

Green logistics and supply chain management in Türkiye: A systematic literature review, policy gap analysis and a green logistics readiness matrix

Türkiye’de yeşil lojistik ve tedarik zinciri yönetimi: Sistematik literatür taraması, politika boşluğu analizi ve yeşil lojistik hazırlık matrisi

Saim Karabulut^{1*} 

¹ Project Specialist, OSTİM Technical University, Ankara, Türkiye.

ÖZET

Türkiye’de yeşil lojistik ve yeşil tedarik zinciri yönetiminin mevcut durumu, PRISMA 2020 protokolüne dayalı sistematik bir literatür taraması ve politika boşluğu analizi çerçevesinde incelenmiştir. Literatürdeki kavramsal gelişmeler ile operasyonel uygulamalar; Avrupa Yeşil Mutabakatı ve Sınırda Karbon Düzenleme Mekanizması (SKDM) gibi uluslararası iklim yönetişimi araçlarının yarattığı kurumsal baskılar ekseninde sentezlenmiştir. Sentezlenen veriler, karbon temelli ticaret kısıtlarının düzenleyici ve piyasa baskılarını artırdığını; ancak Türkiye’nin yeşil lojistik dönüşümünün düzenleyici uyum, altyapı kapasitesi, emisyon ölçüm hazırlığı (Kapsam 1-2-3) ve teknoloji destekli şeffaflık açılarından heterojen bir yapı sergilediğini göstermektedir. Bu asimetric yapıyı çözümlenmek amacıyla, ulusal hazırlık düzeyini beş stratejik boyutta ve üç olgunluk seviyesinde (düşük, orta, yüksek) sınıflandıran kavramsal bir Yeşil Lojistik Hazırlık Matrisi geliştirilmiştir. Somut sektörel verilerle desteklenen bu matris, politika yapıcılar ve lojistik hizmet sağlayıcılar için analitik bir teşhis aracı olarak kurgulanmış; böylece karbon kısıtlarına maruz kalan ve ihracata dayalı diğer gelişmekte olan ekonomiler için de uyarlanabilir, bütünlük bir değerlendirme altyapısı sunulmuştur.

Anahtar Kelimeler:

*Yeşil lojistik,
Yeşil tedarik zinciri,
Avrupa Yeşil
Mutabakatı,
Sınırda Karbon
Düzenleme
Mekanizması*

ABSTRACT

The current state of green logistics and green supply chain management in Türkiye is examined through a systematic literature review based on the PRISMA 2020 protocol, integrated with a policy gap analysis. Conceptual developments and operational practices are synthesized around the institutional pressures generated by international climate governance, specifically the European Green Deal and the CBAM (CBAM). The synthesis reveals that while carbon-related trade constraints intensify regulatory and market pressures, Türkiye’s green logistics transition exhibits a heterogeneous structure regarding regulatory alignment, infrastructure capacity, emissions measurement readiness (Scope 1-2-3), and technology enabled transparency. To address this structural asymmetry, a conceptual Green Logistics Readiness Matrix is developed, classifying national preparedness across five strategic dimensions into low, moderate, and high maturity levels. By grounding theoretical dimensions in concrete sectoral applications, the matrix functions as an analytical diagnostic tool for policymakers and logistics service providers. Ultimately, an adaptable, integrated evaluation framework is provided for other export oriented emerging economies exposed to tightening carbon regulations.

Keywords:

*Green logistics,
Green supply chain,
European Green Deal,
Carbon Border
Adjustment
Mechanism (CBAM)*

1. Introduction

In recent years, various global trade dynamics and operational factors have fundamentally reshaped the current structure of logistics and supply chain management (Bilgen, 2017). Concurrently, the imperative of economic decarbonization has repositioned the logistics sector from a secondary operational function to a primary arena of climate policy. Since freight systems encompass hard to abate modes such as heavy duty trucking, maritime shipping, and aviation supply chain emission mitigation is strictly embedded within global climate targets (IPCC, 2022). Mentioned structural shift is largely driven by international climate governance. The Paris Agreement’s enhanced transparency frameworks and the European Green Deal’s (EGD) 2050 climate neutrality mandate have established strict, measurable decarbonization standards that inherently transcend domestic production,

Received: 26.02.2026 Revised: 08.03.2026, 26.03.2026 Accepted: 26.03.2026

<http://doi.org/10.29228/jav.89954>

*E-mail address (saimkarabulut0606@gmail.com).

This article is licensed under a [Creative Commons Attribution 4.0 International License \(CC BY 4.0\)](https://creativecommons.org/licenses/by/4.0/).

effectively regulating global supply networks (European Commission, 2019; UNFCCC, 2015). Consequently, carbon accountability has evolved into a binding operational constraint for international trade. Within this evolving regulatory architecture, export oriented emerging economies face critical pressures. Operating under the European Union Customs Union framework, Türkiye exemplifies this exposure; its unprecedented bilateral trade volume inherently links its logistics infrastructure to European low carbon standards (European Commission, 2024). A profound catalyst for this integration is CBAM. By explicitly externalizing the carbon costs of imports through embedded emission allowances, CBAM transforms logistics carbon accounting from a voluntary sustainability metric into a strict determinant of market access and competitive survival (European Parliament and Council, 2023). Therefore, demonstrating verified emissions reductions across the supply chain particularly concerning Scope 1, 2, and 3 emissions is now a fundamental requirement for maintaining integration within European value chains.

Notwithstanding these intensifying regulatory and market pressures, the transition dynamics within the Turkish logistics ecosystem reveal a deep structural asymmetry. While leading industrial segments adopt advanced green practices, national-level preparedness concerning regulatory alignment, intermodal infrastructure modernization, and standardized emissions measurement remains heterogeneous. Current green logistics and green supply chain management scholarship lacks a unified metric or consensus on key performance indicators for assessing structural readiness (Chepurna et al., 2025). Operational optimization studies frequently coexist with abstract calls for institutional reform, yet the mechanisms translating these theoretical paradigms into the specific operational context of emerging economies remain systematically underexplored. To address this theoretical and empirical gap, a systematic literature review (SLR) integrated with a policy gap analysis is conducted, adhering to the PRISMA 2020 protocol (Page et al., 2021). By synthesizing the fragmented metrics surrounding green supply chain management and logistics decarbonization, a conceptual Green Logistics Readiness Matrix is constructed. Rather than offering isolated operational optimizations, this matrix operationalizes national and sectoral preparedness across five strategic dimensions: regulatory alignment, infrastructure capacity, emissions measurement (Scope 1, 2, and 3), technological integration, and market exposure. Consequently, the established diagnostic framework transcends theoretical discourse, providing an adaptable, multi level assessment architecture for export oriented emerging economies striving to align with stringent international carbon trade mechanisms.

2. Conceptual background

2.1. Green logistics: Conceptual evolution and scope

The conceptual boundaries of green logistics have expanded significantly beyond the traditional mitigation of transport induced externalities. Rather than treating environmental impact as a peripheral cost-minimization exercise, contemporary scholarship repositions logistics decarbonization as an operationally embedded necessity driven by institutional pressures and market demands (Rastegardebidi and Su, 2025; Tetteh et al., 2024). While definitional ambiguities historically blurred the distinction between green, sustainable, and low carbon logistics, recent systematic efforts emphasize operationalization over normative sustainability claims. Chepurna et al. (2025) demonstrate that green logistics must be operationalized through specific, measurable interventions across the supply chain, moving away from fragmented environmental gestures. Therefore, environmental performance is no longer an external regulatory burden but an endogenous parameter of logistics network design. Freight transport decarbonization remains the most critical, yet structurally rigid, domain within this transition. Given the heavy reliance on fossil fuels in maritime and road freight, isolated compliance measures are insufficient for mitigating emissions in hard to abate sectors (IPCC, 2022). Instead, literature increasingly conceptualizes green logistics as a systemic capability requiring synchronized investments in alternative fuel infrastructure, regulatory alignment, and carbon accounting standardization (Mumcu, 2025). The emergence of Logistics 4.0 and 5.0 paradigms further operationalize these demands by merging digital transformation with ecological optimization. Artificial intelligence, Internet of Things (IoT) architectures, and real-time data ecosystems function as critical enablers for absolute emission tracking, predictive capacity utilization, and reverse logistics integration (Nicoletti and Appolloni, 2024). Modern green logistics represents a strategic realignment where technological integration directly dictates an organization's capacity to navigate tightening carbon trade mechanisms and institutional pressures.

