihar.gov.in/MainSite/Act_Rules/ColdStorage/Available%20Cold%20Storage.pdf>

Krishi Vigyan Kendras (KVKs) are established under MoA&FW and are an integral part of the National Agricultural Research System (NARS) with the objective to:

- To provide knowledge and resource of agricultural technology and allied initiatives available for local farmers of the district
- To perform on-farm testing to access specific requirements and technologies of location-specific farmlands

To provide farm advisories subject to the interest of farmers and enhance the capacity of farmers by upgrading their skills and knowledge on modern agriculture technologies

Planning & Development Department, Bihar, is an important and key department for the Plan Formulation, Implementation and Policy Determination. The scope of duties & responsibilities has been increased significantly in the present scenario of the development.

KVKs disseminate information related to the government's policy and help farmers be aware of the facilities and infrastructure available to them.

Town and Country Planning Organization is responsible for framing the Model Building Bye-Laws, which are legal tools used to regulate coverage, height, building bulk and architectural design and construction aspects of buildings to achieve orderly development of an area. MBBL addresses architectural design parameters for Storage Buildings, including cold storages and warehouses.

2.2.2 State Government schemes for cold-chain development

The Bihar State Government formulated the **Industrial Investment Promotion Policy (BIIPP) 2016** to focus on developing support infrastructure, prioritizing core sectors, including food processing, tourism, small machine manufacturing, IT, electrical and electronic hardware manufacturing, textile, plastic and rubber, renewable energy, leather and technical education sector.

Under BIIPP, Bihar Government approved the **Bihar Agricultural Investment Promotion Policy 2020 (BAIPP)**, which envisions encouragement and promotion of the agribusiness sector in Bihar through creating an enabling environment and enhancing the level of processing, storage, waste reduction, value addition and export promotion, thereby generating higher income returns to farmers and creating more employment opportunities. Implemented by the Bihar Horticulture Development Society (BHDS), Agriculture Department, and Bihar Government, the policy will be applicable till March 31, 2025. BAIPP focuses on seven sectors, including fruits & vegetables, makhana, honey, maize, seeds, medicinal & aromatics plants and tea⁴¹. BAIPP will also explore synergies between the existing cold-chain initiatives by the centre and the state.

According to the policy, capital subsidies would be offered to qualifying individual investors/entrepreneurs or registered farmer-based firms for the establishment, modernisation, diversification, and growth of agro-processing units in the selected agricultural sectors in Bihar. This support would be credit-linked, with qualifying promoters receiving funds based on completing specific objectives. The entrepreneurs/ Investors may set up their units as a partnership firm, Limited Liability Partnership (LLP), company including Farmer Producer Company (FPC). This policy recognizes the need for capital subsidy to improve the investment prospects in the agribusiness sector/corresponding units in the state. Any existing or new unit, expanding its capacity, diversifying, or modernizing during the policy period will be given the benefits as applicable to new units on their incremental approved project cost. As per the policy,

- There will be a support of capital subsidy, which will be credit-linked and will be released to eligible promoters on achievement of defined milestones.
- Institutional support would be provided by creating an enabling environment so that the agricultural department can work in close coordination with all the concerned departments and stakeholders.

The food processing units discussed in Table 8 shall be considered under the priority sectors to avail the incentives under this policy.

Table 8: Priority sectors identified under Bihar Agri Industrial Investment Policy (2016)⁴²

Sectors	Investment Opportunities
Food-grain (Cereal and pulses) and oilseed processing	Maize processing units within the stalled capacity of more than 100TPD, including units for manufacturing starch and cattle and/or poultry feed Any other cereal processing/flour/starch/dough mixes, breakfast food manufacturing unit with an installed capacity of more than 100TPD. Pulses processing unit Modern unit for oilseeds processing or extraction from raw materials obtained locally; like Vanaspati oil manufacturing from rice bran and vegetables like soya-bean, safflower/sunflower, mustard, groundnut, etc. as well as fats and oils extracted from bovine/sheep/goat/fish/marine animals, etc. Unit for solvent extraction for edible oils with or without integrated refining facility.
Fruits & Vegetable	All kinds of F&V processing units (including units for manufacturing dehydrated and

⁴¹ Government of Bihar. Bihar Agri Investment Promotion Policy. [online] Available: <<http://horticulture.bihar.gov.in/HORTMIS/BAIPP/Home.aspx#about>>

⁴² Government of Bihar. Bihar Agri Investment Promotion Policy. [online] Available: <<http://horticulture.bihar.gov.in/HORTMIS/BAIPP/Home.aspx#about>>

(F&V) Processing	Frozen F&V items using IQF/Blast Freezer/Spiral Freezer, etc.) Dehydration and powdering of vegetables like onions, mushrooms, etc. Unit for processing litchi (e.g. units for manufacturing litchi pulp, juice, pulp slabs, jam, jelly, beverage, nectar, candies, powder, etc.) Unit for processing a local variety of mangoes into pulp, juice, pulp slabs, jam, jelly, beverage, nectar, candies, powder, etc. (units using mango pulp imported from other states or countries shall not be considered under the priority sector.) Unit for banana processing (e.g. banana chips, pulp, powder, baby food, jam, jelly, banana flower vegetables, banana trunk vegetables & pickles, etc.) Unit for makhana processing (e.g. unit for producing makhana pops, making flavoured and/or roasted makhana snacks, RTC kheer, baby food. etc.)
Milk Processing and Dairy Product Manufacturing	Milk processing units with installed capacities of more than 50 thousand litres per day Units for manufacturing pasteurized milk, milk powder, ice cream powder, condensed milk, infant food, milk cream, butter, buttermilk, lassi, yoghurt, cheese, ghee, khoya, ice-cream, kulfi, flavoured milk and other dairy products. Units that manufacture products out of milk powder imported from other states or countries shall not be considered under the priority sector. Only products manufactured from milk procured or milk powder manufactured by another unit within the state shall be considered under the priority sector.
Honey Processing	Natural honey processing unit.
Meat, Poultry and Fish Processing	Meat, poultry and fish processing units (e.g. fresh, chilled, and frozen fish; fish fillets and pieces; fish cured or smoked and fish meal fit for human consumption; fresh and chilled meat of bovine animals such as sheep or goat; meat & edible offal of poultry meat; dried eggs; etc.) Modern slaughterhouse
Spice and herbs Processing	Modern processing unit for spices (e.g. extracts essence & concentrates of spices, powder and paste manufacturing etc.) Unit for extraction of food flavours, colours, oleoresins, etc. Health and wellness food supplements made from herbs
Tea Processing	Modern tea processing units
Other edible preparation	Modern unit for manufacturing of biscuits/cookies, etc. Modern bakery unit (e.g. bread, pastries and cakes manufacturing) Modern unit for manufacturing ice-cream Modern unit for manufacturing chocolate & non-chocolate based confectionery items Unit for manufacturing of frozen or non-frozen and packaged ready to eat (RTE) meals and snacks, ready to cook (RTC) food, powdered energy concentrate, instant drink concentrates, etc.
Sugarcane Processing	Manufacture of sugar
Warehousing	Fruit ripening chambers Controlled atmosphere (CA)/modified atmosphere (MA) chambers, cold rooms/ deep freezers/ pre-cooling chambers Multiple cold storage facilities/infrastructure including pre-cooling chambers, ripening chambers, CA/MA chambers, cold rooms, deep freezers, bulk chillers, etc. including cold chain logistic arrangements and modern grain silos
General/ Business Development Services	Research & development facilities, quality control laboratories/ testing laboratories, training/incubation centres/skill development centres, etc. related to the food processing sector Food machinery manufacturing and the Irradiation unit

Bihar State Vegetable Processing and Marketing Scheme (also discussed under Institutions): The Cooperative Department, Government of Bihar, launched a scheme, namely, Bihar state Vegetable Processing and Marketing Scheme to establish a brand of trust in the society by marketing the vegetable produced in the state under the umbrella brand "Tarkaari". The Federation, popularly known as VEGFED, is the nodal agency implementing this project on hub and spokes model and was formed in March 2020.

The scheme aims to create a virtuous cycle for vegetable producers and consumers through a three-tier cooperative structure, i.e. primary vegetable cooperative societies (PVCS) at grassroots/farmer/block level, Unions at cluster (a group of districts) level and an apex federation at the state level. In addition to the schemes focusing on developing supporting infrastructure, the Bihar government has also launched initiatives that will help fast-track overall agriculture development by helping build the capacity of youth employed in such support infrastructure.

