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The Impact of Green Logistics on Sustainable Economic Development in Vietnam

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Abstract---*Logistics has long been regarded as a key factor in facilitating the flow of the economic value chain, contributing to the construction and enabling of timely goods delivery and service provision, meeting customer needs and expectations. However, logistics activities have also posed considerable environmental challenges - an issue that has been widely acknowledged and recognized as one of the core obstacles to achieving sustainable development, particularly evident in urban areas. In practice, logistics has made positive contributions to the transportation system, giving rise to the concept of "Green Logistics" which aims to promote environmentally friendly solutions. This article focuses on Green Logistics and the environmental impacts associated with the logistics industry, while analyzing how logistics managers can proactively implement sustainable initiatives by integrating environmental management principles into the decision-making process. Finally, the article will examine the practical situation in Vietnam to highlight that the path toward developing Green Logistics still faces numerous challenges ahead.*
Keywords---*Green Logistics, Sustainable Development, Flexibility, Supply Chain, 3BL (Triple Bottom Line).*

Introduction

Vietnam is widely recognized as one of the fastest-growing economies in Southeast Asia, currently undergoing a demographic transition toward an aging population. The country is endowed with abundant natural resources, a favorable climate, and a strategically advantageous geographic location, all of which position it as a vital hub for international trade. A substantial proportion of Vietnam's foreign direct investment (FDI) originates from developed Asian economies, predominantly allocated toward infrastructure development and physical capital enhancement, both essential foundations for sustained economic growth.

However, economic development has been accompanied by a parallel rise in logistics activities and transportation demand, leading to increasing environmental concerns, particularly related to emissions and pollution. These challenges are especially acute in urban areas characterized by high traffic density. In response, sustainable development and the concept of "green logistics" have gained prominence, highlighting the imperative to align economic expansion with environmental responsibility.

Recent research on sustainable supply chains and green logistics plays a critical role in shaping innovative strategies for logistics operations and broader economic activities. Nevertheless, Vietnamese enterprises continue to encounter considerable barriers in adopting green logistics solutions. These challenges include the need to swiftly adapt to shifting consumer demands, manage shorter product life cycles, handle a broader diversity of products, and coordinate increasingly interdependent supply chain functions. Additionally, global markets are placing greater

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emphasis on environmental accountability, prompting logistics service providers to more rigorously assess the ecological impact of their operations.

This study aims to explore the development and practical implementation of green logistics, offering a conceptual analysis of its core components. Furthermore, it integrates theoretical frameworks with the contemporary Vietnamese context in the evolution of green logistics practices. The following research questions guide the scope of this investigation:

- What are the fundamental pillars of Green Logistics?
- Which factors contribute to sustaining Green Logistics operations?
- What paradoxes exist within Green Logistics in relation to its socio-economic value?
- What are the key dimensions of Green Logistics?
- What is the current status of Green Logistics in Vietnam?

Research Methodology

The concept of green logistics remains relatively novel and underdeveloped, both in scholarly discourse and in practical implementation. Despite its growing relevance in the context of global sustainability efforts and environmentally responsible supply chain management, the field has not yet been systematically or comprehensively explored. As such, developing a robust research methodology in this emerging discipline requires the careful collection, examination, and interpretation of a substantial body of academic literature. Establishing a solid theoretical foundation is essential for advancing meaningful research, and this begins with identifying, retrieving, and analyzing pertinent scholarly works from reputable academic databases.

To this end, a systematic literature review was undertaken to capture and synthesize the current state of knowledge in the field. This review commenced with a strategic search using a set of targeted keywords, including but not limited to “green logistics,” “sustainable supply chain,” and “environmental logistics.” The search aimed to uncover a comprehensive set of studies that reflect both foundational and contemporary developments in the discipline.

The literature review was structured around two core objectives. First, it aimed to consolidate the existing body of research by critically analyzing prevailing models, identifying key thematic trends, and highlighting unresolved or contested issues within the domain of green logistics. Second, it sought to clarify the conceptual frameworks that define the field, as well as to delineate the boundaries and scope of ongoing scholarly inquiry. This dual-purpose approach was instrumental in constructing a coherent and insightful theoretical backdrop against which further research can be effectively positioned.

Conducting a focused and systematic literature review is not only a logical preliminary step but also a necessary one, particularly in a nascent and evolving area such as green logistics. This process plays a critical role in organizing the fragmented insights currently available, thereby contributing to the maturation and intellectual structuring of the field. Moreover, the review facilitates the identification of existing research gaps and underexplored areas, which, in turn, supports the development of well-informed, targeted, and impactful research agendas. Ultimately, the synthesis and systematization of current academic contributions catalyze the advancement of knowledge and the refinement of practical approaches in the sustainable management of logistics and supply chains.

