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Sustainable green logistics and remanufacturing: a bibliometric analysis and future research directions

Ali Nikseresht
Department of Industrial Management and Information Technology, Faculty of Management and Accounting, Shahid Beheshti University, Tehran, Islamic Republic of Iran
Davood Golmohammadi
Management Science and Information Systems Department, College of Management, University of Massachusetts Boston, Boston, MA, USA, and
Mostafa Zandieh
Department of Industrial Management and Information Technology, Faculty of Management and Accounting, Shahid Beheshti University, Tehran, Islamic Republic of Iran

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Abstract

Purpose – This study reviews scholarly work in sustainable green logistics and remanufacturing (SGLR) and their subdisciplines, in combination with bibliometric, thematic and content analyses that provide a viewpoint on categorization and a future research agenda. This paper provides insight into current research trends in the subjects of interest by examining the most essential and most referenced articles promoting sustainability and climate-neutral logistics.

Design/methodology/approach – For the literature review, the authors extracted and sifted 2180 research and review papers for the period 2008–2023 from the Scopus database. The authors performed bibliometric and content analyses using multiple software programs such as Gephi, VOSviewer and R programming.

Findings – The SGLR papers can be grouped into seven clusters: (1) The circular economy facets; (2) Decarbonization of operations to nurture a climate-neutral business; (3) Green sustainable supply chain management; (4) Drivers and barriers of reverse logistics and the circular economy; (5) Business models for sustainable logistics and the circular economy; (6) Transportation problems in sustainable green logistics and (7) Digitalization of logistics and supply chain management.

Practical implications – In this review, fundamental ideas are established, research gaps are identified and multiple future research subjects are proposed. These propositions are categorized into three main research streams, i.e. (1) Digitalization of SGLR, (2) Enhancing scopes, sectors and industries in the context of SGLR and (3) Developing more efficient and effective climate-neutral and climate change-related solutions and promoting more environmental-related and sustainability research concerning SGLR. In addition, two conceptual models concerning SGLR and climate-neutral strategies are developed and presented for managers and practitioners to consider when adopting green and sustainability principles in supply chains. This review also highlights the need for academics to go beyond frameworks and build new techniques and instruments for monitoring SGLR performance in the real world.

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Originality/value – This study provides an overview of the evolution of SGLR; it also clarifies concepts, environmental concerns and climate change practices, particularly those directed to supply chain management.

Keywords Green logistics, Sustainability, Sustainable development, Remanufacturing, Climate change, Supply chain management, Climate neutral supply chains, Decarbonization, Bibliometrics, Content analysis, Literature classification

Paper type Literature review

1. Introduction

The implementation of sustainable green logistics and remanufacturing (SGLR) is important for the reduction of carbon footprints and emissions, the attainment of climate-neutral logistics and supply chains, the regulation of emissions, the management of climate change and the resolution of environmental and climatic issues. Sustainable green logistics can enhance transportation and logistics procedures, diminish energy consumption, curtail waste and pollution and augment the utilization of renewable energy sources (Domagala *et al.*, 2022), among other factors. In contrast, remanufacturing encompasses a range of procedures, such as the reuse and restoration of previously utilized products and components, thereby reducing the demand for newly manufactured products and the consequent release of carbon emissions (Rizova *et al.*, 2020).

Over the last two decades, carbon emissions have increased proportionally to the rise in global commerce, resulting in major global challenges that endanger the existence and development of the planet and all its people (Naber *et al.*, 2015). According to the World Bank in 2014, global carbon emissions from various sectors in 2011 were almost 375% more than in 1960 (Zhou *et al.*, 2021). They increased from around 9.3 billion metric tons in the 1960s to more than 34.6 billion metric tons in 2011. Logistics, procurement, manufacturing and transportation activities accounted for an average of 75% of total industrial-sector carbon emissions (Genovese *et al.*, 2017; Shaharudin *et al.*, 2019; Zhou *et al.*, 2021).

During the last decade, the idea of sustainability has grown in popularity due to growing socioenvironmental issues such as climate change, air pollution and pollution-related health concerns (Khan *et al.*, 2020). Integrating the idea of sustainability into supply chain operations offers a corporation a "competitive edge" in the marketplace (Akdoğan and Coşkun, 2012; Raut *et al.*, 2019). Implementing low-carbon activities across supply chains is crucial for a cleaner and more sustainable future (Jira and Toffel, 2013; Klymenko and Lillebrygfjeld Halse, 2022; Oglethorpe and Heron, 2010). In this regard, SGLR have the potential to result in a noteworthy decrease in greenhouse gas emissions. The points outlined above have been shown to assist companies in the development of a sustainable business model, climate-neutral logistics and supply chains and the creation of a positive impact on society and the planet. Additionally, this approach has been found to improve the financial performance of these companies (Kumar *et al.*, 2012). Hence, it is imperative for enterprises to accord priority to SGLR as an integral component of their comprehensive logistics and sustainability frameworks, in order to facilitate their contribution towards a sustainable and resilient future.

The most probable reason for low adoption rates of SGLR is the result of senior management's unwillingness to incorporate sustainable practices into core firm operations, despite considerable pressure from consumers and regulatory authorities (Zhang and Awasthi, 2014). The reluctance of senior management to incorporate sustainable practices into the fundamental operations of the organization can be ascribed to multiple factors, as noted by Zhang and Awasthi (2014). Initially, it is plausible that a deficiency in comprehension or recognition regarding the advantages and potential repercussions of sustainable methodologies on the enterprise's enduring prosperity may exist. Certain high-level executives may perceive sustainable practices as an extraneous expenditure or a diversion from the principal objective of optimizing financial gains. Senior executives may encounter pressure from shareholders and investors who prioritize short-term financial returns over long-term sustainability, as a second point. The pressure exerted on businesses could potentially result in prioritizing short-term financial benefits over sustainable practices, which may require a longer period for return on investment. In addition, it is possible that senior executives may not possess the requisite expertise and understanding to effectively incorporate sustainable methodologies into fundamental organizational processes. The aforementioned circumstance could arise from an insufficiency of instruction or learning pertaining to sustainability, thereby impeding the ability to make well-informed choices and proficiently execute sustainable methodologies. Finally, it is possible that a deficiency of appropriate incentives exists, which may hinder companies from incorporating sustainable practices into their fundamental operations. The absence of explicit motivators may lead to a lack of recognition by higher-level executives regarding the significance of allocating both temporal and material resources towards the implementation of environmentally conscious measures (Zhang and Awasthi, 2014). There is a need for research that adds to the exploration of SGLR across several elements in order to increase the frequency and speed of adoption.

Despite the importance of climate and environmental aspects, this literature review is focused on a holistic view of SGLR, with the circular economy and reverse logistics as related subjects. The goal is not only to cover appropriate solutions for the decarbonization of logistics operations and remedies for climate-related concerns but also to provide more general theoretical insights for future research agendas. In the literature, based on the exhaustive research and elaboration on the similar recent and more important review papers[1], the comprehensive reviews on developments in SGLR have been limited to specific aspects of SGLR.

The all-encompassing evaluations are generally based on one of two interrelated fundamental approaches for delineating their extent: structural approaches, or conceptual approaches. As examples of the structural approach, there are a limited number of reviews that assess the progress of SGLR literature elements by correlating the explored subjects with diverse factors such as sustainability and reverse logistics concerns, decarbonization themes, transportation contexts, digitalization features and circular economy dimensions. This is evident in the works of (Chelly *et al.*, 2019; Waltho *et al.*, 2019). The study conducted by (de Sousa Jabbour *et al.*, 2019) primarily centers on identifying the obstacles that impede the adoption of low-carbon operations management strategies in response to the challenge of climate change (Meyer, 2020). review employs bibliometric analysis as a systematic quantitative approach to examine the literature pertaining to the decarbonization of road freight transportation. These studies exemplify a structural approach to the process of reviewing.

In comparison to the structural approach, some comprehensive reviews have focused on elucidating the fundamental conceptual issues, such as studies in SGLR pertaining to climate issues. An example of this can be seen in the scholarly review conducted by (Mina *et al.*, 2022), which presents a conceptualization of the transformative functions of technology in the advancement of supply chains that are free of carbon emissions. However, only a limited number of endeavors have been undertaken to identify the overarching conceptual themes that are prevalent in the literature across a broader range of studies, in contrast to the present review study (Maditati *et al.*, 2018). concentrated their research on the literature pertaining to green logistics and supply chain management. To date, there is not a comprehensive literature review that encompasses the entirety of the SGLR corpus, particularly with regard to the incorporation of climate-neutral and decarbonization viewpoints. This comprehensive literature review endeavors to address these concerns by providing a holistic mapping of the literature on SGLR, using content analysis and mapping to assess the inherent conceptual themes. The distinctive stage of advancement in the developmental process of SGLR is considered a significant aspect, which is characterized by unique attributes and critical concerns. Our methodology is distinct and unparalleled, aiming to elucidate the fundamental aspects of the distinct conceptual perspectives as advocated by the designated themes (and their corresponding sub-themes).

Against this introduction and mentioned gaps in the current literature, these are the key holistic questions to be answered and elaborated on in this review:

RQ1. What are the key research problems that have been addressed in the literature of SGLR management?

RQ2. What are the general themes and trends in SGLR research?

RQ3. What are the emerging directions for future SGLR research?

To identify the research on SGLR, we conduct a thorough literature evaluation based on bibliometric and theme analyses, content analysis and literature categorization of the available literature. In order to address the above-mentioned research questions, we conduct a comprehensive literature analysis of studies from 2008 to 2023 that practitioners and academics can use as a reference to track the progress of research and anticipate the likely future trends and tendencies of the SGLR sector.