Bihar Agriculture Growth and Reform Initiative (BAGRI): The Government of Bihar (GoB) implemented the Bihar Agriculture Growth and Reform Initiative (BAGRI) programme with the support of the Department for International Development (DFID), UK. BAGRI intends to complement the Government of Bihar in implementing its Agricultural Road Map to enable sustainable and inclusive growth, leading to poverty reduction in the state by strengthening capacity building of the human resources and developing market linkages between farmers and consumers. One of the critical deliverables of BAGRI is the formation and strengthening of 20 farmer producer organisations (FPOs), which will provide an institutional mechanism to small and marginal farmers and will operate as a one-stop-shop, which will also be known as BAGRI Kisan Sewa Kendra (BKSK) for managing all agri-business needs of farmers. Dholi Sakra FPCL and Muraul FPCL were created under the BAGRI project facilitating market linkages for vegetables such as Cauliflower and Brinjal to be sent to other states such as West Bengal in regular trucks. The main mandi for the two FPCLs is the Motipur mandi between Muzzafarpur and Samastipur.

Bihar Rural Livelihoods Project (BRLP) (also discussed under Institutions): The Government of Bihar (GoB), through the Bihar Rural Livelihoods Promotion Society (BRLPS), an autonomous body under the Department of Rural Development, is spearheading the World Bank aided Bihar Rural Livelihoods Project (BRLP), locally known as Jeevika, with the objective of social & economic empowerment of the rural poor. The BRLP objective is to enhance the social and economic empowerment of the rural poor in Bihar. Jeevika is playing a catalytic role in promoting the development of microfinance and agribusiness sectors by investing in the capacity building of public and private service providers.

Further, the state government has also prepared the **State Action Plan for Climate Change (2015)**, indicating some of the climate change impacts on the produce, for instance, at farm level gets aggregated to the level of the food system in terms of food shortages and rising prices, which can endanger food and livelihood security. The SAPCC also outlines several action points relevant for agriculture with an overall strategy to transform agriculture and its allied sectors into a climate-resilient and vibrant production system while developing their full potential and ensuring sustained food and nutritional security in the state. The overall motto of the State Action Plan of Climate Change (SAPCC) is 'Building Resilience through Development'. SAPCC provides an overarching climate response framework at the State Government level to reduce vulnerability, reduce hazards and exposure, pool, transfer, and share risks, prepare and respond effectively, and increase capacity to cope with unforeseen events while articulating flexible sector-specific response strategies and actions keeping in mind the overall Vision.⁴³ The action plan proposes to:

- Promote Sustainable Agricultural advancement in the state by encouraging environmentally friendly practices such as organic farming, soil health improvement, and waste and by-product reuse.
- Promoting the adoption of solar and wind power systems for irrigation and other uses.
- Encourage collecting, disseminating, and implementing best management practices to develop improved and diverse crop and livestock varieties, promoting efficient irrigation systems, demonstrating appropriate technology, capacity building, and skill development.

⁴³ Government of Bihar. 2015. Bihar Action Plan of Climate Change. [online] Available: <<http://moef.gov.in/wp-content/uploads/2017/08/Bihar-State-Action-Plan-on-Climate-Change-2.pdf>>

- Substantial warehousing and storage facility augmentation for agriculture growth and food security will be carried out. Marketing of agricultural produce will be promoted through the involvement of multiple agencies and innovations in institutional structures. Rapid expansion in infrastructure will be ensured through increased investments.

At present, SAPCC lacks specific action points for incorporating energy efficiency in cold-chain or even substituting renewable energy sources for power generation for cold-chain components.

The chapter (section 2.1.2, 2.1.3 and 2.2.2) summarised the initiatives (specific to cold-chain and energy-efficiency) and suggested recommendations to integrate the aspects of energy efficiency, energy transition and improved energy management with the existing schemes. The policy mapping exercise indicated that while there is a government interest, political will and financial support available towards improving the cold chain infrastructure, these initiatives are not always reaching to, or applicable to, the needs of the small-holder farmers. The key challenges include, access to information about the government initiatives amongst the farmers and an unclear understanding of their cold-chain needs amongst the state government departments. The potential opportunities addressing these challenges are briefly discussed in the key recommendations chapter.

After the institutional and policy landscape was mapped, the team assessed the various stakeholders' relative strengths to identify and prioritise key stakeholders for the subsequent discussions for the larger project. One of the frameworks to prioritise the stakeholders is to develop an adapted power interest matrix⁴⁴ as shown in Figure 7 below. The power interest matrix allows to differentiate and categorise stakeholders in 4 categories, namely –

Key players are the ones who have high interest and high power and can influence decision-making, e.g. state agencies and governmental institutions.

Context setters are the ones who have high power but low interest. However, these stakeholders can influence any outcome and usually set the context for various projects, e.g. facilitators such as financial institutions.

Subjects are the ones who have high interest but low power, thus capable of partnering and execution of work, e.g. implementors such as business and partner institutions.

Potentials are the ones having low interest and low power but might move to some extent in the future and should therefore be monitored with limited effort.

⁴⁴ Fran Ackermann and Colin Eden, Strategic Management of Stakeholders: Theory and Practice. Long Range Planning 44, no. 3 (June 2011): 179–96, [online] Available: <<https://doi.org/10.1016/j.lrp.2010.08.001>>

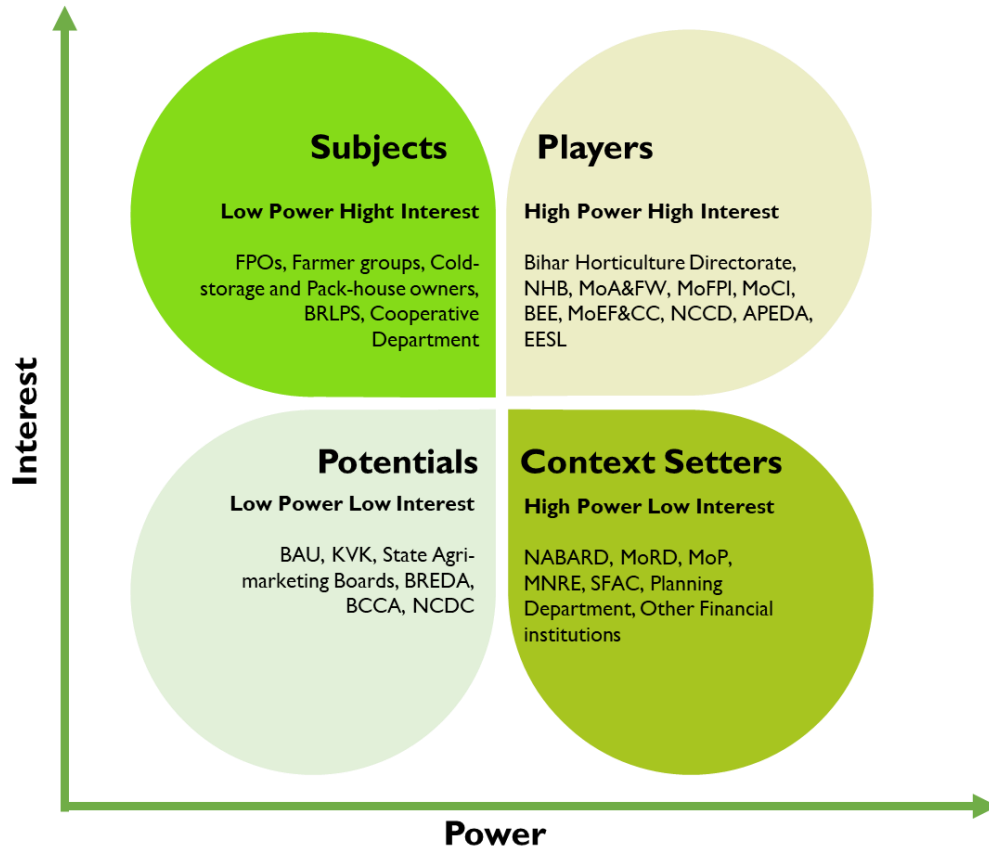


Figure 8: Stakeholder Assessment

The power matrix is based on the first few consultations conducted in this study. It will evolve in the larger project focusing on sustainable cold-chain development in Bihar.

3 Cold-chain Infrastructure Status

3.1 Current and future trends at the national level

A typical cold-chain infrastructure (Figure 9) consists of four main components: pack-house, cold storage (bulk⁴⁵ and hub⁴⁶), reefer vehicle, and ripening chamber. These cold-chain components do not alter the essential characteristics of the product handled and primarily offers two functions: preserving a product's quality and enhancing the product's life by maintaining the optimum temperature and humidity requirements, thereby reducing post-harvest losses.

