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Green Logistics and Strategies for Reducing Carbon Footprints: Global Trends and the Turkish Perspective

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ABSTRACT

This study investigates green logistics and strategies for reducing the carbon footprint within the Turkish context, highlighting the current state of sustainability practices in the logistics sector. Using an exploratory research approach, the sustainability reports of logistics companies operating both nationally and internationally in Turkiye were analyzed. The findings indicate that strategies such as deploying electric and low-emission vehicles, implementing intermodal transportation, investing in renewable energy, adopting the circular economy approach, leveraging digitalization, and optimizing routes play a crucial role in minimizing environmental impacts while enhancing operational efficiency and reducing costs. The results demonstrate that public policies, sector collaborations, technological investments, and comprehensive carbon accounting must develop simultaneously for the logistics sector to meet its carbon reduction goals.

Keywords: Green logistics, Carbon footprint, Logistics sector, Turkiye, Sustainability

Yeşil Lojistik ve Karbon Ayak İzi Azaltma Stratejileri: Küresel Eğilimler ve Türkiye Perspektifi

ÖZ

Bu çalışma, yeşil lojistik ve karbon ayak izi azaltma stratejilerini Türkiye bağlamında inceleyerek lojistik sektöründe sürdürülebilirlik uygulamalarının güncel durumunu ortaya koymaktadır. Keşifsel araştırma yöntemi kullanılarak Türkiye'nin ulusal ve uluslararası alanda faaliyet gösteren lojistik firmalarının sürdürülebilirlik raporları değerlendirilmiştir. Bulgular, elektrikli ve düşük emisyonlu araç kullanımı, intermodal taşımacılık, yenilenebilir enerji yatırımları, döngüsel ekonomi yaklaşımı, dijitalleşme ve rota optimizasyonu gibi stratejilerin hem çevresel etkileri azaltmada hem de operasyonel verimlilik ve maliyet avantajı sağlamada kritik rol oynadığını göstermektedir. Sonuçlar, lojistik sektörünün karbon azaltım hedeflerine ulaşabilmesi için kamu politikaları, sektörel işbirlikleri, teknoloji yatırımları ve bütüncül karbon muhasebesinin eşzamanlı ilerlemesi gerektiğini ortaya koymaktadır.

Anahtar Kelimeler: Yeşil lojistik, Karbon ayak izi, Lojistik sektörü, Türkiye, Sürdürülebilirlik

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1. INTRODUCTION

Interest in green strategies within the logistics sector has been increasing among both academics and industry professionals, driven by factors such as global warming, environmental degradation, and governmental policies. Similar to other areas of economic activity, the logistics sector is being evaluated within the framework of sustainability goals, with environmentally friendly approaches gaining prominence (Akbal, 2022). Global warming and environmental degradation have reduced greenhouse gas emissions to a strategic imperative, particularly in the logistics industry. It is estimated that logistics activities account for approximately 24% of global greenhouse gas emissions. Moreover, according to data from the International Energy Agency, carbon dioxide emissions from transportation—the core activity of logistics—have increased by nearly 65% over the past 31 years (Kamacı, 2024). In this context, green logistics has emerged as a paradigm aimed at minimizing negative environmental impacts and reducing the carbon footprint. It is also regarded as an effort to establish a sustainable balance among environmental, economic, and social objectives (Bardakçı, 2022; Jou et al., 2024).

The carbon footprint—defined as the total amount of carbon dioxide (CO_2) emitted directly and indirectly into the atmosphere over the lifecycle of a product or organization (Wiedmann & Minx, 2008)—has become a priority target for policymakers and businesses alike amid growing climate change and environmental concerns. Green logistics supports environmental sustainability by optimizing business processes to minimize these carbon emissions. Measuring the carbon footprint plays a critical role in assessing the effectiveness of green logistics practices and is regarded as a key indicator for ensuring sustainability in the logistics sector. In this process, logistics companies have been compelled to develop strategies that prioritize not only cost efficiency and speed but also environmental sustainability. Accordingly, businesses are utilizing technological innovations and implementing strategies such as route optimization, fuel efficiency measures, transitioning to electric or hybrid vehicles, and improving recycling and waste management systems. These practices not only reduce carbon emissions but also enhance firms' environmental performance and strengthen their corporate social responsibility. Furthermore, the transparency and measurability of green logistics practices improve the accuracy of environmental reporting and encourage stakeholder participation. From a social perspective, environmental awareness training for employees and social responsibility initiatives help embed green logistics into corporate culture and play a crucial role in increasing the societal acceptance of sustainability goals (Krejza et al., 2019; Yurtkuran, 2021).

This study adopts a holistic approach to both the theoretical framework in the literature and real-world practices. It first examines the concept of green logistics in the context of global trends and developments and then explains strategies for reducing the carbon footprint. In the application section, sustainability reports of leading logistics companies in Turkiye are analyzed to evaluate green logistics strategies and case studies. The findings are presented along with concrete recommendations for policymakers, academics, and industry representatives.

The research problem explores the effectiveness of current green logistics practices in improving firms' environmental performance, how carbon footprint reduction strategies are shaped, and to what extent Turkish logistics companies align with the green logistics trends of international logistics firms. Within this scope, the article aims to contribute to the academic literature and provide practical roadmaps for policymakers and industry professionals through a critical examination of the challenges faced in green logistics practices and the opportunities created by new technologies.