Theoretical Framework of Green Logistics

Aspects of Sustainable Development

Since the term *“sustainability”* first appeared in academic literature over two decades ago, numerous scholars and practitioners have proposed various interpretations and approaches related to the concept. While many definitions converge on the core principle of balancing current development needs with the preservation of future generations' interests, significant differences remain in how sustainability is interpreted, applied, and measured across disciplines and contexts. As Linton et al. note, sustainability has been conceptualized in diverse fields, including engineering, supply chain management, and the social sciences. Carter & Rogers (2008) further highlight that the abundance of definitions in academic literature reflects the inherently multidimensional and complex nature of the concept.

One of the most influential and foundational definitions comes from the *World Commission on Environment and Development* in the *Brundtland Report* (1987), which defines sustainable development as: “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This definition underscores the notion of intergenerational responsibility**,** implying that businesses must not only optimize

for short-term economic gains but also consider natural ecosystems and the long-term welfare of society. Consequently, corporations are expected to go beyond financial performance and integrate environmental and social thinking into their core strategic planning. This perspective has laid the groundwork for the development of practical theories and models to implement sustainability within organizational contexts (Mathur, 2019).

A widely accepted theoretical framework that emerged from this foundational definition is the Three Pillars of Sustainable Development, which emphasizes the integration of economic viability, environmental protection, and social equity. These three interdependent dimensions represent the core of sustainability and are often depicted as overlapping pillars or circles that highlight their interconnectedness (see Figure 1). The strength of sustainable development lies in achieving a balance among these three components, as an overemphasis on one may undermine the others. This framework serves as the theoretical underpinning for various sustainability models, including the Triple Bottom Line and other operational tools used by organizations to evaluate and improve their sustainable performance.

Figure 1. The Three Pillars of Sustainable Development

A pivotal development in operationalizing sustainability in the corporate environment was the introduction of the *Triple Bottom Line* (3BL) concept by John Elkington, later reinforced by Willard (2002), who positioned it as an effective tool for evaluating a company's overall performance based on three primary dimensions: Profit**,** People**,** and Planet. This framework marked a departure from traditional profit-centric models by broadening the scope of corporate accountability to include social and environmental impacts.

In addition to 3BL, alternative frameworks such as the 3Ps (People, Planet, Profit) and 3Es (Economy, Environment, Equity) have also been adopted by researchers and institutions. Although these terms vary in expression, they consistently emphasize the need to balance and integrate economic development, social equity, and environmental protection. Minor terminological differences often reflect contextual priorities; for instance, the term *equity* highlights fairness in access to resources and social justice.

Nevertheless, the quantification and measurement of environmental and social dimensions remain significant challenges. Whereas financial metrics are governed by standardized accounting systems, environmental and social impacts are often qualitative, context-dependent, and influenced by geographic, cultural, and developmental factors. Although frameworks such as the *Global Reporting Initiative (GRI)*, *ISO 14001*, and *SA8000* have improved transparency and standardization, not all companies have the capacity or willingness to implement them.

Despite these obstacles, as Seuring & Muller (2008) point out, an increasing number of firms face mounting pressure to adopt social and environmental initiatives, driven by customers, investors, international organizations, and government bodies. Encouragingly, a growing body of research suggests that engaging in sustainable practices does not necessarily compromise economic performance. On the contrary, it can enhance brand value**,** attract green investments, and expand access to ethically conscious consumer markets.

Economic Aspect of Sustainable Development

The economic dimension represents a foundational pillar of sustainable development, playing a decisive role in determining a firm’s competitive advantage, viability, and long-term growth. While social and environmental aspects are often difficult to quantify and shaped by ethical values or public policy frameworks, the economic component

tends to be more measurable, typically assessed through specific indicators such as profitability, productivity, costs, and return on investment (ROI).

The economic objective in logistics is twofold. On one hand, it involves maximizing the value generated by logistics services, which is reflected in key financial indicators such as revenue, asset utilization, and customer service performance. On the other hand, it focuses on minimizing logistics-related costs through the efficient use of available resources (Greater Vancouver Regional District, 2009). In today's highly competitive global markets, achieving these goals depends not merely on the volume of services provided but increasingly on the quality of those services (Bajdor, 2012; Bansal, 2005). Looking ahead, the traditional benchmark of success is expected to shift, with sustainability emerging as a central criterion for evaluating enterprise performance.

