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A POLICY-ORIENTED ANALYSIS OF PUBLIC-PRIVATE PARTNERSHIPS (PPPS) IN AGRICULTURAL LOGISTICS AND SUPPLY CHAIN DEVELOPMENT

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ABSTRACT
Agricultural logistics and supply chains form the effective support system of modern Agri- product systems. still, inefficiencies in warehouse, transportation, processing and distribution limit productivity, increase losses after crop and lower the farmers income in numerous developing economies. Public-Private Partnerships (PPPs) offer an institutional medium to uplift the infrastructure and service delivery in these disciplines. This paper provides a policy- oriented and relative analysis of PPPs in agrarian logistics and force chains across India, Indonesia, China and Vietnam. It explores the enabling policy environment, models of collaboration, success factors and challenges. The study tries to conclude to the conclusion that logistics transformation can be driven in well- designed PPPs, but inclusive governance, transparent contracting and strong institutional capacity are needed.
Key words: PPPs, Policy, Agri- logistics, Supply-Chain,

INTRODUCTION

Modern agricultural output systems are based on agricultural logistics and supply chains which aim to ensure that agricultural products are move efficiently from farm to market. Inadequate warehousing and transportation infrastructure, as well as substandard processing and distribution networks continue to hinder productivity, as they do in many developing economies. These limitations not only contribute to significant post-harvest losses but also suppress farmers' incomes and constrain broader agricultural development. PPPs have emerged as a strategic institutional mechanism to address these challenges by leveraging private sector efficiency alongside public sector support. Enabling the policy frameworks, collaboration models and common bottlenecks across the countries are tried to examined in this policy- oriented and comparative analysis of PPPs in agricultural logistics and supply chains. This Article try to recommend the respective PPPs with comparative study of global Agri-Logistics and Supply chain with Indian scenario.

REVIEW OF LITERATURE

Various studies have explored different aspects of agricultural logistics in rural areas and e- commerce for Agri-products. Li et al. (2023) demonstrated how E-commerce platforms like Tudouec in Inner Mongolia, China, is potential in premium agricultural supply chains by offering multi-functional services, including technical support, warehousing, and supply chain finance[1]. Nkunda, (2023) During the COVID-19 pandemic, governments played crucial roles in maintaining agricultural logistics by exempting food delivery trucks from restrictions, provided financial support to ensure the movement of agricultural products and introducing technological solutions like robot delivery [2]. Shekhar et al., (2023) identified key barriers to minimizing agricultural product wastage through logistics optimization in India using ISM modeling approaches has revealed obstacles to effective Agri-logistics in India, such as post- harvest waste caused by ineffective management and ineffective distribution mechanisms [3]. Yadav et al., (2022) showcased the integration of Industry 4.0 technologies, including IoT, blockchain, big data, and cloud computing, has emerged as essential for addressing global food demand and safety concerns in agricultural food supply chains. These studies highlight the importance of government involvement, e-commerce integration and addressing logistical barriers to enhance agricultural supply chains and reduce wastage in rural areas.

Zhu et al. (2023) and Bai et al. (2023) highlight the importance of government involvement in cold chain logistics networks for fresh agricultural products, with government subsidies proving essential for system optimization and evolutionary stability. Empirical evidence from Uganda shows that agricultural PPPs generate significant economic benefits for smallholder farmers, with bundled interventions through PPPs increasing productivity, sales volumes, and market access more effectively than single interventions (Aseete et al., 2022). Moreddu (2016)

emphasizes that successful PPPs require common objectives, mutual benefit sharing, and complementary resources, with clear governance structures and transparent processes being critical success factors. The literature consistently shows that collaborative partnerships in agricultural supply chains, particularly those involving government support, create positive outcomes by addressing market failures, improving efficiency, and fostering innovation while benefiting both producers and consumers (Nguyen Thi Nha Trang et al., 2022; Lodhi & Shah, 2024).

OBJECTIVES OF THE STUDY

1. To understand the recent global innovation of Public–Private Partnerships (PPPs) in agricultural logistics and supply chain development.
2. To study the comparative analysis of case-based models in cold-chain logistics and government-subsidy frameworks that enhance efficiency and reduce post-harvest losses.
3. To evaluate the effectiveness of PPPs in improving smallholder farmers' access to inputs, finance and markets through integrated service delivery models.
4. To examine innovation and high-value chain in Agri culture sectors through PPPs models from advanced agricultural economies

RESEARCH METHODOLOGY

This study is exploratory in nature. The secondary sources of data are used for the purpose of the study. The article tries to adopt a qualitative, comparative case-study approach combined with a systematic literature review to analyze public–private partnerships (PPPs) and various policies adopted to uplift the agricultural logistics and supply chains in different states and countries from published articles, books, real time case studies and websites.