2. CONCEPTUAL FRAMEWORK

2.1. Green Logistics and Global Trends

Emission levels are directly linked to the carbon emissions of vehicles used in logistics operations. Given that transportation activities relying heavily on fossil fuels alone account for approximately 23% of global carbon dioxide emissions, it can be concluded that the logistics sector significantly contributes to environmental pollution and, consequently, climate change (Kamacı, 2024; Sayın, 2022). Carbon dioxide emissions are projected to increase by one-third by 2050, which places growing pressure on the logistics sector

to improve its carbon management structure (Jou et al., 2024). Within this context, green logistics represents a holistic approach designed to reduce the environmental impacts of logistics processes. The concept is defined as supply chain management strategies that minimize the carbon footprint of activities focusing on material handling, waste management, warehousing, packaging, and transportation (Nguyen & Nguyen, 2020). Green logistics encompasses a comprehensive set of activities such as assessing the environmental impact of different distribution strategies, reducing energy consumption in logistics operations, minimizing waste and managing it effectively, as well as implementing reverse logistics for product returns and recycling (de Paula Alvarenga et al., 2018).

The intensifying global sustainability pressures are increasing the importance of green logistics. Growing interest in sustainability among key stakeholders—governments, consumers, and investors—has led to the adoption of stricter environmental standards and policies, thereby making the regulatory environment more complex. These developments have positioned green logistics not only as a tool for reducing environmental impacts but also as a critical mechanism for achieving sustainable development goals, supporting industrial modernization, and accelerating economic transformation (Chatzoudes et al., 2024). While traditional logistics prioritized performance and often relegated environmental sustainability to a secondary role, green logistics integrates the environmental, social, and economic dimensions of logistics systems by balancing economy and ecology. Modern green logistics involves environmentally friendly strategies such as using low-emission or alternative-fuel vehicles, optimizing transport routes, and applying advanced technologies to increase operational efficiency. This approach aims to address environmental problems without compromising organizational performance or economic growth, thus maximizing revenue and asset utilization while minimizing the environmental footprint (Jefimovaitė & Vienažindienė, 2025; Jou et al., 2024).

Green logistics has undergone a three-phase development process over the last three decades: an emergence period from 1993 to 2003, a slow-growth period from 2004 to 2014, and a period of rapid development since 2015. Recently, the logistics sector has assumed a pioneering role in the implementation of green technologies and sustainability strategies; green logistics is increasingly defined as the technological processes and the efficient management of resource and energy flows aimed at reducing environmental and economic harm. Current trends are concentrated in three main areas: developing models and management approaches that support sustainable development, addressing environmental and social threats, and optimizing vehicle routing and scheduling for low-carbon logistics. Much of the existing research focuses on the contributions of green logistics initiatives to the "triple bottom line"—social, environmental, and economic performance—and particularly emphasizes carbon emissions, energy consumption, social sustainability, and cost-benefit analyses of externalities (Hasanspahić et al., 2021; Ma & Kim, 2023).

However, current levels of technological implementation appear insufficient to meet climate targets, making it necessary to accelerate transformation within the sector. It is argued that significant short-term emission reductions can be achieved through increased collaboration across the supply chain, more effective use of excess capacity in different transport modes, and integrated flow management. Furthermore, in line with 2050 sustainability and carbon neutrality targets, substantial opportunities are emerging for innovative applications in electric and autonomous vehicles, alternative fuels, and logistics optimization (Đuric & Viskovic, 2024). Green logistics practices are shaped through operational strategies (route optimization, fleet electrification, use of alternative fuels, intermodal transport), technological innovations (IoT-based tracking systems, AI-assisted planning, energy-efficient warehouses), and managerial processes (GRI/TCFD reporting, independent verification, supply chain collaboration). Green logistics encompasses all processes related to green transportation, green warehousing, green packaging, green circulation, and green reverse logistics. Its primary objective is to prevent environmental harm from logistics activities, contribute to environmental remediation, and optimize the use of logistics resources. This holistic approach underpins sustainable transformation in the logistics sector.

2.2. Carbon Footprint

A carbon footprint is a measure of the total greenhouse gas emissions generated over the lifecycle of a product, process, service, or activity, expressed in equivalent tons of carbon dioxide per unit (Grachev, 2019). In brief, it represents the cumulative value of direct and indirect carbon dioxide emissions caused by a product or activity (Wiedmann & Minx, 2007). The concept derives from the broader notion of the "ecological footprint" developed by Wackernagel and Rees in the 1990s. However, as concerns about climate change have intensified, the carbon footprint has emerged as an independent indicator and a fundamental tool for environmental sustainability assessments (Altın, 2024; Dada, 2021).

Measuring and calculating a carbon footprint is typically performed using Life Cycle Assessment (LCA) or input-output analysis methodologies, in compliance with international standards such as ISO 14040, ISO 14064, and ISO 14067. At the corporate level, the carbon footprint is classified under Scope 1, Scope 2, and Scope 3 categories in accordance with the Greenhouse Gas Protocol (Gandola & Asdrubali, 2024). Scope 1 covers direct emissions from sources owned or controlled by an organization, such as the combustion of fossil fuels, company vehicles, or on-site production processes. Scope 2 includes indirect emissions from the generation of purchased electricity, steam, heating, or cooling consumed by the organization. Scope 3 is the broadest category, encompassing all other indirect emissions across the organization's value chain—from suppliers to customers—including business travel, logistics activities, product use, and end-of-life waste treatment. These scope distinctions enable organizations to prepare more transparent greenhouse gas inventories and develop more effective carbon management strategies (G.G. Protocol, 2011; Wiedmann & Minx, 2008).

