



Research on the Development Paths of Green Logistics for Agricultural Products under Low Carbon Economy

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Abstract. In the context of China's rapidly advancing socio-economic framework, there is a heightened societal emphasis on elevating the standard of living, which has consequently led to a surge in the popularity of environmentally sustainable agricultural produce. As a prominent agricultural nation, China has observed a growing concern across all societal strata regarding food safety, with a particular focus on the domain of green logistics. The current state of green logistics for agricultural products in China is confronted with a multitude of challenges, including a deficiency in awareness, inadequate accessibility, a shortfall in digitalization, and an incomplete management structure. In response to these challenges, this research advocates for a series of pivotal strategies aimed at enhancing the green logistics ecosystem for agricultural products. These strategies encompass the cultivation of a green logistics philosophy, the establishment of specialized green logistics channels, the innovation of an intelligent sorting system tailored for agricultural goods, and the refinement of the overarching logistics management framework. The collective goal of these measures is to diminish carbon emissions associated with the distribution and logistics of agricultural products and to markedly augment the efficiency of their circulation.

Keywords: Low Carbon Economy, Agricultural Products, Green Logistics

1 Introduction

The escalating consciousness regarding the deleterious implications of global warming has firmly established the development of a low-carbon economy as a shared aspiration across the global community in the 21st century. The concept of green logistics for agricultural products is in perfect harmony with the developmental ethos of a low-carbon economy, presenting a novel opportunity amidst the international community's concerted efforts to promote sustainability [1]. The integration of green logistics within the agricultural sector is not only pivotal in ensuring the safety and freshness of products throughout the logistics process but also instrumental in facilitating the adherence to low-carbon developmental requirements within the agricultural sector, thereby laying the foundation for China to fully

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embrace and achieve its set low-carbon objectives. Green logistics in agriculture involves the integration of sustainable logistics principles into the transportation and handling of agricultural products, employing efficient material flow, bolstering the ecological management of both forward and reverse logistics of agricultural goods, minimizing waste generation during the logistics process, and ensuring that waste treatment is both recyclable and harmless, ultimately leading to the effective value addition of agricultural products. The overarching aim is to mitigate environmental pollution, reduce energy consumption, and conserve resources.

2 Analysis of Core Concepts

2.1 Low Carbon Economy

A low-carbon economy represents a transformative approach to economic development, one that is firmly anchored in the principles of sustainability and environmental stewardship [2]. At its core, this economic model seeks to fundamentally restructure the way in which societies produce and consume energy, with a particular emphasis on diminishing dependence on traditional high-carbon energy sources such as coal and oil. The transition away from these carbon-intensive fuels is not merely a gradual shift but a deliberate and strategic reorientation of economic activities towards more sustainable alternatives. The pursuit of a low-carbon economy is driven by the recognition that unchecked carbon emissions can have profound and irreversible impacts on the global climate system, with potentially catastrophic consequences for ecosystems, human health, and economic stability. As such, this development model places a premium on technological and institutional innovations that can accelerate the transition to a more sustainable energy matrix. These innovations encompass a wide array of technologies, from renewable energy sources like solar, wind, and geothermal power to advancements in energy efficiency, smart grid systems, and carbon capture and storage.

As per the latest Green Logistics Development Report released in China for the year 2023, the sector of logistics stands out as a substantial consumer of energy, contributing notably to the release of greenhouse gases. Currently, the carbon footprint generated by the logistics sector in China represents approximately 9% of the country's overall emissions. The report identifies three principal activities within the logistics industry that are responsible for the majority of these emissions: the transportation and distribution of goods, the handling and storage operations, and other ancillary logistics functions. Notably, the transportation and distribution of cargo are the most significant contributors, accounting for roughly 85% of the industry's carbon output. A visual representation of the logistics industry's carbon emissions is depicted in Figure 1.