This review makes five main contributions: **(a)** The current and emerging key SGLR themes and facets are identified and explained in detail: (1) The circular economy facets; (2) Decarbonization of operations to nurture a climate-neutral business; (3) Green sustainable supply chain management; (4) Drivers and barriers of reverse logistics and the circular economy; (5) Business models for sustainable logistics and the circular economy; (6) Transportation problems in sustainable green logistics; and (7) Digitalization of logistics and supply chain management. **(b)** Two conceptual models (Figure 1) are developed by the authors: (1) depiction of SGLR with respect to various other concepts in reverse logistics and the circular economy; and (2) a model for climate-neutral logistics and supply chain steps. These two models can help practitioners and researchers know the implementation steps and identify the probable spots of motivations, drivers and barriers to the adoption of climate-neutral logistics and supply chain practices in response to climate change. **(c)** This study presents a thorough and rigorous analysis of the advancements made in the SGLR field, using quantitative methods such as bibliometric analysis and qualitative methods such as comprehensive content analysis. This approach enables a comprehensive comprehension of the developments in this area. **(d)** The present study sheds light on the limitations of existing research and provides insights into potential avenues for future development in the field of SGLR, with the aim of informing subsequent research endeavors. **(e)** The possible ramifications of the suggested research plan for professionals and executives are articulated.

The rest of the paper is organized as follows: Section 2 presents a brief background regarding the subjects of the current paper. Section 3 discusses the techniques used to select the articles investigated and assessed for this literature review. Section 4 covers the findings of bibliometric and network investigations, including topic mappings and evolution of research papers in different software and tools, citation and co-citation evaluation outcomes and descriptive analyses. Section 5 has content analysis and literature classification. Section 6 explores the direction of current research and prospective future research. Section 7 has concluding remarks.

2. Background

Sustainable green logistics and supply chain management includes the objectives of upholding social and environmental values in addition to the speed, cost and reliability of operations that are the focus of conventional supply chain management. This entails addressing global problems like corruption, fair labor practices, deforestation, water security and climate change.

Sustainable, efficient, adaptable and responsive logistics are crucial to a company's worldwide market success (Khan and Qianli, 2017). Sustainable supply chain management (SSCM) refers to the management of information, equity and the flow of raw materials, in addition to the collaboration with supply chain partners trying to implement the economic,

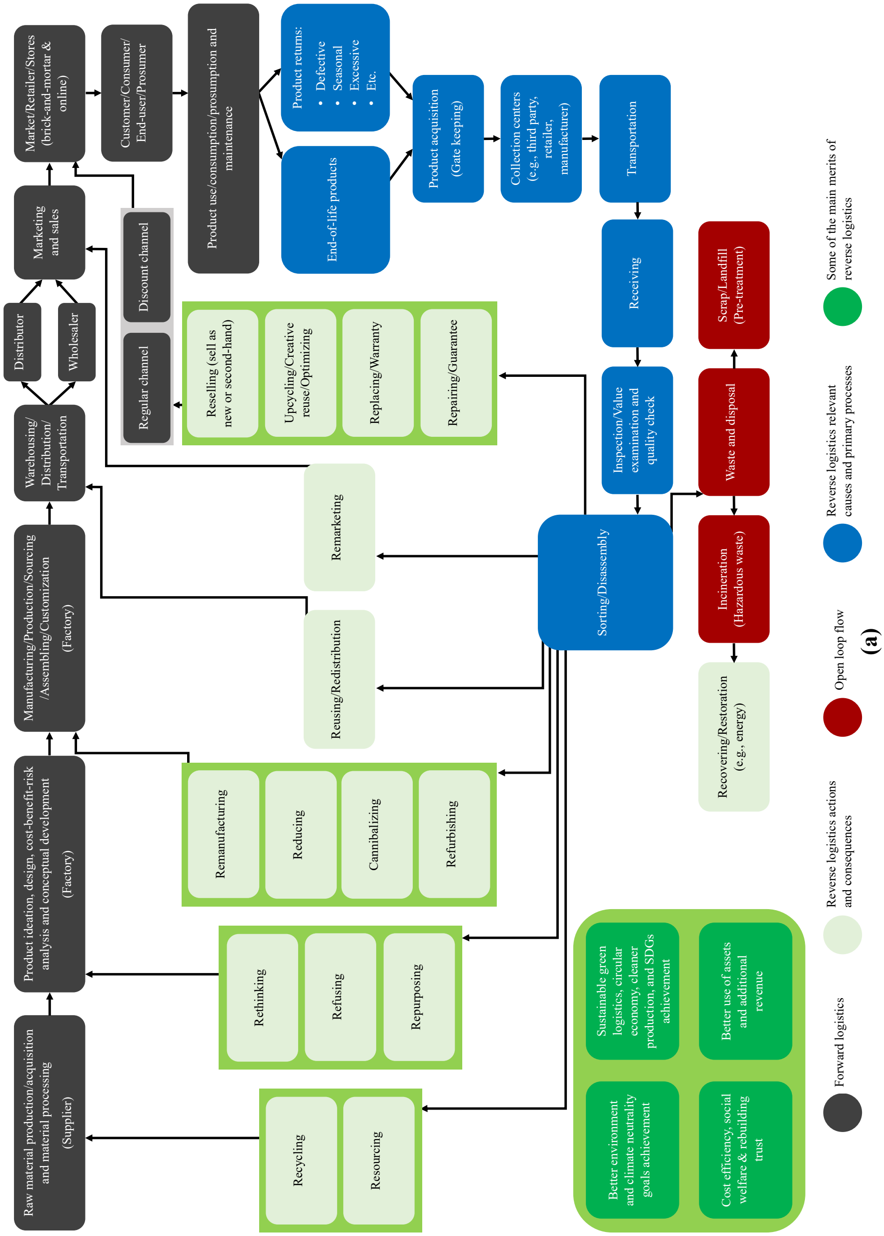
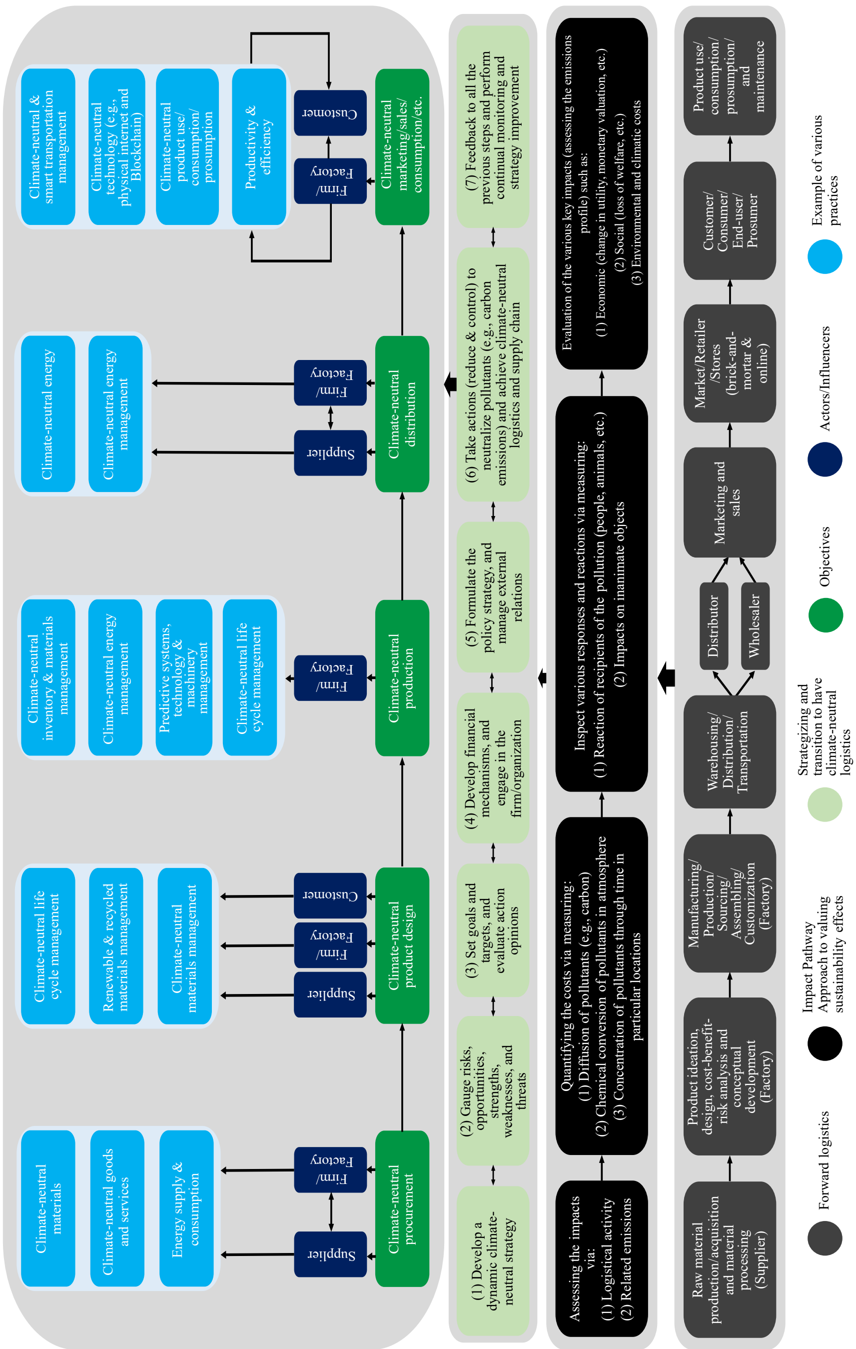


Figure 1.
The holistic logistics and supply chain flow diagram. (a) SGLR depiction concerning various other reverse logistics and circular economy concepts[2] and (b) Climate-neutral (forward) logistics and supply chain conceptual model[3]



(b)

Source(s): Developed by the authors

Figure 1

social and environmental dimensions of sustainable development initiatives (Seuring and Müller, 2008). Companies are under substantial pressure to adopt green practices in their logistics and supply chain operations in order to improve their socioenvironmental sustainability. Despite dealing with the aftermath of the COVID-19 outbreak, companies have increased their emphasis on sustainability (Klymenko and Lillebrygfjeld Halse, 2022).

