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Toward Low-Carbon Supply Chains in Morocco: Mapping the Current Situation and Establishing a Research Agenda

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ABSTRACT

In a context marked by increasingly stringent climate and regulatory requirements, the decarbonization of supply chains is a strategic challenge for the transition to sustainable economic models. However, despite growing interest from the scientific community, knowledge regarding decarbonization strategies remains fragmented, particularly in emerging economies. This study aims to map the main research trends on low-carbon supply chains, identify scientific gaps, and propose a research agenda tailored to the Moroccan context. The methodology is based on an integrated approach combining a review of the state of the art, a bibliometric analysis of 123 publications indexed in Scopus between 2015 and 2026, and a qualitative contextual analysis. The results highlight three major thematic areas: the decarbonization of freight transport and logistics activities, sustainable supply chain governance, and digitalization linked to energy optimization. The analysis also reveals limited representation of the Moroccan context in the literature reviewed.

On this basis, the study proposes a research agenda centered on carbon emissions accounting, the implications of the Carbon Border Adjustment Mechanism (CBAM), intermodality, and public policy. Its main contribution lies in linking international scientific knowledge to the specific challenges of the low-carbon transition of Moroccan logistics chains.

Keywords: Decarbonization; low-carbon supply chains; bibliometric analysis; sustainable logistics; Morocco.

1. INTRODUCTION

Climate change is now one of the most fundamental challenges facing contemporary economies. Since the Paris Agreement, governments, international organizations, and businesses have gradually placed the reduction of greenhouse gas emissions at the heart of their transformation strategies. In this context, supply chains play a critical role due to the emissions generated by transportation, warehousing, distribution, procurement, and the coordination of physical and informational flows (McKinnon, 2018).

The decarbonization of supply chains is no longer merely an environmental requirement. It has become a matter of competitiveness, regulatory compliance, and securing access to international markets. Companies now face increasing demands for carbon traceability, reporting of indirect emissions, and management of the environmenta impacts of their suppliers, carriers, and logistics providers (Hettler & Graf-Vlachy, 2024).

In the Moroccan context, this issue takes on particular significance. Morocco aims to consolidate its position as a regional logistics hub through the development of its port, rail, highway, and logistics infrastructure. This ambition is set against a backdrop of energy transition, rising international environmental standards, and the heavy reliance of Moroccan exports on European markets. In this regard, the Carbon Border Adjustment Mechanism (CBAM) serves as a major catalyst for exporting companies and their value chains.

Despite this strategic importance, academic research specifically focused on low-carbon supply chains in emerging economies remains limited. The international literature remains largely dominated by studies focusing on developed economies or certain major emerging economies, while Morocco and North Africa are still underrepresented in research on logistics decarbonization (Wanke et al., 2021).

Consequently, the central question of this research can be formulated as follows: how does the scientific literature address the transition to low-carbon logistics chains, and to what extent does this research shed light on the specific challenges of the Moroccan context?

The objective of our study is to map the current state of knowledge on low-carbon supply chains and to propose a research agenda tailored to Morocco's specific characteristics. This paper thus combines a bibliometric analysis of the international literature with an examination of the constraints, levers, and research needs specific to the Moroccan context.

2. LITERATURE REVIEW

2.1. Definition of Low-Carbon Supply Chains

Logistics decarbonization refers to the set of practices, processes, and strategies aimed at reducing greenhouse gas emissions associated with supply chain activities, from the procurement of raw materials through final delivery and even to the product's end of life (He et al., 2023). It differs from green logistics in its explicitly measurable focus: the goal is not merely to reduce environmental impacts in general, but to track and reduce emissions expressed in CO_2 equivalents.

The literature frequently draws on the Greenhouse Gas Protocol taxonomy. Scope 1 covers direct emissions from sources owned or controlled by the company; Scope 2 covers indirect emissions related to purchased energy; Scope 3 encompasses other indirect emissions along the value chain, particularly those related to suppliers, outsourced transportation, product use, and downstream activities (GHG Protocol, 2011). This last category explains the growing centrality of supply chains in carbon-neutrality strategies.

2.2. Key Approaches

Low-carbon supply chains fall within the field of Sustainable Supply Chain Management (SSCM), which aims to simultaneously integrate economic, environmental, and social dimensions into supply chain management processes (Carter & Rogers, 2008; Seuring & Müller, 2008). Recent literature also draws on institutional theory, stakeholder theory, the Resource-Based View, and the dynamic capabilities approach to explain the adoption, diffusion, and performance of decarbonization practices.

