A SYSTEMATIC LITERATURE REVIEW ON LOW-CARBON LOGISTICS

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1. Introduction

The world-widely significant economic growth has resulted in some environmental problems and pollution concerns (Isaksson, 2018). Over the decades, the upcoming climate change issues have made industries, academia and governments reach consensus that reducing carbon emissions is a necessary step to slow down and lessen the effects of climate change (Meyer, 2020a). Thereby, transportation is recognised as one of the most important social activities to be decarbonized, due to its high dependency on fossil fuel (Tang & Zhou, 2012). Incorporating low-carbon and green logistics into the transportation and logistics sector signifies a crucial move towards sustainable development in response to increasing environmental concerns and the worldwide decarbonization plan.

To construct an all-encompassing depiction of the literature, many reviews have been constructed to evaluate the research on decarbonisation and sustainability, varying distinct geographic scope, number of papers examined, and period of observation (Meyer, 2020b). In many comprehensive reviews, broader field of green management and environmental sustainability including and beyond logistics and freight transportation was analysed (Choudhary & Sangwan, 2022; Karimi Takalo et al., 2021; Marchet et al., 2014; Meyer, 2020b). Most of the reviews consider specific aspects of low-carbon logistics and freight transportation in specific circumstances.

However, with all the literature reviews articles, the pure literature review on low-carbon logistics without any specific constraints and from any specific perspectives is not among the top research topics, and not enough articles can conclude the current research stage on it. Therefore, this study is aiming at conducting a systematic literature review to examine low-carbon logistics without specific constraints and identifying the academic streams in this topic by further adopting bibliographic analysis. The cluster analysis will then be listed and explained by content analysis to build research communities in low-carbon logistics. In summary, the research questions and research structure are as follows:

1	How did the research field of low-carbon logistics and freight over time in terms of Year and Journal?
2	What specific research topics have been discussed in the research field of low-carbon logistics?
3	What are the potential research directions and trends in the research field of low-carbon logistics?
4	What low-carbon strategies and technologies in terms of low-carbon logistics practices are currently welcomed and discussed?

Figure 2 Research questions

a)	presenting and defining sustainable supply chain and low-c logistics.
b)	presenting the research design.
c)	depicting results of the bibliometric and cluster analysis.
d)	providing a comprehensive discussion and summary, alon proposing future research directions.

Figure 1 Research structure

2. Literature review: low-carbon logistics

Low-carbon, or decarbonisation, as a widely discussed term, can be dated back to the simple definition as the reduction of carbon emissions of the economic practices (Nakicenovic, 1996). The review conducted by de Sousa Jabbour et al (2019c) concluded low-carbon operation practices into three main areas: Low-carbon products focused on green product designs, Low-carbon production and processes to encourage the decarbonized inventory, and Low-carbon logistics to reduce the carbon emission from transport activities.

Low-carbon logistics is an essential factor of sustainability (Coley et al., 2009) and it has been explored from many perspectives in many articles. However, the definition of low-carbon logistics has not been clearly defined (Cheng and Zhang 2017).

As a result, low-carbon appears in the literature under various names, including 'greenhouse gas emissions, decarbonization, carbon emissions, CO2 emissions, carbon footprints, and carbon management (Tozanli et al., 2017). The concept of low-carbon logistics/green logistics was accepted from 1990s (Srivastava 2007) and then subsequently reviewed and discussed by companies, researchers and other decision-makers in supply chain management (Bi et al., 2020). Low-carbon logistics is regarded as an activity to reduce carbon emissions in supply chain (Das and Jharkharia 2018). The narrow meaning of decarbonization logistics can be the actions of reducing and managing pollutants caused by logistics activities, such as reducing carbon dioxide emissions generated in transporting freight (Kwak et al. 2020).