2.2. Green supply chain management

Transcending isolated transport optimizations, green supply chain management (GSCM) embeds environmental parameters across the entire value chain through rigorous life cycle approaches and inter organizational coordination. Historically anchored in operational dimensions such as green procurement, green manufacturing, and reverse logistics (Srivastava, 2007), the paradigm has fundamentally shifted from fragmented, firm level initiatives toward synchronized network level sustainability (Seuring and Müller, 2008; Tetteh et al., 2024). This structural evolution is heavily dictated by strict carbon accounting imperatives. Specifically, the Greenhouse Gas (GHG) Protocol Corporate Value Chain Scope 3 Standard forces focal firms to assume direct accountability for indirect upstream and downstream transportation emissions, effectively transforming collaborative environmental management into a strict compliance mechanism rather than a voluntary practice (World Resources Institute and World Business Council for Sustainable Development, 2013). The operationalization of such systemic accountability relies exclusively on standardized measurement architectures. The implementation of ISO 14083 establishes a definitive methodological consistency for quantifying greenhouse gas emissions across multidimensional transport chains, eliminating previous calculative discrepancies (International Organization for Standardization, 2023). Complementing this regulatory standardization, the Global Logistics Emissions Council (GLEC) Framework translates international standards into harmonized, actionable calculation guidelines for both logistics service providers and shippers (Smart Freight Centre, 2024). Driven by these rigid institutional frameworks, GSCM transcends normative corporate aspirations, functioning instead as a highly auditable governance mandate. Consequently, verified emissions data acts as a critical determinant for market access, institutional investor confidence, and regulatory alignment, directly linking operational transparency with the long-term competitive survival of export oriented firms.

2.3. International climate governance and regulatory pressure

The trajectory of green logistics is fundamentally dictated by the coercive pressures of international climate governance and regional regulatory architectures (Rastegardebidi and Su, 2025). Rather than functioning as normative guidelines, instruments such as the Paris Agreement establish strict, iterative accountability mechanisms that compel heavy-emitting sectors to operationalize macro level climate targets into measurable decarbonization outcomes (UNFCCC, 2015). At the regional frontier, the European Green Deal imposes a binding policy architecture that systematically restructures industrial and transport networks toward complete climate neutrality by 2050 (European Commission, 2019). Driven by these frameworks, environmental compliance transitions from a voluntary corporate initiative to a stringent institutional mandate. Within this rigorous regulatory environment, CBAM emerges as a critical market constraint. By explicitly internalizing the cost of embedded emissions through a trade linked pricing logic, CBAM eliminates the feasibility of carbon leakage and forces global value chains to adopt standardized carbon accounting (European Parliament and Council, 2023). Although initially targeting specific emission intensive sectors, the underlying logic of the mechanism amplifies the necessity for continuous transparency and data driven reporting across all supply chain tiers. Consequently, logistics induced emissions are now permanently embedded within international trade compliance parameters. For an export oriented emerging economy deeply integrated into European production networks, such as Türkiye, these extraterritorial governance structures directly dictate logistics competitiveness. The capacity to sustain market access now relies exclusively on credible emissions measurement, infrastructural adaptation, and technology enabled transparency rather than traditional cost efficiency advantages. Delayed regulatory alignment inherently amplifies the risk of stranded assets, operational bottlenecks, and severe competitiveness losses in European markets. Thus, international climate policies fundamentally rewrite the economic incentives of freight distribution, positioning green logistics readiness not merely as an environmental expectation, but as the ultimate determinant of national economic resilience and sustained trade performance (Tetteh et al., 2024).

3. Methodology

Serving as an architectural blueprint, the methodology justifies the analytical choices that link philosophical assumptions to practical data analysis (Schoonenboom and Johnson, 2017). A mixed analytical design rooted in the pragmatism paradigm is utilized, integrating a systematic literature review (SLR) with a policy gap analysis. This abductive approach enables the translation of theoretical dimensions into an applied assessment tool, specifically the Green Logistics Readiness Matrix (Saunders, Lewis, and Thornhill, 2007). The review process strictly adheres to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) 2020 guidelines to ensure methodological transparency and replicability (Page et al., 2021). Data acquisition was

conducted utilizing Web of Science (WoS) and Scopus, given their extensive coverage of high impact, peer reviewed management and environmental science literature (Fahimnia, Sarkis, and Davarzani, 2015). Boolean operators were applied to construct a search string targeting titles, abstracts, and keywords: ("green logistics" OR "sustainable logistics" OR "green supply chain management") AND ("policy" OR "readiness" OR "decarbonization" OR "framework") (Sauer and Seuring, 2023).

Specific inclusion and exclusion criteria were enforced during the screening phase. Inclusion criteria were strictly defined as: (1) peer reviewed journal articles and official institutional policy documents; (2) publications written in English; and (3) publication dates between 2015 and 2025 to accurately capture regulatory shifts following the Paris Agreement and the European Green Deal. Exclusion criteria eliminated nonpeer reviewed materials, conference abstracts, and studies lacking a direct operational or strategic focus on logistics decarbonization. The study selection process comprised three main phases: identification, screening, and eligibility assessment. Initial database searches retrieved 325 records, with 145 from Web of Science and 180 from Scopus. After removing 65 duplicate entries, we screened the remaining 260 articles based on their titles and abstracts. This initial screening excluded 140 papers that lacked conceptual relevance to green logistics, decarbonization, or policy frameworks. We then conducted full text assessments on the remaining 120 articles. During this stage, 55 studies were excluded primarily because they focused exclusively on technical engineering aspects without policy or managerial implications. Any discrepancies during the selection phases were resolved through discussion among the researchers to ensure interpretive alignment. Ultimately, 65 primary sources met all inclusion criteria and formed the final corpus for analysis. The entire selection procedure is visually summarized in the PRISMA 2020 flow diagram given in the figure 1.