2.1 Sustainable green logistics

Regardless of their comprehension of customer expectations, businesses continue to strive for sustainable logistics and supply chain operations (Khan *et al.*, 2021). Businesses of the future will need the manufacturing of ecologically friendly goods (Abdulrahman *et al.*, 2014). Although the market for green goods is still relatively small, it is expanding, and a rising number of businesses are transitioning from unsustainable logistics operations to sustainable operations (Khan *et al.*, 2021). To maintain the new business platform, firms must use sustainable practices in their logistics operations; this includes reducing their use of fossil fuels and using environmentally friendly disposal techniques (Abdallah *et al.*, 2012; Al Zaabi *et al.*, 2013; Xie, 2016). Companies worldwide are seeking to integrate SSCM into their end-to-end business processes (Carter and Rogers, 2008). The literature indicates that a company's activities related to its supply chain have a greater influence on the environment than the company's internal activities (Bove and Swartz, 2016; Jira and Toffel, 2013; Villena and Dhanorkar, 2020). Worldwide, there is continuing discussion among governments, lawmakers, regulatory organizations and investors concerning how a more stringent regulatory framework might be imposed on a company's direct and supply-chain-related environmental consequences (Houlder and Livsey, 2021). Among the key causes for the failure of sustainable green logistics practices and SSCM are uncertainty in comprehending the concept of sustainability, a lack of corporate trust, a deficiency or absence of information and a lack of visibility (Khan *et al.*, 2021).

Sustainable green logistics practices entail the incorporation of ecologically sound practices into the procedures for logistics and supply chain management. Incorporating sustainable practices into logistics processes is imperative for mitigating environmental pollution and carbon emissions, both of which have substantial detrimental effects on the environment. The objective of sustainable green logistics practices is to attain sustainability in the logistics sector through the implementation of measures that reduce carbon emissions and foster environmental sustainability (David B Grant and Wong, 2017; Piecyk, 2015). The subsequent text presents a compilation of the prevailing significant obstacles and advantages associated with the implementation of sustainable green logistics practices.

These are the prominent obstacles to implementation of sustainable green logistics practices (Barros *et al.*, 2021; David B Grant and Wong, 2017; Farooque *et al.*, 2019; Piecyk, 2015):

(1) *Limited awareness and uncertainty in understanding sustainable green logistics practices:* A significant obstacle in the adoption of sustainable green logistics practices is insufficient cognizance and comprehension of the significance of sustainable logistics practices. The adoption of sustainable logistics practices is limited due to the prioritization of cost reduction and operational efficiency over environmental sustainability by logistics managers and supply chain practitioners.

(2) *High cost of implementation:* The implementation of sustainable green logistics practices is faced with a significant challenge, namely the high cost of implementation. The implementation of sustainable logistics practices, including the use of electric vehicles, renewable energy sources and eco-friendly packaging materials, necessitates substantial financial investment. This may pose a considerable obstacle for logistics systems that are small or medium-sized.

(3) *Lack of appropriate infrastructure:* The effectiveness of sustainable logistics practices is contingent upon the availability of suitable infrastructure. The use of electric vehicles necessitates the availability of charging stations, while the implementation of sustainable energy sources mandates access to uncontaminated energy resources. The insufficiency or absence of requisite infrastructure poses a challenge for logistics systems to embrace sustainable practices in several instances.

(4) *Complex supply chain networks:* Logistics procedures are frequently intricate and encompass various parties, including suppliers, producers, vendors and consumers. The intricate nature of supply chain networks poses a challenge for logistics systems to effectively execute sustainable practices throughout the entire supply chain.

(5) *Regulatory compliance:* The regulations and standards pertaining to sustainability and environmental protection are in a state of constant evolution. It is imperative for organizations to remain current with pertinent regulations and adhere to them to avoid sanctions and penalties. Adhering to regulations can pose a financial and temporal burden, especially for entities functioning across diverse jurisdictions with varying regulatory frameworks.

These are the advantages from implementation of sustainable green logistics practices (Barros *et al.*, 2021; David B Grant and Wong, 2017; Farooque *et al.*, 2019; Piecyk, 2015):

(1) *Environmental benefits:* The implementation of sustainable green logistics practices yields considerable environmental advantages. The implementation of sustainable logistics strategies results in a decrease in carbon emissions, thereby mitigating the adverse effects of such emissions on the climate. Furthermore, it diminishes the quantity of waste produced, leading to a reduction in pollution and a more pristine ecological setting.

(2) *Cost savings:* The implementation of sustainable logistics practices has the potential to yield cost reductions for logistics systems. The implementation of electric vehicles has the potential to decrease fuel expenses, and the use of eco-friendly packaging materials can lead to a reduction in packaging expenses.

(3) *Competitive advantage:* The implementation of environmentally sustainable logistics practices has the potential to confer a competitive edge to logistics systems. There is a growing trend among consumers to prioritize environmental sustainability when choosing to engage with businesses. This preference is driven by an increasing awareness of the importance of environmental sustainability.

(4) *Enhanced brand reputation:* The implementation of environmentally conscious logistics practices has the potential to improve the public perception of logistics systems. Organizations that prioritize environmental sustainability are commonly perceived as exhibiting social responsibility and are more prone to garnering customer trust.

(5) *Risk mitigation:* The adoption of sustainable green logistics practices can aid organizations in managing the potential hazards linked with environmental regulations and climate change. Organizations can mitigate their exposure to regulatory penalties and fines, as well as the risks associated with climate change, by minimizing their environmental impact and carbon footprint.

Overall, the adoption of sustainable green logistics and supply chain is a complex process that involves business processes such as these: the adoption of an appropriate set of standards jointly by the marketing team, the human resource team and the operations team; the selection of suitable suppliers; strategic acquisition of cores and old components;

finalizing contracts with vendors and providers of logistics services; the receiving and dismantling of old products; and remanufacturing, refurbishment, quality control and warehousing (Bag and Gupta, 2020; Lambert *et al.*, 2011).

Various perspectives and approaches can be followed to implement sustainable green practices in logistics and supply chains to reach climate-neutral goals (Bag *et al.*, 2021a; David B Grant and Wong, 2017; de Sousa Jabbour *et al.*, 2019; McKinnon, 2018; Piecyk, 2015). Two of the most prominent perspectives and conceptual models are presented in Figure 1. These two diagrams have been developed by the authors based on various sources, showing (a) the flow and full model of reverse logistics and the circular economy that can bring climate-neutral supply chains and logistics for firms and organizations and (b) the strategies, action plans and practices that can be directly implemented into forward logistics and supply chains to help achieve carbo-neutral firms. In the latter approach, first, the costs and various impacts resulting from a firm's logistics and supply chain are analyzed, then a dynamic decarbonizing strategy is developed, and action plans and practices are defined and implemented. Finally, there is the feedback that continually checks the benefits, risks, goals achieved, costs, etc. Since the current paper's perspective aligns with the first approach (Figure 1 (a)), we explain more of the first approach, and we do not go into further details of the second conceptual model. Readers interested in the second model can see the references given in the footnote to the caption for Figure 1 (b).

In the first approach (Figure 1 (a)), for brevity, the definitions and interconnections of multiple components are provided in Appendix B in the supplementary file. However, one point worth mentioning here is the reason for choosing remanufacturing from among other components to be alongside sustainable green logistics in this paper. First, remanufacturing has been identified as a prominent topic in prior literature reviews, as it is considered a critical component of reverse logistics and the circular economy. This area of study has the potential to facilitate the attainment of green, sustainable objectives.[4] Second, remanufacturing is a multifaceted process that encompasses various other concepts, including but not limited to refurbishing, repairing, reselling, replacing, recovering and reusing. All of these concepts are integral to the remanufacturing process and exhibit interdependence (Bag *et al.*, 2021a; Lieder and Rashid, 2016). The next section addresses the literature in remanufacturing.

2.2 Remanufacturing

Remanufacturing, a component of reverse logistics shown in Figure 1(a), is one of the green sustainable principles in logistics and supply chains. The literature says that remanufacturing is an intriguing recovery option, since it may be used to return old, worn-out items to their original state. The adoption of reverse logistics and remanufacturing operations provides several obstacles for businesses. The difficulties that are stated by Hall *et al.* (2013) can be grouped into inbound difficulties and outbound difficulties. Inbound difficulties include the removal of old products, poor contracts, problems in organizing transportation, elevated numbers, inappropriate guidelines, consumer errors, consumer demands, rigorous importing and exporting regulatory requirements, complexity in setting standards to endorse reverse logistics, acknowledgment and categorization of returned goods and absence of visibility. Outbound difficulties include complicated outbound logistics and skyrocketing costs. The adoption of environmentally friendly perspectives such as remanufacturing requires firms' coordinated efforts to increase innovation and their participation in training programs (Antonioli *et al.*, 2013). Further, Jabbour *et al.* (2015) provided a conceptual framework that takes into account the technical and human components of environmental product development as well as the influence of this development on environmental, operational and market performance. In response to environmental changes, businesses are taking into account the significance of human aspects and increasing employee engagement in the development of environmentally friendly goods and innovations (Bag and Gupta, 2020).

In addition to dealing with institutional demands, manufacturing companies may find it advantageous to embrace other principles (recycle, reuse, reduce, etc.) and incorporate remanufacturing processes for environmental concerns, for sustainable green logistics and for financial rewards (Srivastava and Srivastava, 2006).