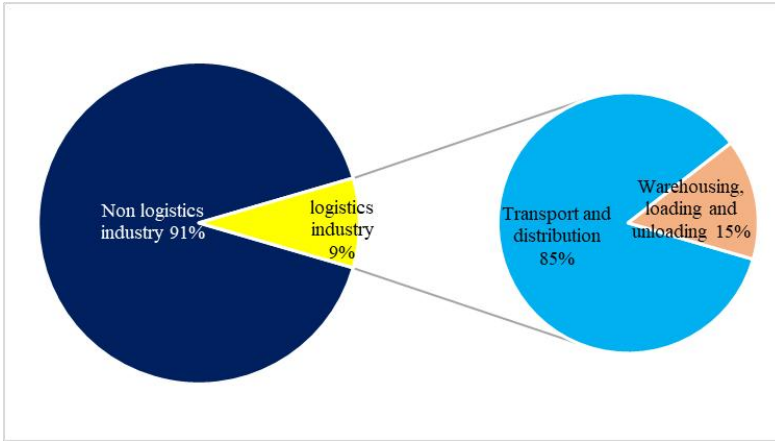


Fig. 1. Carbon emission proportion of the logistics industry in China (figure credit: original)

2.2 Agricultural Products Logistics

The logistics of agricultural products constitutes a specialized segment within the broader logistics industry, encompassing the movement and management of tangible agricultural goods and pertinent information from the point of production to the point of consumption [3]. This process is designed to satisfy consumer demand by safeguarding and enhancing the value of agricultural products through a series of post-harvest logistics stages, including processing, packaging, storage, and distribution, ultimately ensuring that these products reach the end consumer in optimal condition. As a nation with extensive agricultural output and diversity, China's agricultural products are inherently perishable due to their nature, necessitating stringent control over conditions such as temperature and humidity during transportation and distribution. This meticulous management is crucial to minimize product deterioration and loss throughout the supply chain. Indeed, the loss rate for fruits and vegetables in China's distribution process is reportedly five times higher than in Western developed countries, underscoring the imperative to enhance logistics efficiency and reduce waste. Moreover, given the susceptibility of agricultural products to spoilage and contamination, it is imperative to implement stringent controls across both the supply and circulation channels. This involves streamlining the distribution process to ensure prompt delivery and optimizing logistics strategies to minimize loss and safeguard the quality and safety of the agricultural products that ultimately reach consumers [4].

In the year 2023, China's logistics sector witnessed a robust growth, with the total logistics value reaching 352.4 trillion yuan, marking a 5.2% increase from the previous year. Within this context, the logistics of agricultural products alone amounted to 5.3 trillion yuan, reflecting a 4.1% increase from the corresponding period of the prior year and indicating a positive developmental trajectory. The

evolving landscape of China's agricultural product logistics is visually detailed in Figure 2, illustrating the sector's progress and potential for further advancement.

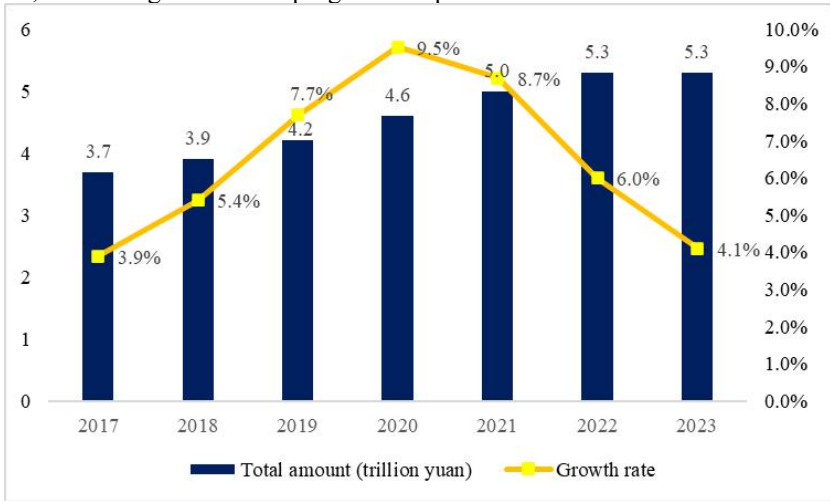


Fig. 2. Current development status of agricultural product logistics in China (figure credit: original)

2.3 Green Logistics

In essence, the concept of green logistics entails a strategic approach to minimizing the environmental footprint of logistics operations. This is achieved by optimizing the utilization of available logistics resources and embracing cutting-edge logistics technologies. Green logistics is not just about damage control; it's about actively enhancing the cleanliness of the logistics environment throughout the supply chain. The purview of green logistics extends to encompassing both the operational and managerial aspects of logistics [5]. On the operational side, it involves the implementation of eco-friendly practices such as green transportation methods, sustainable packaging solutions, and environmentally responsible circulation processing. From a managerial perspective, green logistics is about adopting a holistic approach to logistics systems with the dual objectives of environmental protection and resource conservation at its forefront. This approach takes into account not only the greening of the traditional forward logistics processes but also integrates the concept of reverse logistics, ensuring that the entire supply chain is aligned with sustainability principles. The end goal of green logistics is to foster sustainable development, striking a balance between economic growth, social well-being, and environmental health [6]. By integrating sustainability into every facet of logistics, the aim is to create a logistics ecosystem that is not only efficient and cost-effective but also mindful of its impact on the planet. The overarching vision of green logistics is depicted in Figure 3, illustrating the harmonious integration of economic, social, and environmental considerations in the pursuit of a sustainable future.