3.Research design

3.1 Process of SLR

The process of SLR includes identification, searching, screening, analysing, and interpreting the research in a specific academic area (Abduljabbar et al., 2021). The SLR review process of this manuscript is therefore as Figure 3:

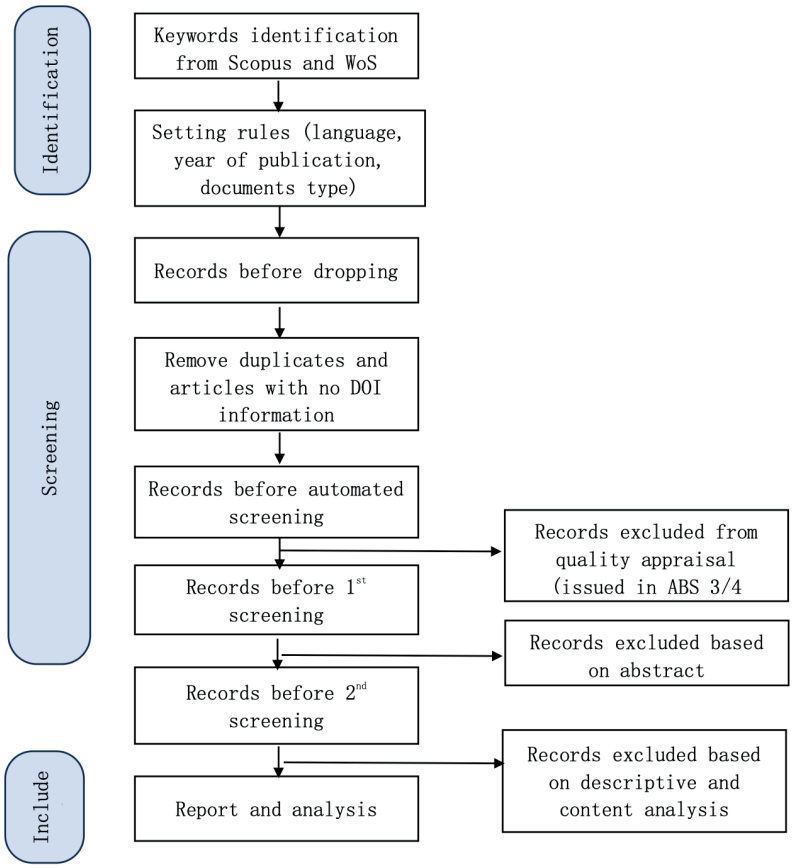

Figure 3 SLR process.

With the previously defined research aims and research questions, the keywords related are then identified and used to search for articles from two specific databases: Web of Science (WoS) and Scopus. These two databases are chosen because they share similar advantages such as extensive coverage, high quality of sources, citation analysis and tracking, updated content, cross-disciplinary research support and advanced search and filtering options (Vieira & Gomes, 2009).

3.2 Keywords and inclusion and exclusion criteria

The search was conducted both in Scopus and Web of Science based on 'titles, keywords and abstract'. The keywords and criteria as follow:

Keywords search string

Low-carbon logistics keywords: Low carbon logistics* OR Green logistics* OR Decarbon* logistics* OR Decarbon* distribution* OR Decarbon* transportation OR Decarbon* freight OR Alternative powered heavy good vehicles OR Alternative powered light good vehicles - filtered with motivations/ enablers/pressures/drivers

AND

Low-carbon vehicle technology: Freight vehicle technology OR Electric freight vehicles OR Hydrogen freight vehicles OR Bio-fuels freight vehicles

Figure 5 Searching Keywords

- Only journal articles are included
- Articles like conference paper, book chapters, etc are excluded
- Only articles published during 2018-2024 are included
- Articles only in English language are included
- The Web of Science applied index: Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCI-EXPANDED)

Figure 4 Inclusion and exclusion criteria

3.3 Search results and quality screening

The numbers returned from Scopus and WoS are varied a lot, with 514 from Scopus and 1109 from WoS, and 157 for the overlapTo weaken the influence of irrelevant articles and take a critical analysis, the quality of articles needs to be assessed. The automatic screen makes sure that only articles published in above ABS (Chartered Association of Business School) 3-star journals are included. The numbers after the quality screening drop to 109 for Scopus and 383 for WoS, and 67 for the overlap.

4.Analysis

As VOSviewer offers appropriate functions for bibliographic analysis and its features can properly explain research questions, VOSviewer is selected in this study (Arruda et al., 2022).

