SUPPLY CHAIN AND SUSTAINABILITY RESEARCH: SCSR
VOL.3, NO.3; JUL. – SEP. ; 2024, ISSN 2822-0412 (Online)

Global Green Logistics: Challenges and Opportunities in Vietnam's Sustainable Development

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Received: October 18, 2024 / Revised: December 9, 2024 / Accepted: December 12, 2024

Abstract

DOI: 10.14456/scsr.2024.22

The continuous intensification of global climate change makes it imperative for governments and companies to take effective measures to achieve carbon neutrality goals and reduce carbon emissions. As one of the main sources of carbon emissions in the global supply chain, the logistics industry is facing an urgent need for transformation. As a global manufacturing and exporting powerhouse, Vietnam's logistics industry is facing the challenge of high carbon emissions and technological lag while promoting economic growth. This study aims to explore the problems faced by Vietnam's logistics industry in terms of infrastructure, technology application, policy framework and finance, and propose short-term, medium-term and long-term development strategies based on international experience to promote the green transformation of Vietnam's logistics industry. The results of this study show that Vietnam should strengthen infrastructure construction, promote policy and regulatory reforms, raise environmental awareness of enterprises and society, and actively introduce smart logistics technologies and green financial tools to achieve carbon neutrality. Finally, this study provides concrete policy recommendations aimed at assisting the Vietnam government and enterprises to accelerate the sustainable development of the logistics industry.

Keywords: Green Logistics, Carbon Neutrality, Vietnam Logistics Industry, Green Technology, Sustainable Development

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Introduction

Green Logistics - Challenges and Opportunities in Vietnam

The urgency of global climate change and the goal of net-zero emissions

1. Global impacts of climate change According to the United Nations Framework Convention on Climate Change (UNFCCC), the average global temperature has risen by about 1.2 degrees Celsius since the Industrial Revolution. This change has led to frequent extreme weather events such as droughts, floods, and heat waves, which have far-reaching impacts on the global economy and the environment (UNFCCC, 2021). Scientists warn that if the global average temperature rises by more than 2 degrees Celsius, it will trigger an irreversible ecological catastrophe (Ogunbode, 2020). As a result, countries around the world must take more stringent measures to reduce emissions to ensure that temperature rise is kept under control.

2 The development of carbon neutrality policies and the trend of green logistics in various countries Countries have put in place several policies to achieve carbon neutrality to reduce carbon emissions and promote the development of green logistics:

- European Union: The European Union has proposed a "European Green Deal" to achieve carbon neutrality by 2050 and a series of policies for the transport sector to phase out fossil fuel vehicles and support the development of electric and hydrogen vehicle technologies (Gengnagel & Zimmermann, 2022).
- China: China's 14th Five-Year Plan clearly states that it will peak carbon emissions by 2030 and achieve carbon neutrality by 2060. China's logistics industry is actively adopting electric vehicles and intelligent logistics management systems to promote green warehousing technologies to reduce carbon emissions (Wei et al., 2020).
- United States: The United States passed the Clean Energy Act, which commits to net zero emissions by 2050 and increases investment in green infrastructure, especially in electric vehicle infrastructure, to encourage logistics companies to transition to electrification (Zhou & Noonan, 2019).

3. Support from international organizations for the development of green logistics International organizations have played an important role in promoting green logistics:

- United Nations: The United Nations promotes green logistics in global supply chains through the Sustainable Development Goals (SDGs). The United Nations Climate Change Conference (COP) is held annually to promote cooperation between countries in carbon emission reduction, carbon trading and technology transfer (Clark & Wu, 2016).
- World Bank and International Monetary Fund (IMF): The World Bank and IMF support developing countries to build green logistics infrastructure through green financial instruments and funds, and provide technical assistance and financial support to countries such as Vietnam to promote sustainable development (Khan, 2019; Gabor et al.,2019)

Current situation and challenges of Vietnam's logistics industry

1. Vietnam's important position in the global supply chain

Vietnam is a key manufacturing and exporter in the global supply chain, especially in the fields of electronics, textiles and agricultural products. According to Vietnam's government data, the country's annual exports have exceeded $240 billion, with about 70% of its goods relying on the global logistics system to operate. However, as Vietnam continues to integrate into the global market, logistics demand continues to rise, which also brings serious problems of high carbon emissions. Currently, the logistics sector accounts for nearly 20% of Vietnam's total carbon emissions, becoming one of the important challenges for Vietnam to achieve carbon neutrality (Vu, 2019; Le, 2022).