ANALYSIS AND INTERPRETATION

Through the literature Review I tried to Review the peer-reviewed journal articles, Government reports, policy related press release and institutional publications preferably from 2020–2025. While analysing the same, some interesting facts and unknown figures were tried to rectify which can be the base for future scope of the research.

Thematic Table of objective and the related key theme of the topic;

To Compare the cited works in this article represented systematically to make sure the relevance of the topic, objectives of the study and the suitable model for the same.

Objective	Key Themes	Supporting Articles	Insights for Analysis	Policy Relevance	Country /Context & methodology
Understand PPP innovations in Agri-logistics	Digital Platforms, E-commerce PPPs, ICT	Li et al. (2023); Moreddu (2016)	ICT enables coordination, PPPs in logistics are increasingly tech-enabled, enhancing transparency and coordination.	Use for digital PPP design Risk sharing principles	China & OECD & Case study Review
Comparative analysis of cold-chain PPPs	Government subsidies, evolutionary game models	Zhu et al. (2023); Bai et al. (2023)	Cold-chain subsidy -Cold-chain PPPs reduce post-harvest losses, but efficiency depends on subsidy models.	Incentive policy-Optimal subsidy reduces loss. Equilibrium depends on gov. role	China & Network model
Evaluate PPPs for smallholders	Access to finance, inputs, and markets	Aseete et al. (2022)	Smallholder inclusion - PPPs improve inclusiveness by linking small farmers with private services and credit.	Inclusion design-Increased farmer income via PPP	Uganda & Field survey
Examine innovations in high-value chains	Policy frameworks, systemic reviews, barriers	Nkunda (2023); Shekhar et al. (2023)	Government role is critical in crisis; barriers like wastage and weak logistics remain.	Gap mapping- 10 major barriers	India & ISM model

The cited studies provide a structured basis for analysing PPPs and agricultural logistics across different perspectives. Li et al. (2023) and Aseete et al. (2022) highlight the impact of digital tools and inclusive PPPs on coordination and farmer income and serving as measurable indicators of partnership effectiveness. Zhu et al. (2023) and Bai et al. (2023) focus on cold-

chain supply systems, demonstrating how government subsidies and regulatory roles influence efficiency and post-harvest loss reduction. Shekhar et al. (2023) identify ten major logistical barriers in India, which can be quantified and mapped to operational gaps. Nkunda (2023) provides a global perspective on PPP resilience during crises, emphasizing contract adaptability, while Moreddu (2016) outlines governance and risk-sharing frameworks applicable for policy evaluation. Collectively, these studies offer variables, models, and key metrics that can be used to systematically assess the relevance, effectiveness, and policy implications of PPP interventions in agricultural supply chains.

National Food Processing Infrastructure Policy Framework (PMKSY & AIF):

Some of the Schemes Initiatives by the Government towards uplifting the Integrated logistics and supply chain. The success ratios differs from place to place and with its core objectives.

Theme	Scheme / Initiative	Implementing Ministry	Launch Year	Objective	Key Instruments
Post-harvest Infrastructure	**Pradhan Mantri Kisan SAMPADA Yojana (PMKSY)**	Ministry of Food Processing Industries (MoFPI)	2016–17	Build integrated supply chain from farm gate to retail	Grants-in-aid, credit-linked subsidy, integrated cold chains
Cold Chain & Value Addition	**Integrated Cold Chain & Value Addition Infrastructure** (under PMKSY)	MoFPI	2017	Minimize post-harvest losses, improve processing levels	Financial assistance to entrepreneurs
Agri Infrastructure Development	**Agriculture Infrastructure Fund (AIF)**	Ministry of Agriculture & Farmers Welfare	July 2020	Medium-to-long term financing for cold storages & warehouses	Interest subvention, credit guarantee
Storage Modernization (Grains)	**Steel Silos via PPP model**	Food Corporation of India (FCI), Ministry of Consumer Affairs	2017–24	Modernize grain storage; reduce wastage	PPP construction mode (Hub & Spoke, Circuit- based)

Source: Tabulated from the data posted in the website and press releases by the MoFPI, MAFW,FCI and MCA, etc.