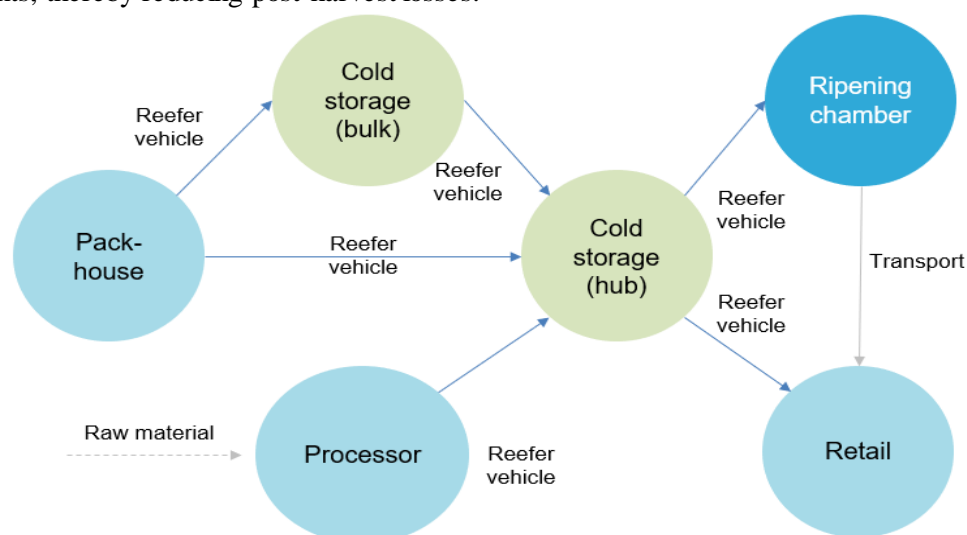


Figure 9: Typical cold-chain (Source: India Cooling Action Plan (ICAP) 2019)

Present gap and requirement: India has a large inventory of cold storage or refrigerated warehouses - primarily utilised for storing potatoes. Moreover, the country has demonstrated continued progress in cold storage capacity additions relative to the urban population. There are around 8,186 cold storage in India with a total capacity of ~37 million MT, mainly concentrated in the states of Uttar Pradesh, West Bengal, Gujarat, Andhra Pradesh, and Punjab⁴⁷. Even though India has many cold storages, the other elements that make up an uninterrupted cold-chain – pack-houses, reefer transport, and ripening chambers – are largely missing. As per ICAP⁴⁸, there are 450-550 pack-houses in India. Out of these, ~200 pack-houses are Agricultural and Processed Food Products Export Development Authority (APEDA) registered pack-houses, and more than 70% are located in Maharashtra (Figure 10)⁴⁹. The National Centre for Cold-chain Development (NCCD) estimates that there is a 99% gap in pack-houses, 85% in reefer vehicles, and 91% in ripening chamber in terms of infrastructure requirement versus the infrastructure created⁵⁰.

⁴⁵ 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.

⁴⁶ 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.

⁴⁷ Pib.gov.in. 2020. *Cold Storage Facilities in the Country*. [online] Available at: <<https://pib.gov.in/PressReleasePage.aspx?PRID=1658114>>

⁴⁸ MoEF&CC. 2019. *India Cooling Action Plan*. [online] Available at: <<http://ozoncell.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf>>.

⁴⁹ APEDA. 2019. *Recognized Pack House list issued by APEDA*. [online] Available at:

<[https://apeda.gov.in/apedawebsite/Announcements/UPDATED_LIST_OF_PACK_HOUSES_FOR_CHINA_\(11.03.2019\).pdf](https://apeda.gov.in/apedawebsite/Announcements/UPDATED_LIST_OF_PACK_HOUSES_FOR_CHINA_(11.03.2019).pdf)>

⁵⁰ NCCD. 2015. *All India Cold chain Infrastructure Capacity (Assessment of Status and Gap)*. [online] Available at:

<https://nccd.gov.in/PDF/CCSG_Final%20Report_Web.pdf>.

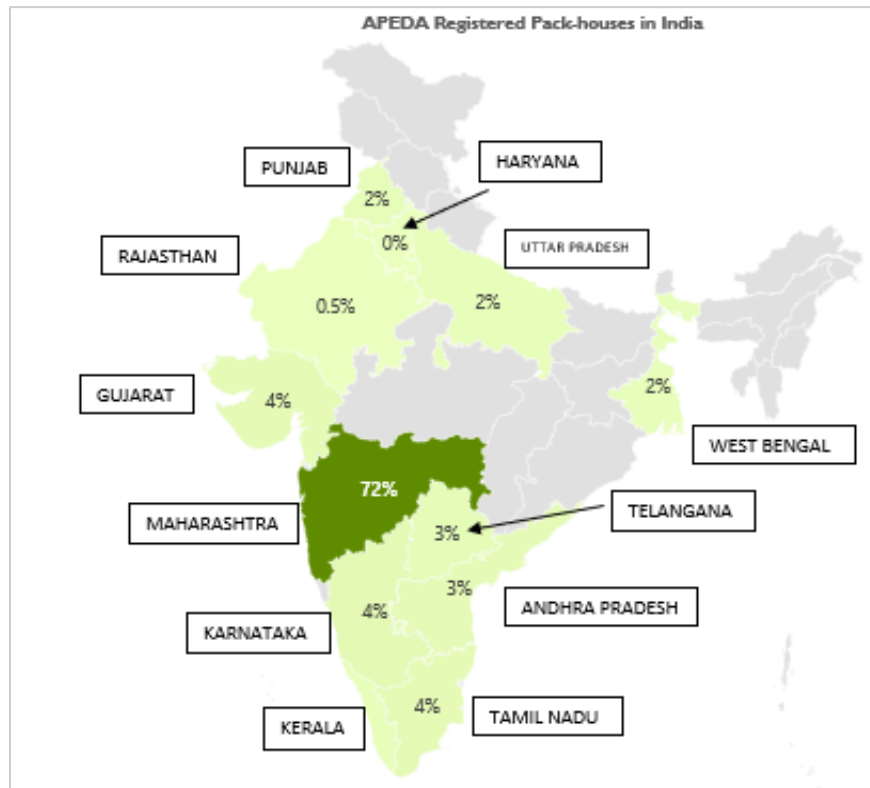


Figure 10: APEDA Registered Pack-houses in India

Pack-house growth and energy consumption: As per the ICAP, the cold-chain sector is poised for significant growth in the near future. The number of pack-houses in India is expected to grow from about 500 to 55,000 by 2027 and 125,000 by 2037. The energy consumption in pack-houses, estimated at only 0.02 TWh today, is expected to jump to 2.4 TWh in 2027 and to 5.2TWh in 2037 (Figure 11). Potential improvements in the energy efficiency of the pack-house infrastructure and cooling equipment by employing efficient compressors, improved insulation, and optimised operations can result in energy savings of up to 12% in the next decade.

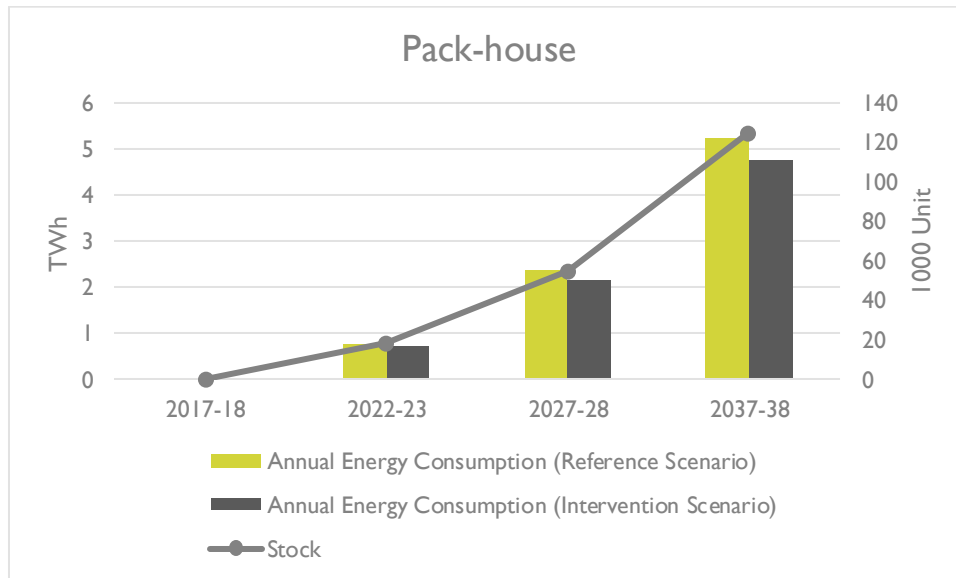


Figure 11: Pack-house growth and energy consumption

Cold storage growth and energy consumption: Unlike other components of the cold chain infrastructure, only marginal growth (1% to 2%) is projected for cold storage capacity, expected to grow from ~38 million Metric Tonne (MT) in 2020 to ~44 million MT in 2030. The sizes of cold storage range from 15,000-25,000 cubic meters per facility in emerging and developing economies compared to over 100,000 cubic meters in developed economies. India's average capacity per warehouse stands at 19,651 cubic meters, which is small compared to developed countries such as Australia, the United States, Canada, the United Kingdom, and Belgium.⁵¹ Per ICAP, the energy consumption from cold storage is estimated to be ~4 TWh in 2017, expected to grow up to 5 TWh in the next two decades. The energy performance of cold storage can be optimised by using improved insulation, variable frequency drives (VFDs), efficient compressors, automation and programmable logic controller (PLC) and retrofitting and retro-commissioning practices.