2. The rapid growth and challenges of Vietnam's logistics industry

Vietnam's logistics industry is growing at an annual rate of more than 12%, especially driven by the booming cross-border e-commerce, which has become one of the core drivers of the country's economic growth. However, poor infrastructure and inefficient operating models, especially traffic congestion, make it difficult for Vietnam to cope with the growing demand for green logistics. According to the World Bank, Vietnam's port operations are significantly less efficient than the global average, and cargo clearance takes an average of 2 to 3 days longer than the rest of Southeast Asia, which negatively impacts the operational efficiency of international supply chains. In addition, the dependence of ports and logistics facilities on fossil fuels further exacerbates the problem of carbon emissions (Nguyen et al., 2018; Hansen, 2023).

Research Objectives

This study aims to achieve the following specific objectives:

1. Analyze the role of Vietnam's logistics industry in the global green transition
   - Deeply explore the current situation and development potential of Vietnam's logistics industry in the process of green transformation and analyze the challenges facing the country in terms of infrastructure, technological innovation, policy promotion and financial support.
2. Formulate short-, medium- and long-term green logistics development strategies
   - Propose a specific development path:

   Short-term (1-2 years): Rapid improvement of infrastructure efficiency and promotion of the initial application of green logistics technologies.

   Medium-term (3-5 years): Strengthen the popularization of green technologies and improve the implementation of relevant policies and regulations.

   Long-term (5-10 years): Achieve a nationwide low-carbon logistics network and enhance Vietnam's competitiveness in the global green supply chain.

3. Draw on international successful cases and put forward policy recommendations Analyze successful international green logistics cases, learn lessons from other countries and regions, and provide feasible policy

recommendations for the Vietnam government and enterprises to promote the sustainable development of the logistics industry.

Literature review

As an important strategy to cope with global climate change, green logistics has become a widely discussed topic in academia and industry. According to the report of the United Nations Framework Convention on Climate Change (UNFCCC), the average global temperature has risen by 1.2 degrees Celsius, and extreme weather events are frequent (UNFCCC, 2020). Therefore, countries have promoted carbon neutrality policies, and the logistics industry, as an important part of the global economy, is also facing transformation pressure. The European Green Deal proposed by the European Union emphasizes achieving carbon neutrality by 2050 (European Commission, 2019), while major economies such as China and United States have also introduced policies to promote the development of low-carbon logistics (State Council of China, 2021; U.S. Congress, 2022)

In the practice of green logistics, the upgrading of technology and infrastructure is the key driving force. The literature states that the adoption of intelligent logistics systems and green energy technologies can help reduce carbon emissions (Zhu & Sarkis, 2004). However, many developing countries face challenges in promoting green logistics, such as insufficient funding, technological backwardness, and difficulties in policy implementation (Verma, 2024). As an important manufacturing country in the global supply chain, Vietnam's logistics industry is growing rapidly, but its inefficient infrastructure and dependence on traditional fuels pose challenges to carbon neutrality goals (Nguyen & Le 2020).

At the same time, international organizations such as the World Bank and the International Monetary Fund (IMF) are also actively promoting green finance and technology transfer to support developing countries such as Vietnam in achieving the Sustainable Development Goals (World Bank, 2021). These international assistance is crucial for Vietnam's green logistics transition, with the scholars emphasizing government-business cooperation in formulating policies and drawing on international success stories, such as the experiences of Europe, Japan and other countries, to provide direction for the sustainable development of Vietnam's logistics industry (Pham et al., 2023).

In conclusion, the existing literature shows that countries around the world are facing different degrees of challenges and opportunities in the process of promoting green logistics. Although Vietnam plays an important role in the global supply chain, it still needs international cooperation, technological progress and strong government policies to achieve a low-carbon transition.