1. Weak Integration Between Public & Private Players

PPP projects are more urban-centric or underutilized due to complex tendering, policy delays and lack of local awareness. Majority of the Private cold chain investors hesitate due to high operational costs and low assured volume flow from rural areas or from farmers, moreover its less profit motive. 4PL logistics models (end-to-end integrators) are still rare in Agri-startups like DeHaat and Samunnati are pioneers but not widespread in Karnataka.

2. **Cold Chain Infrastructure Gap**

In India the cold storage When compared to Karnataka, Cold chain coverage is available for only 10–15% of horticultural produce, while more than 30% of output is perishable. **676,800 MT** (Approx.6.76 lakh MT). From 2001–2023, the number of units rose from 102 to 250 (Approx.3.97% CAGR), while capacity jumped from 300,000 MT to Approx. 839,000 MT (Approx. 4.57% CAGR). Currently i.e., during 2025 nearly 268 units with 9,10,000 MT capacity primarily government-managed, which is covering the 2.3% share of Indian Cold storage infrastructure mainly focusing on Horticulture commodities but sadly the utilisation rate is 35%.

- **State wise Distribution of Cold Storage Infrastructure (2025)**
- **Purpose:** Establish the regional base for policy analysis.

State	No. of Units	Capacity (MT)	Share (%)	Commodity Focus	Utilisation Rate (%)
Uttar Pradesh	2,488	15.09 M	38.1	Potato	85
West Bengal	517	5.95 M	15.0	Potato/F&V	72
Karnataka	268	0.91 M	2.3	Horticulture	35

Source: NHB & MoFPI state capacity annexures (Jan 2025).

Rank	State	No. of Units	Capacity (LMT / annum)	Share of Total (%)

1	**Maharashtra**	93	72.71	30.1%
2	**Gujarat**	35	20.28	8.4%
3	**Punjab**	61	14.69	6.1%
4	**Karnataka**	35	12.17	5.0%
5	**Uttarakhand**	64	11.61	4.8%
6	**Tamil Nadu**	59	10.6	4.4%
7	**Telangana**	16	9.49	3.9%
8	**Haryana**	30	8.89	3.7%
9	**Uttar Pradesh**	38	16.92	7.0%
10	**Others (26 states + UTs)**	192	64.97	26.6%
TOTAL		**643 units**	**241.33 LMT/annum**	**100 %**

PMKSY-supported cold storage capacity is concentrated in Maharashtra and western states. Southern and hilly states show increasing but smaller-scale adoption.

Cold Chain Infrastructure Gap (with reference to Karnataka)

Metric	Current Status	Ideal Coverage
Number of units	Approx.221–268 units	Evenly spread across districts
Storage capacity	Approx.676,800–839,000 MT	Capacity matched to horticulture output
Distance to nearest cold store	50 km in some areas (e.g., Kolar)	Ideally <15 km
Cold chain utilization (storage)	Approx.10–15% of horticultural produce	>50%, scalable via rural units
Cold chain utilization (transport)	Less than 5% of produce	Target 20–30% via reefer/logistics use

Source: This is based on official cold-storage statistics, parliamentary reports, and recent media sources(2020-2025).
https://www.pib.gov.in/PressReleasePage.aspx?PRID=1658114&utm_source=chatgpt.com

PPP-based cold chain infrastructure examples (e.g., PMKSY, NABARD projects)

Project / Scheme	Location	Capacity	Public–Private Setup
Belgaum Pack-house & Cold Storage	Belgaum	500 t/day	KAPPEC (30%) and private partner
Kolar Multi-Fruit Processing Unit	Kolar	600 t/day	KAPPEC (49%) and private partner
Hubli IQF Unit	Hubli	Approx.600 MT	KAPPEC (26%) and Ken Agritech (74%)
Koppal & Bijapur Cold Stores	Koppal/Bijapur	200–300 MT	KAPPEC and RKVY/APEDA funding
Belagavi Cold Storage	Belagavi	2,240 MT	NABARD RIDF polyfunding via PPP
PMKSY Integrated Cold Chains	Nationwide	Multiple projects	Central subsidy to state- level & private
AIF Loan Scheme	Nationwide	Various capacities	Long-term finance for private/PPP storage

3. Digital Penetration and Platform Access

ReMS and eNAM exist in over 160 markets, but only 20–25% of farmers actively use these platforms. Digital

literacy, internet access, and trust in online transactions remain barriers in Tier 3/4 regions.

PPP Model Comparison for Agri-Logistics
Purpose: Compare structural differences among PPP variants.