Pagell & Wu (2009), through empirical case studies, explored how sustainability-oriented firms manage such trade-offs. Their findings suggest that sustainable enterprises do not merely seek to balance the three pillars, but rather redesign their operational systems to simultaneously generate value across economic, environmental, and social domains. This indicates that economic sustainability cannot be achieved in isolation but must be embedded within the broader context of socio-environmental interdependencies. A core challenge of sustainable development lies in making strategic trade-offs between competing objectives. For example:

- Reducing logistics costs by optimizing distribution networks may lead to higher emissions from long-distance transportation.
- Enhancing environmental standards in manufacturing can increase capital expenditure but reduce legal risks and strengthen brand reputation in the long run.
- Implementing digital technologies in supply chains improves efficiency and transparency, but demands investment in infrastructure and human capital development.

Lehtonen (2004) argues that although environmental aspects of sustainability have become increasingly prominent in academic discourse, the interlinkages between the economic, social, and environmental dimensions are often underemphasized. This represents a critical weakness in current approaches and explains why many sustainability initiatives fail to deliver a holistic impact. To overcome these barriers, businesses must:

- Adopt comprehensive analytical frameworks that evaluate the multidimensional impact of each decision.
- Utilize integrated performance metrics that reflect the combined outcomes of economic, social, and environmental initiatives.
- Generate shared value for all stakeholders - including investors, consumers, employees, and society at large.

In the context of green logistics, the integration of these three pillars at key operational touchpoints - such as transportation, warehousing, packaging, and distribution - is essential for achieving development that is not only efficient and cost-effective, but also environmentally responsible and socially inclusive.

Green Logistics and Sustainable Economic Development

Logistics represents an integrated approach that encompasses the coordination of information, transportation, inventory management, warehousing, material handling, and packaging, with security being a more recent addition. Among these components, transportation is regarded as the most critical element of logistics services (Islam et al., 2013). It is commonly believed that the core objective of logistics is to maximize profit while minimizing costs throughout the supply chain. This approach is predominantly reflected in financial statements and remains a central focus in the strategic planning of commercial enterprises. However, with increasing attention being paid to environmental issues and sustainable development, the concept of Green Logistics has emerged and gained growing traction in both academic research and practical applications.

Green Logistics extends beyond the traditional cost-centric perspective to encompass environmental, social, and corporate responsibility considerations - dimensions that are not typically captured in conventional financial reporting. According to Rodrigue et al. (2013), Green Logistics involves a set of supply chain management techniques and strategies designed to minimize the energy use and environmental impact of goods distribution activities. This represents a shift from a purely economic objective to a more integrated goal that balances economic, environmental, and social priorities.

Mesjasz-Lech (2011) defines Green Logistics as a process involving environmentally conscious handling of materials, waste management, packaging, and transportation. This implies that each stage of the supply chain - from input to output - is assessed through the lens of sustainability.

Furthermore, Green Logistics encompasses the responsible management of both product and information flows, in both forward (from producer to consumer) and reverse (including product return, recycling, and post-consumer

waste treatment) directions. The aim is not only to meet but potentially exceed customer expectations concerning environmental responsibility.

Sbihi & Eglese (2010) approach Green Logistics from the standpoint of measuring the environmental impact of various distribution strategies. They propose solutions such as reducing energy consumption, minimizing waste generation, and improving waste management efficiency.

According to Fortes (2009), the primary objective of green logistics is to coordinate all activities in the most efficient way possible, ensuring a balance among economic, environmental, and social priorities. Enterprises should aim to maximize the net benefits of economic development while minimizing logistics-related costs and protecting the environment.

In a broader context, Lee & Klassen (2008) view Green Logistics as a component of Green Supply Chain Management (GSCM), which entails the integration of environmental considerations into all decision-making and operational processes across the supply chain. The ultimate goal is to enhance environmental performance not only within individual firms but also across their suppliers and customers, thereby fostering sustainability throughout the entire supply chain ecosystem.

Green logistics can be conceptualized based on the three foundational pillars of sustainable development: economic, social, and environmental dimensions (see Figure 1). Contemporary companies are no longer focused solely on cost optimization in logistics activities such as transportation, warehousing, packaging, material handling, and data management. Instead, there is a growing shift toward evaluating the broader social and environmental impacts of these operations.