4.1 Bibliographic coupling analysis

Bibliographic coupling indicates the relationship between two articles when they reference one same third work in their bibliographies. The occurrence of bibliographic coupling suggests the possibility that two articles discuss a related research topic (Kessler, 1963). The analysis is based on data collected from both Scopus and WoS, and the nodes represent articles connected to other articles by links.

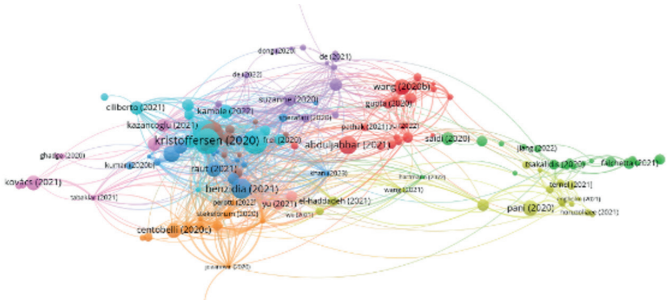

Figure 7 Scopus clusters

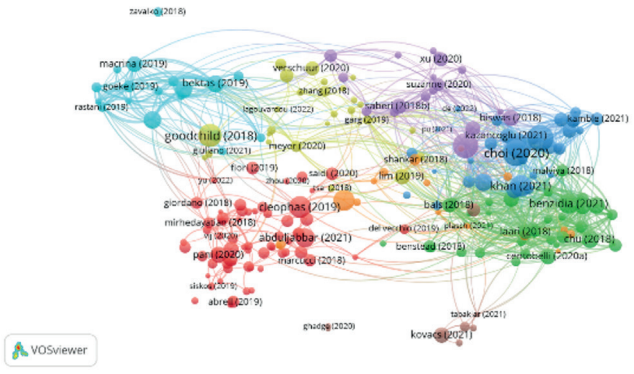

Figure 6 WoS clusters

4.2 Cluster analysis

A content analysis is conducted by manually screening the articles of each cluster mainly based on the 'title, keywords and abstract', but will extend to the whole body of articles if necessary. The following tables illustrate the content descriptive analysis and the typical used research methods of clusters of both Scopus and WoS data.

Cluster No.	Content Discriptive analysis	Methodology implication
1	1.Electrification in transport; 2.What barriers and motivators for the promotion on the use of EVs in different contexts 3.Alternative fuel-powered transport 4.Policy related issues highly discussed	1.Mostly literature-review type articles 2. Delphi study
2	Mostly articles considering low-carbon logistics and environmental management in the context of SCM	Mostly conclusive articles. For example: literature review and cross-regional research
3	1.Circular economy 2.Reverse logistcs 3.How to achive low-carbon/sustainable management in different industries by using different strategies and techniques 4.Considering green logistics activities to material recycling and production planning process	Literature review and algorithm modeling
4	1.Smart technology and digital supply chain 2.IoT in circular economy	Review, theory and conceptual framework based research
5	1.Block chain technology in sustainable supply chain 2.Sustainable practices for SDGs 3Considering problems within specific industrial context	Literature review
7	=cluster 2+3+4	=cluster 2+3+4
11	Logistics sector in sustainable supply chain	
(Cluster 4 and 5 are similar and cluster 11 should be included to cluster 2)		