2.3 SGLR impacts on climate change

SGLR concepts and practices are crucial components for mitigating climate change's detrimental consequences. As a subset of sustainable logistics, green logistics include the use of eco-friendly methods in transportation and logistics operations to decrease emissions, pollution and waste. Remanufacturing, on the other hand, entails returning old products to a like-new state, thereby prolonging the products' life cycle and decreasing the need to manufacture new products.

Concerns over the environmental effect of logistics and supply chain operations have grown as a result of global warming. Transportation and logistics are major contributors to global carbon emissions, and lowering emissions in these sectors may greatly help to mitigate climate change. Sustainable green logistics techniques, including the use of alternative fuels, efficient routing and eco-friendly packaging, may minimize carbon emissions and other adverse environmental consequences (Aronsson and Huge Brodin, 2006).

In addition, remanufacturing contributes significantly to the preservation of natural resources, less trash is produced and less greenhouse gas emissions are produced (Peng *et al.*, 2022). These are only a few of the substantial environmental advantages. As compared to the creation of new goods, remanufacturing may result in an 80% reduction in the emissions of greenhouse gases (Liao *et al.*, 2018).

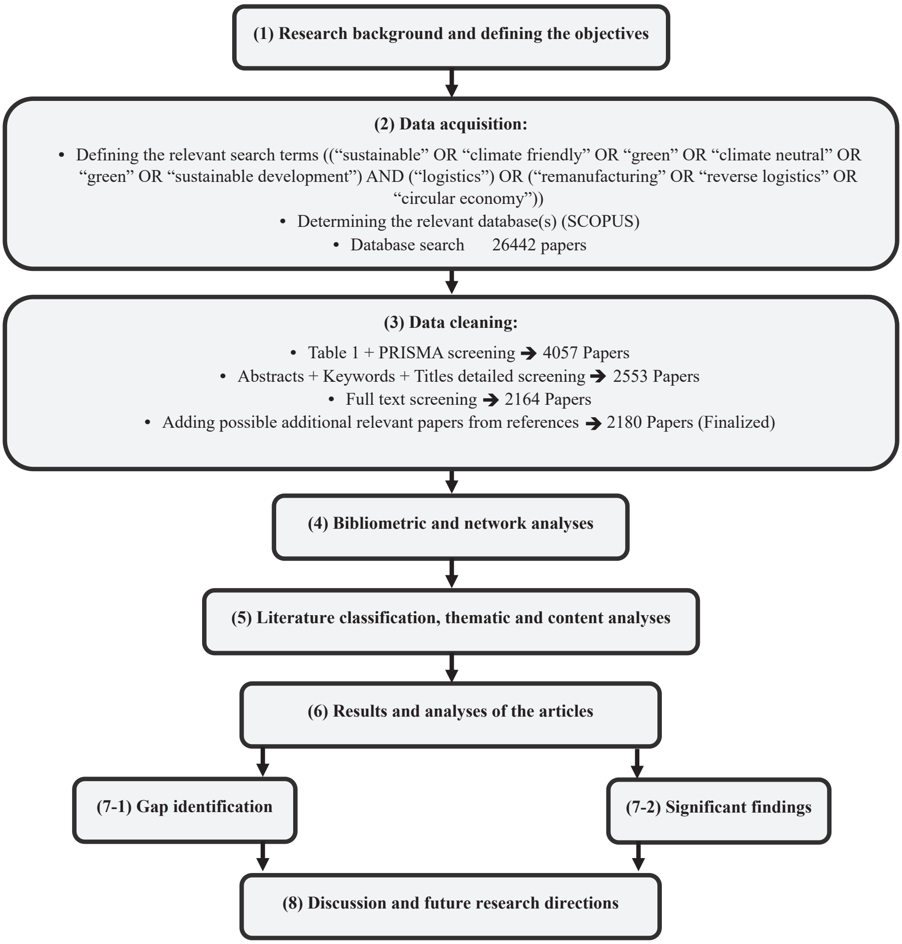
The combined topics of SGLR, as well as the inclusion of the circular economy and reverse logistics as relevant topics, have not been covered in the literature as a review paper, despite the abundance of academic research papers and books in several areas: green logistics (Al-Minhas *et al.*, 2020; de Souza *et al.*, 2022), the relevant sustainable practices (Domagala *et al.*, 2022; Grant *et al.*, 2015) and remanufacturing (Chakraborty *et al.*, 2021; Santos *et al.*, 2023; Yang *et al.*, n.d.). The goals of this paper are to determine the significance of SGLR and the trends in scholarly research from recent academic works that focus on multiple aspects of SGLR, in order to improve the development of the SGLR research field and to provide a resource for researchers and practitioners.

3. Research methodology

After defining the goals, the keywords for the search are defined and a list of publications is extracted from the Scopus database from 2008 to 2023 based on the defined keywords. The list of publications is sifted multiple times according to criteria for inclusion or exclusion. Next, descriptive, bibliometric and network analyses are performed, followed by thematic content analyses and literature classification. Finally, research gaps are identified, and future research directions and insights are provided. The details of each step are explained in what follows. Figure 2 gives a holistic view of the entire paper process flow.

3.1 Defining the appropriate search keywords

Several words and their combinations are used to compile the necessary database for continuing the study and analyses. SGLR has many related keywords; however, we used only the core terms to extract as many relevant high-quality papers as possible. The criteria for choosing the search keywords are based upon three considerations. Based on (1) The specific subjects and themes of interest in this review article, i.e., SGLR, (2) The authors' own research experience and expert views from fellow academics and also (3) The previous literature



Source(s): Compiled by the authors

Figure 2.
The literature review process and research design outline

reviews on similar topics (cf. (Kazemi *et al.*, 2018; Shaharudin *et al.*, 2019)), in which the main topic became the keywords with different combinations. The search string is ((“sustainable” OR “climate friendly” OR “green” OR “climate neutral” OR “sustainable development”) AND (“logistics”) OR (“remanufacturing” OR “reverse logistics” OR “circular economy”)).

3.2 Overview of the extracted data and the refinement process

Scopus is used as the data extraction source for this work. Scopus is a more thorough database than Web of Science (WoS) (Fahimnia *et al.*, 2015). When doing a search in the Scopus database using the parameters “title, abstract and keywords”, only journal articles are retrieved. Conference papers, books and book chapters are not taken into consideration.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards is followed for the screenings of the available data for this review (Moher *et al.*, 2009; Page *et al.*, 2020). Following PRISMA standards and the establishment of inclusion and exclusion criteria, the list of articles is filtered. Table 1 shows the criteria for inclusion and the criteria for exclusion. After application of the first-stage filters (as shown in Figure 2), 4057 papers remained for further analysis. Detailed screening of the abstracts and titles of the 4057 papers leaves us with 2553 papers. Screening the full text of the 2553 papers leaves 2164 papers. Adding relevant papers from references in those papers results in a total of 2180 papers.

In the end, 2180 articles are selected using all of the techniques shown in Figure 2. The full list of the 2180 articles is in Appendix C. Due to the insignificant number of papers published before 2008 as a consequence of the combination of subjects selected for performing the review, they are excluded at the step of exclusion. A database including 2180 journal articles published between 2008 and 2023 is produced as a consequence of the content-gathering strategy. As shown in Table 1, only papers from journals with Chartered Association of Business Schools[5] (ABS) scores of at least 3 and Australian Business Deans Council[6] (ABDC) grades of at least A are chosen for this paper.

3.3 Data descriptive analysis

Figure 3 shows the trend of published publications. The findings of this study indicate that the topic is expanding and growing. The observed decline in the depicted graph line in Figure 3 between 2022 and 2023 can be attributed to the limited inclusion of 2023 papers that solely belong to the initial four months of 2023.

According to the statistics, 32 journals produced the 2180 peer-reviewed research papers. Approximately 85% of all accepted peer-reviewed research publications are published in ten journals. Table 2 displays the number of articles published by the top ten journals throughout the years (cumulative for each five years).

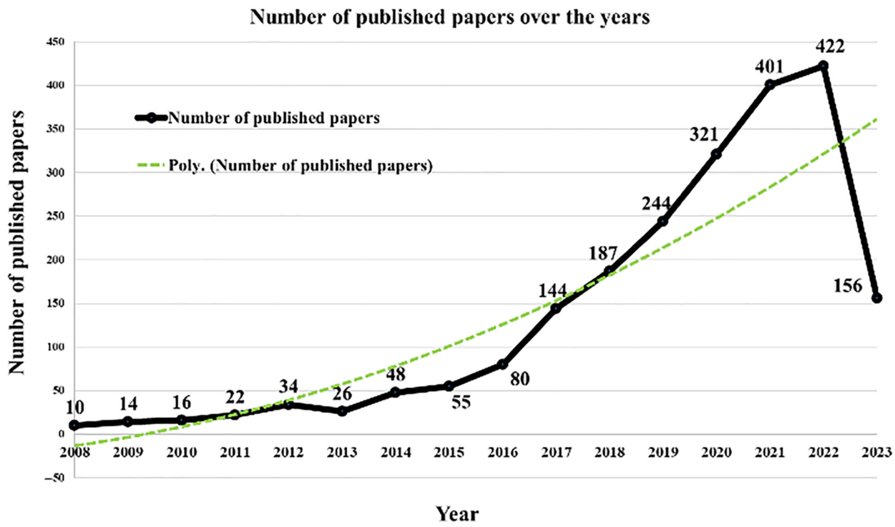
3.4 Data analysis

A deductive approach is used for our data analysis (Seuring and Müller, 2008). It has two components: bibliometric analysis in Section 4.2 and network analysis in Section 4.3. The R software program is used in our study because of its adaptability when coping with large datasets and its compatibility with a variety of computer software, including Pajek, Excel and Gephi (Aria and Cuccurullo, 2017; Bastian *et al.*, 2009; Persson *et al.*, 2009). Throughout the network analysis, Gephi is used alongside R to do a citation analysis and thematic content-based categorization. Also, for some of the reports, VOSviewer is selected because of its unique visualizations (Van Eck and Waltman, 2019).