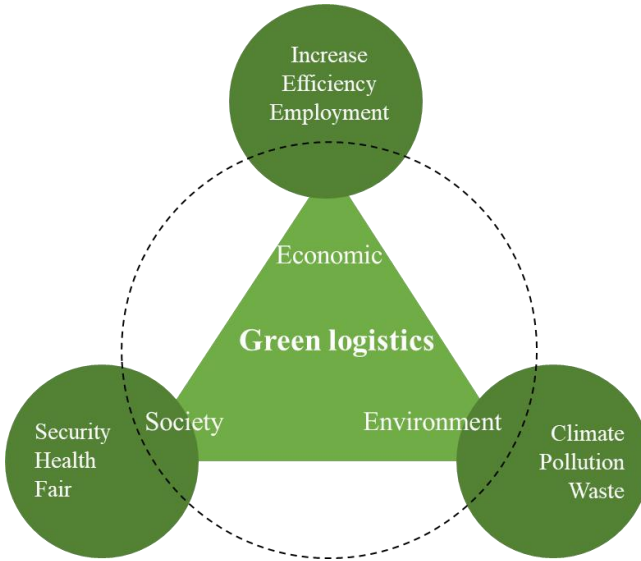


Fig. 3. Three goals of green logistics (figure credit: original)

3 Importance of Developing Green Logistics for Agricultural Products

As one of the largest agricultural producers in the world, with the increase of agricultural exports, in order to ensure the freshness of agricultural products in transportation, the use of preservatives in the transportation of agricultural products, as well as vehicle exhaust, will lead to an increase in carbon dioxide emissions. In order to realize the development mode of low-carbon economy in the logistics distribution of agricultural products, we should actively carry out the green logistics mode in the distribution process of agricultural products, reduce the carbon dioxide produced in the transportation of agricultural products, and lay the foundation for the full implementation of the development mode of low-carbon economy in various fields in China. At the same time, as an important producer and seller of agricultural products in China, farmers should actively respond to the national low-carbon economic development policy, cooperate with logistics enterprises with green logistics capabilities, realize the green ecological management mode of the whole industrial chain from the packaging, transportation, sorting and distribution of agricultural products, and apply modern technology to agricultural products. Promote the regularization, process and standardization of agricultural products in China. Especially in the logistics transportation of agricultural products, the use of preservatives or pesticides should be restricted, and physical means should be used as far as possible to protect the fresh quality of agricultural products [7]. In addition, we should choose clean energy as far as possible in logistics transportation to reduce

carbon dioxide emissions and make due contributions to environmental protection. Therefore, in the field of agricultural products, the construction of green logistics is of great significance for the implementation of low-carbon economic development model.

4 Main Problems of Green Logistics of Agricultural Products

4.1 Lack of Awareness

The lack of awareness of developing green logistics of agricultural products is reflected in the choice of means of transport. In the transportation of agricultural products, traditional fuel vehicles still occupy a dominant position. These vehicles not only emit a lot of harmful gases and pollute the environment, but also cause damage to agricultural products and reduce their quality. In contrast, the use of clean energy or new energy-driven vehicles, such as electric vehicles and solar vehicles, can not only reduce the impact on the environment, but also improve the freshness and quality of agricultural products [8]. However, due to the high cost or technical constraints, many agricultural products transportation enterprises are not aware of this, and still use the traditional way of transportation. Degradable and environmentally friendly packaging materials, such as corn starch packaging and degradable plastics, are not only environmentally friendly, but also can ensure the quality and safety of agricultural products. However, due to cost and technical reasons, many agricultural products transportation enterprises do not realize the importance of environmental protection packaging, and still use traditional plastic packaging.