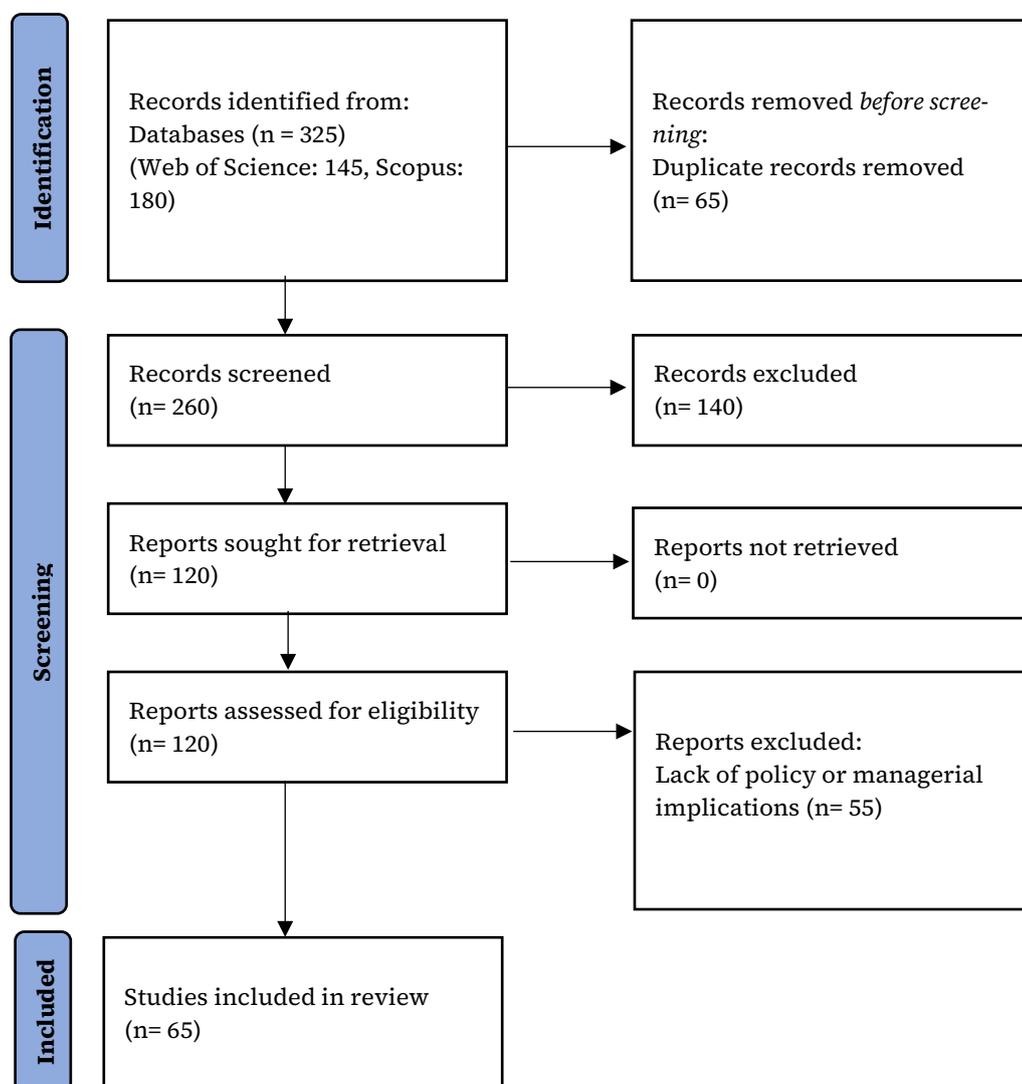


FIGURE 1. PRISMA 2020 flow diagram for the systematic literature review

Source: Generated by author (from PRISMA 2020 template)

Selected literature was analyzed through qualitative content analysis. Extracted data were coded into five predefined dimensions: regulatory alignment, infrastructure capacity, emissions measurement, technological integration, and market exposure. To satisfy the requirement of operational clarity, the synthesized data directly informed the specific criteria for the matrix's maturity levels. Specifically, low readiness is categorized by fragmented compliance and the absence of carbon tracking; moderate indicates partial technological integration and baseline awareness of Scope 1 and 2 emissions; and high represents full systemic alignment with international mechanisms alongside comprehensive Scope 3 reporting capabilities.

Methodological integrity is strictly maintained through the established principles of trustworthiness inherent in qualitative inquiry (Lincoln and Guba, 1985; Yıldırım and Şimşek, 2008). Dependability is operationally demonstrated via the PRISMA audit trail, systematically documenting every phase of literature identification, screening, and exclusion. Confirmability is secured through rigorous data triangulation; specifically, academic findings are continually corroborated against official regulatory mandates, including the CBAM legislation and the Global Logistics Emissions Council (GLEC) methodology, thereby neutralizing potential researcher bias. Finally, transferability is ensured by explicitly defining the contextual parameters of export oriented emerging economies, enabling future researchers and policymakers to evaluate and adapt the readiness matrix to alternative geopolitical settings (Seuring and Gold, 2012).

Synthesizing systematic literature review with the policy gap analysis culminates in the construction of the Green Logistics Readiness Matrix. Functioning as a conceptual diagnostic model, the matrix operationalizes national and sectoral preparedness across five predefined strategic dimensions: regulatory alignment, infrastructure capacity, emissions measurement, technological integration, and market exposure. Rather than generating a static quantitative ranking, the classification of readiness into low, moderate, and high categories provides an analytical architecture designed to expose structural asymmetries and regulatory vulnerabilities within the logistics ecosystem. The conceptual logic of the matrix is directly anchored in the intersection of academic findings and stringent extraterritorial policy mandates. Consequently, the matrix transcends theoretical discourse, serving as a transferable diagnostic instrument for other export dependent emerging economies facing identical carbon transition pressures. Furthermore, establishing this conceptual foundation directly enables subsequent empirical operationalization. The theoretically defined criteria can be translated into quantitative measurement scales, survey instruments, or multi criteria decision making models. Accordingly, future empirical research can utilize this framework to comparatively benchmark the logistics decarbonization trajectories of varying industries and emerging markets.

4. Findings from the systematic review

The thematic synthesis of the selected corpus reveals an explicit structural shift in green logistics and supply chain scholarship: moving from broad, normative sustainability claims toward strict operationalization, measurement discipline, and policy embedded transition pathways. Fundamentally, the literature is organized around five interconnected thematic clusters: (1) conceptual convergence and definitional refinement, (2) systemic operational practices, (3) measurement and reporting standardization, (4) technology enabled transformation and (5) institutional and market drivers.

The initial cluster highlights definitional consolidation as an absolute prerequisite for both managerial execution and comparative empirical research. Historically, the interchangeable use of terms such as green logistics, sustainable logistics, and low carbon logistics generated severe conceptual noise, thereby undermining the interpretability of empirical outcomes and creating profound uncertainty for practitioners (Chepurna et al., 2025). Transcending this ambiguity, contemporary scholarship explicitly integrates decision sciences into the conceptual refinement process. Consequently, green logistics is increasingly repositioned from a superficial compliance layer into a rigorous operational framework where strict environmental constraints are mathematically embedded into routing, network design, and inventory algorithms. Furthermore, integrating location allocation decisions with recycling processes and optimal shipping frequencies has proven essential for designing transport networks that effectively curb carbon emissions (Abbasi et al., 2026). This conceptual convergence is far from merely terminological; it fundamentally shifts the discipline toward auditable frameworks directly tied to extraterritorial policy requirements and intensifying competitive pressures.

The second cluster encompasses operational practices, documenting a definitive evolution from isolated, firm-level interventions such as basic modal shifts or fleet efficiency upgrades toward highly integrated, network-level coordination. Current evidence dictates that meaningful decarbonization requires synchronized optimization across transport, warehousing, reverse flows, and circularity-oriented supply chain designs rather than fragmented technical upgrades. For instance, urban freight decarbonization paradigms demonstrate that mitigating emissions necessitates resolving complex trade-offs among multiple actors, infrastructure bottlenecks,

and service level demands, rendering incremental operational optimization insufficient (Toktaş et al., 2024). In this context, successfully managing low carbon supply chains requires optimizing the delicate balance between adhering to strict environmental targets and maintaining competitive service levels for customers (Kumar et al., 2025). Recent evidence highlights that the widespread adoption of circular economy practices, underpinned by industrial symbiosis and ecological modernization, significantly enhances overall firm performance, particularly within the supply chains of developing economies (Dadsena et al., 2025). Executing these systemic practices requires viewing freight decarbonization as an inter organizational coordination challenge. Advanced procurement strategies synchronized contracting structures, and shared incentive mechanisms within buyer-supplier dyads function as the primary catalysts for diffusing green transport practices. Ultimately, this cluster establishes a transition logic where operational performance improvements are exclusively dependent on systemic, multi tier supply chain coordination rather than isolated technical adoption.