As noted by Nowakowska-Grunt (2008), costs in traditional logistics are typically measured in monetary terms. However, with the emergence of the green logistics paradigm, externalities such as pollution, noise, CO_2 emissions, and climate change are increasingly regarded as integral components of total logistics cost structures.

In the modern context, the environment is no longer viewed as an ancillary concern but has become a critical element in pricing strategies and corporate competitiveness. Leading firms are proactively integrating environmental considerations into logistics planning through investments in electric vehicle fleets, efficient transport management systems, emissions-reduction technologies, and recyclable packaging models. These initiatives aim not only to minimize environmental impact but also to foster a positive corporate image among consumers and stakeholders.

Thus, Green Logistics is not merely a strategy for mitigating environmental costs; it serves as a strategic tool for building long-term competitive advantage by achieving balance across the three pillars of sustainable development.

Two primary drivers for companies to "green" their logistics practices have been clearly identified:

- Market pressure and consumer expectations - This is the predominant motivator. Modern consumers increasingly favor environmentally friendly products and expect transparency and sustainability across every stage of the supply chain. Companies failing to meet these expectations risk losing both consumer trust and market share.
- Heightened environmental awareness - Societal pressure, along with increasing scrutiny from governments, non-governmental organizations, and local communities, is compelling businesses to reevaluate their operational practices. Non-compliance may result in legal penalties, environmental taxes, or loss of access to financial and investment incentives.

According to McKinnon et al. (2015), while transitioning to green logistics, companies tend to undervalue the importance of green logistics network design. Instead, what most significantly drives the adoption of green logistics practices is the management of strong, collaborative relationships with key stakeholders**,** including suppliers, customers, environmental organizations, and regulatory authorities. This finding underscores the crucial role of trust and supply chain collaboration in achieving sustainable logistics outcomes.

Conceptual Model of Green Logistics

According to Thiell et al. (2011), the theoretical framework of green logistics extends beyond mere measures to reduce greenhouse gas emissions or energy consumption. Rather, it constitutes an integrated system comprising several core components:

- Waste Management: This focuses on minimizing waste generation during production, transportation, and distribution processes, while maximizing the reuse and recycling of materials.
- Green Transportation: This involves the deployment of environmentally friendly vehicles, such as electric and hybrid trucks, or the use of biofuels, as well as route optimization to reduce fuel consumption.

- Green Warehousing: Refers to the design and operation of warehouses in an energy-efficient manner, leveraging renewable energy sources and optimizing spatial layout to minimize environmental impact.
- Green Packaging: This entails the use of biodegradable, recyclable, or reusable packaging materials, while also optimizing package weight and volume to lower transportation costs and emissions.
- Green Logistics Data Management: The application of information technologies to monitor, measure, and control environmental indicators - such as CO_2 emissions, fuel consumption, and recycling rates - supports the continuous improvement of logistics systems in a sustainable direction.

In contrast, Rogers & Tibben-Lembke (1999) emphasize that the essence of green logistics lies in leveraging advanced technologies and modern equipment to simultaneously minimize environmental harm and optimize resource utilization. This includes tools such as Energy Management Systems (EMS), Internet of Things (IoT) for real-time supply chain tracking, and Artificial Intelligence (AI) for demand forecasting and transport optimization to avoid inefficiencies and waste.

Voigt (2019) further expands this perspective by integrating a crucial element into green logistics - reverse logistics, particularly relevant in the context of managing end-of-life products or returned goods. Reverse logistics includes:

- Collection of used or returned products from end consumers;
- Inspection and classification based on usability (e.g., reusable, repairable, or recyclable);
- Disassembly and separation of reusable components;
- Recycling of raw materials to reintroduce them into the production cycle;
- Redistribution of usable parts back into the supply chain.

These activities not only help reduce waste but also create new economic value from materials traditionally considered waste. Moreover, reverse logistics plays a key role in advancing the circular economy model, which is increasingly being adopted by governments and major corporations around the world.