The carbon footprint serves as an assessment tool for measuring environmental impacts and identifying emission sources to support the development of mitigation strategies. Reducing the carbon footprint offers not only environmental benefits but also economic advantages such as cost savings, risk mitigation, and enhanced return on investment. It also facilitates compliance with climate agreements like the Kyoto Protocol. By allowing comparisons of climate-sensitive impacts of individuals, products, businesses, and governments, the concept contributes to informed decision-making for sustainable development (Altın, 2024; Fantozzi & Bartocci, 2016).

3. CARBON FOOTPRINT REDUCTION STRATEGIES

According to the Council of Supply Chain Management Professionals, 75% of a company's carbon footprint originates from logistics activities. Furthermore, disruptions in logistics operations can increase supply chain carbon emissions by approximately 20% (Amiruddin et al., 2021; Turgut & Budak, 2022). As a result, the sector is under considerable pressure to achieve energy savings and reduce emissions, with sustainability efforts closely monitored by both researchers and governments. To address carbon emission issues, companies set emission-reduction targets and conduct greener operational processes using environmentally friendly vehicles and machinery (Ghosh et al., 2020; Ma et al., 2018; Senir & Büyükkeklik, 2023).

3.1. Transportation and Modal Optimization

Effective management of transport modes plays a critical role in reducing the carbon footprint. Compared to single-mode road transport, the use of multimodal systems integrating different transport types can reduce costs by about 20% while cutting CO_2 emissions by up to 57% (Fang et al., 2020). Additionally, route optimization and vehicle planning based on real-time tracking and data analytics can lower energy consumption by up to 20% and reduce carbon emissions by approximately 100 kg (Kalwar, 2024). Another key strategy for reducing transport-related emissions is the reduction of fossil fuel use. Integrating electric, hydrogen fuel cell, and biofuel-powered vehicles into fleets stands out as an innovative solution accelerating the transition to low-carbon logistics (Etukudoh et al., 2024).

3.2. Supply Chain and Distribution Practices

Supply chain management and distribution strategies play a vital role in reducing the carbon footprint. Practices such as minimizing handling, shortening transport distances, reducing empty returns, choosing direct routes, and using warehouse space more efficiently form the basis of sustainable distribution strategies. Collaborating with third-party logistics providers that have environmental expertise and high sustainability capacity also contributes to minimizing negative environmental impacts. Moreover, logistics network optimization is a critical element. Strategic design and facility siting of storage and distribution centers can reduce transport distances and shipment frequency, lowering both costs and carbon emissions (Esfahbodi et al., 2016).

3.3. Packaging and Materials Management

Replacing conventional plastic and cardboard packaging with biodegradable or recyclable materials reduces environmental pollution and promotes resource recovery. Additionally, reverse logistics and closed-loop systems encompassing product recovery, reuse, and recycling lower waste disposal costs while contributing to minimizing environmental impacts (Wang, 2024).

3.4. Technology and Digital Solutions

Transitioning to renewable energy sources constitutes one of the most effective technological strategies for reducing the carbon footprint. Organizations are increasingly replacing fossil fuel dependency with renewable sources such as solar, wind, and hydroelectric power, and investing in on-site renewable energy generation—such as rooftop solar panels—to reduce reliance on grid electricity (Odeyemi et al., 2024). Within the integration of Information and Communication Technologies (ICT), the Internet of Things (IoT), GPS-based systems, route tracking, and fuel consumption sensors enable more effective management of transportation activities. Digital technologies and data analytics optimize vehicle planning and operations, thereby increasing efficiency and contributing to emission reductions. In addition, the use of hybrid engine technologies in transport fleets and the adoption of energy-efficient storage practices are among the innovative applications supporting environmental sustainability in the logistics sector. Industry 4.0 technologies contribute to reducing the carbon footprint by increasing energy efficiency, minimizing waste, and optimizing production (Kalwar, 2024; Wang et al., 2024; Yurtay, 2025).

3.5. Measurement and Management Approaches

Effective management of the carbon footprint requires comprehensive assessments across the entire supply chain to identify reduction opportunities and monitor progress regularly (Wang et al., 2024). At the regional level, analyses based on the spatial distribution of energy use and carbon emissions contribute to reducing efficiency gaps between regions and establishing a more balanced logistics network. However, the success of sustainable transformation in the logistics sector depends not only on the individual efforts of firms but also on collaboration among suppliers, customers, and public institutions. Such stakeholder engagement paves the way for the dissemination of best practices within the logistics network and the development of green policies (Olaleye et al., 2024).

4. TECHNOLOGY AND INNOVATION IN GREEN LOGISTICS

The integration of digital technologies into green logistics creates a strong synergy by enhancing both environmental and operational performance. Technologies such as the Internet of Things (IoT), GPS systems, and sensors enable real-time monitoring and optimization of vehicle routes, fuel consumption, and logistics processes. This digital transformation offers sustainability advantages such as reducing the carbon footprint, optimizing transport routes and delivery times, lowering costs, and minimizing waste (Kalwar, 2024). Artificial intelligence has also become a critical enabler for sustainable urban logistics. AI-based applications facilitate alignment with global sustainability goals by reducing unnecessary fuel consumption and improving energy efficiency. The implementation of low-emission urban freight corridors in several European cities—where environmentally friendly delivery options such as electric vehicles and cargo bikes are prioritized—demonstrates the practical impact of this approach. These systems integrate models that optimize the carbon

footprint, track fuel consumption through predictive modeling, and continuously improve delivery strategies over time through cybernetic feedback loops (Fatorachian et al., 2025).