The third thematic cluster establishes measurement and reporting standardization as the definitive threshold for operationalizing green logistics. Contemporary scholarship unequivocally demonstrates that in the absence of credible, standardized emissions accounting, decarbonization strategies risk being marginalized as superficial greenwashing, fundamentally failing to satisfy stringent extraterritorial trade mandates. Consequently, the Greenhouse Gas Protocol's Scope 3 standard has transitioned from a voluntary corporate reference into a strict regulatory boundary, dictating the compliance profiles of entire value chains (World Resources Institute and World Business Council for Sustainable Development, 2013). However, achieving this integration remains structurally constrained. Organizations persistently encounter severe implementation barriers regarding Scope 3 emissions, primarily driven by pervasive data gaps, methodological fragmentation, and supplier non-compliance (Borchardt et al., 2025). To navigate these bottlenecks, the literature emphasizes the critical necessity of harmonized calculation architectures. Specifically, industry frameworks such as the Global Logistics Emissions Council (GLEC) methodology are positioned as essential mechanisms to enforce calculative comparability across diverse transport modes and regional providers. Ultimately, measurement readiness operates as a rigid, binding constraint for strategic green transitions. Because the feasibility of policy compliance and sustained market access depends exclusively on auditable emissions data, this cluster establishes the core operational rationale for the proposed readiness matrix (Smart Freight Centre, 2024).

The subsequent cluster reframes technology enabled transformation, shifting the discourse from generic digitalization paradigms toward establishing an essential digital infrastructure for absolute environmental performance. Advanced analytics, real time data integration, and artificial intelligence are increasingly positioned as critical operational levers required for dynamic routing, predictive load consolidation, and systemic waste mitigation (Nicoletti and Appolloni, 2024). Recent comprehensive bibliometric analyses further confirm that integrating Industry 4.0 technologies with the triple bottom line framework has become the dominant research trajectory for achieving true sustainability in modern supply chains (Anurag & Johnpaul, 2026). Deployment of Large Language Models (LLMs) and AI driven frameworks is rapidly emerging as a critical capability for accurately identifying and classifying supply chain risks, thereby enhancing the overall resilience and sustainability of logistics networks (Kühl et al., 2025). Crucially, recent evidence dictates that the actual sustainability yield of algorithmic integration depends exclusively on embedding strict environmental constraints directly into optimization objectives, rather than relying on the superficial adoption of digital tools (Chen et al., 2024). Indeed, recent empirical evidence strongly supports that the expansion of the digital economy and deep technological integration directly enhance carbon emission efficiency in the logistics sectors of emerging markets (Chen et al., 2026). This distinction is particularly critical for export oriented contexts such as Türkiye. Hardware and software acquisition alone cannot guarantee emissions performance or safeguard market access if parallel measurement systems and institutional governance structures remain underdeveloped. Therefore, achieving durable decarbonization outcomes requires a highly synchronized co-evolution of digital architecture, rigorous emissions accounting, and coercive institutional drivers.

The final thematic cluster firmly anchors green logistics research within the dynamics of political economy, identifying institutional and market drivers as the primary determinants of adoption (Rastegardebidi and Su, 2025). Across the corpus, extraterritorial regulatory pressures and market access constraints consistently emerge as coercive forces that fundamentally reshape domestic incentives. Specifically, the European Green Deal functions as a comprehensive policy architecture that unilaterally dictates investment expectations, reporting discipline, and operational standards far beyond the borders of the European Union (European Commission, 2019). Concurrently, the CBAM operates as a strict trade linked instrument; by enforcing embedded emissions transparency, it inherently alters the cost structures and locational planning of global supply networks (European Parliament and Council, 2023). Consequently, environmental compliance is no longer a localized corporate initiative, but a rigid prerequisite for international market integration (Zhu et al., 2007). For export dependent emerging economies such as Türkiye, these externally anchored mandates dictate that logistics readiness cannot be managed through isolated policy domains. Instead, sustaining market access strictly depends on the systemic

synchronization of regulatory alignment, infrastructural capacity, measurement discipline, and technological capability. Ultimately, the systematic synthesis reveals a definitive structural transition within literature: conceptual refinement is inextricably linked to operational execution, operational practices necessitate network level coordination, measurement standards act as binding market constraints, and digital technology serves as an absolute performance infrastructure.

5. Türkiye's current green logistics position

The trajectory of Türkiye's green logistics transition is fundamentally dictated by its high trade exposure to European production networks, effectively positioning logistics performance at the critical intersection of environmental compliance and international competitiveness (Karadağ Albayrak, 2025). As extraterritorial regulatory frameworks, most notably the CBAM, increasingly link carbon accountability directly to market access, freight distribution transcends operational execution to become a strategic determinant of national economic policy (Republic of Türkiye Ministry of Trade, 2021). By penalizing embedded emissions in imported goods, CBAM enforces strict transparency mandates on supply chains extending beyond the borders of the European Union (European Parliament and Council, 2023). For an export dependent economy such as Türkiye, sustaining integration within European value chains inherently requires rigorous emissions accounting and verifiable reporting mechanisms across all logistics tiers. Consequently, demonstrating absolute carbon performance throughout transportation and distribution activities is no longer a peripheral sustainability gesture, but a rigid prerequisite for maintaining cross-border market viability (Sünbül, 2025).

Operationally, navigating these coercive market pressures depends exclusively on the systemic implementation of standardized measurement architectures across domestic logistics service providers. Regulatory compliance necessitates the adoption of definitive frameworks, such as ISO 14083 and the Global Logistics Emissions Council (GLEC) methodology, which enforce methodological consistency for quantifying transport induced emissions (International Organization for Standardization, 2023; Smart Freight Centre, 2024). Furthermore, stringent Scope 3 reporting mandates compelling focal firms to assume direct accountability for upstream and downstream logistics emissions within their corporate disclosures (World Resources Institute and World Business Council for Sustainable Development, 2013). However, contemporary literature unequivocally demonstrates that actualizing these standards within the Turkish context is severely constrained by pervasive data fragmentation, structural interoperability issues, and disparate digital readiness levels among supply chain actors (Mumcu, 2025). These structural bottlenecks are particularly acute given the heavy reliance on small and medium sized enterprises (SMEs) within the Turkish freight sector, which frequently lack the financial capacity and technical expertise required to deploy advanced carbon tracking infrastructures (Karagülle, 2012; Sünbül, 2025).

The structural composition of Türkiye's freight network severely dictates the pace of its decarbonization trajectory. With road transport completely dominating the modal split, the sector remains structurally locked into fossil fuel dependency, thereby escalating absolute emission volumes and obstructing rapid mitigation efforts (UTIKAD, 2024). Although national master plans explicitly prioritize rail and intermodal infrastructure expansion to alleviate this ecological burden (Republic of Türkiye Ministry of Transport and Infrastructure, 2022), the physical integration across critical logistics corridors exhibits profound fragmentation. This infrastructural bottleneck directly prevents the scalability of low carbon transport models and exacerbates regional emission intensities. Consequently, isolated digital optimization efforts, while theoretically promising for routing and efficiency gains, fail to yield systemic environmental benefits due to this persistent modal imbalance and disparate technological adoption rates among supply chain actors (Karadağ Albayrak, 2025).

Transcending operational limitations, aligning national strategies with extraterritorial mandates specifically through the ratification of the Paris Agreement and the promulgation of the Green Deal Action Plan signifies a critical regulatory awakening. However, contemporary scholarship emphasizes that declarative policy alignment is fundamentally insufficient without synchronized institutional coordination bridging environmental regulation, transport planning, and trade policy. Within the Turkish context, the transition is systematically hindered by an implementation gap, particularly concerning the deployment of robust data infrastructures required for auditable emissions verification. Therefore, the national logistics ecosystem occupies a highly transitional phase characterized by regulatory progress juxtaposed with deep structural vulnerabilities. Driven by immense exposure to European markets, the adoption of transparent carbon accounting and low emission practices is no longer a peripheral corporate sustainability initiative but a strict determinant of market survival. While pioneering logistics providers actively invest in intermodal networks and advanced tracking technologies to secure competitive market access, organizations failing to institutionalize these measurement architectures face severe cost penalties and irreversible exclusion under emerging carbon trade mechanisms (Republic of Türkiye Ministry of Trade, 2021; Rastegardebidi and Su, 2025).