Table 1: Summary of the main approaches cited in the literature

Trend / Concept	Key References	Contribution to the analysis	Link to low-carbon chains
SSCM	Carter & Rogers (2008); Seuring & Müller (2008)	Integration of economic, environmental, and social objectives.	Helps situate decarbonization within a broader sustainability framework.
Low-carbon logistics	McKinnon (2018); Kaur & Singh (2017)	Measurable reduction in emissions related to transportation, logistics networks, and operational decisions.	Introduces trade-offs between cost, service, lead time, and carbon emissions.
Institutional pressures	Sarkis et al. (2011); Hettler & Graf-Vlachy (2024)	Role of standards, regulations, clients, and reporting mechanisms.	Sheds light on the impact of MACF/CBAM and international requirements.
Dynamic Capacities and Green Resources	Singh & Foropon (2025); Naz et al. (2024)	Analysis of companies' ability to identify, leverage, and reconfigure their resources.	Shows that carbon, digital, and organizational competencies are becoming strategic.

Source: Prepared by the author based on Carter & Rogers (2008), Seuring & Müller (2008), McKinnon (2018), Sarkis et al. (2011), Hettler & Graf-Vlachy (2024), Singh & Foropon (2025), and Naz et al. (2024).

An analysis of the main theoretical frameworks presented in Table 1 highlights the complementary nature of the approaches used to understand the decarbonization of supply chains. While Sustainable Supply Chain Management (SSCM) frames emissions reduction within a broader sustainability perspective, low-carbon logistics focuses on operational levers related to transportation, storage, and flow optimization. At the same time, institutional theory emphasizes the role of regulatory pressures and stakeholder demands in the adoption of environmental practices, while the approach based on resources and dynamic capabilities highlights the importance of organizational and technological competencies in driving this transition. These perspectives suggest that decarbonization is not solely a matter of technical optimization but results from the interplay between external constraints, strategic choices, and firms' internal capabilities. Their combined application thus provides a relevant analytical framework for examining the determinants and conditions for implementing low-carbon practices, particularly in the Moroccan context, where the challenges of logistical competitiveness and adaptation to international environmental requirements call for an integrated approach.

2.3. Drivers and Barriers to Decarbonization

Recent research shows that the transition to low-carbon supply chains depend on the set of drivers and barriers, both external and internal. External drivers primarily relate to regulations, client requirements, reporting standards, and market pressure. Internal drivers include energy efficiency, cost reduction, digitalization, logistics innovation, and organizations' ability to transform their operational routines.

Table 2: Drivers and barriers to the decarbonization of logistics chains

Category	Identified Drivers	Identified Barriers	References Cited
External pressures	MACF/CBAM, reporting standards, customer requirements, international clients.	Regulatory complexity, compliance costs, difficulty accessing carbon data.	Hettler & Graf-Vlachy (2024); Kumar et al. (2024)
Internal capabilities	Energy efficiency, cost reduction, process improvement, organizational innovation.	Lack of carbon expertise, low maturity of information systems, resistance to change.	Singh & Foropon (2025); Naz et al. (2024)
Technologies and Data	AI, IoT, traceability, route optimization, reporting platforms.	Incomplete data, poor interoperability, cost of digital solutions.	Jiang et al. (2024); Mrad et al. (2026)
Moroccan Context	Strategic logistics location, rail potential, port projects, energy transition dynamics.	Fragmented sector, aging vehicle fleet, inadequate carbon measurement, limited capacity of SMEs.	AMDL (2023); ITF-OECD (2021)

Source: adapted from Kumar et al. (2024), Hettler & Graf-Vlachy (2024), Jiang et al. (2024), AMDL (2023), and ITF-OECD (2021).

An analysis of the drivers and barriers presented in Table 2 highlights the multidimensional nature of the transition to low-carbon supply chains. While regulatory pressures and market demands are major incentives, their effectiveness remains contingent on companies' organizational and technological capabilities. Digitalization, improved energy efficiency, and logistics innovation thus emerge as complementary drivers, the deployment of which may be limited by financial constraints, skills gaps, and insufficient environmental data. This comparison of driving factors and obstacles reveals a potential gap between decarbonization ambitions and actual implementation capabilities. In the Moroccan context, this gap warrants particular attention due to the predominance of road transport, the aging vehicle fleet, and the still-limited maturity of carbon measurement systems. Consequently, the low-carbon transition cannot rely exclusively on individual corporate initiatives but requires coordination between public policies, technological investments, and organizational capacity building. This analysis underscores the importance of further research into the conditions for adopting decarbonization practices and their adaptation to the structural specificities of the Moroccan logistics system.