Table 2 WoS clusters content

Cluster No.	Content Discriptive analysis	Methodology implication
1	1.Electrification in transport; 2.Decarbonising freight transportation 3.Routing problems for electric vehicle logistics	1.Mathematical model - Data analysis 2. Literature review - bibliographic analysis
2	1.How is E-Vs used now? 2.Is electrification beneficial for both environmental and economic performance of logistics? 3.Electrification for fleets 4.Electric commercial vehicles	Mostly emperical studies
3	1.Sustainable supply chain management 2.Technology employment in sustainable supply chain 3.Big data analytics and Artificial intellegence in SSC	Literature review and Data analysis
5	1.Circular economy 2.Reverse logistcs/closed-loop supply chains 3.Green reverse logistics network design 4.Carbon regulatory mechanisms 5.Cold supply chain for sustainable objectives 6.More real technique and strategies in specific industrial context	Modeling and matheuristic algorithm analysis
6*	1.Digital/smart circular economy 2.Industry 4.0 within Circular Economy 3.Business models and business strategies for Circular Economy	Literature review
7*	Green and sustainable supply chain management level	1.Literature review 2.Document analysis 3.Factor analysis
8	1.Block chain technology 2.United Nations' Sustainable Development Goals (SDGs)	Modeling and literature review
9	1.Reverse logistics 2.Network design for green reverse logistics	Algorithm modeling
10	1.The outside factors that affect sustainable supply chain 2.drivers for green initiatives	Natural Resource-Based View (NRBV)
(Cluster 2 is the extension of cluster 1; Cluster with stars are the significant and highly related clusters)		

Table 1 Scopus clusters content

Based on the cluster analysis from Scopus, the detailed discussion of significant clusters will follow in the subsequent section. Some clusters such as cluster 2, which should be incorporated into other clusters will not be specifically discussed. Cluster 3, 6 and 9 are also discarded as they only include limited numbers of articles and are not distinct in contents.

4.2.1 Cluster 1: Electrification and routing problem

Electrification and alternative fuel utilization in transport is one of the most important ways to achieve decarbonization logistics. To obtain green transportation, different logistics strategies are discussed based on different types of logistics activities. The review by Meyer (2020b) uses data-driven review technique to examine the reduction of carbon emissions in road freight transportation. It addresses three fast growing research topics as: routing problems, decarbonization in last-mile, and alternative fuels. Similarly, as an important solution to last-mile delivery and short-distance travel, a review on micro mobility is conducted by Abduljabbar et al. (2021). It offers another potential solution to a transport with lower carbon.

The details of the key research areas and potential research directions addressed by cluster 1 are as follows:

- **Electrification in Transport:** This includes exploring the adoption and impact of electric vehicles (EVs) in urban transport and logistics, particularly micro-mobility solutions that can reduce reliance on private vehicles for short-distance travel, contributing to sustainable urban transport. In addition, eco-packaging can be related to more sustainable last-mile delivery (Jovanovic et al. 2020; Meyer 2020b; Thiel et al. 2020; Tsakalidis et al. 2020; Wang et al. 2020; Abduljabbar et al. 2021; Jiang et al. 2022; Zhang et al. 2022).
- **Decarbonizing Freight Transportation**: This includes analysing strategies for reducing carbon emissions in freight transport, such as the adoption of alternative fuel-powered heavy-duty trucks and green logistics practices. The focus is on overcoming barriers to the adoption of these technologies and optimizing their implementation (Anderhofstadt and Spinler 2019; Bhardwaj et al. 2020; Zhang et al. 2022).
- **Routing Problems for Electric Vehicle Logistics**: Research here involves developing and refining mathematical models and algorithms to optimize routes for electric vehicles, enhancing efficiency, and minimizing environmental impact (Anderluh et al. 2021; Behnke et al. 2021; Florio et al. 2021; Basso et al. 2022).

Figure 9 Cluster 1: Research topics

- **Barriers for decarbonisation of freight transport:** Future research can identify and address policy, organizational and technological barriers that hinder the widespread adoption of alternative fuels and electric vehicles in freight transportation, with focusing on operational measures and collaborative efforts to overcome these barriers. Understanding the interplay between government regulations, stakeholder influences, and technological innovation is crucial.
- **Infrastructure Development**: Researching the development and deployment of fuelling and charging infrastructure for alternative fuel and electric vehicles, with a focus on overcoming the current limitations and fragmentation.
- **Collaboration Mechanisms**: Exploring cooperation mechanisms between LSPs for last-mile deliveries and shared transport solutions to enhance efficiency and sustainability in logistics.