6. Policy gap analysis: Türkiye vs European Union

An analytical evaluation of current regulatory frameworks reveals that the European Union has successfully institutionalized an integrated transition architecture. Within this system, long term climate neutrality targets are rigorously supported by coercive policy levers combining strict regulation, standardized measurement, and sector specific transformation mandates (European Commission, 2019). Rather than functioning merely as a conceptual framework, the European Green Deal dictates an operational ecosystem that comprehensively synchronizes climate objectives with industrial, transport, and financial mechanisms. Ultimately, this comprehensive approach directly translates macro level decarbonization aspirations into absolute operational prerequisites, systematically reshaping corporate strategy and supply chain dynamics. Expanding this rigid architecture beyond domestic borders, the CBAM operates as a transformative extraterritorial trade instrument. By explicitly linking market access to verifiable emissions reporting and import compliance obligations, the regulation operationalizes an embedded carbon pricing logic. Although initially enforced upon specific emission intensive industries, the underlying regulatory logic universally amplifies the demand for continuous emissions transparency, standardized calculation methodologies, and credible verification across all supply chain tiers. For export oriented firms embedded within European production networks, the carbon content of distributed goods is now inextricably tied to international competitiveness. Consequently, this extraterritorial framework creates severe institutional incentives to establish auditable decarbonization tracking systems throughout logistics and distribution operations (European Parliament and Council, 2023).

Contrasted against this highly institutionalized European framework, the fundamental vulnerability within the Turkish context is not an absence of strategic direction, but rather a profound structural incapacity to operationalize these rigid transition requirements (Rastegardebidi and Su, 2025). While the European policy architecture operates on the assumption of harmonized data infrastructures enabling continuous comparability, the capacity of domestic logistics service providers to generate standardized, auditable carbon data remains severely asymmetric (Çağlar & Karagöz Taşkın, 2025). Consequently, this structural disparity inherently limits the scalability of low carbon logistics networks. Methodological alignment between local operations and international measurement expectations constitutes a critical operational bottleneck. As European directives increasingly enforce strict calculation and disclosure mandates as ultimate determinants of market competitiveness, adoption within Türkiye exhibits deep heterogeneities, disproportionately penalizing small and medium sized enterprises that lack sufficient digital integration and financial capital (Mumcu, 2025). Resultantly, green logistics initiatives risk remaining completely confined to a niche segment of leading exporters integrated into multinational supply chains, while broader sector wide diffusion is systematically obstructed by severe data interoperability issues (Karadağ Albayrak, 2025). Ultimately, while the European Union enforces long term targets through a highly synchronized structure linking regulation, finance, standardization, and trade instruments, the domestic ecosystem struggles with fundamental emissions accounting discipline and technology enabled transparency (Çağlar & Karagöz Taşkın, 2025; Rastegardebidi and Su, 2025).

7. Green logistics readiness matrix

Functioning as a comprehensive diagnostic architecture rather than a static quantitative scorecard, the Green Logistics Readiness Matrix evaluates national and sectoral preparedness for structural decarbonization. The model operationalizes readiness across five strategic dimensions consistently validated by contemporary scholarship and extraterritorial policy mandates: regulatory compliance capacity, infrastructure preparedness, measurement and reporting capacity, technological integration, and market exposure. The fundamental objective of this analytical architecture is to expose binding capability constraints, thereby directing targeted policy interventions and strategic investment priorities.

The initial dimension, regulatory compliance capacity, evaluates the degree of synchronization between domestic legislative frameworks, sectoral strategies, and the coercive expectations of international climate governance. Beyond mere declarative policies, this dimension assesses the institutional capacity of public authorities to translate macro level climate commitments into sector specific enforcement mechanisms. Sustaining regulatory coherence across transport, industrial, and environmental domains is positioned as an absolute prerequisite for navigating stringent trade related carbon constraints (Rastegardebidi and Su, 2025). Infrastructure preparedness captures the physical and logistical foundation required for absolute decarbonization. Readiness within this domain dictates whether focal firms and logistics service providers can seamlessly adopt low carbon practices without encountering prohibitive operational bottlenecks induced by structural infrastructural deficits (Kekkonen et al., 2023; Rahman et al., 2020).

The third strategic pillar, measurement and reporting capacity, interrogates the methodological and institutional competency required to accurately quantify and disclose logistics related to greenhouse gas emissions. Structural readiness strictly depends on the systemic application of standardized carbon accounting architectures, particularly concerning comprehensive value chain transparency. Consequently, Scope 3 accounting mandates for transportation and distribution assume a central role in corporate disclosures, capturing embedded emissions across upstream and downstream logistics activities (World Resources Institute and World Business Council for Sustainable Development, 2013). Establishing methodological consistency is further enforced by ISO 14083, which dictates a definitive approach for quantifying emissions from complex transport chain operations (International Organization for Standardization, 2023). Complementing this regulatory baseline, industry frameworks provide harmonized calculation guidance ensuring alignment with both ISO based standards and corporate reporting obligations (Smart Freight Centre, 2024).

The fourth dimension, technological integration, transcends the superficial adoption of digital tools, evaluating the systemic diffusion of advanced computational architectures required for simultaneous efficiency optimization and absolute emission reduction. The implementation of tracking technologies, real time data platforms, and artificial intelligence fundamentally restructures logistical operations by enabling dynamic routing, predictive load consolidation, and holistic process redesign (Nicoletti and Appolloni, 2024). Crucially, contemporary scholarship dictates that algorithmic integration exclusively yields environmental benefits when strict sustainability criteria are mathematically embedded into optimization objectives (Chen et al., 2024). Therefore, technological capability is never positioned as an isolated modernization agenda; its strategic relevance is strictly contingent upon its seamless synchronization with auditable emissions measurement systems and environmentally constrained decision making parameters.

The final dimension, market exposure, quantifies the extent to which domestic logistics networks and export oriented sectors are subjected to the coercive pressures of climate related trade mechanisms and buyer driven sustainability mandates (Rastegardebhidi and Su, 2025). Heightened international exposure inherently dictates stronger institutional incentives for operationalizing harmonized measurement architectures and low carbon logistics networks. Global market competitiveness is no longer determined by traditional cost efficiencies but is exclusively dictated by continuous emissions transparency and rigorous compliance capacity. To operationalize these theoretical parameters, each strategic dimension is systematically evaluated across three qualitative maturity thresholds categorized as low, moderate, and high. Rather than generating a rudimentary cumulative score, this classification architecture is specifically engineered to expose structural asymmetries within the logistics ecosystem. For instance, an export dependent economy might exhibit immense market exposure juxtaposed against severely deficient measurement capabilities, or it may establish ambitious regulatory frameworks while simultaneously encountering prohibitive infrastructure bottlenecks.