3. RESEARCH METHODOLOGY

3.1. Methodological Approach

This study adopts a state-of-the-art approach. This approach is relevant for emerging fields of research, as it allows for mapping existing work, identifying dominant trends, pinpointing under-explored angles, and developing research perspectives. Here, it combines a literature review, a bibliometric analysis, and a qualitative contextualization of the Moroccan case.

3.2. Compilation and Selection of the Corpus

The literature search was conducted in the Scopus database, selected for its coverage of journals in management, logistics, transportation, economics, and environmental sciences. The period 2015–2026 was chosen to cover developments following the Paris Agreement and the recent surge in research on net-zero strategies.

The main search query used is as follows:

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("supply chain decarbonization" OR "net zero supply chain" OR "low-carbon logistics" OR "carbon neutral supply chain") AND ("supply chain management" OR
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The initial search identified 268 publications. After applying the inclusion and exclusion criteria, the final corpus comprised 123 articles and reviews. The selection process prioritized publications directly related to decarbonization, low-carbon logistics, supply chain management (SCM), carbon measurement, and flow optimization. Documents outside the scope, conference proceedings, book chapters, editorials, duplicates, and texts that were inaccessible or irrelevant were excluded.

Table 3: Inclusion and Exclusion Criteria for the Corpus

Inclusion Criteria	Exclusion Criteria
Scientific articles and reviews	Conference proceedings, book chapters, editorials, and non-scientific notes
Publications in English	Publications in other languages when the full text was not available
Period: 2015–2026	Documents prior to 2015, except for foundational references cited in the discussion
Management, logistics, transportation, economics, environmental sciences	Documents primarily related to technical fields with no direct connection to the supply chain, such as medicine, physics, and astronomy, etc.
Work on decarbonization, low-carbon logistics, net-zero, and Scope 3	Documents addressing general sustainability unrelated to carbon reduction in supply chains

Source: Prepared by the author based on the literature search protocol applied in Scopus.

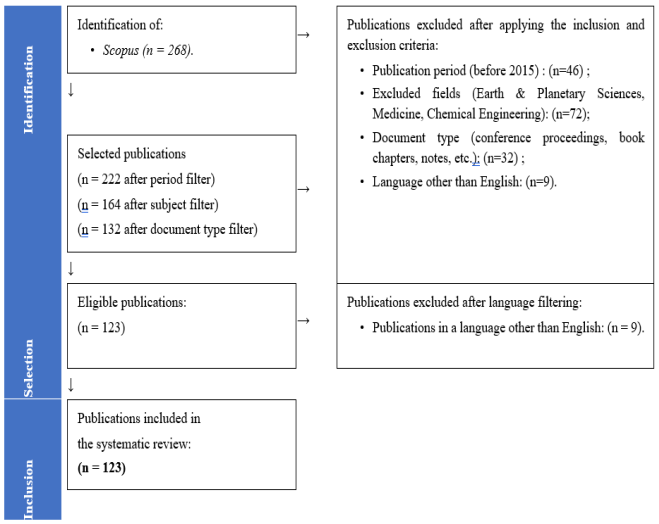


Figure 1: Simplified process for selecting the study population, inspired by PRISMA

Source: Prepared by the author based on Scopus search results.

3.3. Bibliometric Analysis and Qualitative Review

The bibliometric analysis focused on keyword co-occurrences to identify the main thematic clusters in the field. It was supplemented by a targeted qualitative review of the most relevant studies, as well as a documentary analysis of the Moroccan context. This triangulation makes it possible to link international trends to Morocco's specific constraints, notably carbon pricing, the structure of road transport, pressure from the MACF/CBAM, operators' digital maturity, and public policy instruments.

4. RESULTS: MAPPING THE CURRENT SITUATION

4.1. Trends in the Literature Over Time

Analysis of the corpus reveals a marked increase in publications dedicated to the decarbonization of supply chains since the early 2020s (Figure 2). This trend accompanies the rise of net-zero policies, the expansion of carbon reporting requirements, the widespread adoption of Scope 3 approaches, and the integration of decarbonization into industrial and logistics strategies.