⁵¹ Savills India. 2021. *On an Upward Trajectory: Cold-chain Logistics in India*. [online] Available at: <<https://pdf.savills.asia/asia-pacific-research/india-research/on-an-upward-trajectory-cold-chain-logistics-india.pdf>>

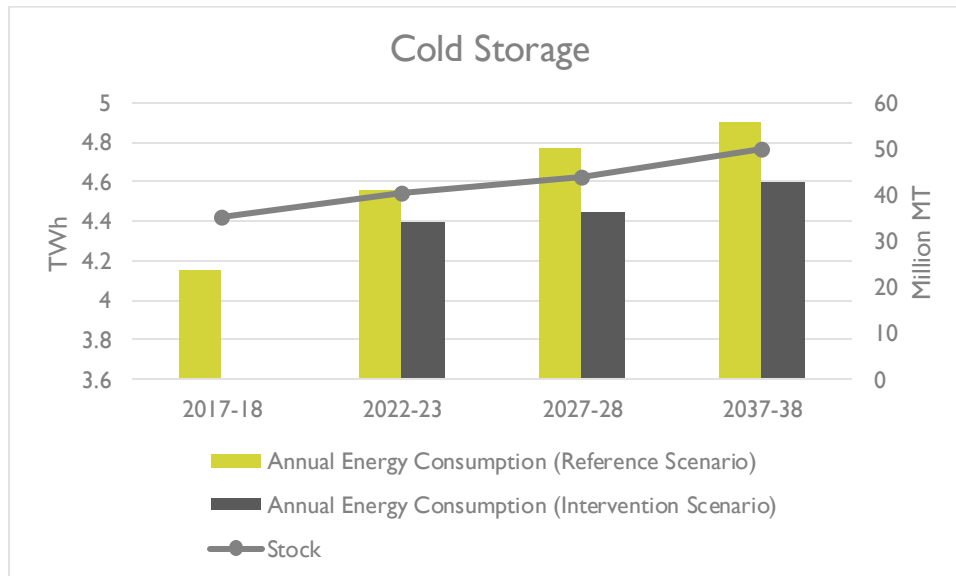


Figure 12: Cold storage growth and energy consumption

Reefer vehicle growth and energy consumption: Reefer vehicles are road transport vehicles with a fixed insulated body equipped with active refrigeration designed for the environment-controlled carriage of products. There are around 12,000-15,000 reefer vehicles in India, which is likely to grow to 3,00,000-5,00,000 by 2037-38⁵². The refrigeration system in reefer vehicles can be broadly classified as direct drive or diesel drive. Direct drive units are those where the main engine of the vehicle powers the compressor. In contrast, a separate diesel or CNG engine is available for driving the compressor and other accessories in diesel drive. The diesel drive units are more prevalent in India since they are used on medium to large trucks and cover a wide range of temperatures. On the other hand, direct-drive units are more common for specific temperatures and are installed on small to medium vans catering to local movement or last-mile deliveries. Per ICAP, the annual energy consumption from reefer vehicles is expected to increase from ~4,000 TJ in 2017-18 to 87,000-1,50,000 TJ by 2037-38.

⁵² MoEF&CC. 2019. *India Cooling Action Plan*. [online] Available at: <<http://ozonecell.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf>>.

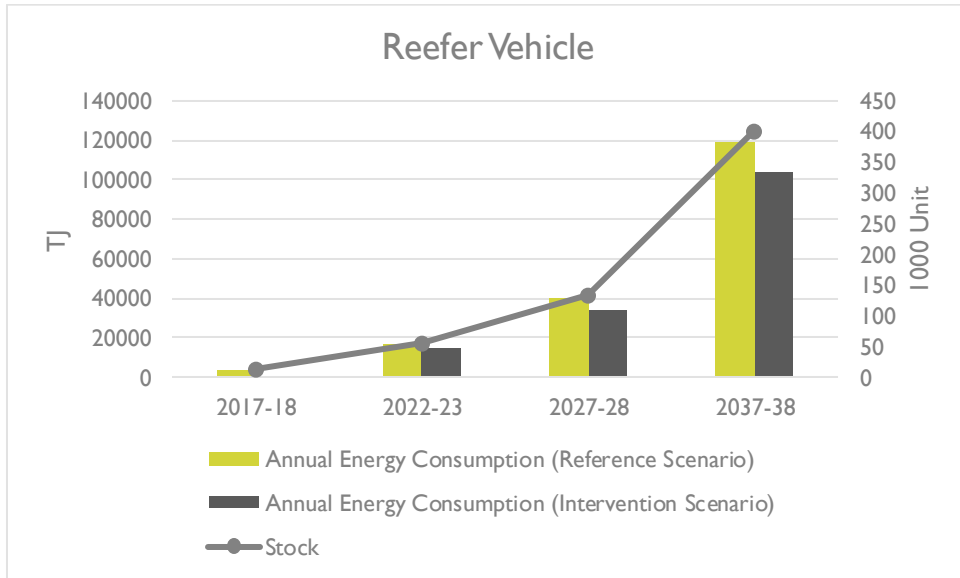


Figure 13: Reefer vehicle growth and energy consumption

Ripening chamber growth and energy consumption: Ripening chambers are a consumption-centric facility in the cold-chain, designed to function for controlled and hygienic ripening of certain fresh produce such as bananas, mangoes, avocados, kiwis, tomatoes, pears, etc. Per ICAP, steady growth in ripening chambers is expected in the next two decades, and the stock is likely to increase from 1000 units in 2017-18 to 14,000 units by 2037-38. The annual energy consumption from this growth is expected to reach 1.4 TWh in the next two decades.

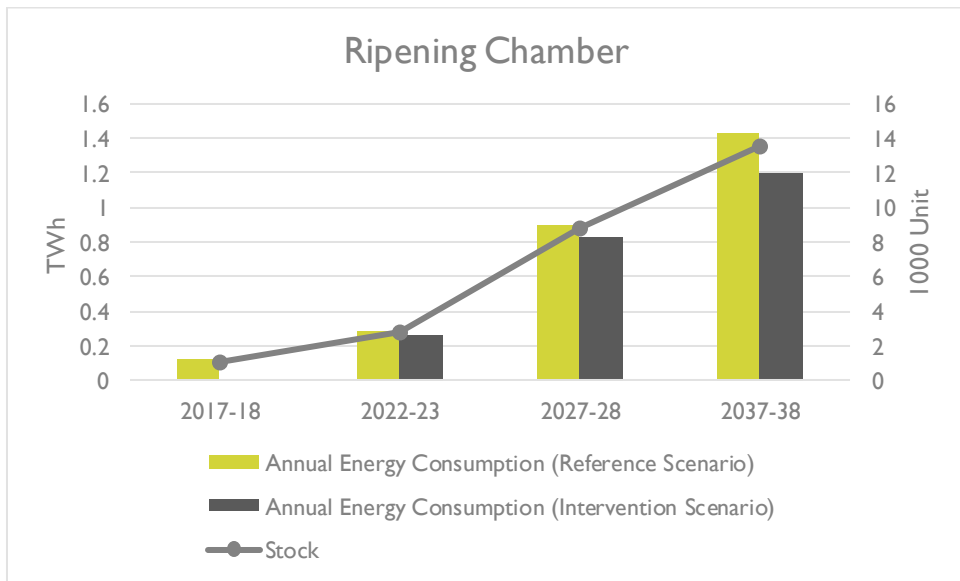


Figure 14: Ripening chamber growth and energy consumption

3.2 Infrastructure status in Bihar

The team prepared a set of data points and questions for stakeholder consultation to gain a deeper understanding of the current challenges for developing cold-chain infrastructure in Bihar, including limited first-mile connectivity, energy-intensive operations, lack of skilled workers, and much-needed

technology upgrade of the existing cold-chain infrastructure. Lack of enabling cold chain infrastructure in remote areas with inadequate transport, and further exacerbated by unreliable power supply, is a significant challenge in Bihar. Other issues which have affected the cold-chain sector include low awareness (amongst state departments, owners and farmer groups), insufficient training on handling temperature-sensitive products, funding constraints, and affordability of modern technology. The Bihar government, in collaboration with central actors, continue to make efforts in creating required infrastructures such as pack-houses, pre-cooling facilities, which would boost the agricultural exports potential of the state.

A 2015 study conducted by NCCD⁵³ estimates the state-wise breakdown of cold-chain infrastructure requirements. As the best available source of information at this point, we referred to this study as a starting point to understand the infrastructure requirement in Bihar. For data related to the existing cold-chain infrastructure in Bihar, our team interacted with key stakeholders, including the Directorate of Horticulture. The table below presents the status of cold-chain infrastructure in terms of the actual requirement and existing facilities in Bihar.