4.1 Unblocked Channels

The smooth flow of green logistics channels for agricultural products is of great significance to the safety, freshness and quality of agricultural products. However, in reality, due to various reasons, the green logistics channel of agricultural products is not satisfactory. The production sites of agricultural products are often distributed in remote rural areas, with inconvenient transportation and narrow roads, which makes the transportation of agricultural products difficult. Secondly, the traditional mode of transportation of agricultural products uses backward means of transport and equipment, which cannot meet the needs of modern logistics. In some areas, the logistics infrastructure of agricultural products is not perfect, and there is a lack of modern storage and transportation facilities, which makes agricultural products vulnerable to damage and pollution. Information asymmetry is also one of the important reasons why the green logistics of agricultural products is not smooth. The information communication between producers and consumers of agricultural products is not smooth, which leads to the imbalance between supply and demand and affects the circulation efficiency of agricultural products.

4.2 Insufficient Digitalization

The information sharing and coordination mechanism of agricultural products logistics links need to be strengthened. In the traditional mode of agricultural products logistics, the phenomenon of information island is serious, and there is a lack of effective information sharing and communication among various links, which leads to information asymmetry and poor coordination [9]. This not only increases the cost and risk of agricultural products logistics, but also reduces the efficiency and controllability of the whole supply chain. The construction and operation of the digital platform for green logistics of agricultural products are facing certain technical and financial pressures. Building a complete digital platform for green logistics of agricultural products requires a lot of manpower, material and financial resources, and the cost of technology updating and maintenance is also high. This is a big challenge for some small agricultural enterprises and farmers, which requires the participation and support of the government, enterprises and all sectors of society. In addition, the standardization and standardization of green logistics digitalization of agricultural products need to be strengthened urgently. Because the green logistics of agricultural products involves many links and stakeholders, the standards and norms among all parties are not uniform, which leads to difficulties in information exchange and data inconsistency. Therefore, the establishment of unified standards and norms and the formulation of relevant policies, laws and regulations are important guarantees to promote the digitalization of green logistics of agricultural products.

4.3 Imperfect Management System

The imperfection of the green logistics management system of agricultural products is also reflected in the inadequate supervision. Due to the limited strength and technical level of the regulatory authorities, there are blind spots and loopholes in the supervision of the production, processing and transportation of agricultural products, which lead to some illegal elements taking advantage of them, thus bringing certain risks and hidden dangers to the market of agricultural products. At the same time, some illegal elements often use the loopholes of inadequate supervision to carry out jerry-building, tax evasion and other acts, which damage the interests of regular production enterprises and disrupt the market order. There is also a lack of uniform standards and norms in the picking, packaging and transportation of agricultural products, which can easily lead to pollution or damage of agricultural products in the transportation process and reduce the quality and added value of agricultural products. Finally, in the sales and distribution links, due to the lack of standardized management, the circulation efficiency of agricultural products is low, which makes the price of agricultural products fluctuate greatly, and it is difficult for consumers to obtain stable high-quality agricultural products.

5 Development Paths of Green Logistics of Agricultural Products

5.1 Establish the Concept of Green Logistics of Agricultural Products

Low carbon economy can not only save resources and maintain a good environment, but also enable farmers to develop a good habit of green cultivation and practice low-carbon concept in the whole process of production, transportation and sale of agricultural products [10]. We should establish the concept of green logistics of agricultural products is an effective guarantee to promote the development of agricultural products logistics. In this process, we should give full play to the role of the government, increase publicity efforts, so that farmers can timely understand the relevant low-carbon economic policies and respond to the call of the policy, and strive to develop green logistics distribution mode. At the same time, through the improvement of relevant laws and regulations, farmers can further practice the green transportation mode of low-carbon economy. In addition to giving full play to the role of the government, farmers and agricultural products processing enterprises should establish the idea of green logistics. In the process of logistics, we should use big data to screen all kinds of green information and rationally apply it to logistics to realize the value-added services of agricultural products in the process of logistics, including classified packaging value-added services, distribution value-added services, implementation of small packaging value-added services after moderate processing, and transportation value-added services of special agricultural products to promote agricultural products.