The peak observed between 2024 and 2025 confirms that the decarbonization of supply chains is now a rapidly expanding field of research. However, research remains primarily concentrated on developed economies and certain major emerging economies. This geographic concentration limits consideration of the specific constraints facing middle-income economies, particularly regarding green financing, the availability of carbon data, the structure of the logistics sector, and companies' technological capabilities.

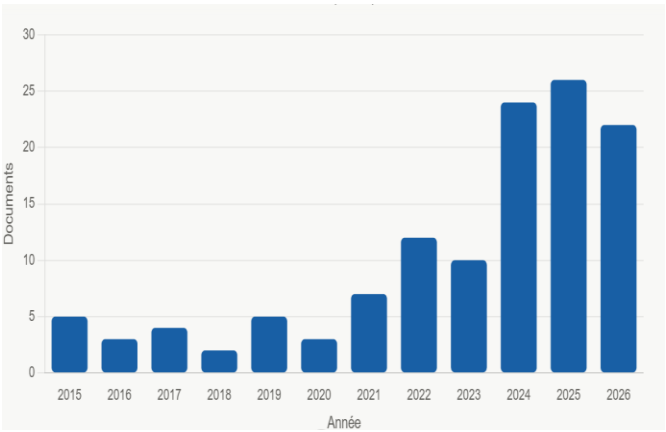


Figure 2: Annual distribution of scientific publications (2015–2026)

Source: Prepared by the author based on Scopus search results.

4.2. Dominant Bibliometric Clusters

A bibliometric analysis of keyword co-occurrences conducted using VOSviewer software on the corpus of publications indexed in Scopus (2015–2026), identifies the main scientific trends shaping research on the decarbonization of supply chains. The resulting map (Figure 3) highlights three thematic clusters, reflecting the diversity of approaches employed in this field of research.

The first cluster (C1), shown in green**,** encompasses studies focused on low-carbon transportation and logistics, including the optimization of flows, energy efficiency, and the reduction of emissions associated with logistics operations. The second cluster (C2), identified in red**,** brings together research on the sustainable governance of supply chains, *Sustainable Supply Chain Management* (SSCM) practices, carbon reporting, and environmental requirements. Finally, the third cluster (C3), represented in blue**,** concerns technological approaches based on digitalization, data analytics, and intelligent decision-support tools.

The central position of the term "carbon" in the co-occurrence network underscores the cross-cutting nature of the carbon issue and the interrelationships among these different scientific areas of focus.

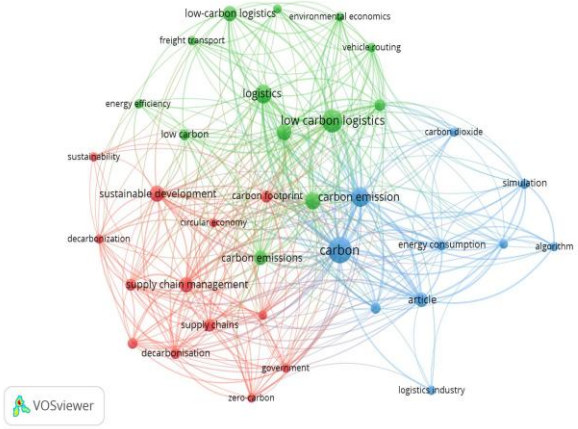


Figure 3: Co-occurrence map of keywords from the 2015–2026 Scopus corpus — VOSviewer.

Source: Prepared by the author based on a bibliometric analysis of the Scopus corpus.

The thematic interpretation of this map, summarized in Figure 4, reveals three complementary areas: operational and energy optimization of logistics activities (C1), environmental governance and carbon reporting (C2), and digitalization and smart technologies applied to supply chains (C3).

This framework suggests that the operational, organizational, and technological dimensions of decarbonization are complementary. In particular, it highlights the importance of aligning emissions reduction strategies with environmental governance mechanisms and digital tools for measuring and managing carbon performance.