TABLE 1. Operational indicators for the green logistics readiness matrix

Strategic Dimension	Low Readiness	Moderate Readiness	High Readiness
Regulatory Alignment	Complies only with mandatory national laws. Lacks voluntary ESG reporting.	Adopts basic ISO 14001 standards. Tracks some environmental metrics internally.	Fully aligned with EU EGD and CBAM directives. Regularly publishes audited sustainability reports.
Infrastructure Capacity	Relies heavily on aging, fossil fuel dependent fleets. No intermodal transport use.	Gradual fleet renewal (e.g., Euro 6 engines). Limited integration of rail or maritime alternatives.	Substantial investments in electric/hybrid vehicles and LEED-certified warehouses. Optimized intermodal networks.
Emissions Measurement	Uses rough fuel-consumption estimates. No Scope 3 tracking.	Calculates Scope 1 and 2 emissions systematically. Shows partial awareness of Scope 3.	Implements the GLEC Framework or ISO 14083. Ensures accurate, real time tracking of Scope 1, 2, and 3 emissions.
Technological Integration	Uses basic routing software. High reliance on manual data entry and traditional planning.	Adopts standard ERP systems for transport management. Utilizes basic fuel optimization tools.	Integrates IoT, telematics, and AI for dynamic route optimization and automated carbon footprint tracking.

Market Exposure	Operates mostly domestically. Faces low pressure from clients regarding green practices.	Serves some international clients. Responds to green requirements mainly when explicitly asked.	Deeply integrated into European supply chains. Actively uses green credentials as a competitive market advantage.
-----------------	--	---	---

Source: Generated by the author.

To illustrate the practical utility of this matrix, it can be considered a hypothetical mid sized Turkish logistics provider exporting automotive components to the European Union. Initially operating at the *low* readiness level, the firm relies on an aging diesel fleet and estimates its environmental impact solely through basic fuel receipts, neglecting Scope 3 emissions. The impending CBAM regulations present a severe market constraint for this provider. To secure existing contracts with European manufacturers, the firm must upgrade its operations. By investing in Euro 6 vehicles, adopting telematics for route optimization, and implementing the GLEC framework for comprehensive emission tracking, the provider systematically advances to the *moderate* and eventually *high* readiness tiers. Future empirical studies can leverage this specific matrix as a diagnostic roadmap to benchmark various industry sectors, identify operational bottlenecks, and guide green investments in emerging economies.

1. *Low readiness* threshold signifies a strictly reactive operational paradigm wherein logistics networks prioritize short term cost minimization and baseline legal compliance over strategic environmental sustainability. Within this stratum, infrastructural dependence remains heavily locked into fossil fuel intensive modes, notably traditional road freight, with negligible capital allocation toward low carbon alternatives. Consequently, emissions measurement is either completely non-existent or highly ad hoc; organizations systematically fail to track direct emissions and remain structurally oblivious to Scope 3 value chain reporting mandates. Technological integration is fundamentally restricted to rudimentary operational tracking, devoid of environmental optimization protocols, rendering these organizations highly vulnerable and unresponsive to coercive international market constraints such as the CBAM (World Resources Institute and World Business Council for Sustainable Development, 2013).

2. Transitioning toward the *moderate* readiness tier characterizes an evolutionary phase wherein organizations exhibit emerging regulatory awareness and partial synchronization with international climate governance. Infrastructural adaptations manifest through initial investments in intermodal connectivity and energy efficient warehousing, although structural integration across critical logistics corridors remains highly asymmetric. Operationally, while firms successfully quantify direct operational emissions (Scope 1 and 2), they persistently encounter severe interoperability bottlenecks regarding Scope 3 reporting, primarily driven by fragmented supply chain architectures and deficient supplier coordination. Furthermore, although digital tools are incorporated for basic routing efficiencies, their algorithmic architectures are not mathematically optimized for absolute decarbonization. Nevertheless, escalating market exposure and coercive European regulations compel these firms to initiate strategic environmental adaptations (Borchardt et al., 2025).

3. Ultimately, the *high readiness* classification denotes a proactive, system oriented transformation wherein absolute environmental performance is aggressively leveraged as a core competitive advantage. At this apex, regulatory compliance achieves full synchronization with advanced extraterritorial frameworks, notably the European Green Deal. The infrastructural foundation is characterized by sophisticated low emission transport alternatives, electrified fleets, green consolidation hubs, and systemic circular economy integration. Crucially, measurement and reporting capacities are rigorously institutionalized, ensuring strict compliance with definitive methodologies such as ISO 14083 and the GLEC Framework. This ensures absolute transparency and auditable data continuity across Scope 1, Scope 2, and Scope 3 emission parameters (International Organization for Standardization, 2023; Smart Freight Centre, 2024). Moreover, advanced technological integration encompassing Logistics 4.0 and 5.0 paradigms, artificial intelligence, Internet of Things, and big data analytics directly enables real time emissions monitoring, predictive load consolidation, and dynamic routing optimization. Consequently, organizations operating at this optimal threshold effectively neutralize climate related trade barriers, strategically transforming coercive market constraints into lucrative opportunities for sustained market leadership (Boz and Pinto, 2024; Nicoletti and Appolloni, 2024).

Transcending its theoretical conceptualization, the Green Logistics Readiness Matrix establishes a structured architectural foundation for subsequent empirical and comparative inquiry. Methodologically, future scholarship can operationalize this qualitative framework into rigorous quantitative diagnostic instruments by deploying multi criteria decision making algorithms or structural equation modeling to assign empirical weights to each strategic dimension. From a comparative standpoint, the matrix serves as a definitive benchmarking mechanism to evaluate the green logistics maturity of diverse industrial sectors or varying emerging economies, thereby exposing how distinct regulatory architectures and institutional contexts systematically shape logistics

decarbonization trajectories. Empirical manifestations of this diagnostic framework within the Turkish context elucidate how leading organizations strategically navigate the transition from moderate to high readiness thresholds. Regarding infrastructural and technological integration, Borusan Lojistik demonstrates a profound systemic transformation by operationalizing the eTA digital platform for dynamic route optimization while rigorously institutionalizing Scope 1, Scope 2, and Scope 3 emissions tracking in strict compliance with ISO 14064 standards, heavily augmented by extensive capital allocations toward renewable energy and intermodal networks (Borusan Lojistik, 2024). Concurrently, Ekol Logistics epitomizes the proactive management of market exposure and infrastructural adaptation by strategically pivoting toward integrated intermodal transportation architectures encompassing rail, maritime, and road networks (Eşmen et al., 2012). Arkas Logistics reflects progress in regulatory synchronization and operational measurement through targeted investments in eco friendly fleets adhering to Euro 6 standards, alongside marine vessel trim optimization protocols engineered to systematically minimize fuel consumption (Mersin, 2021). From the perspective of focal shippers, dominant manufacturing and retail conglomerates, prominently Arçelik and Migros, exert coercive green supply chain pressures by strictly demanding verified emission measurements and optimized delivery algorithms from their contracted logistics service providers (Desticioğlu, 2021).

8. Policy recommendations

Navigating the coercive pressures of international climate governance, policy interventions must be systematically sequenced across short term, medium term, and long term horizons, reflecting both structural constraints and the institutional logic of sustainable transition. The fundamental premise dictates that national green logistics agendas cannot advance through fragmented, isolated initiatives. Instead, measurement discipline, technology adoption, infrastructure adaptation, and regulatory alignment must co evolve as a synchronized ecosystem. Consequently, the proposed prioritization is strictly governed by the binding capability constraints identified in the diagnostic matrix and the extraterritorial mandates imposed by the European Green Deal.

8.1. Short term priorities: Measurement readiness and transparency

Initial policy interventions must urgently prioritize the institutionalization of measurement readiness and absolute transparency across all logistics networks. This necessitates the systemic diffusion of Scope 3 compatible data architectures, particularly targeting transportation and distribution operations that constitute the core of corporate value chain emissions (World Resources Institute and World Business Council for Sustainable Development, 2013). The primary regulatory objective must focus on operationalizing harmonized carbon accounting practices strictly aligned with definitive international benchmarks, notably ISO 14083 and established global industry frameworks (International Organization for Standardization, 2023; Smart Freight Centre, 2024). Practically, this mandates targeted capacity building for focal firms and logistics service providers through sector specific compliance guidance, advanced training programs, and standardized reporting infrastructures. Public authorities can aggressively accelerate this uptake by embedding rigid measurement prerequisites directly into public procurement contracts, state sponsored logistics support schemes, and export compliance mechanisms. Furthermore, establishing a credible measurement regime requires robust institutional coordination governing data security, third party verification, and systemic interoperability. In the absence of these foundational architectures, corporate emissions reporting risks remaining severely fragmented, methodologically inconsistent, and exclusively confined to a niche segment of elite exporters.