Enterprise Resource Planning (ERP) systems are increasingly being integrated with carbon footprint management and energy efficiency strategies alongside Industry 4.0 technologies. While these systems provide real-time monitoring, predictive analytics, and opportunities for cross-sector collaboration, they also present challenges such as high initial costs, the complexity of data integration, and gaps in regulatory frameworks (Yurtay, 2025). Infrastructure innovation focuses on integrating green technologies across logistics, construction, and energy systems by developing low-carbon multimodal transport hubs. These facilities promote clean energy use, reduce reliance on fossil fuels, and facilitate cross-sector collaboration through government support and resource sharing. Advanced logistics facilities can achieve significant environmental benefits by reducing total energy consumption by up to 23% through passive energy efficiency measures such as natural daylighting. Furthermore, the integration of solar panels and battery storage systems can reduce carbon emissions by up to 56%, creating comprehensive feasibility for sustainable logistics practices (Yasir et al., 2024).

The digitalization of logistics processes is triggering a sector-wide transformation by facilitating the emergence of new industries and business models focused on sustainable development through new technologies, equipment, and transport methods. However, implementation challenges persist, as poor-quality logistics infrastructure and service levels can increase fossil fuel consumption, leading to adverse effects on both human health and the environment.

5. ECONOMIC IMPACTS OF GREEN LOGISTICS

Green logistics practices provide significant economic returns to companies in addition to their environmental benefits. The adoption of transportation management systems can support green supply chain activities and yield savings of 5–40% in shipping costs. Specific optimization strategies make these economic benefits measurable: for instance, route optimization can reduce energy consumption by 20% while cutting carbon emissions by approximately 100 kg, demonstrating how green logistics projects improve both environmental protection and economic performance (Li & Cao, 2024).

The financial advantages of green logistics stem from operational improvements such as reduced energy consumption, minimized packaging and container use, lower greenhouse gas emissions, and enhanced waste management. Energy-focused initiatives offer particularly high returns. For example, systematic measures such as harnessing natural daylight can cut total energy use by up to 23%, while active technologies like solar panels and battery storage systems both generate operational cost savings and create new market opportunities (Yasir et al., 2024).

Research has shown a direct link between the environmental and cost performance of sustainable distribution practices. Green packaging solutions reduce waste and CO_2 emissions and, although requiring initial technology investment, increase profitability over the long term (Esfahbodi et al., 2016). Similarly, lighter and recyclable materials in packaging lower packaging weight and material costs, boosting cost efficiency and operational productivity. These initiatives also strengthen brand image and competitiveness among environmentally conscious consumers, creating market differentiation that supports premium pricing strategies (Wang, 2024).

6. IMPLEMENTATION CHALLENGES IN GREEN LOGISTICS

Although green logistics is a proven approach with environmental and economic benefits, various obstacles in the implementation process limit the success of this transformation. One of the most significant challenges is high initial costs. The adoption of advanced technologies—such as ERP systems integrated with carbon footprint management and energy efficiency strategies—requires substantial upfront investment, posing a heavy financial burden, particularly for small-scale logistics companies. In addition, data integration complexity is another major barrier. Real-time monitoring, predictive analytics, and cross-sector collaboration necessitate sophisticated data management infrastructure and competencies. The lack of such capacity in many

firms hampers emissions tracking and optimization within supply chains, making existing technological gaps more visible (Yurtay, 2025).

The insufficiency of standardized regulatory policies also creates uncertainty during implementation. The absence of clear policies to support green logistics initiatives makes it difficult for companies to develop long-term strategies and justify investments to stakeholders. Furthermore, top management support, employee training, and corporate culture play decisive roles in the success of sustainability projects. Green logistics, therefore, requires not only technological investments but also deep cultural transformations in organizational structures and operational processes (Jayvardhan & Kaustubh, 2024).

Infrastructure shortcomings emerge as a major constraint, especially in developing countries. Current levels of technological adoption fall short of meeting climate targets, highlighting the sector's need for innovative solutions and large-scale investments for a sustainable future (Đuric & Viskovic, 2024). In this context, successful implementation depends not only on organizational efforts but also on coordinated collaboration among public institutions, suppliers, and customers. Finally, although blockchain and other digital technologies offer significant advantages in transparency, traceability, and efficiency, their high costs and the need for qualified personnel make them inaccessible to many organizations (Pham et al., 2023; Seroka-Stolka, 2014). These challenges indicate that the barriers to green logistics are not limited to technical and financial aspects but require a multidimensional transformation encompassing regulatory frameworks, corporate culture, infrastructure limitations, and multi-stakeholder collaboration.

7. METHODOLOGY

An exploratory research design was adopted for this study. Exploratory research involves techniques such as literature review, the use of secondary sources, and expert interviews (Karabey, 2020). This method was chosen to deepen the understanding of green logistics and carbon footprint reduction strategies and to contribute to the foundation for more comprehensive future research. Data were gathered from secondary sources alongside the literature. In this context, the sustainability reports of leading logistics companies based in Turkiye were examined and evaluated.

8. FINDINGS

In line with the purpose of this study, the sustainability reports of leading logistics firms operating in different segments in Turkiye were analyzed in the context of green logistics and carbon footprint reduction strategies. Since all data are based on companies' own reports, the absence of independent verification and data gaps constitutes a limitation of this study.