Inclusion criteria	Exclusion criteria	Number of research articles
• Focus on the topics and research goals • ABS (=>3) + ABDC (=>A) • Peer-reviewed research articles from 2008 to April 2023 • English journal papers • Related subject areas • Publication stage in Scopus: Final	• Irrelevant to the subject or weakly related papers • Conference papers, book chapters, book reviews, commercial magazines • Non-English language papers • Not related or loosely related subject areas • Duplicates	• Before any screening, filtering and exclusion 26,442 • After all of the screening, filtering and exclusion steps 2180

Source(s): Developed by the authors

Table 1.
Inclusion and exclusion criteria at the refinement stage



Source(s): Developed by the authors

Figure 3. The publishing trend in the current literature reviews' selected areas (the green curve demonstrates the polynomial smoothing of second order as a trend line of the publications over the years)

Year/Journal	2008–2012	2013–2017	2018–2023	Total
Journal of Cleaner Production	24	143	978	1145
Journal of Environmental Management	5	7	113	125
International Journal of Production Economics	15	39	66	120
Business Strategy and the Environment	3	9	85	97
International Journal of Production Research	12	19	64	95
Computers and Industrial Engineering	3	7	71	81
Transportation Research Part E: Logistics and Transportation Review	3	16	28	47
Transportation Research Part D: Transport and Environment	3	19	24	46
Technological Forecasting and Social Change	3	5	32	40
International Journal of Logistics Management	2	11	24	37
Total	73	275	1485	1833

Source(s): Developed by the authors

Table 2. Contributions of the top 10 publishing journals to the areas of interest (cumulative for e very five years)

4. Bibliometric and network analyses

This analyzes the 2180 selected papers. There are three major sections: descriptive analysis, bibliometric analysis and network analysis.

4.1 Descriptive analysis

The data source is described in Table 3 after preliminary statistical analysis in R. Table 3 gives descriptive information on keywords, records, references, time periods and the number of citations received on average by each publication. Table 3 also assesses co-authorship indicators. The index of writers based on articles, for example, compares the overall number of authors to the number of articles. By using the co-authors per document index, one is able to calculate the average number of co-authors for any individual article.

4.2 Bibliometric analysis

Historically, bibliometric analysis has used a variety of software programs, each with their own weaknesses and strengths. R, HistCite, Publish or Perish, Citespace and BibExcel are popular tools. R and bibliometrix software package (Aria and Cuccurullo, 2017) within it are selected for the current study due to their adaptability and versatility in modifying or acquiring input data from PubMed, Scopus and WoS, as well as their capability to carry out each necessary evaluation for a suitable review of the literature of articles, such as network analysis, classification of the literature essential to content analysis. The software programs allow for sufficient data analysis using VOSviewer, Gephi and Pajek (Persson *et al.*, 2009).

The only software programs that generate network analysis data are R and BibExcel. VOSviewer and Gephi are used to improve visualization and processing, despite the fact that R is capable of producing all the required outputs. For instance, the preliminary study can be carried out using R and the output data from the preliminary study data can be prepared in NET file extension in order to be used in Gephi to do data clustering or modularity computations. The R program reads paper bibliographies in the Bib extension file format (Scopus and WoS outputs).

4.2.1 Countries and institutions statistics. A data repository captures an author's nationality and connection with an institution. According to the affiliation data, member organizations are dispersed across the world, with China, the USA, the United Kingdom (UK) and Italy receiving the most attention. Figure 4 shows a variety of organizations and governments engaged in SGLR. The change in blue density in Figure 4 is related to the degree of collaboration between each institution/nation. Table 4 provides a summary of the author's statistics divided by country. As shown in Table 4, China and the UK have the most published papers pertaining to a single nation (SCP).

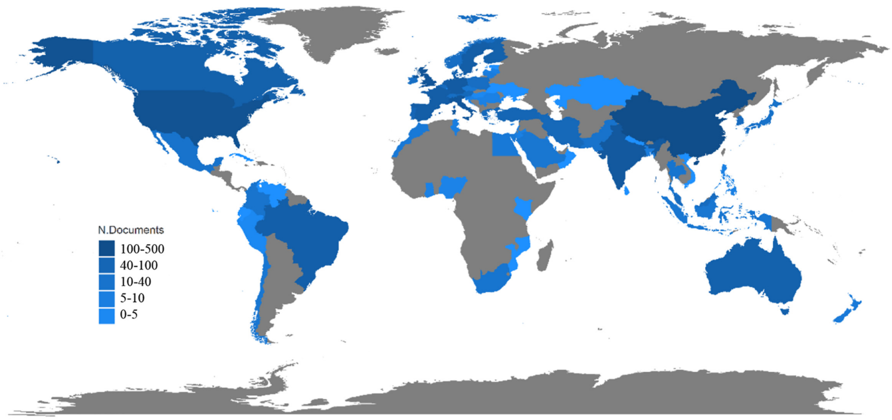
Table 5 shows the top twenty institutions or organizations that contributed to this literature analysis, based on their number of publications. As shown in Table 5, the nations with the most publications are China and Sweden.

4.2.2 Variation of keywords. A similar strategy is used to determine the words and phrases that appear most often in the most often occurring terms from the collection of the author's keywords that are shown in Table 6.

Description	Results	Description	Results
MAIN INFORMATION		AUTHORS	
Timespan	2008:2023	Authors	5769
Sources (Journals)	32	Single-authored documents	97
Documents	2180	Documents per Author	0.38
Average years from publication	3.99	Authors per Document	2.65
Average citations per document	52.72	Co-Authors per Document	3.83
Annual Growth Rate %	27.39	International co-authorships %	41.28
References	144785		
DOCUMENT TYPES			
Research Articles	1984		
Review Articles	196		
DOCUMENT CONTENTS			
Keywords Plus (ID)	10355		
Author's Keywords (DE)	5684		

Note(s): ID: the frequency distribution of keywords associated with the manuscript by SCOPUS and Clarivate Analytics
DE: the frequency distribution of authors' keywords
Source(s): Developed by the authors

Table 3.
Primary information about the data source



Source(s): Developed by the authors

Figure 4. Geographical locations of all contributing countries/affiliations

Country	Number of articles published in each country	Number of corresponding author's articles	SCP	MCP	Freq. of corresponding author's articles	MCP ratio	Total citations	Average citations
China	483	506	493	13	0.194	0.026	20,962	41.40
USA	305	152	138	14	0.058	0.092	12,408	81.60
UK	232	216	212	4	0.083	0.019	14,668	67.90
Italy	197	193	191	2	0.074	0.01	12,487	64.70
India	159	117	114	3	0.045	0.026	4264	36.40
Germany	132	93	91	2	0.036	0.022	8191	88.10
Sweden	103	74	71	3	0.028	0.041	5034	68.00
Spain	102	101	100	1	0.039	0.01	4130	40.90
Netherlands	98	72	71	1	0.028	0.014	6694	93.00
France	97	75	74	1	0.029	0.013	4572	61.00

Note(s): SCP: Single Country Publication, MCP: Multiple Country Publication
Source(s): Developed by the authors

Table 4. The top 10 most productive country-based statistics

This collection has over 10,000 terms culled from 2180 distinct sources. Circular economy, sustainability, remanufacturing, sustainable development, reverse logistics and supply chain management are the six most frequently used keywords listed in Table 6. This is because these six most frequently used keywords are the search words used for this literature review.

4.3 Network analysis

The bibliometric investigation that is carried out for this paper includes a very important component called network analysis (Donthu *et al.*, 2021; Mukherjee *et al.*, 2022). In this evaluation, 2180 papers are used for network analysis and graphical analysis by generating significant links and key connections. In particular, this review focuses on the relationships between the papers. Using the abovementioned tools permits the co-occurrence of authors' keywords, the examination of citations, the assessment of co-citations between authors and journals and the bibliographic linking of countries.

Table 5.
The top 20 contributing affiliations (From, 2008 to 2023)

Affiliations	Country	No. of articles
The Hong Kong Polytechnic University	Hong Kong	38
University of Southern Denmark	Denmark	34
Chalmers University of Technology	Sweden	28
National University of Singapore	Singapore	25
Delft University of Technology	Netherlands	23
Central South University	China	23
Tongji University	China	23
Shanghai Jiao Tong University	China	20
RMIT University	Australia	20
Cardiff University	Wales	20
Chongqing University	China	19
University of Vaasa	Finland	19
Lund University	Sweden	18
The University of Hong Kong	Hong Kong	17
Islamic Azad University	Iran	17
Yasar University	Turkey	17
Utrecht University	Netherlands	16
KTH Royal Institute of Technology	Sweden	16
University of Technology Sydney	Australia	16
Montpellier Business School	France	16

Source(s): Developed by the authors

Table 6.
The top 30 of the most frequently used words in author keywords

Word	Freq	Word	Freq	Word	Freq
Circular economy	813	Environmental sustainability	62	Resource recovery	33
Sustainability	418	Industry 4.0	58	Sustainable Supply Chain	32
Remanufacturing	163	Recycling	55	Cleaner Production	28
Sustainable development	126	Waste management	51	Climate change	28
Reverse logistics	118	Supply chain	49	CO_2 emissions	28
Supply chain management	89	Carbon emissions	39	Environment	28
Logistics	70	Green supply chain management	39	Green supply chain	28
Closed-loop Supply Chain	67	China	38	Industrial symbiosis	28
Green logistics	66	Carbon emission	36	Transportation	28
Life cycle assessment	66	Carbon footprint	36	Environmental management	27

Source(s): Developed by the authors

4.3.1 Co-citation analysis. Journal articles are represented by nodes in a co-citation map or network; edges indicate co-occurrence in reference lists (Aria and Cuccurullo, 2017). Co-cited papers are included in the references of other publications. Analysis of co-citations will provide clusters of analytical components. Co-citation analysis of scholarly papers may highlight a subject's fundamental issues and themes (Zhang *et al.*, 2020a; Zhang *et al.*, 2020b).