8.2. Medium term priorities: Interoperability and technology diffusion

Subsequent interventions must focus on enforcing digital interoperability and accelerating the widespread diffusion of advanced technologies throughout the logistics ecosystem. Contemporary evidence dictates that digitalization exclusively drives decarbonization when it facilitates dynamic operational optimization, complete traceability, and real time monitoring, strictly contingent upon its seamless integration with auditable emissions accounting systems. Therefore, regulatory frameworks must aggressively subsidize the adoption of Logistics 4.0 and emerging Logistics 5.0 architectures. These computational tools are essential for maximizing routing efficiency, enabling predictive load consolidation, and executing holistic process redesign, thereby achieving absolute emission reductions through data driven decision making. Transcending experimental pilot projects, this developmental phase necessitates scalable technology diffusion supported by coercive incentive structures. Policymakers must deploy targeted grants, progressive tax incentives, and low interest financing specifically engineered to alleviate the prohibitive adoption costs burdening small and medium sized logistics operators.

Equally critical is the deployment of an interoperable digital infrastructure that ensures frictionless data exchange among focal firms, port authorities, customs agencies, and third party logistics platforms. Ultimately, without enforced interoperability, technological investments risk generating highly isolated efficiency gains, fundamentally failing to deliver the systemic transparency and strict comparability demanded by international trade and climate disclosure expectations (Nicoletti and Appolloni, 2024).

8.3. Long term priorities: Structural transformation and competitiveness alignment

Long term policy imperatives must transcend incremental operational adjustments, dictating a profound structural transformation that perfectly synchronizes regulatory frameworks, infrastructure modernization, and international competitiveness parameters (Rastegardebidi and Su, 2025). Rather than functioning as a distant normative ideal, the European Green Deal operates as a highly coercive, extraterritorial policy architecture that irrevocably dictates sectoral transformation pathways and global investment mobilization (European Commission, 2019). Reinforcing this structural shift, the CBAM aggressively penalizes embedded carbon, systematically transforming supply chain transparency and absolute decarbonization capacity into absolute determinants of market survival (European Parliament and Council, 2023). Consequently, for an export dependent economy like Türkiye, long term strategic interventions must exclusively prioritize the establishment of low emission logistics corridors, aggressive intermodal freight expansion, and massive capital reallocations designed to eliminate the systemic reliance on carbon intensive road transport (Karadağ Albayrak, 2025).

Furthermore, navigating these complexities necessitates robust institutional governance capable of enforcing strict policy coherence across transport, environmental, trade, and industrial domains. Sustaining the competitive viability of the Turkish logistics ecosystem relies exclusively on generating auditable emissions data, executing low emission freight services, and ensuring absolute compliance with fluid international standards. Therefore, long term strategic planning must unequivocally reposition green logistics from a peripheral sector specific environmental agenda into the core engine of national export resilience and industrial survival. Synthesizing this transition trajectory, the proposed sequencing, prioritizing measurement readiness and transparency in the short term, enforcing digital interoperability and technology diffusion in the medium term, and executing European aligned structural transformation in the long term, reflects the strict realities of contemporary political economy. This strategic chronology establishes that escalating global competitiveness pressures will disproportionately reward early movers possessing the institutional capacity to construct credible, highly scalable, and structurally resilient green logistics architectures.

9. Conclusion

Through the integration of a systematic literature synthesis and a policy oriented evaluation, the evolving landscape of green logistics and supply chain management in Türkiye is comprehensively assessed within the context of intensifying international climate governance and European climate related trade mechanisms. Combining conceptual analysis, policy gap assessment, and a readiness based diagnostic architecture provides a structured perspective on how regulatory expectations, operational practices, and technological developments interact in shaping logistics transition pathways. Contemporary scholarship unequivocally demonstrates a structural transition toward a highly operational and measurement oriented paradigm. Conceptual convergence, the strict imperative of harmonized emissions accounting, and the systemic integration of digital technologies dictate that logistics decarbonization has transcended peripheral sustainability initiatives. Rather, it constitutes a rigid competitiveness and governance challenge dictated by massive trade exposure and coercive regulatory evolution. Practical readiness relies exclusively on the absolute synchronization of institutional frameworks, measurement capacity, infrastructural conditions, and technology integration, rather than fragmented, isolated improvements.

From a policy perspective, the Turkish transition trajectory is fundamentally characterized by profound structural heterogeneities across these strategic dimensions. While regulatory awareness and immense market exposure generate severe incentives for strategic adaptation, profound operationalization bottlenecks persist regarding emissions reporting consistency, data interoperability, and the widespread diffusion of technology enabled transparency architectures. Addressing these vulnerabilities, the conceptualized Green Logistics Readiness Matrix functions as a robust diagnostic architecture for evaluating sectoral preparedness and directing targeted policy interventions. By systematically stratifying readiness across regulatory, infrastructural, measurement, technological, and market dimensions, the matrix establishes a definitive analytical foundation linking academic synthesis directly to policy formulation and strategic capital allocation. Crucially, while contextualized within the Turkish ecosystem, this framework serves as a highly transferable diagnostic

instrument for other export dependent emerging economies navigating identical pressures from climate related trade mandates and fluid global value chain requirements. Ultimately, this evaluation fundamentally advances the management and political economy literature by inextricably linking conceptual green logistics paradigms with coercive policy realities, establishing a readiness based architecture that actively supports rigorous comparative analysis and evidence informed decision making. Future empirical scholarship can operationalize this framework through targeted sectoral or firm level analyses, alongside longitudinal assessments designed to track the dynamic evolution of readiness thresholds as extraterritorial climate governance architectures continue to mature.

Declarations

Ethical declaration

The research does not require ethical committee approval, as it does not involve human participants, personal data or experimental procedures. The author declares that scientific and ethical principles were adhered to during the conduct and writing of this study, and that all sources have been appropriately cited.

Funding

The author declares that no financial support was received for the research, authorship, or publication of this article.

AI disclosure

The author declares that artificial intelligence tools were used solely for language editing and proofreading purposes due to the author's use of English as a second language (Gemini AI, DeepL). The author further declares that all scientific and ethical principles, including transparency and accountability, were adhered to in the use of these tools. All intellectual content, analysis, and interpretations presented in this study are entirely the original work of the author.