Table 1
Summary of Green Logistics Components

Component	Description	Key References
Waste Management	Minimizing waste generation throughout the logistics chain; increasing reuse and recycling rates.	Marcus Thiell et al. (2011)
Green Transportation	Utilizing fuel-efficient and environmentally friendly vehicles (e.g., electric vehicles, biofuels); optimizing routing.	Marcus Thiell et al. (2011), Rogers & Tibben-Lembke (1999)
Green Warehousing	Designing energy-efficient warehouses, using renewable energy sources, and reducing emissions.	Marcus Thiell et al. (2011)
Green Packaging	Using recyclable or biodegradable materials, optimizing weight and volume to reduce fuel consumption during transportation.	Marcus Thiell et al. (2011)
Data Collection & Management	Applying digital technologies (e.g., IoT, logistics software) to measure environmental impact and optimize logistics performance.	Marcus Thiell et al. (2011), Rogers & Tibben-Lembke (1999)
Green Technologies & Equipment	Adopting advanced technologies to minimize environmental harm and optimize resource usage.	Rogers & Tibben-Lembke (1999)
Reverse Logistics	Collecting, inspecting, recycling, and reusing end-of-life products; contributing to the circular economy.	Voigt (2019)
Disassembly & Reprocessing	Dismantling components, sorting, and re-manufacturing materials or products.	Voigt (2019)

Source: Compiled by the author based on relevant literature

The Paradigm of Green Logistics

The term "Green Logistics" originates from the convergence of two seemingly contradictory concepts: "green" - symbolizing sustainability and environmental friendliness, and "logistics" - which emphasizes the optimization of

supply chain operations to reduce costs, improve efficiency, and accelerate delivery speed (Rodrigue et al., 2013). While the overarching objective of green logistics is to reconcile economic efficiency with environmental responsibility, in practice, these two goals frequently conflict, resulting in paradoxes that are difficult to resolve.

The paradoxes in green logistics typically manifest across four critical dimensions: cost, time, and availability, distribution network design, and operational reliability. According to Rodrigue et al. (2013), several key barriers hinder the realization of sustainability in logistics and supply chain management. These barriers are systematically below.

Green logistics initiatives, while central to advancing sustainable supply chain management, often embody a range of benefits and inherent contradictions, resulting in several paradoxes that complicate their practical implementation. These paradoxes emerge from the complex trade-offs between economic efficiency, environmental protection, and operational performance.

From a cost perspective, environmentally conscious measures, such as improved packaging design, material reuse, and waste reduction, can yield considerable long-term financial benefits. However, the initial capital investment required to adopt recycled materials, integrate eco-friendly technologies, or reconfigure existing logistics processes is often substantial. This financial burden creates a tension between short-term profitability and long-term environmental responsibility, posing a strategic dilemma for firms operating in competitive markets.

In terms of time efficiency and availability, lean supply chain strategies such as Just-In-Time (JIT) have been widely adopted to reduce inventory costs and ensure prompt deliveries. While these models enhance operational responsiveness, they necessitate frequent transportation and continuous production cycles, which in turn contribute to elevated energy consumption and increased CO_2 emissions - outcomes that run counter to the objectives of green logistics.

With regard to logistics network design, optimization efforts often focus on minimizing delivery distances, improving transit times, and enhancing service reliability. However, these benefits may lead to the geographical concentration of logistics activities in specific urban or industrial zones. This clustering effect imposes localized environmental pressures, including noise pollution, traffic congestion, and deteriorating air quality, thereby transferring the burden from global sustainability to community-level environmental degradation.

In the domain of transportation reliability, maintaining timely and predictable delivery schedules is essential for customer satisfaction and supply chain integrity. Nonetheless, achieving such performance frequently depends on high-emission transport modes, such as trucking and air freight, which are among the most significant contributors to greenhouse gas emissions. Consequently, the pursuit of service reliability can undermine the environmental goals of green logistics initiatives.

Concerning storage strategies, reducing the reliance on private warehousing can streamline operations and reduce fixed overhead costs. However, this approach typically leads to an increase in the frequency of goods movement, placing greater strain on transportation infrastructure and exacerbating issues such as traffic congestion and energy use.

Furthermore, the rapid rise of e-commerce has fundamentally transformed distribution models, enabling expanded market access and multi-channel delivery strategies. While these developments enhance consumer convenience and market penetration, they also intensify the demand for transportation services, particularly through practices such as same-day or next-day delivery. These expedited services often require low-volume, high-frequency shipments, which significantly elevate fuel consumption and carbon emissions.

These paradoxes - adapted from Rodrigue et al. (2013) - illustrate the intricate interplay between efficiency and sustainability in modern logistics systems. While the overarching goal of green logistics is to reconcile the three pillars of sustainable development - economic viability, environmental stewardship, and social equity - its practical realization remains fraught with challenges (Carter & Jennings, 2000). Common obstacles include high implementation costs, limited awareness of long-term benefits, inadequate stakeholder coordination, and organizational inertia.

