Green Supply Chain Construction Strategies for Agricultural Products in the Guangdong-Hong Kong-Macao Greater Bay Area: A Systematic Approach

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Abstract. The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) is a key economic region in China with strong agricultural production and high product demand. This paper examines strategies for building a green agricultural supply chain in the GBA, integrating logistics, information, and finance. It aims to improve sustainability and efficiency and includes models for supply chain optimization.

Keywords: Green Supply Chain，Guangdong-Hong Kong-Macao Greater Bay Area，Agricultural Products，Construction Strategies

1 Introduction

The GBA, encompassing 11 cities, is vital to China's economy. Its agricultural resources and dense population drive high demand for farm products. Developing a green supply chain here is key to food security, sustainable growth, and economic competitiveness. This study outlines a systematic approach, focusing on logistics, information, and finance.

2 Literature Review

2.1 Green Supply Chain Management in Agriculture

Green supply chain management (GSCM) has gained attention for balancing economic growth and environmental sustainability. Aboelmaged (2020)[1] emphasized digital transformation, including IoT, blockchain, and big data analytics, for real-time monitoring and efficient resource management in agricultural supply chains. Ageron et al. (2022)[2] found digital technologies enhance transparency and reduce waste but noted limited adoption in less developed regions. Ahi and Searcy (2021)[3] highlighted the need for a unified framework, distinguishing GSCM's environmental focus from sustainable supply chain management's broader scope.

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2.2 Limitations of Existing Research

Gaps in GSCM research include: focus on manufacturing/retail over agriculture[4]; limited exploration of logistics, information, and finance integration[5]; and scarce quantitative models for regional economies like the GBA[6].

3 Characteristics of the Agricultural Supply Chain in the GBA

3.1 High Load and Potential

The GBA's large population creates a significant demand for agricultural products, making the supply chain highly loaded and potential-rich. In 2022, Guangdong Province produced 12.91 million tons of grain, 39.99 million tons of vegetables, and 18.96 million tons of fruits, all showing a growing trend.

3.2 Long Chain and Multiple Stakeholders

The agricultural supply chain in the GBA involves multiple stages, including production, processing, transportation, and sales, with numerous stakeholders such as farmers, processors, logistics providers, and retailers (see Table 1 for the detailed logistics network structure).

Table 1. Logistics Network of Agricultural Products Supply Chain in the GBA

Production Bases	Logistics Centers	Demand Points
Guangzhou	Shenzhen Logistics Center	Hong Kong
Foshan	Dongguan Logistics Center	Macau
Dongguan	Zhongshan Logistics Center	Zhuhai

3.3 Diverse Products and High Requirements

The GBA's urban population has diverse demands for agricultural products (refer to Table 2 for the green supply chain strategy framework), ranging from organic rice to specialty animals, which increases the complexity and requirements of the supply chain.

4 Construction Strategies for the Green Supply Chain

Table 2. Framework of Green Supply Chain Construction Strategies

Logistics Channel	Information Channel	Financial Channel
Service + Technology + Layout	Five Forces Collaboration + Four-in-One Model	Inclusive + Safe + Efficient

4.1 Logistics Channel Construction

Service + Technology + Layout: The logistics channel, foundational to the green supply chain, should prioritize service quality, advanced technology, and strategic layout for efficient, eco-friendly agricultural product transportation (see Table 1 for the multi-path logistics network optimization scheme). **Multi-Path, Precision Technology, and Detailed Layout:** Establish a multi-path logistics network using precision technologies (e.g., blockchain, RFID) for traceability and detailed planning to optimize routes and reduce environmental impact.

4.2 Information Channel Construction

Five Forces Collaboration + Four-in-One Model: Design an information channel integrating data from governments, enterprises, agricultural associations, universities, and research institutes for transparent, efficient value exchange (key information flow metrics are summarized in Table 2) .**Information Optimization Management:** Optimize information flow using IoT and big data analytics to enhance accuracy, timeliness, and reduce distortion and the "bullwhip effect."

4.3 Financial Channel Construction

Inclusive + Safe + Efficient: Build an inclusive, safe financial system using fintech to provide efficient services to all stakeholders.**Financial Services Support:** Strengthen financial support for agriculture, guide investment funds to weak supply chain links, and use policies to promote green agriculture.

5 Mathematical Models

5.1 Logistics Optimization Model

- Objective: Minimize the total logistics cost while ensuring timely delivery of agricultural products.