Figure 8 Cluster 1: Research directions

4.2.2 Cluster 5 and 9: Circular Economy and Reverse Logistics

Clusters 5 and 9 in the systematic literature review focus on sustainable supply chains, circular economy, and reverse logistics. The main areas of discussion and research direction suggestions within these clusters are:

- **Circular Economy and Reverse Logistics:** The research emphasizes the importance of integrating circular economy principles into supply chain management, specifically focusing on reverse logistics and closed-loop supply chains. This includes strategies for green reverse logistics network (Kristoffersen et al. 2020; Moktadir et al. 2020; Suzanne et al. 2020; Kazancoglu et al. 2021; Zhang et al. 2021; Agrawal et al. 2022).
- **Carbon Regulatory Mechanisms:** Carbon regulatory mechanisms such as carbon cap-and-trade schemes and their impact on supply chain operations are studied in the clusters. These mechanisms are analysed for their effectiveness in reducing emissions and promoting sustainable practices (Sherafati et al. 2020; Yang et al. 2021).
- **Humanitarian Logistics and Supply Chain Disruptions:** Lessons from humanitarian logistics are applied to manage supply chain disruptions, with a focus on designing resilient supply networks that can cope with unexpected events such as the COVID-19 outbreak (Kovács and Falagara Sigala 2021).

Figure 11 Cluster 5&9: Research topics

- **Exploring Drivers and Barriers to Circular Supply Chain Management:** More empirical studies are needed to investigate the drivers and barriers to transitioning to CSCM. This includes studying the enablers and barriers to new decarbonization technologies and systems.
- **Enabling Technologies for CSCM:** Future research should focus on enabling technologies such as blockchain and information systems that support CSCM. This involves understanding how these technologies can facilitate the transition to more sustainable supply chain practices.
- **Impact of Carbon Policies on Supply Chains:** Further exploration of how carbon regulatory mechanisms such as cap-and-trade schemes impact supply chain operations. Research should analyse the effectiveness of these policies in promoting sustainable practices and compliance among companies.

Figure 10 Cluster 5&9 Research directions

4.2.3 Cluster 7: Sustainable Supply Chain (SSC)

Cluster 7 focuses on the integration of low-carbon and sustainable practices within supply chains, particularly from the perspective of third-party logistics providers (3PLs). The key areas of discussion and potential research directions within this cluster are:

- **Low-Carbon Supply Chain Integration (LCSCI):** This research explores how 3PLs interact with customers and governments to initiate and integrate low-carbon supply chain practices. It considers factors such as customer outsourcing scope and government regulations, highlighting their impacts on the effectiveness of LCSCI initiatives (Liu et al. 2020).
- **Green Practices and Enabling Technologies:** The adoption of green practices and enabling technologies by logistics service providers (LSPs) is a significant focus. This includes identifying motivations and barriers for adopting these technologies and practices and developing a taxonomy of strategies for LSPs to adopt green initiatives (Centobelli et al. 2020a; Centobelli et al. 2020b; Jovanovic et al. 2020).
- **Sustainability-Oriented Service Quality:** Sustainability performance includes both economic and environmental performances. This area examines the relationship between the service quality of LSPs and corporate sustainability, emphasizing the need for service quality perceptions to meet customer demands and expectations within the context of competition (Ozbekler and Ozturkoglu 2020; Perotti et al. 2022).

Figure 13 Cluster 10: Research topics

- **Service Quality and Sustainability:** Examine the impact of sustainability-oriented service quality on customer satisfaction and competitive advantage. Future research should focus on identifying key service quality attributes that align with sustainability goals and meet customer demands.
- **Impact of Customer and Government Interactions:** Further research should explore the specific interactions between 3PLs, customers, and governments that drive successful sustainable supply chain management. This includes understanding how these interactions vary across different regulatory environments and customer expectations.
- **Adoption of Single-Firm Technologies:** Investigate the motivations and barriers for LSPs to adopt single-firm technologies, particularly from a cost and policy perspective. This includes analysing the mismatch between the demands of shippers and the capabilities of LSPs to adopt these technologies.
- **Behavioural Factors and Green Initiatives:** Investigate the behavioural factors influencing the adoption of green initiatives, particularly in the logistics and freight transport sectors. This includes understanding how organizational culture, management practices, and employee behaviours impact the effectiveness of green initiatives.