In the co-citation network, the PageRank algorithm (Brin and Page, 2012) assesses the frequency with which a publication is referenced in conjunction with other additional articles (popularity) and the frequency with which several highly co-cited articles have drawn attention to a document (prestige measure). PageRank offers more consideration to articles that are (1) co-cited with many articles and (2) co-cited with highly cited publications. Co-citation PageRank is an outstanding indicator of high-quality content in co-citation clusters (Ding, 2011; Ding *et al.*, 2009; Yan and Ding, 2011). The top ten publications with the highest PageRank are shown in Table 7. This table also shows two additional important measures: betweenness and closeness. Betweenness is used to identify the nodes that influence the flow of information in a system. Closeness describes a node's speed of access to other network nodes. In Table 7, the highest value for each of the three mentioned measures is in bold. The highest value for PageRank belongs to the (Ghisellini *et al.*, 2016) paper, showing that this paper has the highest value for the popularity and prestige metrics explained earlier. PageRank is affected by citations from highly cited articles. The highest values for closeness and the betweenness belong to the same paper (Govindan *et al.*, 2015). Table 7 shows that the majority of papers are from 2017 or before. In the last one to two years, newly published articles have not gained much momentum, since citations still need to be gathered. In the subsequent content analysis and literature classification, all co-citation network evaluations are examined.

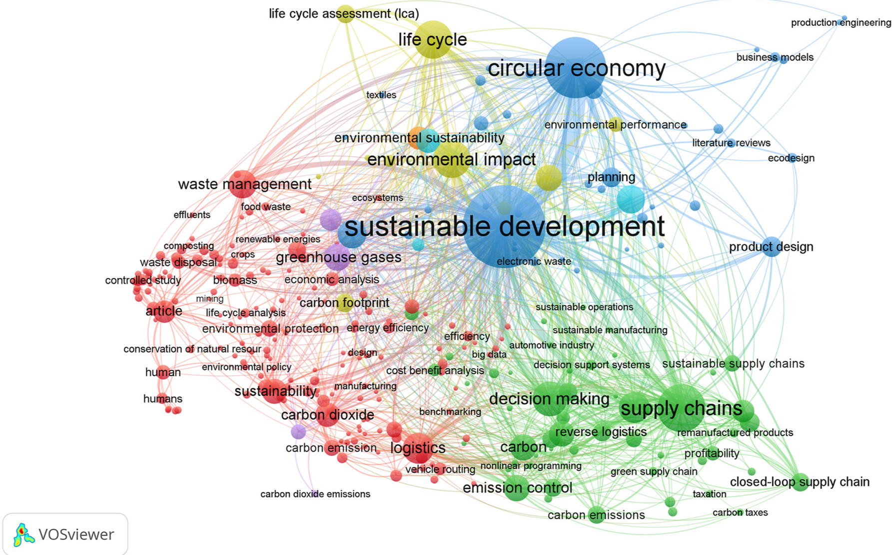
4.3.2 Keywords co-occurrence analysis. By evaluating the author's title, abstract phrases and keywords using R's keywords-plus program, clusters regarding related research subjects can be identified. This section combines keywords-plus and co-occurrence to create a keyword co-occurrence network. When two keywords appear in the same abstract or title, it is considered that they have co-occurred. The co-occurrence graph is drawn so that phrases that are more similar have a shorter distance between their nodes. Using co-occurrence analysis among keywords-plus, the R program generates a NET format file that is then displayed in VOSviewer. Based on the co-occurrence of words, Figure 5 shows a co-occurrence diagram. When terms are grouped into a single-color cluster, they are more likely to be connected with the same subject. Red, blue, green and yellow are the dominant identified keyword clusters. The red cluster mostly consists of logistics, sustainability, waste management, climate change and carbon dioxide. The blue cluster is mostly considering sustainable development, circular economy, planning and product design. The green cluster is concerned with closed-loop supply chains, supply chains, remanufacturing, emission control, carbon, reverse logistics and decision making. Finally, the yellow cluster is concerned with environmental impact, life cycle, carbon footprint and life cycle assessment.

4.3.3 Countries' collaboration analysis. Figure 6 shows the countries' collaboration network system, based on the density of university academic works and activities inside each country by the authors and institutions in a topic area and their connections with other nations. China, the UK and the USA are the top three active countries in this field (SGLR), and

Paper	PageRank	Betweenness	Closeness
Ghisellini *et al.* (2016)	*0.014202759*	278339.9914	0.000212721
Kirchherr *et al.* (2017)	0.010586659	109687.7192	0.000200160
Lieder and Rashid (2016)	0.009468362	115319.6445	0.000202840
Murray *et al.* (2017)	0.007173609	67531.52133	0.000194932
Korhonen *et al.* (2018)	0.006116462	24723.64973	0.000187056
Su *et al.* (2013)	0.005922073	59883.12087	0.000198491
Geissdoerfer *et al.* (2017b)	0.005160480	16992.08176	0.000184060
Govindan *et al.* (2015)	0.005055129	*437797.7433*	*0.000219877*
Seuring and Müller (2008)	0.004709717	285865.5259	0.000207943
Bocken *et al.* (2016)	0.004615567	15809.30997	0.000183993

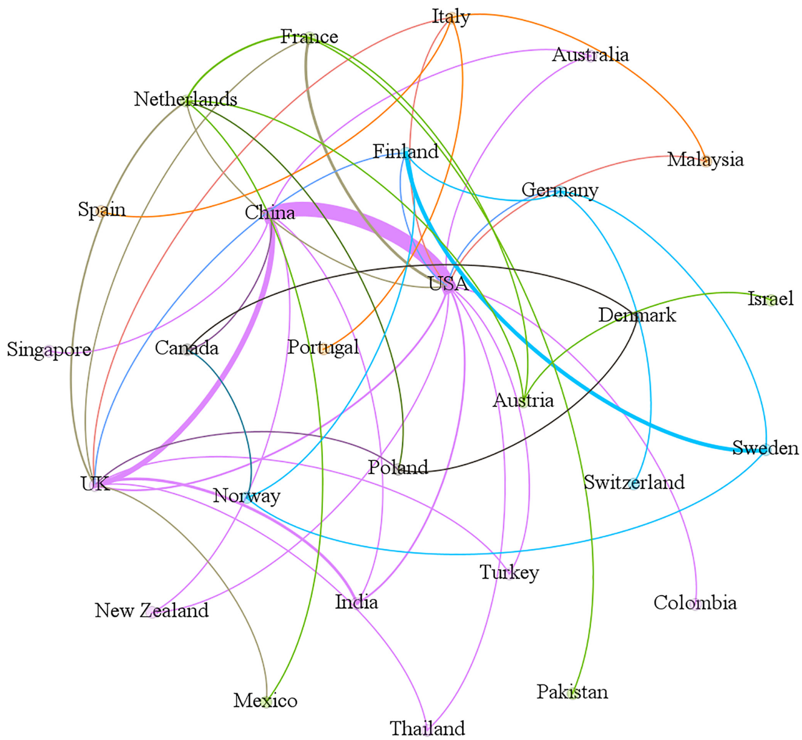
Note(s): The numbers in italics show each column's highest value, which is also the most significant
Source(s): Developed by the authors

Table 7. The top 10 documents based on PageRank Measure (From, 2008 to 2023)



Source(s): Developed by the authors

Figure 5.
Co-occurrence network analysis of keywords-plus feature in R (authors' keywords + title + abstract)



Source(s): Developed by the authors

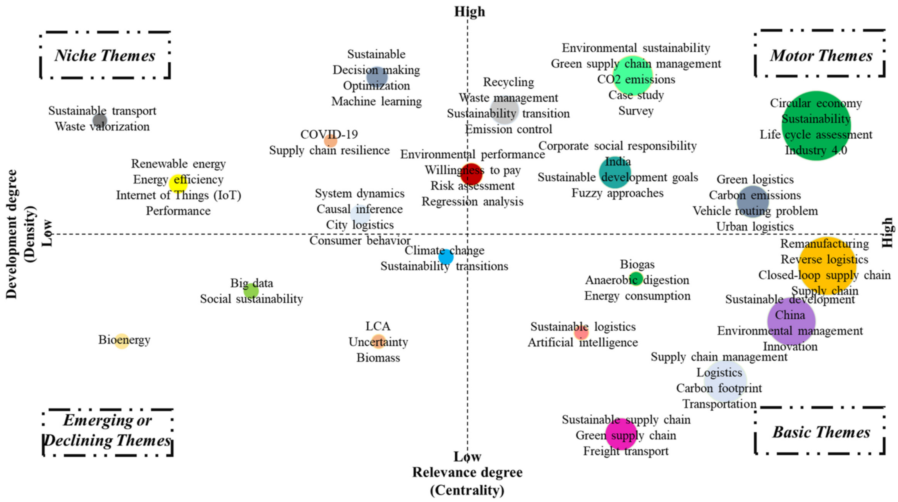
Figure 6.
Countries collaboration network

they shape a cluster with each other that is shown in thick purple color, showing that they collaborate with one another more than they do with other nations The rest of the clusters can be interpreted similarly. For instance, Sweden and Finland in the sky-blue cluster are demonstrating active collaboration.