Table 9: Status of Cold-chain Infrastructure in Bihar

Cold-chain Component	Infrastructure Requirement	Infrastructure Available
Pack-house	2,205 numbers	Very few (less than 30 pack-houses) as per stakeholder inputs
Cold Storage	5,123,982 MT	1,850,718 MT
Ripening Chamber	2,873 numbers	Limited information

Status of cold storages: Most cold-storages in Bihar are potato-based, storing potatoes from mid-February to mid-November every year. Per NCCD, Bihar requires cold storage capacity of ~5 million MT. However, only 387 cold storages, having a total capacity of 1.8 million MT, existed in 2017 as per the data from Bihar government. Of these, 246 were functioning, 17 were under construction, and 124 were non-functioning cold storages⁵⁴ (Figure 15). One primary reason for non-functioning facilities is that the second generation is not taking up the cold storage business. Moreover, cold-chain schemes focus on developing new infrastructure rather than modernising old and existing non-functional cold-storages. The district-wise list of the number of cold storages in Bihar is shown in Figure 16. A GIS mapping of each facility (existing and planned) can be explored in the near future to develop data-driven policies on sustainable cold-chain and their implementation.

⁵³ NCCD. 2015. *All India Cold chain Infrastructure Capacity (Assessment of Status and Gap)*. [online] Available at: <https://nccd.gov.in/PDF/CCSG_Final%20Report_Web.pdf>.

⁵⁴ Government of Bihar. 2017. *Cold Storages in Bihar*. [online] Available at: <http://horticulture.bihar.gov.in/MainSite/Act_Rules/ColdStorage/Available%20Cold%20Storage.pdf>

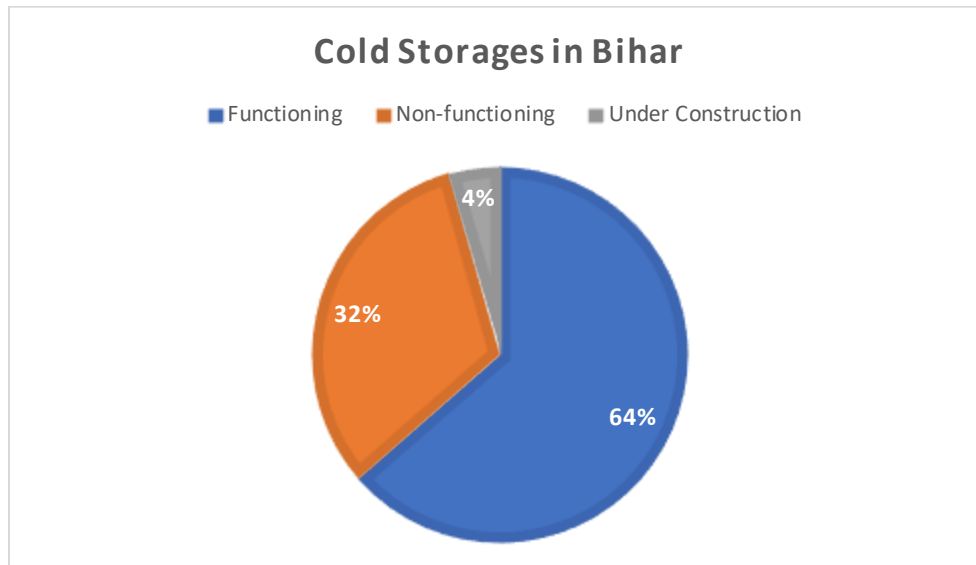


Figure 15: Status of Cold Storage in Bihar in 2017



Figure 16: District-wise cold storages in Bihar

Status of pack-houses: There are few existing pack-houses in Bihar and the available information is limited. Per inputs from the horticulture department, around 26 pack-house facilities were constructed between 2014-15 to 2016-17. In addition, two APEDA recognised pack-housed are operational in the state in Muzaffarpur and Vaishali district⁵⁵. During stakeholder consultations, the National Horticulture

⁵⁵ APEDA. 2021. [online] Available at: <http://apeda.in/agriexchange/Market%20Profile/one/LIST_OF_PACKHOUSES>

Board (NHB) and Bihar Agriculture University (BAU) emphasised the need to build pack-houses in Muzaffarpur and Champaran for Litchi, and in Bhagalpur and Vaishali district for Mangoes.

Status of reefers and ripening chambers: The information related to the existing stock of reefer vehicles and ripening chambers in the state is limited. Most fruits and vegetables are sold within the state and transported in regular non-refrigerated vehicles. Stakeholders highlighted that Bihar is landlocked, and of the exports, the bulk go to Nepal (~97%) and are sold at similar prices as within the state. Farmers can export their produce to Karnataka, Tamil Nadu, Gujarat and Maharashtra since they are close to sea and vessels. But transportation is expensive and costs INR 2-3 lakhs for transporting by a reefer to the port. Further, exit points in Bihar are a challenge, making it critical to strengthen the airport.

Inputs from key stakeholders in Bihar: The team engaged with diverse stakeholders, from the state departments, financial institutions, farmer producer organisations, cold storage owners, associations, and academic institutions, to understand the status of cold-chain infrastructure in Bihar. The key points highlighted during the discussion are presented below.

- There is a lack of cold-chain infrastructure in the state, leading to food and monetary losses for the farmers. However, the more significant challenge mentioned by most stakeholders is that not many people, including the farmers, are aware of the need for and the benefits of cold-chain infrastructure. Moreover, access to information on the policies and schemes available to support the development of cold-chain infrastructure is significantly low among the ground-level actors. Awareness is also needed on the multi-commodity storage aspect so that cold storages can be more effectively utilised throughout the year.
- Affordable cooling solutions such as solar-based cold rooms are available in the state. Still, the users are reluctant to install and use them due to unskilled labour. In addition, farmers will need to aggregate the demand in order to cost-effectively utilize the cold room. One such example was highlighted by the Bihar Cold Storage Association, where a solar-based cold room (by Cool Crop) was installed and remotely monitored from Gujarat. But the operation and maintenance became a challenge, and the technical issues could not be addressed locally.
- The banking sector lacks involvement in financing cold-chain projects for small-scale farmers. One of the biggest challenges is the lack of support from financial institutions such as NABARD likely based on their understanding that the produce is consumed within the state and may not require cold-chain infrastructure. However, development of cold-chain infrastructure will be vital when the requirement for moving and storing surplus produce will be high. Because of their high moisture content, the horticultural crops are inherently more likely to deteriorate, especially under tropical conditions. Faster evacuation/movement to markets and adequate near market storage of surplus produce will help realise higher prices while selling the produce to consumption centres (distant markets) depending on demand.
- Stakeholders recommended that there is a need to understand the horticulture production, potential market linkages and transportation (both domestic and international) while planning the cold-chain infrastructure in Bihar. Successful case studies from other states such as Maharashtra, Gujarat, Punjab, and Haryana can be replicated in Bihar for better post-harvest management and strengthening the cold-chain infrastructure.

Drawing upon our assessment of the cold-chain infrastructure in the state and the learnings from the stakeholder-interactions, our team has developed a set of recommendations for the advancement of adequate cold chain infra in Bihar, which are presented in Chapter 5.

4 Key Recommendations

Horticulture has turned up as one of the significant agricultural enterprises in the state with the implementation of agriculture road maps. The sector offers small and marginal farmers many opportunities to experiment and diversify. The increasing diversification potentially provides opportunities to farmers for advancing their incomes. Furthermore, the state offers a substantial opportunity for the food processing industry and is expected to play a leading role in the industrialisation drive of this state. With planned interventions and dedicated resources, agriculture can be one of the most significant sources of employment, growth, export and prosperity for the state.

As part of this study—through desktop research, stakeholder engagement and site visits—we have discussed the cold chain landscape in Bihar, identifying key challenges and opportunities in the sector. Based on the observations and learnings in the study, in this chapter, we present recommendations and the critical stakeholders to support the development of suitable cold-chain infrastructure in Bihar.

With the larger goal of building integrated cold-chain infrastructure employing energy-efficient and affordable technologies in Bihar, the emphasis must be on developing and strengthening market linkage and increased income for the farmers.

The table below discusses the recommendations prioritising on creating awareness about cold-chain implementation through demonstration projects in the state, ensuring its sustainability and scalability, devising financing models for the uptake of affordable and more climate-friendly solutions and sensitising the state actors such as government officials, cooperatives and FPOs about post-harvest management and the role of cold-chain. Moreover, the table also suggests strengthening the state agencies to fast-track the approval process needed for cold-chain infrastructure development, which is a long-term intervention.

The roll-out strategy of the recommendations and its implementation will be taken up during the larger project on sustainable cold-chain over the next three years in consultation with central and state-level actors.