8.1. Aras Cargo

Aras Cargo is one of the leading companies in Turkiye, and it has an extensive transport network and logistics services. The company has developed comprehensive strategies in sustainability and environmental responsibility, aiming to enhance operational efficiency while reducing its carbon footprint (Aras Kargo, 2023).

To minimize carbon emissions, Aras Kargo is transforming its fleet and operational processes in line with green logistics principles. By increasing the use of electric vehicles, the company reduces fossil fuel consumption and carbon emissions. In 2023, the addition of 31 electric vehicles increased the total number of electric vehicles by 47% compared to 2022. Furthermore, fuel consumption and driving efficiency are optimized through route optimization and vehicle tracking systems, thereby reducing carbon emissions. The implementation of a single-driver courier model enables more efficient vehicle usage.

In its logistics centers and branches, the company uses LED lighting, high-efficiency heating/cooling systems, and smart building automation to improve energy efficiency. In 2023, these improvements led to a 9% reduction in total energy consumption and a 31% decrease in natural gas usage. By increasing the use of renewable energy sources, fossil fuel dependency has been reduced and sustainable energy consumption achieved.

Aras Kargo also targets reducing its carbon footprint by using environmentally friendly and recyclable materials in packaging processes. Its zero-waste packaging approach, reusable bags, and digitalization projects reduced paper usage by 14%, achieving both environmental and operational efficiency. Through the "Zero Waste Training" program, employees are made aware of sustainability and recycling practices.

In terms of carbon emissions performance, while direct emissions (Scope 1) remain significant, the use of renewable energy has reduced energy-related indirect emissions (Scope 2) to zero. Other indirect emissions (Scope 3) constitute the majority of total emissions. The company's emission intensity was 2.02 tons of CO_2e per employee, showing progress in carbon management despite its size and operational scale.

With its green logistics practices and carbon footprint reduction strategies, Aras Kargo plays a pioneering role in the logistics sector. Fleet electrification, route optimization, and digital tracking systems stand out as critical tools for controlling carbon emissions. Energy efficiency projects and renewable energy usage not only reduce environmental impacts but also lower operational costs. Sustainable packaging solutions and employee awareness programs comprehensively support the company's environmentally oriented approach.

8.2. Arkas Line

Arkas Line is a Turkiye-based and globally operating leader in maritime transport and logistics. The company aims to systematically enhance efficiency and reduce its carbon footprint in maritime operations through comprehensive sustainability and environmental responsibility strategies (Arkas Line, 2023).

Since 2011, Arkas Line has systematically measured vessel-related greenhouse gas emissions within the Clean Cargo initiative, and as of 2023, reports Scope 1 and Scope 2 emissions from 18 countries and 59 facilities. Approximately 98% of emissions stem from maritime transport. Compared to 2011, total vessel emissions decreased by 25.38% and sulfur emissions by 82.8%. These results have been achieved through the systematic implementation of low-sulfur fuels (VLSFO/ULSFO), route optimization, propeller and hull cleaning, friction-reducing coatings, energy-efficient "eco-design" vessels, and other technical improvements.

Arkas Line became the first Turkish maritime company to test biofuel (Bio24F) and secured a sustainable fuel supply with ISCC certification. In 2023, shifting from road to rail transport on certain routes resulted in 56–78% carbon savings and prevented over 1,000 tons of emissions. The company aims for 100% electric and zero-emission transport with its hybrid train investment planned for 2025.

The Operations Excellence Department monitors vessel energy efficiency, EEXI indicators, and emissions trading data at the managerial level. The use of EU ETS software supports route and fuel optimization; migration to Microsoft Cloud reduced digital workload emissions by 99.73%, and carbon intensity fell by 58% between 2019 and 2023. Onboard waste separation and UV-filtered ballast water treatment systems protect marine ecosystems, reinforcing the company's environmental integrity approach.

These strategies demonstrate Arkas Line's leadership position in sustainability, reducing its carbon footprint not only in vessel operations but also across land connections and digital processes.

8.3. Ekol Logistics

Ekol Logistics is a Turkiye-based company providing integrated logistics services through a strong intermodal network extending to Europe. The company develops strategies that systematically address not only operational efficiency but also environmental sustainability. These strategies cover a wide range of areas, from supply chain transparency and waste management to energy efficiency, renewable energy investments, green fleet practices, intermodal transport models, and LEED-certified facility investments (Ekol Lojistik, 2024).

The company's environmental performance vision is embodied in its target to reduce Scope 1, 2, and 3 emissions per revenue by 55% by 2030 compared to its 2020 baseline and to achieve a carbon-neutral logistics network by 2050. Under its green fleet and alternative fuel strategies, the integration of electric trucks into operations prevents approximately 800 tons of CO_2 emissions annually. The use of low-emission Euro 6

vehicles, biofuels, and alternative fuel technologies minimizes fossil fuel consumption. Intermodal transport practices integrating road, sea, and rail modes offer up to 50% reductions in CO_2 emissions and significantly lower fossil fuel dependence.

Within its green building initiatives, LEED-certified facilities ensure water, energy, and material efficiency, while its 5,589 kWp solar power investment meets 65% of its energy needs from renewable sources. Its waste management and circular economy approach, based on the "reduce–reuse–recycle" principle, has led to hazardous and non-hazardous waste segregation at the source, all major warehouses obtaining "Zero Waste Certificates," and a reduction in total waste from 4,239 tons in 2023 to 3,291 tons in 2024. In digitalization and operational optimization, applications such as digital twin modeling, route optimization algorithms, and carbon emission tracking modules have achieved 12% fuel savings and 8% reductions in carbon emissions.