4.3.4 Thematic analysis. The co-occurrence matrix of the authors' keywords is used to identify communities using the simple centers approach (Cobo *et al.*, 2011). This method may help in the discovery of research subjects by identifying clusters of closely similar phrases, with each cluster representing a distinct study topic. Names are assigned to each cluster based on the words with the highest degree of similarity (Wang *et al.*, 2020). The centrality and density of each cluster may be used to characterize the linked cluster: the centrality indicates its significance, and the density indicates its expansion. A cluster with a high centrality score contributes to the subject's strategic significance (Fosso Wamba *et al.*, 2021). At this stage, the study area may be linked to a graph, which is a two-dimensional graph constructed based on the centrality and density scores and described as a strategic diagram with four subsections reflecting four various types of themes (Fosso Wamba *et al.*, 2021). The upper-right quadrant is distinguished by a high concentration and density of motor motifs. The ideas in this quadrant are well-established and essential to the study topic. Motor motifs, which are also referred to as motor themes, exhibit a significant degree of abstraction and embody overarching concepts or notions that are fundamental to the subject under scrutiny. The nomenclature "motor" is attributed to these themes as they function as the impetus for the advancement of more precise themes and sub-themes. In the lower-right quadrant, fundamental and crossing motifs are more centralized and less dense. Moreover, the primary motifs, also referred to as basic themes, are the most essential and tangible classifications that arise from the investigation, and they commonly embody distinct notions, principles, or occurrences that pertain to the research subject. The importance of themes in this field is acknowledged despite the fact that internal relationships have only recently been established. The predominant themes in this cluster are also dynamic. Consequently, they need more exceptional attention and investment. In the bottom left corner, themes are either expanding or contracting. These topics are separated from others by their lack of centrality and density. Low centrality and density imply themes with poor formation. On the other hand, the motifs in the upper left corner are well-established and distinct concepts. The high density of themes in this region suggests well-established internal links, although the low centrality indicates only moderately significant external ties (Cobo *et al.*, 2011). A strategic map is generated in R with a minimum occurrence frequency of 3 for each term and a maximum of 9000 keywords in order to identify the most effective themes in the field of SGLR (Figure 7). The size of each circle in Figure 7 corresponds to the number of keyword occurrences in each cluster, with the most frequent phrases serving as labels.

According to Figure 7, environmental sustainability, green supply-chain management, CO_2 emissions, case study, and survey are bundled together in the Motor Themes section in the upper right corner. There is no term among them specifically mentioning the relevance to Industry 4.0-related techniques such as artificial intelligence (AI), big data, or Internet of Things (IoT). This probably indicates that mostly the managerial facets of sustainability and supply-chain management are considered and only a few engineering or algorithmic solutions are provided in this category. The rest of the themes in this part of Figure 7 can be analyzed similarly.

In the Basic Themes section in Figure 7, there is a combination of supply chain management, logistics, carbon footprint and transportation. Scholars can readily understand that this specific scientific scope is of great importance, and these themes are going to become Motor Themes and receive great attention in the near future, especially considering the climate-change concerns and day-by-day technological advancement of transportation. Typically, basic themes serve as an initial framework for the advancement of more complex



Source(s): Developed by the authors

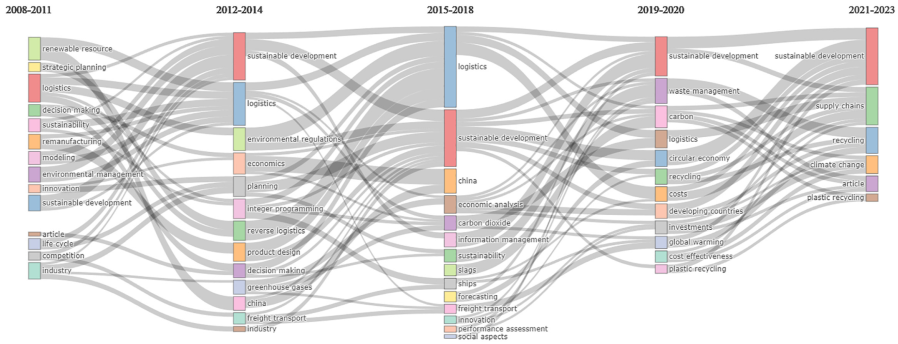
Figure 7.
Thematic analysis

themes within the process of conducting thematic analysis. They are regarded as the fundamental units for developing a more intricate and sophisticated comprehension of the research. Therefore, it is imperative to conduct a thorough analysis of basic themes and their interconnections to unveil the overarching patterns and significance inherent in the subject matter under consideration.

In the Niche Themes part of Figure 7, system dynamics, causal inference, city logistics and consumer behavior are gathered together to shape a theme. Niche Themes can be either left alone or nurtured via more topics at the frontiers of science, especially regarding the novel concepts of sustainable development and Industry-4.0-related techniques such as machine-learning approaches. Researchers should be cautious about why they select a topic and be ready to push it toward more valuable themes while they proceed with their research. For instance, one can take advantage of consumer behavior by considering the logistics service interface and aiming to reduce greenhouse gas emissions and packaging waste in the context of home deliveries.

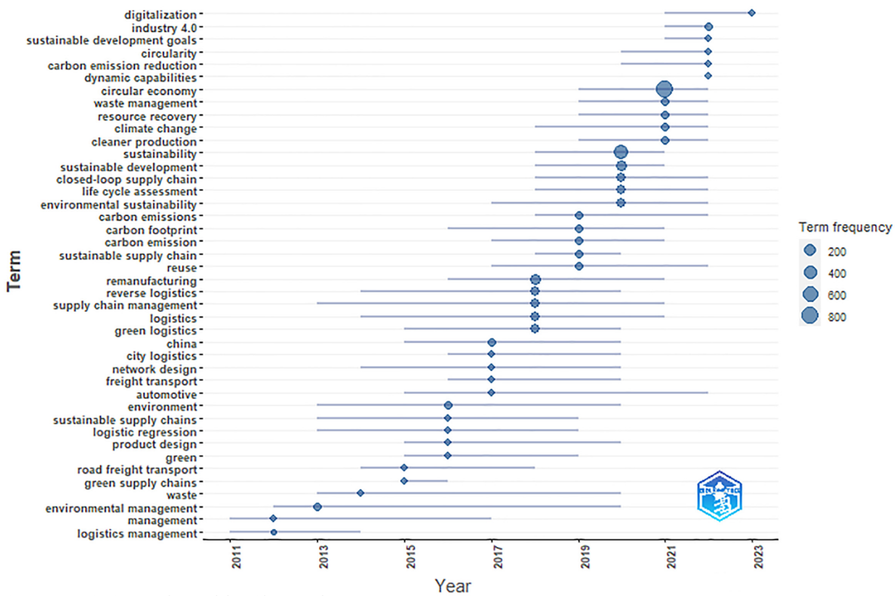
In the Emerging or Declining Themes section of Figure 7, big data and social sustainability are brought to attention as one of the themes. This theme is either emerging or declining; from the perspective of SGLR, this cluster is most likely the emerging type worthy of further investment.

Figures 8 and 9 present additional thematic analysis. Figure 8 shows the thematic evolution of the topics of interest in the extracted papers based on the current review's missions and search keywords over the years 2008–2023. As shown in the 2021–2023 time window of Figure 8, sustainable development, supply chains, recycling and climate change are the current top three topics of interest in the SGLR literature. Figure 9 shows the trend topics of research during the years 2011–2023. Trend topics are defined as recurring themes or ideas that hold prominence within a given field or discipline during a specified timeframe. The analysis of trending topics can offer significant contributions to comprehending the present status of research and the nascent domains of interest within a discipline. Additionally, it can underscore the deficiencies in the current knowledge that necessitate further exploration. Upon identification of trending topics, researchers can use this data to steer their own research, recognize possible collaborators or research associates and remain current with the most recent advancements in their respective fields. In Figure 9, the light blue



Source(s): Developed by the authors

Figure 8.
Thematic evolution of the topics of interest in papers through the years 2008–2023



Source(s): Developed by the authors

Figure 9.
Trend topics of research during the years 2011–2023

horizontal line shows the period in which a corresponding keyword has been a trending topic. On the other hand, the blue circle in this figure serves two purposes: (a) it shows the most trended year for a specific keyword in a specific period, and (b) it demonstrates the frequency of using a keyword in papers in that specific period.

As shown in Figure 9, the topics that are related to digitalization, Industry 4.0, sustainable development, circularity concept and carbon emission reduction are among the most recent trends. This reflects the increased attention to the Industry 4.0 revolution by firms and researchers. Environmental management and supply-chain management have endured as trend topics for a more extended period of time. Investigators can take advantage of these evolutionary maps of the trend topics in their future research.

5. Literature classification and content analysis

5.1 Identification of research clusters

The themes of research articles that are often cited together are typically comparable (Hjørland, 2013). The co-citation map is a graph-theory-based exploratory data analysis (Hernon, 2004). 1432 of the 2180 articles have been co-cited by other database documents, determined by R. Then, this pool of 1432 articles are clustered using R co-citation statistics and the Gephi data-clustering approach. Nodes in a network create clusters or modules. Similar cluster nodes have a greater density of border connections or edges than nodes in other clusters (Clauset *et al.*, 2004; Leydesdorff, 2012; Radicchi *et al.*, 2004). The term "co-citation network" refers to a cluster as a collection of interconnected articles in a single study field with few connections to other clusters' publications and scientific topics. Data clustering, also known as modularity, is used to categorize articles (Radicchi *et al.*, 2004). It helps find subjects, relationships and cooperative patterns. The standard clustering algorithm of Gephi is based on the Louvain method, a recurrent optimization model that optimizes modularity (Blondel *et al.*, 2008). The partition modularity index runs from −1 to 1 and represents the frequency of connections within and across communities. Gephi used this approach to the 1432-node co-citation network to generate six meaningful clusters. To set the research topic for each cluster, the top ten papers from each cluster are selected (Table 8). Since the latest publications have not yet accrued many citations, and they have not been considered in a full co-citation network to be accounted for in the identified clusters, we conduct a thorough analysis of the top 10 papers (most cited globally) published within the time frame of 2021 to April 2023, as Cluster Seven, to identify the most recent prevailing trends.