Table 10: Challenges, opportunities, recommendations and key stakeholders to develop sustainable cold-chain in Bihar

S. No	Challenges	Opportunities	Recommendations	Implementing Agency
1	<p>Cold chain infrastructure</p> <p>Existing cold-chain infrastructure is fragmented, with cold-chain elements such as reefer vehicles, ripening chambers completely missing.</p>	<p>Develop cold-chain infrastructure based on the state requirement (for local vegetable markets and export purposes), ensuring that produce's nutritional value is maintained till it reaches the consumer</p>	<p>To develop state-level cold chain action plans to build suitable cold-chain infrastructure (focusing on improved handling in the first mile) at the village/taluka/district level, employing energy-efficient and affordable technologies that will facilitate and strengthen market linkages. The infrastructure should be appropriately planned for local mandis and export markets.</p> <p>One key aspect discussed during the stakeholder consultations were on the major districts in Bihar where cold-chain development has/should happen. The stakeholders identified the following districts as potential regions primarily because they are major fruits and vegetables producing regions. They are best suited to establish the cold-chain infrastructure based on needs and market demand.</p> <p>Potential districts for cold chain development- Vaishali, Samastipur, Muzaffarpur, East Champaran, Bhagalpur, Nalanda, Patna, Purnia and Darbhanga</p>	<ul style="list-style-type: none"> • Directorate of Horticulture, Bihar • National Centre for cold-chain Development • Civil Society Organizations
2	<p>Cold store Modernisation</p> <p>Existing cold stores</p>	<p>Mitigate the food loss, avoid</p>	<p>Replace aged refrigeration systems, including</p>	<ul style="list-style-type: none"> • Directorate of Horticulture, Bihar

	present in the state are very old, energy-intensive and, in several cases, non-operational, leading to food and energy loss.	energy loss and design multi-commodity cold storages by retrofitting existing facilities in Bihar	insulation in districts like Vaishali, Nalanda, Patna, Saran, and Samastipur, with more than 30 aged cold stores. Allocate focused funds for modernising existing cold storages.	<ul style="list-style-type: none"> ● Energy Efficiency Services Limited ● FPOs
3	<p>Business models and financing</p> <p>Lack of financing models to uptake innovative and low-cost refrigeration solutions.</p>	<p>Report on DFI Vol 11 has recommended that performance and achievement monitoring systems should not focus only on infrastructure creation and financial expenditure but should focus on throughput, market expansion, etc. That may be implemented for which the state will need to focus on cooling as a service model.</p> <p>Identify business models and financing mechanisms that can support and upscale implementation of energy-efficient technologies in cold-chain development</p>	<p>Act on performance and monitoring matrix, which include market expansion, throughput and mitigating of food loss. This will require promoting service models. Hence, Bihar Government should place a target for subsidising those projects which provide services rather than promoter owned projects for captive use.</p>	<ul style="list-style-type: none"> ● National Cooperative Development Corporation ● NABARD ● Directorate of Horticulture, Bihar ● Industries Department, Bihar
4	<p>Technical know-how</p> <p>Lack of awareness on the technical know-how of designing a cold-chain infrastructure using energy-efficient technology/appliances</p>	<p>Provide evidence-based training and capacity building to consultants, practitioners, and designers to develop energy-efficient cold-chain infrastructure.</p>	<p>To commission lighthouse projects demonstrating the design of energy-efficient cold-chain components such as pack-house, ripening chambers, etc. for both small and large in the identified districts (mentioned in the first recommendation)</p>	<ul style="list-style-type: none"> ● Energy Efficiency Services Limited ● National Cooperative Development Corporation ● Directorate of Horticulture, Bihar

				<ul style="list-style-type: none"> ● Bihar Rural Livelihood Promotion Society ● Vegetable Federation
5	<p>Lack of adequate capacities</p> <p>Minimal emphasis on training causes operating errors leading to shrinkage, wastage, and damage, which occur after energy application, translating into gross energy loss.</p> <p>Lack of appropriate cold-chain infrastructure and awareness amongst FPOs and farmers leads to food loss and associated monetary loss. In addition, this food loss substantially contributes to GHG emissions.</p>	<p>Address the current skill gaps through extensive capacity building and training necessary for professionals, operators and technicians to promote the proper functioning of cold chains</p> <p>Create awareness amongst the government officials, owners of cooperatives, FPOs, about post-harvest management and the role of cold-chain infrastructure in reducing food loss and associated emissions.</p>	<p>To strengthen the state's technical capacity by providing training for machine operators and other skilled professionals who can be employed in operating cold-chain infrastructure.</p> <p>To develop awareness campaigns targeting about cold-chain utilisation and good post-harvest management practices on cold-chain infrastructure development.</p>	<ul style="list-style-type: none"> ● FPOs ● NABARD ● Bihar Agriculture University ● Krishi Vikas Kendras ● Polytechnic and other Academic Students/Agri-professionals/Cold storage and packhouse owners ● Bihar Rural Livelihood Promotion Society
7	<p>Institutional challenges</p> <p>Most departments in the state work in silos; their business-as-usual functioning and complicated procedures have delayed the approvals and implementation of cold-</p>	<p>Improve coordination between departments by developing an adequate mechanism to ensure seamless flow of information and fast-tracking approval of cold chain development.</p>	<p>As a way forward, to explore means to streamline the administrative processes to fast-track the approval process for cold-chain projects</p>	<ul style="list-style-type: none"> ● Directorate of Horticulture, Bihar ● NHB

	chain infrastructure and led to stalling a few projects.			
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In addition to mapping the institutional and policy landscape for cold-chain in Bihar, reviewing the cold-chain infrastructure status and conducting stakeholder consultations with the state government departments, the study also included initiating discussions to quantify GHG emissions from food losses in Bihar. In this context, the team developed a methodology to estimate these emissions, detailed in the Annexure.

Annexure: Greenhouse Gas (GHG) Emissions from Food Loss

Overview of food loss and GHG emissions

Globally, food loss is a widespread issue, posing a challenge to food security, food safety, the economy, and environmental sustainability. Global estimates on food loss indicate it is roughly 30% of all food produced⁵⁶. Food loss represents a wastage of resources, including the land, water, labour, and energy used to produce food. Greenhouse gases are emitted during food production, distribution, and biological decomposition of food. It has a detrimental impact on the environment and plays a significant role in climate change. Food loss also impacts the value chain since it reduces income for food producers, raises costs for consumers, and restricts food security. Hence, food loss reduction could result in significant food security and environmental benefits.

Food losses (FL) refers to a decrease, at all stages of the food chain prior to the consumer level, in mass, of food initially intended for human consumption, regardless of the cause⁵⁷. Food loss occurs in the food supply chain due to improper handling in the post-harvest logistics chain and a lack of cold-chain infrastructure. These failures can arise from the lack of appropriate infrastructure, technology solutions, insufficient skills and knowledge in the supply chain, failures in market connectivity and market linkages, or a combination of these factors. The supply chain stages on which food loss and waste occur is shown in the Figure below.

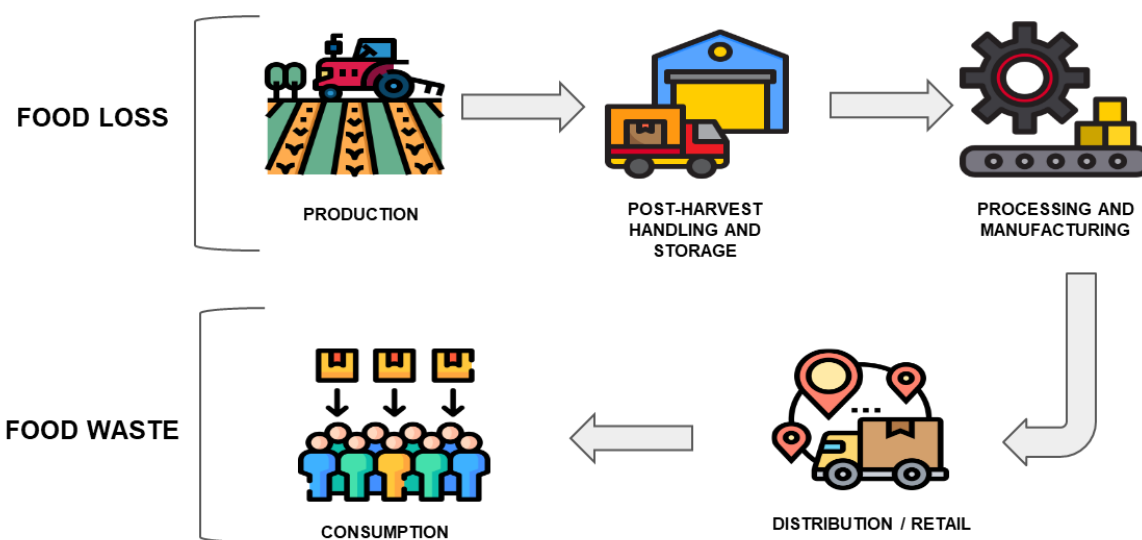


Figure 17: Supply chain stages of food loss and waste⁵⁸

Food loss has a negative influence on the environment as well. Food loss in the supply chain not only contributes to GHG emissions due to biological decomposition, but it also contributes to inefficient resource use because the land, water, and energy (agricultural inputs) used to produce and transport the food. As per FAO, GHG emissions from food loss and waste are estimated to be 3.3 Gigatonnes of