Conflict of interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Note: *This information has been provided by the author.*

References

- Abbasi, S., Sheykhizadeh, M., Khalaji, G. M., Ghasemi, P., & Alizadeh, M. (2026). Location-allocation with green logistics and transport modeling: Consideration of carbon emissions, recycling processes, and shipping frequency. *Cleaner Logistics and Supply Chain*, 100318. <https://doi.org/10.1016/j.clscn.2026.100318>
- Anurag, A. S., & Johnpaul, M. (2026). Mapping the global research landscape of sustainable supply chains in the industry 4.0 era through a triple bottom line perspective. *Cleaner Logistics and Supply Chain*, 19, 100323.
- Bilgen, İ. (2017). Lojistik ve tedarik zinciri yönetiminin güncel yapısını şekillendiren faktörler üzerine kavramsal bir çalışma. *International Journal of Academic Value Studies (Javstudies)*, 3(15), 190-196.
- Borchardt, M., Pereira, G., Milan, G., Pereira, E., Lima, L., Bianchi, R., & Scavarda do Carmo, A. (2025). Are sustainable supply chains managing Scope 3 emissions? A systematic literature review. *Sustainability*, 17, 6066. <https://doi.org/10.3390/su17136066>

- Borusan Lojistik. (2024). *Borusan Lojistik sürdürülebilirlik raporu 2024*. Borusan Lojistik.
- Boz, E., & Pinto, A. R. F. (2024). Evaluation of Logistics 5.0 vs. Logistics 4.0. In H. Nozari (Ed.), *Information Logistics for Organizational Empowerment and Effective Supply Chain Management* (pp. 163-184). IGI Global.
- Chen, H., Wang, Y., Jia, Q., & Liu, Y. (2026). The impact of the digital economy on carbon emission efficiency in logistics: Empirical findings from China. *Cleaner Logistics and Supply Chain*, 100298. <https://doi.org/10.1016/j.clscn.2026.100298>
- Chen, W., Men, Y., Fuster, N., Osorio, C., & Juan, A. A. (2024). Artificial intelligence in logistics optimization with sustainable criteria: A review. *Sustainability*, 16(21), 9145. <https://doi.org/10.3390/su16219145>
- Chepurna, M., Alvarez Palau, E. J., Castillo Gutierrez, C., & Viu Roig, M. (2025). Green logistics: In pursuit of a final definition. *Business Strategy and the Environment*, 34(7), 8983-9007. <https://doi.org/10.1002/bse.70055>
- Dadsena, K. K., Rathore, P., Mathiyazhagan, K., Jayaraman, R., & Saha, E. (2025). Adoption of circular economy practices in supply chains to enhance firm performance: industrial symbiosis and ecological modernization theory perspective. *The International Journal of Logistics Management*. <https://doi.org/10.1108/IJLM-06-2024-0341>
- Desticioğlu, B. (2021). Green supply chain management and sample applications. *Journal of Naval Sciences and Engineering*, 17(2), 283-308.
- Eşmen, O., Bedük, F., & Bedük, A. (2012). Yaşanabilir bir dünya için yeşil lojistik: Türkiye ve dünya uygulama örnekleri. *Ulusal Lojistik ve Tedarik Zinciri Kongresi*, 42-48.
- European Commission. (2019). *The European Green Deal*. European Commission.
- European Commission. (2024). *European Union trade relations with Türkiye*. Directorate General for Trade.
- European Parliament & Council. (2023). Regulation (EU) 2023/956 of the European Parliament and of the Council establishing a CBAM. *Official Journal of the European Union*.
- Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics*, 162, 101-114. <https://doi.org/10.1016/j.ijpe.2015.01.003>
- Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- International Organization for Standardization. (2023). *ISO 14083:2023 Greenhouse gases: Quantification and reporting of greenhouse gas emissions arising from transport chain operations*. ISO.
- Karadağ Albayrak, Ö. (2025). A simulation model based on system dynamics for factors affecting logistics development and performance in Türkiye. *Acta Infologica*, 9(2), 641-663.
- Karagülle, A. Ö. (2012). Green business for sustainable development and competitiveness: An overview of Turkish logistics industry. *Procedia-Social and Behavioral Sciences*, 41, 456-460.
- Kekkonen, A., Pesor, R., & Täks, M. (2023). Stepping towards the green transition: Challenges and opportunities of Estonian companies. *Sustainability*, 15(5), 4172.
- Kumar, V., Bardhan, A. K., & Das, D. (2025). Low carbon supply chains: a service level perspective. *International Journal of Systems Science: Operations & Logistics*, 12(1), 2537217. <https://doi.org/10.1080/23302674.2025.2537217>
- Kühl, L., Wiethölter, J., & Dircksen, M. (2025). Leveraging AI for accurate supply chain risk classification: optimizing the operational parameter space of LLMs. *The International Journal of Logistics Management*.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.
- Mersin, K. (2021). *Yeşil lojistik ve ülkemizde yeşil lojistik uygulamaları*. Gelişim Üniversitesi Yayınları.
- Mumcu, A. Y. (2025). An overview of the concept of green logistics in terms of sustainability and business practices: A bibliographic analysis. *Journal of Business Research-Turk*, 17(2), 1091-1108.
- Nicoletti, B., & Appolloni, A. (2024). Green logistics 5.0: A review of sustainability oriented innovation with foundation models in logistics. *European Journal of Innovation Management*, 27(9), 542-561.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>

- Rahman, T., Ali, S. M., Muktadir, M. A., & Kusi-Sarpong, S. (2020). Evaluating barriers to implementing green supply chain management: An example from an emerging economy. *Production Planning and Control*, 31(8), 673-698.
- Rastegardebhidi, P., & Su, Z. (2025). Key drivers of green logistics: A systematic literature review and conceptual framework. *Sustainability*, 17, 9604. <https://doi.org/10.3390/su17219604>
- Republic of Türkiye Ministry of Trade. (2021). *Green deal action plan*. Ministry of Trade.
- Republic of Türkiye Ministry of Transport and Infrastructure. (2022). *Transport and logistics master plan*. Ministry of Transport and Infrastructure.
- Sauer, P. C., & Seuring, S. (2023). How to conduct systematic literature reviews in management research: A guide in 6 steps and 14 decisions. *Review of Managerial Science*, 17(5), 1899-1933. <https://doi.org/10.1007/s11846-023-00668-3>
- Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research methods for business students* (4th ed.). Pearson Education.
- Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 69(2), 107-131. <https://doi.org/10.1007/s11577-017-0454-1>
- Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. *Supply Chain Management: An International Journal*, 17(5), 544-555. <https://doi.org/10.1108/13598541211258609>
- Smart Freight Centre. (2024). *Global Logistics Emissions Council (GLEC) framework v3*. Smart Freight Centre.
- Srivastava, S. K. (2007). Green supply chain management: A state of the art literature review. *International Journal of Management Reviews*, 9(1), 53-80. <https://doi.org/10.1111/j.1468-2370.2007.00202.x>
- Sünbül, E. (2025). Yeşil tedarik zinciri yönetimi ve sürdürülebilir lojistik: Literatür taraması ve kavramsal değerlendirme. *Ulaştırma Yönetimi Araştırmaları Dergisi (JOTMAR)*, 2(2), 93-112.
- Tetteh, F. K., Kwateng, K. O., & Mensah, J. (2024). Green logistics practices: A bibliometric and systematic methodological review and future research opportunities. *Journal of Cleaner Production*, 476, 143735.
- Toktaş, P., Gül, S., & Erdinç, O. (2024). City logistics decarbonization strategies: A systematic review. *Sustainability*.
- United Nations Framework Convention on Climate Change. (2015). *Paris Agreement*. UNFCCC.
- UTIKAD. (2024). *Türkiye logistics summit sonuç raporu 2024*. Association of International Forwarding and Logistics Service Providers.
- World Resources Institute, & World Business Council for Sustainable Development. (2013). *Corporate value chain (Scope 3) accounting and reporting standard*. WRI and WBCSD.
- Yıldırım, A., & Şimşek, H. (2008). *Sosyal bilimlerde nitel araştırma yöntemleri* (6. Baskı). Seçkin Yayıncılık.
- Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, 15(11-12), 1041-1052. <https://doi.org/10.1016/j.jclepro.2006.05.021>
- Çağlar, M. B., & Karagöz Taşkın, B. (2025). Evaluation of barriers to the adoption of technology in sustainable logistics by DEMATEL method. *International Journal of Contemporary Economics and Administrative Sciences*, 15(2), 1491-1508. <https://doi.org/10.5281/zenodo.18213509>
- Seuring & Müller (2008): Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), 1699-1710. <https://doi.org/10.1016/j.jclepro.2008.04.020>