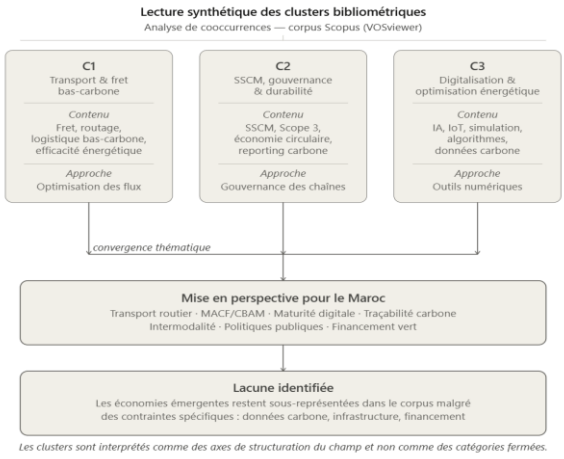


Figure 4: Thematic clusters identified through co-occurrence analysis generated using VOSviewer

Source: Prepared by the author based on a bibliometric analysis of the Scopus corpus.

To provide further insight, Table 4 presents the main themes associated with each cluster, their scientific interpretation, and the research opportunities that may arise from them in the Moroccan context.

Table 4: Interpretive Analysis of Bibliometric Clusters

Cluster	**Main Themes**	**Scientific Interpretation**	**Prospects for Morocco**
C1: Low-Carbon Transportation and Logistics	Freight, routing, low-carbon logistics, energy efficiency.	Operational approaches focused on reducing emissions and optimizing logistics flows	Road transport, urban congestion, modal shift, and logistics corridors.
C2: Sustainable Supply Chain Governance	SSCM, Scope 3, circular economy, carbon reporting.	Shift toward strategic approaches integrating environmental governance and regulatory requirements.	Exporters subject to European requirements, contracting parties, and MACF/CBAM.
C3: Digitalization and Smart Supply Chains	AI, IoT, blockchain, carbon accounting, energy simulation	Emergence of approaches based on data and smart technologies	Logistics digitization, carbon traceability, and smart management systems

Source: Prepared by the author based on co-occurrence analysis and the work of Fahimnia et al. (2015), Hettler & Graf-Vlachy (2024), Jiang et al. (2024), and Mrad et al. (2026).

A cross-analysis of these three clusters highlights the need for an integrated approach to decarbonization, combining operational performance, environmental governance, and digital transformation. In the Moroccan context, this analysis identifies several avenues for further investigation, notably the optimization of road transport, adaptation to the carbon requirements of international markets, and the development of emissions traceability systems. These directions offer relevant avenues for further study of the conditions for transitioning to low-carbon supply chains in Morocco, while taking into account the structural and organizational constraints specific to its logistics system.

4.3. Cross-Cutting Lessons

Three key lessons can be drawn. First, the literature remains heavily focused on technical optimization solutions: electric vehicles, routing, energy efficiency, algorithms, and simulation. Second, recent research is gradually broadening the analysis to include value chain governance, reporting requirements, Scope 3 emissions, and inter-organizational coordination. Third, emerging economies remain underrepresented, even though they face specific constraints related to data, infrastructure, financing, and organizational capacity.

This last point is particularly relevant to the Moroccan context. It shows that models developed in developed economies cannot be applied mechanically. The low-carbon transition of Moroccan supply chains requires taking into account the sector's structure, dependence on road transport, the size of operators, investment constraints, and the presence of strategic actors capable of steering the ecosystem toward new practices.

5. The MOROCCAN CONTEXT

5.1. Overview of the Moroccan Logistics Sector

Morocco occupies a strategic geographic position at the crossroads of Europe, Africa, and the Atlantic. Logistics is a sector of national importance, supported by port infrastructure, logistics zones, highway development, and rail connections. Platforms such as Tanger Med and the logistics corridors linking industrial zones to international markets are major assets for the country's competitiveness.

However, Morocco's logistics system remains heavily reliant on road transport, with a fragmented network of operators and a significant proportion of micro-enterprises and SMEs. This situation exacerbates challenges related to carbon measurement, fleet renewal, digitalization, green investment, and skills development. The low-carbon transition therefore cannot be analyzed solely as a technological challenge; it also involves issues of sectoral structuring, governance, and support for operators.

5.2. Regulatory Framework and Sectoral Initiatives

Morocco's framework for environmental transition has gradually been consolidated through the National Charter for the Environment and Sustainable Development, the National Sustainable Development Strategy, the Nationally Determined Contribution, and the long-term low-carbon strategy. These guidelines create an environment conducive to integrating decarbonization into logistics and industrial policies.

Several Moroccan stakeholders have launched low-carbon transition initiatives. Tanger Med serves as a key example through its port decarbonization initiatives. The ONCF demonstrates the potential of rail as a lever for reducing freight transport emissions. The OCP and certain export sectors, notably the automotive and agri-food industries, are also addressing carbon traceability and the requirements of international markets.