⁵⁶ FAO. 2015. *Food Loss and Waste in the Food Supply Chain*. [online] Available at: <https://www.researchgate.net/profile/Bin-Liu/180/publication/318760768_Food_loss_and_waste_in_the_food_supply_chain/links/597c5e4a458515687b1bca65/Food-loss-and-waste-in-the-food-supply-chain.pdf>

⁵⁷ HLPE, 2014. *Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. [online] Available at: <<https://www.fao.org/3/i3901e/i3901e.pdf>>

⁵⁸ Nikkel, L., Maguire, M., Gooch, M., Bucknell, D., LaPlain, D., Dent, B., Whitehead, P., Felfel, A. 2019. *The Avoidable Crisis of Food Waste: Roadmap; Second Harvest and Value Chain Management International; Ontario, Canada*. [online] Available at: <<https://secondharvest.ca/wp-content/uploads/2019/01/Avoidable-Crisis-of-Food-Waste-The-Roadmap-by-Second-Harvest-and-VCMI.pdf>>

CO₂e⁵⁹. If considered a country, this is the third-largest GHG emitter after the United States and China. If considered a sector, this is the second-largest GHG emitter globally after road transport.

In 2014, FAO's high-level panel of experts evaluated food loss and waste in regions worldwide. It indicates that food loss retains a higher share than food waste in developing and developed regions.

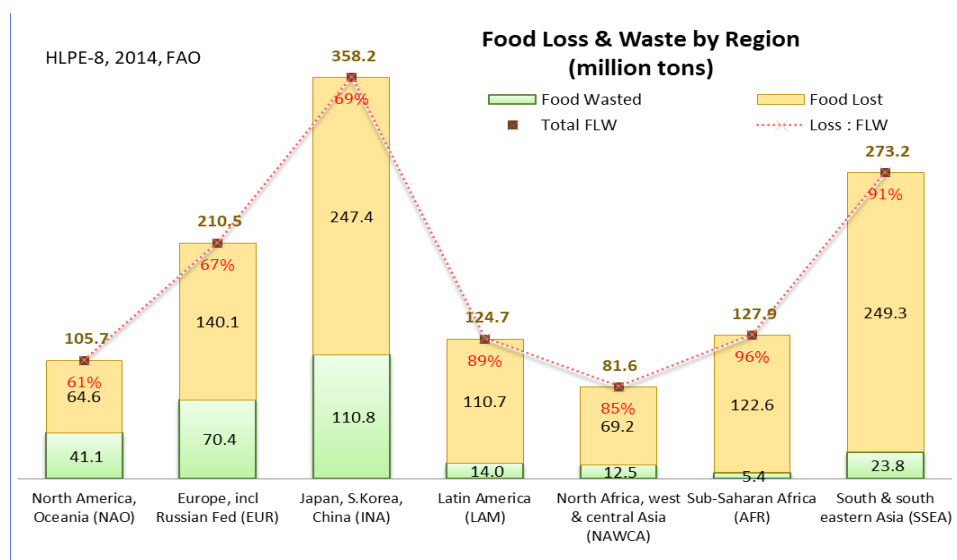


Figure 18: Global food loss and waste by region⁶⁰

In 2017, as per the DFI report, India produced over one billion tonnes of agricultural produce, and current estimates indicate that in 2022 it has risen to over 1.4 billion tonnes, and India is the world's seventh-largest net exporter. The country grows various crops across numerous states, and production is developed in clusters to enhance farm-gate scale economies. India has made an effort to assess its food losses in multiple instances. The one done at the national level was by CIPHET in 2015, which showed a loss of 4.5% to 15.8% in fruits and vegetables. However, another assessment done by SFAC showed losses in the range of 9% to 32%; and yet another study done by NCCD shows losses between 22% to 44%.

Furthermore, the DFI Committee reviewed the unit level information from NSSO 70th round. After comparing the data of production with consumers, it was estimated that losses in the case of fruits and vegetables are 34% and 44.6%, respectively. The DFI report took cognisance of the variance in these reports to suggest that a more comprehensive study on post-harvest food loss under a harmonised yardstick be conducted in all regions of the country.

Table 11: Post-harvest losses of major crops in India (%)

Agriculture Produce	During Transportation	Farm Operations	During storage	Overall Total Loss
Milk	0.02	0.71	0.21	0.92
Meat	0.00	1.99	0.72	2.71
Egg	0.36	4.88	2.31	7.19
Cereals	-	-	-	4.65-5.99
Pulses	-	-	-	6.36-8.41
Oilseeds	-	-	-	3.08-9.96
Fruits and Vegetables	-	-	-	4.58- 15.88

⁵⁹ HLPE, 2014. *Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, [online] Available at: <<https://www.fao.org/3/i3901e/i3901e.pdf>>

⁶⁰ Graphic by Pawanexh Kohli (Former CEO-NCCD), extrapolating on FAO findings

The horticultural crops are inherently more likely to deteriorate, especially under tropical conditions. Moreover, fresh living produce continues to respire, generate heat and hence physiologically deteriorate without a constant source of nutrition. Due to poor post-harvest handling practices in the supply chain, losses during post-harvest operations occur in preconditioning, warehousing, and transportation. Some of the key factors for food loss in India is shown in the Figure below.

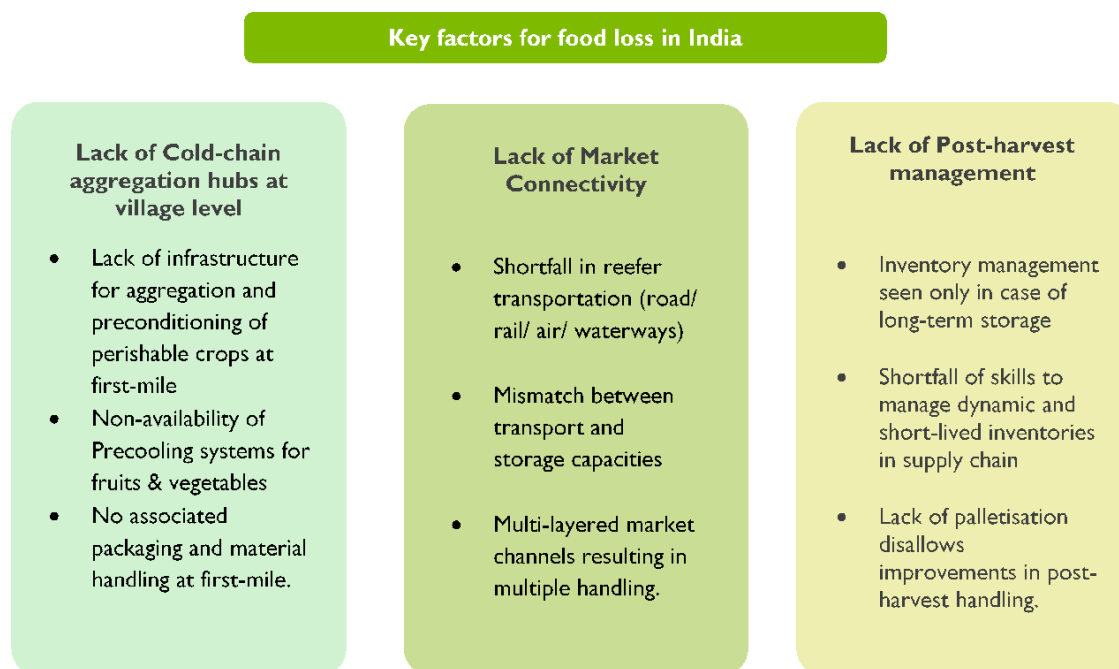


Figure 19: Key factors for food loss in India⁶¹

Bihar, a major fruits and vegetable producer, fails to earn adequate revenue, as there is substantial food loss due to a lack of post-harvest management infrastructure, including cold-chain. It incurs a post-harvest loss of over INR 10,700 crore (1436.82 Million USD) annually in fruits and vegetables (Gujarat ranks second, followed by Bihar, Uttar Pradesh and Maharashtra)⁶². Moreover, 90% of the farmers in the state are marginal/smallholders, holding approximately 57% of the total operational landholdings (out of the total farming land area in Bihar)⁶³. These farmers have low incomes. Additionally, the cost of marketing, excessive deduction by the trader, discomfort in Mandi, low bargaining power, lack of price information, improper weighing practices and delay in sale and payment are the other challenges. These challenges indicate the urgency to streamline the existing horticulture supply chain in Bihar, which may support developing an organised retail market in fresh fruits and vegetables, offering significant opportunities for processing, and value packaging facilities in fruits and vegetables production centres in the state.