Research Methodology

This study uses a combination of literature review and current situation investigation to analyze the green transformation of Vietnam's logistics industry. First, through extensive collection of secondary data related to green

logistics, carbon neutrality policies and global supply chains, the development trends and successful cases of international green logistics were sorted out, and Vietnam's position and challenges in the global supply chain were analyzed. Secondly, in view of the current situation of Vietnam's logistics industry, through policy documents, reports and official data, we understand the current situation of the country in terms of infrastructure, technology application, policy support and capital needs. In addition, this study draws on the green logistics practices of other developing countries, summarizes their successful experiences, and proposes specific short-, medium- and long-term development strategies for the Vietnam government and enterprises to reference.

Results & Discussion

Analysis of survey results: Problems and challenges of green logistics in Vietnam

1. Inadequate infrastructure Challenges of road, port and rail infrastructure:

O There is still room for improvement in Vietnam's road network. Despite the government's heavy investment in infrastructure, traffic congestion and poor road quality persist, resulting in slow logistics and transportation, especially around large cities and ports.

O Case in point: According to the World Bank report, Vietnam's ports are less efficient in handling cargo, with an average loading and unloading time of more than 2 days per 20-foot container, compared to 1.5 days per 20-foot container in other Asian countries (Dappe & Suárez-Alemán, 2016). This not only delays the international movement of goods, but also increases energy consumption and further exacerbates carbon emissions.

The lack of charging infrastructure is limiting the adoption of electric vehicles:

O Although electric vans are seen as one of the main technologies to solve the carbon emission problem of the logistics industry, Vietnam's EV charging infrastructure is severely insufficient, which greatly limits the adoption of electric logistics vehicles. The existing charging stations are mainly concentrated in a few large cities, and the logistics hubs and major transport corridors lack the corresponding infrastructure support.

O Data: According to the Ministry of Industry and Trade of Vietnam, as of 2022, there were only about 500 charging stations in Vietnam, compared to hundreds of thousands of EV charging stations in China and the EU (Le et al., 2022). This means that Vietnam still has a long way to go in terms of infrastructure construction to catch up with global trends.

2. The application of green technologies is lagging behind Difficulties in the application of electric vehicles and clean energy fleets:

O Despite the rapid adoption of electric vehicles worldwide, the use of electric vehicles and clean energy vehicles in Vietnam's logistics industry is still very limited. High purchase costs, insufficient battery life, and a lack of charging infrastructure have led to a low willingness to adopt such technologies.

O Example: According to the statistics of the Ministry of Transport of Vietnam, as of 2023, Vietnam's electric trucks account for less than 1% of the total logistics fleet, compared to more than 20% in EU countries such as Germany (Nguyen et al., 2024).

The penetration rate of smart logistics technology is low:

O Smart logistics technologies, such as the Internet of Things, artificial intelligence and big data, can greatly improve the efficiency of logistics and transportation and reduce energy consumption. However, the awareness and application of these technologies in Vietnam's logistics industry is still low, and many enterprises still rely on traditional manual operations and management methods.

O Data: According to a survey by the Vietnam Chamber of Commerce, less than 15% of logistics companies use smart logistics management systems, compared to more than 50% in the EU and United States (Van Ha, & Giang, 2023).

3. Inadequate policies and regulations Lack of specific carbon reduction policies and incentives:

O Although the Vietnam government has committed to reducing carbon emissions in a number of international agreements, the specific policy framework is still not perfect. Existing environmental regulations are mainly aimed at the manufacturing and energy sectors, while guidance on emissions reductions in the logistics sector is still missing.

O International comparisons: The European Union has introduced the European Green Deal, and the United States has encouraged the development of low-carbon technologies through the Clean Energy Act, which provides clear guidance for companies to reduce emissions (Fetting, 2020).

4. Funding and technical bottlenecks Funding shortfall for SMEs:

O Vietnam's large logistics companies have a certain amount of capital reserves to invest in green technologies, but SMEs often face the problem of insufficient funds. The high cost of technology transition makes it impossible for many SMEs to afford an initial investment in green technology.

O Data: According to a survey by the Vietnam Association for the Promotion of Small and Medium Enterprises, more than 80% of small and medium-sized logistics enterprises said that they were unable to adopt advanced green logistics technologies due to a lack of funds, which led to their disadvantage in the market competition (Chowdhury et al., 2022).