Model	Ownership	Investment Source	Risk Allocation	Typical Sector	Strengths	Limitations
Concession	Private	Private + Viability Gap Funding	Private (O&M risk)	Cold storages	Efficient ops	High capital need
Hybrid-Annuity	Mixed	40:60 Public-Private	Shared	Grain Silos	Predictable returns	Slow to finalize
BOOT	Private	Private	Full life-cycle	Warehousing	Long-term viability	High cost
Service Contract	Public	Public	Minimal	Transport	Quick rollout	Low innovation

POLICY EVALUATION & RECOMMENDATION TABLES
Evaluation Metrics for PPP Performance

Dimension	Indicator	Formula / Data Source	Benchmark	Reference
Efficiency	Capacity Utilization (%)	Actual / Installed × 100	> 70%	NABCONS 2020
Inclusiveness	Share of Smallholder Users (%)	Smallholders served / Total users	> 40%	Aseete et al. (2022)
Sustainability	Public ROI	Net Benefit / Public Subsidy	Positive	Bai et al. (2023)
Resilience	Supply continuity index	% uptime during disruption	> 90%	Nkunda (2023)

4. Post-Harvest Loss (PHL) Gap
- Karnataka loses an estimated 20–25% of its horticultural produce post-harvest— primarily due to:
- Lack of on-farm storage/packaging
- Absence of timely logistics
- Inability to delay sales for better prices
- For crops like banana, tomato, sapota, onion, losses can reach 30–40% in value terms if not cooled or sold quickly.

5. Economic Viability and Small Farmer Access
High rental or energy costs for cold storage facilities (₹1.50–₹2.00 per kg per week) are unaffordable for marginal farmers and no cooperative or shared-use models functioning effectively in most areas. Many FPOs lack access to working capital to reserve logistics or storage space during harvest.

FINIDINGS and SUGGESTIONS
1. A common thread across all cases is the importance of aligned incentives between public and private partners, supported by clear policy frameworks and monitoring.
2. Cold-chain PPPs tackle **infrastructure gaps**, smallholder PPPs address **aggregation and inclusion** and horticulture PPPs promote **innovation and competitiveness**.
3. Cold-chain subsidy and infrastructure PPPs (China: Zhu 2023; Bai 2023) ; Analysis shows that government subsidies coupled with performance-based contracts encourage private investment in cold-chain facilities.
In India, where post-harvest losses remain nearly 30–40% in perishables, such PPP models could be adapted with state-level subsidy schemes for first-mile chilling hubs linked to Farmer Producer Organizations (FPOs).
4. **Smallholder aggregation PPPs (Uganda: Aseete 2022)** Evidence shows that bundled PPPs (inputs, credit, extension, and market access) significantly increased farmer incomes and productivity. This demonstrates that PPPs are not only about infrastructure but also about building service ecosystems around farmers. For India, PPPs could be designed to integrate agri-startups, banks, and cooperatives into FPO-centered models
5. **High-value horticulture co-innovation PPPs (Netherlands/OECD models):** Dutch PPPs in horticulture demonstrate the "golden triangle" (government–industry– research) model, fostering innovation, sustainability, and global competitiveness. For India's horticulture clusters (flowers, fruits, vegetables), adopting co-innovation PPPs could improve export readiness, quality standards, and value addition.

4PL Role (Fourth-Party Logistics)

Function	PHL Benefit
Integrated Transport and Storage	Minimisez Delay, maintins produce freshness
Tech-enabled Coordination	Ensures fast, demand-based aggregation
Inventory & Forecasting	Matches harvest timing with cold chain planning
Financing via Collateral	Prevents distress selling and spoilage

PPP Role (Public–Private Partnership)

Function	PHL Benefit
Cold storage facility development	Extends reach to underserved districts
Shared logistics & market yards	Enhances last-mile access for smallholder farmers
Govt. subsidies (e.g., PMKSY)	Makes 4PL models viable at rural scale

LIMITATIONS OF THE STUDY

1. Secondary Data Dependence:.
2. Case Selection Bias:
3. Contextual Transferability:
4. Time Boundaries:
5. Policy Generalization:

CONCLUSION:

Moderation in each segment of Agriculture is needed in Indian agriculture sector and recommendations of the best practices can be adoptable in India for uplifting the Agri sector-based adoption of the best practices followed in Agriculture developed counties. This research is helping identifying the advanced AI and tech enabled solutions to agriculture sectors from various countries which are successfully running in their region. This also gives a comparative assessment and identified the gap in current agriculture sector in India with special reference to Karnataka.

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