Moreover, the escalating consumer demand, especially in the digital commerce era, is placing unprecedented pressure on distribution networks to operate at higher intensities and with greater speed. Absent the implementation of effective compensation mechanisms and optimization strategies, this heightened activity risks generating substantial environmental externalities, thereby undermining the very principles that green logistics seeks to uphold. Nevertheless, if firms are able to overcome these challenges through technological innovation, sustainable management strategies, and supply chain collaboration, it becomes entirely feasible to generate both economic and social value while minimizing environmental impact (see Table 2 - Sustainable Value Creation through Green Logistics).

Table 2
Sustainable Value Creation through Green Logistics

Value Dimension	Benefits	Explanation and Examples
Economic Value	- Long-term cost reduction - Increased operational efficiency - Enhanced brand value - Supply chain optimization	Although initial investments in green solutions may be high, companies can achieve long-term cost savings through energy efficiency, reduced product loss, optimized delivery networks, and improved logistics performance. For instance, using electric vehicles for last-mile delivery can reduce fuel costs and qualify for green tax incentives in many countries.
Social Value	- Creation of green jobs - Enhanced community well-being - Improved health and safety - Promotion of corporate responsibility	Green logistics supports ancillary industries such as recycling, renewable energy, and eco-packaging design, thereby generating new employment opportunities. In addition, reduced emissions and pollution levels contribute to better air quality, improved public health, and lower risks of traffic-related accidents.
Environmental Value (Toward Sustainability)	- Reduction in greenhouse gas emissions - Lower resource consumption - Decreased pollution and waste - Conservation of urban and natural ecosystems	The integration of green technologies - such as electric delivery fleets, energy-efficient cold storage, and route optimization software- can significantly reduce the carbon footprint of logistics operations. For example, Amazon has committed to deploying 100,000 electric delivery vans to achieve net-zero emissions by 2040. Companies can play a pivotal role in ecological preservation and in aligning with global environmental agreements.

(Source: Author compiled from documents)

Practical Application in Vietnam

Road Transportation

Road transport currently accounts for a dominant share of greenhouse gas emissions in Vietnam's logistics sector, contributing up to 85% of total CO_2 emissions from transportation activities. Compared to both developing and developed countries, Vietnam's road transport emissions are alarming - not only in absolute volume but also in terms of the rapid growth driven by rising consumer demand and accelerating industrialization.

The root causes of this issue stem from multiple structural and operational factors. First, the transport infrastructure remains fragmented and underdeveloped, failing to meet the growing demands of freight movement. Although Vietnam has made some progress in planning and classifying road systems according to modern standards, the actual length of expressways remains limited, and many key arterial routes - especially those along the North-South and East-West economic corridors, as well as routes connecting remote and coastal areas - are still underfunded and delayed in development.

Second, the efficiency of road transport vehicles is relatively low. A significant portion of the fleet consists of aged vehicles with poor maintenance, which results in excessive fuel consumption and high emissions. Furthermore, the lack of clear technical standards for freight vehicles and inconsistent enforcement of emission controls across provinces have contributed to ineffective emission regulation.

Nevertheless, amid the global trend toward green transition, Vietnam has begun to show positive signs in improving the sustainability of its road transport sector. A notable development is the growing adoption of electric vehicles by consumers and logistics companies alike. VinFast, a domestic manufacturer, has played a leading role by offering electric motorbikes and electric cars that cater to this emerging demand.

A particularly promising initiative is the collaboration between VinFast and Ahamove to launch a freight delivery platform powered by electric motorbikes. This initiative not only aims to reduce emissions in last-mile delivery, but also supports supply chain digitalization and operational efficiency through integrated IT platforms. To further accelerate the green transition in road transport, close coordination between the government, private sector, and civil society is essential. Key strategic measures include:

- Investing in eco-friendly transport infrastructure, such as dedicated lanes and charging stations for electric vehicles;
- Implementing preferential tax policies and incentives for low-emission vehicles;
- Establishing and strictly enforcing technical and emission standards for conventional freight fleets.

The integration of infrastructure upgrades, technological innovation, and policy reform will provide a solid foundation for Vietnam to build a green, efficient, and sustainable road transport system - one that meaningfully contributes to national emission reduction targets and supports a circular, green economy.

Maritime and Inland Waterway Transportation

At present, Tan Cang - Cat Lai Port (Ho Chi Minh City) is the first and only port in Vietnam recognized as a Green Port by the APEC Port Services Network (APSN) Council. This achievement reflects the port's long-term investment in modern infrastructure, along with a sustainability-oriented operational strategy that includes the application of digital technologies, emissions reduction programs, waste management systems, and enhanced operational efficiency through supply chain digitalization.