Lack of technology transfer and cooperation platforms:

O Vietnam logistics enterprises lack an effective technology transfer and cooperation platform, and it is difficult to obtain international advanced technology. Many business owners said that although they are aware of the importance of smart logistics and green technology, they are unable to carry out technology upgrades smoothly due to the lack of relevant technical support and cooperation opportunities.

O International experience: China and EU countries have effectively applied advanced electric vehicles and intelligent transportation technologies to the logistics industry through technology transfer cooperation platforms, and have achieved significant emission reduction results (Chen, & Kenney, 2016).

5. Weak social awareness Lack of environmental awareness among the public and businesses:

O In Vietnam, society's awareness of green logistics and sustainable development is still limited. Many logistics companies are still focused on reducing short-term operating costs, with less consideration for long-term environmental benefits.

O Data: According to a survey by the Vietnam Environmental Protection Organization, about 60% of logistics company management lack understanding of carbon neutrality goals, which directly affects the enthusiasm of enterprises in adopting green technologies (Ngo, 2022).

Table 1 Overview of the main issues and challenges of green logistics in Vietnam

Problems and challenges	description	Data/Case
Inadequate infrastructure	Road and traffic congestion affects the speed of logistics.	Port loading and unloading time is more than 2 days.
	Charging facilities are lacking.	Only about 500 charging stations.
Technology adoption lags	Low use of electric vehicles.	Less than 1% are electric vans.
	Smart technology is used sparingly.	Only 15% use smart systems.
The policy is not perfect	There is a lack of policy guidance on emissions reduction.	The EU already has a policy in place.
Funding and technical bottlenecks	Small and medium-sized enterprises are underfunded.	80% of small and medium-sized enterprises cannot transform.
	Lack of technology transfer platforms.	Effective use of technology in China and the EU.
Weak social awareness	Lack of environmental awareness.	60% of management does not understand carbon neutrality.

Short-term strategy (1-2 years): infrastructure and policy framework

1. Promote the establishment of policies and regulations Establish carbon reduction policies and targets:

O Target setting: The Vietnam government should set specific carbon reduction targets based on global trends and domestic demand, such as reducing carbon emissions from the logistics industry by 30% by 2030. This can be achieved through the introduction of a carbon tax and carbon cap system, as well as the development of relevant guidelines.

O International comparisons: The EU's Climate Act provides for a reduction in carbon emissions by at least 55% by 2030 (Bäckstrand, 2022).

Launch of the Low Carbon Transport Act:

O The government should introduce the Low Carbon Transport Law as soon as possible, which will set out mandatory low-carbon measures for the logistics industry, requiring all logistics companies to phase out fuel vehicles and replace them with electric vehicles or other clean energy vehicles in the next 5 to 10 years.

2. Infrastructure construction Investing in green logistics infrastructure:

O Construction of EV charging stations: Vietnam should prioritize the construction of EV charging stations and new energy supply stations in large cities and major logistics hubs to promote the application of electric trucks.

O International comparisons: China has made significant progress in the construction of charging facilities, with the number of charging piles in the country exceeding 1 million by 2023 (Hu et al., 2024).

Promote the energy transformation of logistics warehouses:

O The Vietnam government should encourage logistics companies to retrofit their warehouses and gradually adopt renewable energy sources such as solar and wind power to supply the energy needs of storage facilities.

O Case in point: In Europe, Amazon's green warehouse in Germany uses solar and wind power to provide electricity demand and improve energy efficiency through intelligent management systems (Araujo et al., 2022).

Table 2 Short-term (1-2 years) strategies and infrastructure construction to promote green logistics in Vietnam

Short-term strategy	content
Drive policies and regulations	
Carbon reduction policies and targets	Set a target of reducing carbon emissions by 30% by 2030 and introduce a carbon tax and cap system.
Low-carbon transport law	Mandatory low-carbon measures have been introduced, requiring the phasing out of fuel vehicles and switching to electric or clean energy vehicles.
Infrastructure development	
Green logistics infrastructure	Construction of EV charging stations in major cities and logistics hubs.
Warehouse energy retrofit	Encourage logistics companies to use renewable energy to supply storage facilities.

Medium-term strategy (3-5 years): technology application and regional cooperation

1. Expansion of the application of technology

Full promotion of electric vehicle fleets:

O Among the medium-term goals, Vietnam should fully promote electric trucks and other clean energy vehicles on major logistics routes. The government should develop specific subsidy policies and purchase incentives to incentivize logistics companies to gradually replace old fuel vehicles. This will effectively reduce the carbon emissions of the logistics industry and enhance its international competitiveness.