This holistic and measurable approach positions Ekol Logistics as a pioneering and transformative actor in the fight against climate change in the logistics sector; the company systematically reduces its environmental impacts while including stakeholders and its supply chain in its sustainability objectives, creating an inclusive model.

8.4. Borusan Logistics

Borusan Logistics is a Turkiye-based integrated logistics service provider with a wide service network covering road, sea, air, and rail transport. The company's green logistics and carbon footprint strategies consist of multi-dimensional practices aimed at systematically reducing environmental impacts while increasing operational efficiency (Borusan Lojistik, 2023). Within this framework, energy efficiency projects, renewable energy investments, and the integration of low-emission vehicles into the fleet are among its core strategic priorities. Beyond meeting legal requirements, the company has developed benchmark practices in areas such as efficient use of natural resources, energy conservation, and environmentally responsible process design.

Borusan Logistics expects its suppliers to comply with national and international environmental standards (ISO 14001, ISO 14064, EMAS) and certification processes; where these are lacking, it requires strong environmental policies and procedures to be established. This approach supports the company's environmental commitments and ensures that the entire value chain operates within a shared framework to reduce environmental impacts.

The company also sets clear targets for its suppliers on energy efficiency and renewable energy use. It expects the development of projects to monitor, report, and improve energy consumption in operational processes, the utilization of renewable energy sources (solar, wind, biomass, geothermal, wave), and transparent documentation of this transition. In this context, Borusan Logistics systematically applies energy efficiency principles and tracks their effectiveness through periodic reporting.

With its "carbon-free business model" goal, Borusan Logistics requires the calculation, management, and reduction of carbon footprints not only in its own operations but also in its suppliers' processes. It promotes the use of globally recognized methodologies (IPCC Guidelines, GHG Protocol, ISO 14064) in emissions calculations and encourages transparent, comparable reporting of Scope 1, 2, and 3 emissions separately. It also asks suppliers to develop emission reduction plans, set science-based targets, and report annual results. This approach ensures not only the reduction but also the systematic management of carbon emissions, contributing to the company's decarbonization and "de-plasticization" themes. In 2023, Borusan Logistics achieved a 9.6% absolute reduction in Scope 1 and 2 emissions, preventing 19,463 tons of CO_2 equivalent emissions.

Borusan Logistics' approach to circularity and waste management is based on integrating perspectives of reuse, remanufacturing, and redesign into production and service processes. The company adopts a strategic goal of expanding the zero-waste approach across the entire value chain, increasing recycling, and prioritizing environmentally friendly, recycled, or recyclable products with low carbon emissions. It develops intermodal solutions that produce up to four times fewer emissions than road transport and up to thirty times fewer than air transport, and meets a significant portion of its energy consumption from clean sources through renewable energy certificates. In 2023, 43% of its electricity consumption was supplied from renewable sources. Micro-

distribution with electric vehicles, the conversion to lithium-ion battery equipment, LED applications, and efficient warehouse management activities have improved energy efficiency. Moreover, activities such as digital operations, accommodation, and occupational safety events have been conducted as carbon-neutral.

9. EVALUATION AND CONCLUSION

This study examined green logistics and carbon footprint reduction strategies based on the sustainability reports of leading logistics companies in Türkiye, thereby revealing the current state of green practices in the sector. It also confirmed, through both academic literature and case analyses, the logistics industry's capacity to mitigate environmental impacts in global supply chains. The findings indicate that Türkiye's logistics sector is largely aligned with global green logistics trends but still requires improvement in areas such as the use of standardized methodologies and comprehensive reporting.

The results show that measures such as investments in electric fleets, alternative fuel strategies, digital route optimization, and energy-efficient warehouses can significantly reduce carbon emissions in the short term. The analyzed companies (Aras Kargo, Arkas Line, Ekol Logistics, and Borusan Logistics) are reducing their environmental impact while achieving operational efficiency and cost advantages through strategies such as the use of electric and low-emission vehicles, route optimization, intermodal transport, renewable energy investments, circular economy approaches, and digitalization initiatives. This demonstrates that green logistics is not only an environmental necessity but also a strategic tool for competitiveness. Although progress in reporting has been observed in recent years, the management of Scope 3 emissions, comprehensive carbon accounting across supply chains, and the strengthening of independent verification mechanisms remain priority development areas for the sector.

The study's findings reveal that green logistics practices are not limited to technical investments; factors such as management commitment, organizational culture, stakeholder collaboration, and transparent reporting also play a critical role. To accelerate green transformation in Türkiye's logistics sector, strengthening the regulatory framework, increasing financial incentive mechanisms, and adopting standardized methodologies across the industry are essential. Moreover, achieving national carbon reduction targets in the logistics sector will require the simultaneous advancement of public policies, sectoral collaborations, and technological investments.

For future research, it is recommended to conduct a comprehensive carbon accounting analysis covering all actors of the logistics chain (suppliers, distributors, customers), support firm-level data with independent verification mechanisms, and compare green logistics practices across different sectors in Türkiye. Additionally, spatial modeling studies evaluating the optimization of logistics centers and infrastructure investments according to environmental criteria could contribute to a deeper understanding of the sector's transition process. Such research would provide a robust scientific basis for evidence-based policymaking to help Türkiye's logistics sector achieve its sustainability goals more effectively.