However, these initiatives remain concentrated among major players with investment, engineering, and reporting capabilities. The main challenge is to extend these practices to the entire logistics ecosystem, particularly SMEs, trucking companies, medium-sized logistics providers, and local distribution operators.

5.3. Structural Challenges in the Moroccan Context

Table 5: Key Challenges of Logistics Decarbonization in Morocco

Challenge	Description	Level of Impact	Sources / References
Carbon Measurement	Limited adoption of operational calculation standards, fragmented logistics data, and certification challenges.	Critique	GHG Protocol (2011); AMDL (2023)
Sector fragmentation	Significant proportion of microbusinesses and SMEs with limited capacity for green investment and reporting.	High	AMDL (2023); ITF-OECD (2021)
Reliance on road transport	Dominance of road transport, challenges related to fleet renewal, and low modal shift for certain traffic flows.	High	ITF-OECD (2021); AMDL (2023)
Digital maturity	Low integration of traceability tools, data platforms, and	Moderate to high	Jiang et al. (2024); Mrad et al. (2026)

	carbon reporting systems.		
Institutional Coordination	Need for shared governance among public actors, companies, associations, platforms, and regions.	Moderate	Sarkis et al. (2011); Hettler & Graf-Vlachy (2024)

Source: Prepared by the author based on GHG Protocol (2011), AMDL (2023), ITF-OECD (2021), Jiang et al. (2024), and Mrad et al. (2026).

6. RESEARCH AGENDA

The proposed research areas stem from the intersection of dominant trends identified in the international literature and the specific constraints of the Moroccan context: limited data on carbon-, dependence on road transport, pressure from the MACF/CBAM, low digital maturity among many operators, the need for public-private coordination, and the necessity of developing standards tailored to local realities.

Table 6: Proposed research agenda for the Moroccan context

Research Area	Central Question	Suggested Method	Target Partners
Measuring the logistics carbon footprint	Which standards and emission factors should be applied to Moroccan supply chains?	Comparative study, operator survey, development of a calculation framework.	AMDL, ONEE, universities, industry associations
Impact on the MACF/CBAM	What effects will this have on the competitiveness of Moroccan exporters and logistics service providers?	Sector-specific empirical studies and case analyses.	CGEM, Maroc PME, exporters' associations
Digitalization and carbon traceability	How can AI, IoT, and data platforms support emissions reduction?	Living lab, digital maturity assessments, flow modeling.	Logistics operators, ICT providers, industrial zones
Green urban logistics and circularity	What sustainable urban logistics models are suitable for Moroccan cities?	Regional case studies, interviews, local pilot projects.	Municipalities, regions, carriers, economic sectors
Public policy and governance	What regulatory, economic, and partnership-based tools can accelerate the transition?	International benchmarking, the Delphi method, institutional analysis.	Ministries, donors, local governments, federations

Source: Prepared by the author based on bibliometric clusters, identified Moroccan constraints, and the work of McKinnon (2018), Hettler & Graf-Vlachy (2024), Jiang et al. (2024), and Kumar et al. (2024).

CONCLUSION

This study has mapped the existing body of literature on low-carbon supply chains and provided an analysis tailored to the Moroccan context. Analysis of the Scopus corpus shows that the literature is organized around three major themes: the optimization of transportation and logistics operations, the sustainable governance of value chains, and the growing use of digital technologies for measuring, simulating, and reducing emissions.

One of the key findings is the underrepresentation of emerging economies—particularly Morocco—in the international literature. However, the Moroccan context presents specific characteristics that call for dedicated research: dependence on road transport, sector fragmentation, European pressures related to the MACF/CBAM, a lack of carbon data, and the presence of strategic actors capable of driving change.

The article thus helps establish a research agenda centered on five priorities: measuring the logistics carbon footprint, the impact of the MACF/CBAM, digitalization and carbon traceability, green urban logistics, and public policies for the energy transition. These avenues can help structure a still-emerging field of research and support Moroccan stakeholders in building more sustainable, competitive, and resilient logistics chains.

Our research does, however, have certain limitations. The corpus is limited to the Scopus database, and the analysis remains primarily documentary. Empirical research based on sur vestigations, interviews, and case studies involving Moroccan logistics companies is needed to test, supplement, and operationalize the proposed perspectives.

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