5.2 Open up Green Logistics Channels for Agricultural Products

Green channel mainly refers to a kind of channel without declaration or exemption from inspection, which is also called fast channel in different occasions. As far as the logistics development of agricultural products is concerned, the green passage mainly refers to one or several roads specially opened up for the rapid transportation of agricultural products, which can improve the transportation efficiency of agricultural products, reduce the energy consumption of vehicle transportation and reduce the transportation loss of agricultural products on the basis of reducing charges and vehicle obstacles [11]. The role of green passage is particularly important in the case of natural disasters and other special disasters. The traditional logistics mode often has the problems of energy waste and resource waste, and the transportation cost is high, which makes the profit space of farmers squeezed. Green logistics focuses on the conservation and utilization of resources and the improvement of transportation efficiency, which can reduce transportation costs, increase the added value of agricultural products, and ultimately enable farmers to obtain more benefits. Opening the green logistics channel of agricultural products can shorten the time of agricultural products from field to table and ensure the freshness of agricultural products. By establishing an efficient logistics system, agricultural products can be quickly transported to consumers, avoiding the quality decline and loss caused by long-

distance transportation. The construction of green passage needs the joint efforts of local government and social institutions, especially for the main areas of agricultural production-rural areas, not only to improve the basic road construction, but also to pay attention to the construction of green passage, to lay the foundation for improving the development of green logistics of agricultural products, and further promote the development and progress of green logistics of agricultural products.

5.3 Create Intelligent Sorting System for Agricultural Products

In the realm of contemporary agriculture, the advent of intelligent sorting systems marks a significant leap in technological innovation. These systems harness state-of-the-art methods to automate the process of sorting and classifying agricultural produce, thereby enhancing productivity, mitigating labor expenses, and safeguarding the quality of the end products. As agricultural modernization progresses, such intelligent sorting systems are increasingly recognized as indispensable tools essential for the efficient functioning of agricultural production. In the context of China's commitment to a low-carbon economic trajectory, the logistics of agricultural products must evolve to align with contemporary developmental demands. The adoption of progressive scientific and technological solutions is imperative to establish an intelligent sorting system that caters to the diverse distribution requirements of society. Such a system is designed to bolster the precision and efficiency of the distribution of agricultural products. The construction of an intelligent sorting system for agricultural products encompasses a range of components, including conveyance machinery, computer systems, and electrical automation controls. To ensure the system's scientific and rational design, it is imperative to conduct thorough investigations and analyses of the needs of various stakeholder groups and users prior to implementation [12]. This insight informs the refinement of the sorting and packaging procedures for agricultural products, tailored to the volume and nature of orders received. The use of barcode scanning technology facilitates the mechanized sorting of agricultural products, significantly enhancing the accuracy of the sorting process and contributing to the overall efficiency of the logistics chain.

5.4 Improve Logistics Management System of Agricultural Products

Enhancing the sustainability of the logistics framework for agricultural goods involves a multifaceted approach that begins at the source of extraction and extends through the transportation and distribution phases. It is crucial to take a holistic view of the requirements specific to agricultural products when refining the extraction, transportation, and distribution procedures. Initially, managing the energy usage in transportation is paramount. By bolstering the cold chain infrastructure for agricultural items and elevating the caliber of cold chain logistics services, we can significantly curtail the wastage of agricultural produce during transit, thereby bolstering the economic viability of transporting these goods and enhancing the caliber and efficiency of the transportation process. Further, it is imperative to

upgrade the warehousing management system. This encompasses leveraging technology and systemic improvements to achieve more scientific warehousing and inventory management. The deployment of RFID technology and sophisticated information-based warehousing systems can elevate the degree of automated management for agricultural products within the green logistics ecosystem. Lastly, the selection of standardized handling tools is essential. When choosing tools for loading and unloading, it is vital to consider the specific characteristics of agricultural products and the logistics distribution distance. For items prone to collision, anti-collision design should be incorporated. Also, the safety features of cold chain equipment should be taken into account, and where feasible, establishing temperature-controlled packaging centers for agricultural products can be a strategic advantage for logistics companies and regions with the appropriate infrastructure. By packaging agricultural products in a standardized and categorized manner, we can not only enhance the logistics process but also explore additional services that add value, thus propelling the advancement of green logistics for agricultural goods.

6 Conclusions

In the environment of low-carbon economy development, as a large agricultural country, how to achieve low-carbon economy development in the process of agricultural development is an important issue at present. Green logistics of agricultural products, as an effective development mode consistent with the development of low-carbon economy, can effectively realize the standardization, scale, branding, marketization and internationalization of agriculture, realize the industrialization of ecological agriculture, break through international technical barriers to trade, and promote the steady and healthy development of ecological agriculture in China. To achieve the strategic development goal of low-carbon economy in China.

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