This study demonstrates that logistics represents a field of transformation not only for carbon reduction but also for supply chain resilience, operational efficiency, and economic competitiveness. Türkiye's strategic geographic location and dependence on the EU market make green logistics investments not only an environmental necessity but also a critical strategy for commercial sustainability and economic development. In conclusion, green logistics has emerged as an economic, social, and strategic opportunity for Türkiye beyond its environmental imperative. Turning this opportunity into a lasting transformation will be possible through the adoption of science-based targets, sectoral collaborations, and stakeholder engagement. The study offers insights that can guide policymakers and industry representatives alike in simultaneously advancing environmental sustainability and competitiveness in Türkiye's logistics sector.

REFERENCES

Akbal, H. (2022). Sürdürülebilir Lojistik Kapsaminda Yeşil Lojistik Uygulamalari. *Kapadokya Akademik Bakış*, *6*(1), 15–23.

Altın, H. (2024). The impact of energy efficiency and renewable energy consumption on carbon emissions in G7 countries. *International Journal of Sustainable Engineering*, *17*(1), 134–142.

Amiruddin, S. Z., Hishamuddin, H., Darom, N. A., & Naimin, H. H. (2021). A Case Study of Carbon Emissions from Logistic Activities During Supply Chain Disruptions. *Jurnal Kejuruteraan*, *33*(2), 221–228.

Aras Kargo. (2023). *Aras Kargo Sürdürülebilirlik Raporu 2023*. https://www.araskargo.com.tr/assets/images/pdf/aras_kargo_surdurulebilirlik_raporu_2023.pdf

Arkas Line. (2023). *Arkas Line 2023 Sürdürülebilirlik Raporu*. https://www.ekol.com/wp-content/uploads/2025/09/Ekol-Lojistik-Surdurulebilirlik-Raporu-2024-TR.pdf

Bardakçı, H. (2022). Sürdürülebilir Lojistikte Dünya'nın İki Yeni Trendi Tersine Lojistik ve Yeşil Lojistik Uygulamaları: Türkiye İçin Stratejiler. *Avrasya Dosyası*, *13*(2), 9–37.

Borusan Lojistik. (2023). *Sürdürülebilirlik Raporu*. https://borusanlojistik.com/sites/default/files/bl-surdurulebilirlik.pdf

Chatzoudes, D., Kadłubek, M., & Maditinos, D. (2024). Green logistics practices: The antecedents and effects for supply chain management in the modern era. *Equilibrium (1689-765X)*, *19*(3).

Dada, K. S. J. (2021). Green library: Reducing carbon footprints towards sustainable development in libraries: A case study of Federal College of Education Library, Zaria, Nigeria. *Ciência Da Informação Em Revista*, *8*(2), 4–15.

de Paula Alvarenga, T. H., Rodriguez, C. M. T., & Peña-Montoya, C. C. (2018). Mapping the State of the Art on Green Logistics and Institutional Pressures: A Bibliometric Study. *Engineering Management Research*, *7*(2).

Đuric, Ž., & Viskovic, R. (2024). Global Trends in Road Transport Management and Their Impact on Supply Chains. *Casopis Za Ekonomiju I Trzisne Komunikaije*, *27*(1).

Ekol Lojistik. (2024). *2024 Sürdürülebilirlik Raporu*. https://www.ekol.com/wp-content/uploads/2025/09/Ekol-Lojistik-Surdurulebilirlik-Raporu-2024-TR.pdf

Esfahbodi, A., Zhang, Y., & Watson, G. (2016). Sustainable supply chain management in emerging economies: Trade-offs between environmental and cost performance. *International Journal of Production Economics*, *181*, 350–366.

Etukudoh, E. A., Umoh, A. A., Hamdan, A., Ibekwe, K. I., & Sonko, S. (2024). Carbon Emission Reduction Strategies: A Global Policy Review And Analysis Of Effectiveness. *Economic Growth and Environmental Sustainability*, *3*(2), 69–75.

Fang, X., Ji, Z., Chen, Z., Chen, W., Cao, C., & Gan, J. (2020). Synergy degree evaluation of container multimodal transport system. *Sustainability*, *12*(4), 1487.

Fantozzi, F., & Bartocci, P. (2016). Carbon footprint as a tool to limit greenhouse gas emissions. In B. L. Moya & J. Pous (Eds.), *Greenhouse Gases* (p. 285). IntechOpen.

Fatorachian, H., Kazemi, H., & Pawar, K. (2025). Enhancing Smart City Logistics Through IoT-Enabled Predictive Analytics: A Digital Twin and Cybernetic Feedback Approach. *Smart Cities*, *8*(2), 1–22.

Gandola, D. M., & Asdrubali, F. (2024). A methodology to Evaluate GHG emissions for large sports events. *Sustainability*, *16*(4), 1504.

Ghosh, P., Jha, A., & Sharma, R. R. K. (2020). Managing carbon footprint for a sustainable supply chain: a systematic literature review. *Modern Supply Chain Research and Applications*, *2*(3), 123–141.

Grachev, V. A. (2019). Environmental effectiveness of energy technologies. *GEOMATE Journal*, *16*(55), 228–237.

Hasanspahić, N., Vujičić, S., Čampara, L., & Piekarska, K. (2021). Sustainability and environmental challenges of modern shipping industry. *Journal of Applied Engineering Science*, *19*(2), 369–374.

Jayvardhan, S. T., & Kaustubh, V. J. (2024). Strategic for Reducing Carbon Emission and Promoting Eco-friendly Transportation in Logistics Industry. *International Journal of Science and Research*, *13*(4), 325–329.