O Case in point: Companies such as UPS and FedEx in the United States have replaced some of their fleets with electric and hydrogen vehicles and achieved significant emissions reductions. While reducing carbon emissions, these companies have also reduced long-term operating costs through technological innovation.

Digital management of the whole logistics process:

O Logistics companies in Vietnam should fully promote digital management of the entire logistics process, using the Internet of Things, big data and artificial intelligence technologies for transportation monitoring, route optimization and inventory management. This not only improves transport efficiency, reduces empty trucks and energy waste, but also makes the entire logistics chain more transparent and traceable.

O Case Study: In China, JD Logistics has realized the digital management of the entire logistics process, greatly improved distribution efficiency and reducing carbon emissions by more than 30% through intelligent distribution and automated warehousing technology.

2. Construction of regional green logistics hubs Construction and expansion of green logistics hubs:

O The Vietnam government should turn major cities such as Hanoi and Ho Chi Minh City into green logistics hubs, focusing on green warehousing, low-carbon transportation, and renewable energy infrastructure. These green logistics hubs will provide efficient and low-carbon logistics solutions for domestic and foreign logistics companies, enhancing Vietnam's competitiveness in the global supply chain.

O International example: The Port of Rotterdam in the Netherlands has become the world's leading green logistics hub, with logistics facilities operating entirely on renewable energy and the world's most advanced electric van and hydrogen logistics infrastructure, serving as a model for other countries to follow.

Strengthen regulations and supervision

1. Establish a carbon emission supervision mechanism:

O Vietnam should establish a national carbon emission monitoring system to monitor the carbon emissions of logistics companies through data management. The government can use the Internet of Things and big data technology to track each company's carbon emissions data in real time and regularly publish the achievement of emission reduction targets.

O International comparisons: The European Union has established a complete carbon emission regulatory system, allowing companies in various countries to conduct carbon trading according to carbon emission allowances. This not only effectively monitors carbon emissions, but also incentivizes companies to reduce emissions through market mechanisms.

2 Introduction of carbon trading market:

O In Vietnam, the government should gradually introduce a carbon trading system to allow companies to trade carbon allowances, reduce emission reduction costs through market-based means, and achieve a low-

carbon transformation of the logistics industry. This will provide new investment opportunities for Vietnam's logistics industry and accelerate the adoption of green technologies.

Table 3 Medium-term (3-5 years) strategy for the low-carbon transition of Vietnam's logistics industry: technology application and regional cooperation

Policy category	Specifics	Cases/Comparisons
Technology application	Electric vehicle fleet promotion	Promote electric trucks in key logistics routes, and develop subsidies and preferential policies to reduce carbon emissions and improve competitiveness. Case in point: UPS, FedEx have replaced some of their fleets with electric and hydrogen vehicles.
	Digital management	Promote digital logistics management, use the Internet of Things, big data, and artificial intelligence to monitor transportation and optimize routes, and improve efficiency. Case: JD Logistics realizes digital management, improves distribution efficiency, and reduces carbon emissions by 30%.
Regional cooperation	A green logistics hub	Build green logistics hubs such as Hanoi and Ho Chi Minh City, develop green warehousing and renewable energy infrastructure, and enhance competitiveness. Case in point: The Port of Rotterdam becomes a global green logistics hub that relies on renewable energy.
Regulatory Strengthening	Carbon emission regulation	Establish a national carbon emission supervision system, and use data management to monitor carbon emissions. Comparison: The EU has established a carbon emission regulatory system to support carbon trading.
	Carbon trading market	Gradually introduce a carbon trading system to reduce the cost of emission reduction, promote low-carbon transformation, and provide investment opportunities.

Long-term strategy (5-10 years): zero-carbon logistics and global competitiveness

Fully realize zero-carbon logistics

1. Fully zero-carbon logistics system:

O Vietnam should achieve a fully carbon-free logistics system in its long-term goal, with all logistics hubs, warehouses and means of transport achieving zero carbon emissions. The government should enact

mandatory regulations requiring all logistics companies to use electric or hydrogen vehicles, and convert logistics and warehousing facilities to 100% renewable energy.

