

Sustainable Supply Chains for Agri startups in Indian omnichannel market space: Models for Cost, Waste Reduction, & Emissions Management

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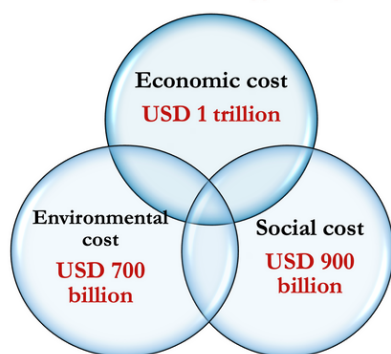


Launched in 2016, Startup India has seen remarkable success, with 182,166 registered startups recognised by the Department for Promotion of Industry and Internal Trade (DPIIT). With the ongoing agri-tech revolution, over 6,000 agriculture startups and 2,800 Agri-Tech startups are now recognised by DPIIT. These startups use technology, precision farming, and data analytics to support smallholder farmers by improving access to markets, finance, and innovations, while also promoting eco-friendly practices.

However, the sector faces major challenges such as food loss and waste, particularly during post-harvest handling. Food losses and waste globally constitute a market failure, costing over US\$1 trillion annually. India alone loses up to US\$14.3 billion annually due to poor post-harvest management, primarily affecting fruits and vegetables. These losses negatively impact the environment, as nearly a quarter of global greenhouse gas emissions stem from lost food in supply chains (United Nations Environment Programme, 2024).

Strengthening supply chain linkages across the multi-echelon network is essential to reduce inefficiencies. An integrated cold chain infrastructure, including refrigerated transport and insulated packaging, is crucial for preserving freshness and reducing waste. However, high costs and low awareness limit technology adoption in India, with an 84% gap in refrigerated vehicle usage. Bridging these gaps is crucial for sustainable agricultural growth in India.

Food loss- The lost opportunity!!



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Several startups, like Ninjakart and Bharat Bazaar, have revived farm-to-form supply chain models to preserve product freshness by reducing the time from harvest to market. However, concerns about fresh food waste and its environmental impacts remain unaddressed. As omnichannel shopping experiences proliferate, startups aim to establish presence in both online and offline retail spaces to enhance customer satisfaction. However, maintaining an omnichannel network poses logistical and transportation challenges, contributing to increased carbon emissions.

Our research proposes a novel mixed integer nonlinear model for a multi-echelon omnichannel fresh food distribution network. The model is designed to optimize freshness preservation and minimize fresh food loss while minimizing carbon emissions associated with transportation. We examine several critical aspects, including the quantity of fresh food transported between echelons, the flow of fresh food, investment decisions regarding freshness-keeping measures, and the corresponding levels of freshness-keeping activities.

Our model incorporates two key parameters: purchase probability and freshness-keeping effort, which account for the perishability of fresh food, transportation time between echelons, and the effort required to maintain quality throughout the network. These interconnected quality parameters enable the model to comprehensively address perishability concerns. Given the intricate and nonlinear nature of the model, the Particle Swarm Optimization (PSO) algorithm is utilized to solve a dataset pertaining to Indian food transportation, specifically originating from Gujarat.

Stakeholders must balance transportation and quality loss costs to achieve better overall cost efficiency. The optimal freshness-keeping effort levels differ at supply chain levels. The first tier prioritizes freshness-keeping due to high purchase probabilities, while downstream routes require higher efforts due to reduced probabilities. Agri startups can optimize freshness-keeping efforts and strike a balance between transportation and quality loss costs when designing a supply chain model. This enhances overall cost efficiency and meets the demands of various channels while maintaining environmental consciousness.



[1] Ms Indira Roy

Research Scholar

[2] Dr Lohithaksha M Maiyar

Assistant Professor

Department of Entrepreneurship and Management