⁶¹ Graphic by Pawanexh Kohli (Former CEO-NCCD)

⁶² Hindustan Times. 2013. [online] Available at: <<https://www.hindustantimes.com/patna/post-harvest-bihar-loses-rs-10-700-crore-worth-of-fruits-veggies/story-eslV5Y54i6sXp7lj3tXbiK.html>>

⁶³ Agriculture Census Division Department of Agriculture, Co-Operation & Farmers Welfare, Ministry Of Agriculture & Farmers Welfare Government of India, 2019. All India Report on Number and Area of Operational Holdings. [online] Available at: <https://agcensus.nic.in/document/agcen1516/TI_ac_2015_16.pdf>

Methodology for quantifying GHG emissions

Key parameters: To estimate the GHG emissions from food loss due to lack of first-mile aggregation and organised handling for specific produce groups within a particular region, the following three sets of information will be necessary.

- **Production data:** This parameter will include the total annual production for a product group (such as fruits and vegetables) in the region. The data for the same can be extracted from various sources such as census or economic survey data, government databases and websites, published reports, and research papers.
- **Share of perishable food losses:** The data for this parameter will be taken in percentage that indicates the amount of food loss due to lack of proper handling and good practices. For India, mean figures can be assumed basis analysis of 3 to 4 different reports, namely– CIPHET 2012 & 2015, NCCD 2017 post-harvest report and NSSO data as mentioned in the DFI report.
- **Emission factor:** Secondary literature/data can be referred to as a proxy for the average value of GHG emission factor for a specific region and product category. For example, a study on greenhouse gas emissions from the production of agricultural produce and products in India⁶⁴ estimates that the average emission factor is 5.65 kg CO₂eq per kg for rice, 45.54 kg CO₂eq per kg for mutton meat, 2.4 kg CO₂eq per kg for milk, and <1 kg CO₂eq per kg for fruits and vegetables.

GHG emission from food loss: The total GHG emission from food loss using the above parameters can be estimated using the equation below.

Equation: GHG emission from food loss

$$\text{GHG}_{\text{food loss}} = \text{Total food}_{\text{production}} \times \text{Percentage}_{\text{food loss}} \times \text{GHG}_{\text{emission factor}}$$

Where,

$\text{GHG}_{\text{food loss}}$ = GHG emission from food loss (tCO₂e)

$\text{Total food}_{\text{production}}$ = Total food production for a product in a region (tonnes)

$\text{Percentage}_{\text{food loss}}$ = Mean figures will be assumed from CIPHT -2012, 2015, NCCD, NSSO of food loss for a product in a region (%)

$\text{GHG}_{\text{emission factor}}$ = Emission factor for each commodity type (fruit, vegetable, meat and fish) in kg CO₂eq/kg of food (covering both emissions from production and decomposition of food)

This methodology estimates a high-level GHG emission from food loss in the region. Different parameters, including food loss for every stage, i.e. production, aggregation, transportation, processing, and distribution, may be required to conduct a more detailed analysis. While all these assessments are only post-harvest, various savings of food loss will directly impact mitigating resource use wastage and GHG emissions incurred during the production phase.

Estimation of GHG emissions in Bihar

The key parameters for calculating the GHG emission from food loss in Bihar were identified using the above methodology, including horticulture production data and the percentage of food loss for each produce. The estimation focuses on fruits and vegetables as they account for around 90% of the total share of horticulture production; the other 10% share is from plantation crops, aromatics & medicinal, flowers and spices.

⁶⁴ Vetter, S., Sapkota, T., Hillier, J., Stirling, C., Macdiarmid, J., Aleksandrowicz, L., Green, R., Joy, E., Dangour, A. and Smith, P., 2017. Greenhouse gas emissions from agricultural food production to supply Indian diets: Implications for climate change mitigation. *Agriculture, Ecosystems & Environment*, 237, pp.234-241.

Horticulture production in Bihar⁶⁵: The government of Bihar has been promoting the horticulture sector to help farmers diversify their cropping patterns to include fruits, vegetables, and other plantation crops. It provides farmers with better remuneration as there is a growing demand for high-quality fruits and vegetables in the local, national, and international markets. The production of fruits in Bihar has been increasing at an average growth rate of 4.9%. The total production was around 4.5 million tonnes in 2018-19. The area and production of major fruits grown in Bihar are presented below.

Table 12: Area and Production of Fruits in Bihar (2018-19)

Fruit	Production (thousand MT)
Mango	1577.43
Guava	433.44
Litchi	307.58
Banana	1591.58
Pineapple	111.83
Papaya	47.58
Gooseberry	15.97
Watermelon	36.37
Muskmelon	16.14
Others	373.87
Total	4511.79

The government of Bihar is also providing substantial support through investments in technology, post-harvest management and processing of vegetables in the state. The climatic condition, soil and water resources are suitable to grow various vegetables at affordable prices. The annual vegetable production has been increasing at an annual growth rate of 7.5%. In 2018-19, 16.6 million MT of vegetables were produced in Bihar. Potato accounted for nearly 50% of the total vegetable production. The area and production of major vegetables grown in Bihar are presented below.

Table 13: Area and Production of Vegetables in Bihar (2018-19)

Vegetable	Production (thousand MT)
Potato	8153.91
Onion	1311.45
Tomato	964.45
Cauliflower	1035.69
Cabbage	721.37
Brinjal	1319.87
Lady's finger	841.6
Chilli	488.66
Bottle gourd	679.83
Cucumber	30.19
Pointed gourd	88.92
Bittergourd	94.86
Pea	65.94
Radish	232
Carrot	144.2
Sweet Potato	13.38

⁶⁵ Government of Bihar Finance Department, 2020. *Economic Survey 2019 - 20*. [online] Available at: <<https://state.bihar.gov.in/finance/cache/12/Reports/Economic-Survey-2020-EN.pdf>>.

Others	416.82
Total	16603.14

Produce wise food loss: The post-harvest loss in different fruits and vegetables vary widely because of variation in handling practices during transportation and distribution. The overall loss for major fruits and vegetables based on a national study conducted by ICAR-CIPHET⁶⁶ is shown in the table below.

Table 14: Percentage of overall loss in major fruits

Major fruit	Overall loss
Apple	12.3%
Banana	6.6%
Citrus	6.4%
Grapes	8.3%
Guava	18.1%
Mango	12.7%
Papaya	7.4%
Sapota	5.8%

Table 15: Percentage of overall loss in major vegetables

Major vegetable	Overall loss
Cabbage	6.9%
Cauliflower	6.9%
Green Pea	10.3%
Mushroom	12.5%
Onion	7.5%
Potato	9%
Tamato	13%
Tapico	9.8%

GHG emission analysis in Bihar: The starting point of the analysis, i.e. the horticulture production, was realised using the data published in the economic survey by the government of Bihar. The values of overall loss percentage for different fruits and vegetables were then applied to the total production to obtain the amount of food loss (for fruits and vegetables). The average value of food loss of different fruits and vegetables was assumed for a few produces, where data on produce-wise food loss percentage was limited. The GHG emission from food loss was then calculated using the following emission factor:

- GHG emissions from the production of fruits and vegetables - 1.0 kgCO₂e/kg produce⁶⁷
- GHG emissions from decomposition of fruits and vegetables - 1.5 kgCO₂e/kg produce⁶⁸

⁶⁶ Nanda, S.K. & Vishwakarma, Rajesh & Bathla, H.V.L. & Rai, Anil, 2012. *Harvest and post harvest losses of major crops and livestock produce in India*. [online] Available at: <https://www.mofpi.gov.in/sites/default/files/phl_2010_ciphet_0.pdf>.

⁶⁷ Vetter, S., Sapkota, T., Hillier, J., Stirling, C., Macdiarmid, J., Aleksandrowicz, L., Green, R., Joy, E., Dangour, A. and Smith, P., 2017. Greenhouse gas emissions from agricultural food production to supply Indian diets: Implications for climate change mitigation. *Agriculture, Ecosystems & Environment*, 237, pp.234-241.

⁶⁸ Kohli, P., 2021. *Stop Food Loss to Stop Climate Change*. [online] Available at: <https://www.researchgate.net/publication/341609223_Stop_Food_Loss_To_Stop_Climate_Change>.

This analysis presents the GHG emissions associated with the production and decomposition of primary fruits and vegetables in Bihar. It incorporates variability in emissions due to a range of food loss in different produce. The key results have been tabulated below.

Table 16: Key results of GHG emission from food loss

	Production (million MT)	Amount of food loss (million MT)	GHG emission from food loss (million tCO ₂ e)
Fruits	4.5	0.5 – 0.9	1.2 – 2.3
Vegetables	16.6	1.5 – 3.2	3.7 – 7.9
Total	21.1	2.0 – 4.1	4.9 – 10.2



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INSTITUTIONAL, POLICY AND INFRASTRUCTURE LANDSCAPE