O Case in point: Amazon has pledged to achieve a company-wide carbon neutrality goal by 2040, and its logistics system has begun to fully adopt electric vehicles and green energy warehousing, and is gradually achieving zero carbon emissions from its logistics operations.

2. Promoting hydrogen energy and advanced logistics technologies:

O Vietnam should actively promote the application of hydrogen energy technology, especially in heavy-duty trucks and long-distance transportation. The government should increase investment in hydrogen infrastructure and work with international partners to develop advanced hydrogen logistics technologies to achieve full decarbonization of the logistics industry.

O International example: The Japan government has vigorously promoted hydrogen logistics technology and cooperated with Germany and Korea on the research and development of hydrogen trucks. Through technical cooperation and investment, these countries have gradually realized the commercial application of hydrogen logistics vehicles.

Enhance Vietnam's competitiveness in the global green logistics market

1. International promotion of green logistics products:

O Vietnam should promote its green logistics products to the global market through international cooperation and market promotion. The government should establish green trade agreements with international trading partners such as the EU, North America and ASEAN, promote the export of low-carbon goods and services, and attract multinational companies to set up their supply chains in Vietnam.

O Case in point: Vietnam can learn from the EU's Green Supply Chain Initiative, which provides incentives for multinational companies to sell green products in the European market, to enhance the international competitiveness of green logistics products through trade agreements and policy support.

Promote international cooperation and technological innovation

1. Deepening international cooperation:

O Vietnam should strengthen cooperation with other countries and regions around the world, participate in the formulation of global logistics standards, and actively promote global green logistics innovation projects. Vietnam can obtain technical support and jointly carry out research and development of green logistics technologies by cooperating with the European Union, United States and Asian countries.

O Examples: For example, the "Green Logistics Technology Alliance" jointly launched by the European Union and Japan focuses on the research of electric vehicles, hydrogen logistics technologies and intelligent logistics systems. Vietnam can participate in such international cooperation and upgrade its logistics technology through technology transfer.

Table 4 Long-term (5-10 years) development strategy of Vietnam's logistics industry: achieving zero-carbon goals and enhancing global competitiveness

tactics	Specific measures
Zero-carbon logistics	- Zero-carbon logistics system: electric and hydrogen vehicles are used, and storage facilities are 100% renewable energy. - Case in point: Amazon plans to be carbon neutral by 2040. - Promoting hydrogen technology: hydrogen applications for heavy-duty trucks and long-distance transportation. - Case study: Japan cooperates with Germany and Korea to promote hydrogen energy technology.
International competitiveness	- International promotion of green logistics products: Establish green trade agreements with trading partners such as the European Union to promote the export of low-carbon products. - Case Study: The European Union's Green Supply Chain Initiative promotes the sale of green products.
International cooperation	- Deepen international cooperation: Participate in the formulation of global logistics standards and promote green logistics innovation projects. - Case study: Collaborative research between the EU and Japan's "Green Logistics Technology Alliance".

Conclusions and Recommendations: The Future of Green Logistics in Vietnam

Looking forward to the opportunities and challenges of the future

As the global demand for reducing carbon emissions becomes more stringent, the green transformation of Vietnam's logistics industry has become an inevitable trend. In the next 10 years, Vietnam will face competitive pressure from domestic and foreign markets, but also huge development opportunities. With infrastructure upgrades, technological innovations, and policy improvements, Vietnam will be able to become an important player in the global green logistics market.

The positive impact of green logistics on Vietnam's economy, society and environment

By promoting green logistics, Vietnam can not only reduce carbon emissions in the logistics industry, but also improve supply chain efficiency, reduce operating costs, and further attract foreign investment and international cooperation. The promotion of green logistics will also create a large number of jobs and improve the living standards of the people, so as to achieve the dual goals of economic growth and environmental protection.

Long-term strategy for sustainable development in the future, Vietnam should continue to maintain a global vision, take green logistics as the core strategy for sustainable development, and gradually realize the comprehensive green transformation of the logistics industry through technological innovation, policy support and international cooperation. This will lay a solid foundation for Vietnam in the global green economy and ensure that Vietnam will maintain a competitive advantage in the international market in the future.

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