However, most seaports in Vietnam have yet to meet the necessary criteria for Green Port certification, even though major ports such as Hai Phong Port, Cai Mep-Thi Vai Port, and Da Nang Port are handling significant volumes of cargo. The key limitation lies in the lack of comprehensive green integration. Many ports have implemented digital information systems for operational tracking and management, but have not yet invested sufficiently in other green benchmarks such as emissions control, clean energy adoption, standardized wastewater and solid waste treatment, and marine ecological management.

In addition, the maritime transport infrastructure in Vietnam remains limited, particularly in terms of adopting renewable energy technologies such as wind and solar power or low-emission alternative fuels (e.g., LNG, methanol, hydrogen). Currently, very few vessels in Vietnam's fleet are capable of operating on renewable or low-carbon energy, which undermines the country's ability to leverage the economic advantages of green shipping - an increasingly dominant trend in developed economies.

Furthermore, offshore renewable energy sources such as wind power and floating solar farms are still in the early stages of pilot testing or planning, and have not yet been effectively harnessed to support maritime logistics activities or provide green fuel for vessels. The lack of integration between port systems, fleets, and alternative energy infrastructure presents a major barrier to the development of a sustainable seaport ecosystem in Vietnam. To move closer to the international model of "sustainable seaports", Vietnam needs to:

- Accelerate green technology investment in port operations;
- Upgrade its shipping fleet toward energy efficiency and low emissions;
- Most importantly, develop financial support mechanisms and incentive policies to encourage maritime logistics enterprises to transition to green operational models.

This transformation is not only essential for aligning with global sustainability goals but also for enhancing the competitiveness and long-term resilience of Vietnam's maritime logistics sector in the face of climate and environmental challenges.

Air Transportation

According to the Vietnam Logistics Review (2022), air freight operations in Vietnam contribute significantly to national greenhouse gas emissions, generating an average of approximately 1.5 million tons of CO_2 annually. This figure highlights the intensive fuel consumption and associated environmental impacts of the aviation sector, particularly concerning in the context of global efforts to reduce emissions and promote sustainable development.

Even though over 75% of surveyed enterprises rated the current air transport management system as "relatively effective" or "very effective," empirical data reveals a worrying paradox: only about one-third of air freight vehicles operate efficiently in practice. This reflects a significant disconnect between businesses' subjective perceptions and

the actual performance of air transport operations, underscoring the urgent need for objective performance metrics and more rigorous operational evaluations in the aviation logistics sector.

Moreover, air transport is inherently energy-intensive, particularly during takeoff and landing phases, which contribute disproportionately to total CO_2 emissions. Against this backdrop, the integration of information and communication technologies (ICT) - such as flight path optimization, fuel data management systems, automated scheduling, and real-time aircraft performance monitoring - offers practical solutions to enhance operational efficiency and reduce emissions.

At the same time, there is a pressing need to accelerate research and adoption of sustainable aviation fuels (SAFs) and to implement green logistics management models within the aviation industry. These approaches will be instrumental in achieving a balanced strategy that reconciles the growing demand for air transport with environmental sustainability goals.

Current Status of Green Warehousing

Compared to other Asian countries such as Singapore, South Korea, and Thailand, the warehouse infrastructure in Vietnam's logistics sector remains underdeveloped, both in terms of quality and operational efficiency. A common issue is the unevenness in warehouse floor quality, which increases the risk of damage to goods, especially fragile or perishable items requiring specialized storage conditions. Moreover, the electrical systems in many warehouses are typically limited to basic lighting and minimal air conditioning, lacking integration of advanced energy-saving or intelligent environmental control technologies.

Although there are existing regulations aimed at standardizing warehouses following environmentally friendly and sustainable management criteria, many warehouse owners, contractors, and logistics enterprises cite limited investment capital as the primary barrier to upgrading current facilities. This funding gap continues to hinder Vietnam's ability to compete with more advanced logistics hubs in the region.

According to data from the Vietnam Ministry of Industry and Trade (2022), approximately 65% of logistics companies have not adopted renewable energy solutions in their warehouse operations. This not only increases long-term operational costs but also significantly weakens environmental performance, at a time when green logistics is becoming a global standard. Furthermore, the technical and managerial workforce in warehouse operations remains limited, reducing the capacity of businesses to effectively implement and benefit from smart technologies.