Figure 12 Cluster 10: Research directions

4.2.4 Cluster 8: Blockchain technology and SSC

Cluster 8 mainly focuses on the integration of blockchain technology within supply chains and its alignment with the United Nations' Sustainable Development Goals (SDGs). The key areas of discussion and future research directions within this cluster include:

- **Blockchain Technology in Supply Chains:** The research explores the application of blockchain technology in supply chain management, addressing its potential to enhance transparency, traceability, and efficiency. The use of blockchain is discussed to create more resilient and sustainable supply chains (Zhu et al. 2022a).
- **United Nations' Sustainable Development Goals (SDGs):** Blockchain technology can be used to meet the SDGs. It investigates specific goals such as responsible consumption and production, climate action, and industry innovation and infrastructure (Cai and Choi 2020).

Figure 15 Cluster 8: Research topics

- **Addressing Implementation Barriers:** Investigate the barriers to implementing new technological innovations in SSC, such as technological, organizational, and regulatory challenges. Research should focus on identifying strategies to overcome these barriers and facilitate wider adoption of sustainable and green practices.
- **Enhancing Supply Chain Transparency:** Explore the potential of blockchain technology to enhance transparency and traceability in supply chains. Future studies could develop and test models that use blockchain to improve visibility across the entire supply chain, from production to consumption.

Figure 14 Cluster 8: Research directions

5. Conclusion

This systematic literature review on low-carbon logistics highlights significant trends, contributions, and future directions within the field. The research illustrates that literature-review-based studies dominate this area, emphasizing the importance of synthesizing existing knowledge to advance the field. The review utilized bibliographic analysis and citation analysis as the primary methodologies for conducting systematic reviews.

Key findings from the review include the identification of core theories such as institutional theory, stakeholder theory, and the Resource-Based View (RBV), including its extension, the Natural Resource-Based View (NRBV). These theories provide a solid foundation for understanding the dynamics and drivers of sustainable practices in logistics and supply chain management.

The key contributions and potential future research directions identified in this study are:

Identifying Predominant Research Areas: The review reveals that electrification of vehicles, especially in freight transport, along with alternative fuel-powered transport, is gaining significant traction. This includes studies on the routing problem, utilization of electric vehicles (EVs) in urban freight, and policy implications for promoting EV adoption

Highlighting the Role of Policy and Government Intervention: The review underscores the critical role of policy and government intervention in achieving decarbonization and advancing green logistics and freight transport.

Exploring Sustainable Supply Chain Management (SSCM): The study finds SSCM to be a popular topic, with numerous articles calling for a deeper exploration of green logistics practices. This includes the application of information technology, optimization algorithms, green truck fleets, and reverse logistics.

Technological Advancements: The review identifies artificial intelligence (AI), digital technologies, blockchain technology, Industry 4.0, and the Internet of Things (IoT) as significant enablers for decarbonization. These technologies facilitate reverse logistics and the circular economy, contributing to sustainable outcomes.

Figure 17 Contributions

Practical Implementation of Technologies and Practices: Future research should focus on the practical implementation of low-carbon technologies and practices in logistics and supply chain management. This includes examining real-world applications and assessing their effectiveness.

Policy Impact Studies: More studies are needed to analyse the role of policy in driving change within the logistics sector. Understanding the impact of various policies on the adoption of green practices can provide valuable insights for policymakers.

Interplay Between Enablers and Barriers: The interactions between different enablers and barriers for adopting low-carbon practices remain ambiguous. Future research should investigate these interactions to identify strategies for overcoming obstacles and enhancing enablers.

Exploring Behavioural Factors: Investigating the behavioural factors influencing the adoption of green initiatives in logistics and freight transport sectors is essential. This includes examining organizational culture, management practices, and employee behaviours.

Figure 16 Future research directions

In conclusion, while significant progress has been made in understanding and promoting low-carbon practices in logistics and supply chain management, future research should aim to bridge the gap between theoretical frameworks and practical applications. This will provide a more comprehensive understanding of how to effectively achieve sustainable and green logistics across different contexts.

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