- Model:

$$Minimize\ Z = \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \tag{1}$$

$$Subject\ to:$$
$$\sum_{j=1}^{m} x_{ij} \geq d_i \forall i$$
$$\sum_{i=1}^{n} x_{ij} \leq s_j \forall j$$
$$x_{ij} \geq 0 \forall i, j$$

Where:

cij is the cost of transporting agricultural products from supplier i to demand point *j*.

xij is the amount of agricultural products transported from supplier i to demand point *j*.

di is the demand at demand point *i*.

sj is the supply capacity of supplier *j*.

5.2 Green Supply Chain Cost Model

- Objective: Minimize the total cost of the green supply chain while considering environmental impact.
- Model:

$$Minimize\ Z = \sum_{i=1}^{n} \sum_{j=1}^{m} \quad (c_{ij} x_{ij} + e_{ij} x_{ij}) \tag{2}$$

$$Subject\ to:$$
$$\sum_{j=1}^{m} x_{ij} \geq d_i \forall i$$
$$\sum_{i=1}^{n} x_{ij} \leq s_j \forall j$$
$$x_{ij} \geq 0 \forall i, j$$

Where:

eij is the environmental cost associated with transporting agricultural products from supplier i to demand point j.

5.3 Inventory Management Model

- Objective: Optimize inventory levels to minimize holding costs and reduce waste.
- Model:

$$Minimize\ Z = \sum_{i=1}^{n} h_i\, y_i \tag{3}$$

$$\begin{gathered} Subject\ to: \\ y_i \geq x_{ij} \forall i,j \\ y_i \geq 0 \forall i \end{gathered}$$

Where:

hi is the holding cost per unit of inventory at location i.

yi is the inventory level at location i.

6 Implementation and Case Studies

6.1 Case Studies

Several GBA case studies show the effectiveness of the proposed strategies:

A Guangzhou logistics firm uses blockchain to boost traceability and cut food waste, with smart contracts ensuring real-time recording and verification.An agricultural cooperative has adopted standardised production, enhancing product quality and market competitiveness, and set up a comprehensive logistics network to reduce costs and improve delivery.The GBA's cold chain logistics system, with over 10 million tons capacity and 80% utilisation, maintains optimal temperatures and humidity, reducing spoilage and extending product shelf life.

6.2 Policy Support

Government policies are crucial in advancing green supply chains[7][8]. In the GBA, policies such as subsidies for green technologies and incentives for sustainable practices have been introduced. For example, a green agricultural product certification system has been established, significantly enhancing the quality and safety of agricultural products.

7 Data Analysis

7.1 Market Demand and Supply

The GBA has high agricultural product demand due to its large population. In 2022, demand exceeded 50 million tons, with much of it met by local production. Guangdong Province supplied the majority, producing 12.91 million tons of grain, 39.99 million tons of vegetables, and 18.96 million tons of fruits.

7.2 Logistics Efficiency

Logistics efficiency in the GBA has improved significantly, with advanced technologies and optimized networks. The average logistics cost per ton of agricultural products dropped by 15% over five years, and delivery times were cut by 20%. A comprehensive cold chain logistics system with over 10 million tons capacity and 80% utilization has enhanced the freshness and quality of perishable products.

7.3 Financial Support

Financial support for the GBA's agricultural sector has increased notably (detailed fund allocation data are provided in Table 3). In 2022, green agriculture received USD 500 million, much of which went to technological innovation and infrastructure. Various financial products and services, such as green bonds and agricultural insurance, have boosted financial stability and risk management for agricultural enterprises.

Table 3. Data Analysis of Agricultural Products Supply Chain in the GBA

Market Demand and Supply	Logistics Efficiency	Financial Support
Total Demand in 2022: Over 50 million tons	Logistics Cost Decreased by 15% Over the Past Five Years	Total Financial Support for Green Agriculture in 2022: USD 500 million
	Cold Chain Logistics System Utilization Rate: Over 80%	

8 Conclusion

The construction of a green supply chain for agricultural products in the GBA requires a systematic approach that integrates logistics, information, and financial channels. By implementing the proposed strategies and utilizing the mathematical models presented, the region can enhance the sustainability and efficiency of its agricultural supply chain, contributing to economic development and environmental protection. Future research should focus on further optimizing these strategies and exploring new technologies and models to support the green transformation of the agricultural sector in the GBA.

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