In addition, warehouse productivity in Vietnam is far from being optimized. Unexpected costs incurred during storage and handling continue to be a financial burden, negatively impacting the overall efficiency of the supply chain. These inefficiencies are largely due to a lack of automation in key warehousing processes, leading to repeated manual tasks that consume unnecessary time and labor.

Another critical issue is the lack of integration between distribution centers, container depots, and customer information systems or other supply chain stakeholders. This disconnection results in insufficient real-time tracking of goods, complicating inventory management, order fulfillment, and supply chain transparency.

In the context of global logistics shifting rapidly toward digitalization, automation, and sustainability, upgrading Vietnam's warehouse systems, in terms of infrastructure, technology, and management, is a strategic imperative. Doing so is essential not only for enhancing competitiveness but also for ensuring long-term sustainable development within the national logistics industry.

Current Status of Green Packaging

Currently, the majority of packaging used in Vietnam's supply chain and logistics operations is made from conventional plastic materials such as polyethylene (PE) and polypropylene (PP). These materials are favored due to their light weight, durability, moisture resistance, and particularly, their low production cost and ease of mass manufacturing. However, these very advantages pose a significant environmental challenge, as PE and PP are not readily biodegradable in natural conditions. Their persistence contributes to the growing volume of plastic waste in soil and water environments, with adverse effects on marine ecosystems and human health.

In contrast, eco-friendly alternatives - including biodegradable, recycled, or organically sourced materials - are being researched and gradually introduced into practice. Nevertheless, their widespread adoption remains limited due to higher production costs, lower product preservation capabilities compared to traditional plastics, and logistical drawbacks related to reduced durability during storage and transportation.

According to the Vietnam Ministry of Industry and Trade (2023), encouraging shifts have been observed in both corporate awareness and behavior related to sustainable packaging. Notably, over 42% of surveyed enterprises have begun adopting eco-friendly packaging options such as paper-based containers, fabric bags, or materials derived

from sugarcane fiber, starch, and polylactic acid (PLA). This trend reflects positive momentum in the transition toward green logistics models, aligning with modern supply chain sustainability standards.

Furthermore, 41% of enterprises now outsource their packaging waste treatment to specialized service providers in compliance with environmental regulations. This strategy not only reduces operational burdens but also highlights the critical role of supporting logistics services, including waste sorting, collection, and standardized processing, as key enablers of a circular economy.

However, a significant gap persists between large corporations and small-to-medium-sized enterprises (SMEs) in adopting sustainable packaging practices. To address this disparity, it is imperative to implement supportive policies, including financial incentives, technical assistance, and tax relief schemes, from both governmental bodies and international organizations. These measures will be crucial for scaling up the adoption of ecological packaging solutions and embedding long-term sustainability into Vietnam's logistics infrastructure.

Conclusion

According to Norman & MacDonald (2004), a sustainable organization is defined as a business that actively contributes to sustainable development by simultaneously creating economic, social, and environmental value - commonly referred to as the Triple Bottom Line (3BL). Within this context, green logistics emerges as a concept closely linked to sustainability, as it not only optimizes transportation activities but also helps reduce environmental pollution, mitigate traffic congestion, improve quality of life, and lower the incidence of health issues related to air pollution. The authors proposed a conceptual framework consisting of five foundational pillars that form the basis of green logistics:

- Green transportation
- Green warehousing
- Green packaging
- Green logistics data collection and management
- Waste management

Among these, waste management plays a central role from an environmental perspective, encompassing activities such as recycling, remanufacturing, reuse, and material recovery - all aimed at fostering a more circular and efficient logistics system. A key principle emphasized is that products with longer lifespans help alleviate environmental pressure by reducing the consumption of new resources and limiting waste generation.

Information and communication technologies (ICT) have become a crucial enabler of green logistics, supporting waste reduction and enhancing operational efficiency throughout the supply chain. Technologies such as automatic identification (Auto-ID), route optimization software, global positioning systems (GPS), and mobile communication platforms (e.g., GSM, GPRS) have facilitated the development of intelligent logistics processes, allowing enterprises to lower operational costs while using existing resources more efficiently.

However, the study also acknowledges certain limitations. As it primarily relies on a synthesis of previous literature, there is insufficient empirical evidence to validate the proposed theoretical assumptions. Therefore, empirical studies or case-based research are essential to test and demonstrate the practical applicability of green logistics concepts within real-world business operations. Such research would enhance both the practical relevance and credibility of the sustainable development models discussed.

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