Jefimovaitė, L., & Vienažindienė, M. (2025). Green logistics concept and the impact of its implementation in the organisation: a systematic literature review and meta-analysis. *Engineering Management*, *17*(1), 39–51.

Jou, Y.-T., Lo, C.-Y., Mariñas, K. A., Saflor, C. S., Gutierrez, C. J., Sanchez, C., Songco, D., Redston, J., Devara, M. B., & Bucal, M. J. (2024). Assessing the E-commerce sustainability readiness: A green logistics study on online sellers. *Sustainability*, *16*(7), 2954.

Kalwar, M. A. (2024). Impact of ICT on the Performance of Sustainable Logistics. *Journal of Applied Research in Technology & Engineering*, *5*(2), 69–74.

Kamacı, K. (2024). An Exploratory Study on Fair and Responsible Logistics in the Context of Sustainable Supply Chain Management. *Journal of Consumer and Consumption Research*, *16*(2), 247–288.

Karabey, C. N. (2020). Modelleme ve Hipotez. In S. Ünal (Ed.), *Sosyal Bilimlerde Araştırma Yöntemleri* (pp. 91–112). Atatürk Üniversitesi Açıköğretim Fakültesi Yayını.

Krejza, Z., Vaňková, L., & Chovancová, J. (2019). Carbon Footprint Associated with Construction Industry and Determination of its Theoretical Amount. *IOP Conference Series: Earth and Environmental Science*, *222*(1), 12013.

Li, Y., & Cao, Z. (2024). Research and practice of energy saving and emission reduction technology in green logistics engineering. *Smart Systems and Green Energy*, *6*(1), 20–25.

Ma, F., Wang, W., Sun, Q., Liu, F., & Li, X. (2018). Ecological Pressure of Carbon Footprint in Passenger Transport : Spatio-Temporal Changes and Regional Disparities. *Sustainability*, *10*(317), 1–17. https://doi.org/10.3390/su10020317

Ma, R., & Kim, Y. J. (2023). Tracing the evolution of green logistics: A latent Dirichlet allocation-based topic modeling technology and roadmapping. *Plos One*, *18*(8), e0290074.

Nguyen, Q. Do, & Nguyen, H. T. T. (2020). Do green business initiatives enhance firm performance? Evidence from an emerging market. *International Journal of Social Science and Economics Invention*, *6*(06), 278–291.

Odeyemi, O., Usman, F. O., Mhlongo, N. Z., Elufioye, O. A., & Ike, C. U. (2024). Sustainable entrepreneurship: A review of green business practices and environmental impact. *World Journal of Advanced Research and Reviews*, *21*(2), 346–358.

Olaleye, I. A., Mokogwu, C., Olufemi-Phillips, A. Q., & Adewale, T. T. (2024). Innovative frameworks for sustainable transportation coordination to reduce carbon footprints in logistics. *International Journal of Science and Technology Research Archive*, *7*(02), 68–75.

Pham, N. D. K., Dinh, G. H., Pham, H. T., Kozak, J., & Hoang, P. N. (2023). Role of green logistics in the construction of sustainable supply chains. *Polish Maritime Research*, *30*, 191–211.

Protocol, G. G. (2011). Corporate value chain (Scope 3) accounting and reporting standard. *Chapter*, *2*, 11.

Sayın, A. A. (2022). Adil ve Sorumlu Lojistik. In E. Gelmez (Ed.), *Lojistikte Güncel Yaklaşımlar* (1.Baskı, pp. 135–154). Nobel Akademik Yayıncılık.

Senir, G., & Büyükkeklik, A. (2023). Karayolu taşımacılığında sürdürülebilirlik performansının ölçülmesi: Karşılaştırmalı bir analiz. *Bmij*, *11*(1), 10–30.

Seroka-Stolka, O. (2014). The development of green logistics for implementation sustainable development strategy in companies. *Procedia-Social and Behavioral Sciences*, *151*, 302–309.

Turgut, A., & Budak, T. (2022). Lojistik ve Taşımacılığın Karbon Ayak İzi: Sistematik Bir Literatür İncelemesi. *Kent Akademisi*, *15*(2), 916–930. https://doi.org/10.35674/kent.1071319

Wang, C., Rahman, M. M., Siddik, A. B., Wen, Z. G., & Sobhani, F. A. (2024). Exploring the synergy of logistics, finance, and technology on innovation. *Scientific Reports*, *14*(1), 21918.

Wang, L. (2024). Enterprise green logistics packaging transformation in the context of dual carbon goals: Taking Alibaba as an example. *Frontiers in Humanities and Social Sciences*, *4*(1), 342–354.

Wiedmann, T., & Minx, J. (2008). A Definition of "Carbon Footprint." In C. C. Pertsova (Ed.), *Ecological Economics Research Trends* (pp. 1–11). Nova Science Publisher.

Yasir, K., Shen, J., & Lin, J. (2024). Sustainable logistics: synergizing passive design and PV–battery systems for carbon footprint reduction. *Buildings*, *14*(10), 3257.

Yurtay, Y. (2025). Carbon Footprint Management with Industry 4.0 Technologies and ERP Systems in Sustainable Manufacturing. *Applied Sciences (2076-3417)*, *15*(1), 480.

Yurtkuran, S. (2021). Çevresel Kuznets eğrisi hipotezinin geçerliliği ve yeşil lojistik: Türkiye örneği. *Balıkesir Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *24*(45), 171–201.