Each cluster is characterized by its lead articles. The focus of each cluster is provided in Table 9. We also identify the most relevant journal sources in each discipline by examining Table 9's top ten publications for each academic cluster. Table 10 lists the leading journals for each cluster.

5.2 Content analysis of the research clusters

This section explores the insights of sub-themes in each of the seven clusters by examining their research issues and methodologies. For brevity, only a brief explanation is presented here. Appendix D in the supplementary file has a more comprehensive summary of the papers in each cluster along with a discussion of their methodologies and research limitations.

Our findings unveil some of the key research issues that merit investigation; they will be discussed in Section 6.

(1) Cluster One: The circular economy facets

Cluster One is identified as the largest cluster, comprising a total of 381 papers. The principal objective of this category is to assess diverse methodologies encompassing the entire process from ideation to execution of the circular economy. The papers of this cluster have garnered increased attention since 2017, primarily due to heightened demand for research on sustainability and environmental issues, including climate change. The papers within this cluster exhibit homogeneous connections and a hierarchical order, as determined through preliminary analysis. To conduct a content analysis, the papers will be divided and reviewed according to three subsections: (1) Conceptualization and implementation of the circular economy, (2) Resource insufficiency and waste generation and (3) China's circular economy.

- **Conceptualization and implementation of the circular economy:** Geissdoerfer *et al.* (2017b) highlight the lack of clarity between the circular economy and sustainability and attempt to establish a connection between the two ideas.

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Ghisellini *et al.* (2016)	Govindan *et al.* (2015)	Seuring and Müller (2008)	Govindan and Hasanagic (2018)
Kirchherr *et al.* (2017)	Savaskan *et al.* (2004)	Carter and Rogers (2008)	Kirchherr *et al.* (2018)
Lieder and Rashid (2016)	Govindan and Soleimani (2017)	Colicchia *et al.* (2013)	de Jesus and Mendonça (2018)
Murray *et al.* (2017)	Atasu *et al.* (2008)	Zhu and Sarkis (2004)	Rosa *et al.* (2020)
Korhonen *et al.* (2018)	Ferrer and Swaminathan (2006)	Barney (1991)	Rajput and Singh (2019)
Su *et al.* (2013)	Devika *et al.* (2014)	Lieb and Lieb (2010)	Ormazabal *et al.* (2018)
Geissdoerfer *et al.* (2017b)	Ferrer and Swaminathan (2010)	Srivastava (2007)	de Sousa Jabbour *et al.* (2018)
Geng *et al.* (2012)	Ferguson and Toktay (2006)	Rao and Holt (2005)	Geissdoerfer *et al.* (2017a)
Merli *et al.* (2018)	Chaabane *et al.* (2012)	Hart (1995)	Yadav *et al.* (2020)
Winans *et al.* (2017)	Kannan *et al.* (2012)	Zhu *et al.* (2005)	Tura *et al.* (2019)
Cluster 5	Cluster 6	Cluster 7	
Linder and Williander (2017)	Bektaş and Laporte (2011)	Kouhizadeh *et al.* (2021)	
Urbinati *et al.* (2017)	Demir *et al.* (2014a)	Bag *et al.* (2021a)	
Bocken *et al.* (2016)	Demir *et al.* (2012)	Bag *et al.* (2021b)	
Bocken *et al.* (2014)	Xiao *et al.* (2012)	Sarkar *et al.* (2022a)	
Geissdoerfer *et al.* (2018)	Demir *et al.* (2011)	Yu *et al.* (2022)	
Boons and Lüdeke-Freund (2013)	Franceschetti *et al.* (2013)	Sarkar *et al.* (2022b)	
Teece (2010)	Erdoğan and Miller-Hooks (2012)	Hina *et al.* (2022)	
Eisenhardt (1989)	Ubeda *et al.* (2011)	Bag and Rahman (2023)	
Lewandowski (2016)	Kuo (2010)	Rusch *et al.* (2023)	
Antikainen and Valkokari (2016)	Demir *et al.* (2014b)	Kurniawan *et al.* (2023)	

Note(s): *Selected and ordered based on co-citation PageRank measure using the Louvain clustering method, except for Cluster 7. Cluster 7 is the top 10 papers from 2021 to 2023, selected manually by the authors
The focus of each cluster is provided in Table 9
Source(s): Developed by the authors

Table 8. The 10 lead papers of each cluster.

Cluster	No. of documents	Area of research focus
1	381	The circular economy facets
2	367	Decarbonization of operations to nurture a climate-neutral business
3	365	Green sustainable supply chain management
4	140	Drivers and barriers of reverse logistics and the circular economy
5	103	Business models for sustainable logistics and the circular economy
6	76	Transportation problems in sustainable green logistics
7	10	Digitalization of logistics and supply chain management
	Total: 1432 + 10	

Source(s): Developed by the authors

Table 9. The 7 major research clusters and their areas of research focus

Table 10.
Key contributing journals among each cluster's top 10 papers

Cluster	Top journal (ISSN)	Frequency in top 10 papers
1	Journal of Cleaner Production (0959-6526)	6
2	European Journal of Operational Research (0377-2217)	3
3	International Journal of Operations and Production Management (0144-3577)	2
	International Journal of Physical Distribution and Logistics Management (0960-0035)	2
4	Journal of Cleaner Production (0959-6526)	3
5	Journal of Cleaner Production (0959-6526)	4
6	European Journal of Operational Research (0377-2217)	3
7	Journal of Cleaner Production (0959-6526)	4

Source(s): Developed by the authors

Ghisellini *et al.* (2016) assert that the global implementation of the circular economy is still in its infancy, with a primary emphasis on recycling rather than reusing. Kirchherr *et al.* (2017) compile 114 concepts of the circular economy that were coded on 17 parameters and reveal that the circular economy is most typically portrayed as a mix of recycle, reuse and reduce operations; however, the need for a systemic transition is usually overlooked. Korhonen *et al.* (2018) seek to describe the idea of a circular economy and identify its current limits. Murray *et al.* (2017) investigate the origins and conceptualizations of the circular economy, monitoring its connotations and performing an analysis of its forerunners in economics and ecology. The purpose of Winans *et al.* (2017) is to (1) explore the history of the idea of a circular economy and to offer a background for (2) a critical analysis of its present use. Merli *et al.* (2018) explore the literature on the circular economy using a methodical approach in order to provide a thorough study of the phenomenon based on rigorous and repeatable research standards. They explain that studies of the circular economy pursue three primary paths of action: the first seeks to alter the economic and social dynamic behavior at the macro and managerial tiers; the second focuses on assisting enterprises in the execution of circular procedures at the micro-scale in order to propagate new types of product design and consumption; and the third, established at the meso level [7], describes experiences with industrial symbiosis.

- **Resource insufficiency and waste generation:** Lieder and Rashid (2016) provide an in-depth review of research efforts on the overarching aspects of resource insufficiency, generation of waste and economic advantages. They explore the circular-economy landscape in the context of these three components, especially when they are considered simultaneously and suggest an action plan using a simultaneous top-down and bottom-up framework based on the idea of a detailed circular economy approach.

- **China's circular economy:** Su *et al.* (2013) present an overview of China's circular economy, while Geng *et al.* (2012) describe China's national system for tracking indicators of the circular economy and the execution strategies that have been dubbed China's economic miracle.

- Cluster Two: Decarbonization of operations to nurture a climate-neutral business

Cluster Two is the second largest cluster, which includes a total of 367 papers. Upon initial examination, scholars primarily aim to assess the process of reducing carbon emissions in various operations through the implementation of remanufacturing, reverse logistics and closed-loop supply chains, with the ultimate goal of fostering a business that is environmentally sustainable. We structure this cluster as (1) SSCM, (2) Reverse logistics network design, (3) Closed-loop supply chains and (4) Remanufacturing.

- **Sustainable supply chain management:** This facet emphasizes the need for businesses to adopt sustainable supply chain management practices to address environmental concerns and comply with regulations. The mixed-integer linear programming framework proposed by Chaabane *et al.* (2012) takes into consideration life-cycle assessment and material balance restrictions to design sustainable supply chains.
- **Reverse logistics network design:** Kannan *et al.* (2012) proposed a mixed-integer linear model for the design of reverse logistics networks based on carbon footprint. This sub-theme highlights the importance of designing reverse logistics networks to minimize carbon footprint and maximize sustainability. Savaskan *et al.* (2004) address the challenge faced by manufacturers in selecting the most suitable topology for a reverse channel to collect old items from consumers.
- **Closed-loop supply chains:** The concept of closed-loop supply chains involves the reuse of materials and products in a circular economy. Atasu *et al.* (2008) categorize the economics of product reuse in closed-loop supply chains as industrial engineering/operations research, design, strategy and behavioral practices. Devika *et al.* (2014) attempt to create a sustainable closed-loop supply chain network using a triple-bottom-line strategy. This sub-theme highlights the need to consider environmental, social and economic factors when designing closed-loop supply chains.
- **Remanufacturing:** Ferguson and Toktay (2006) propose models to help manufacturers develop recovery plans for remanufactured products in a competitive market. Ferrer and Swaminathan (2006, 2010) study the pricing and remanufacturing strategies in monopolistic environments to optimize profitability.
- Cluster Three: Green sustainable supply chain management

This cluster has 365 papers; the primary focus is on the administration of environmentally conscious and green sustainable supply chains. Therefore, a significant number of scholarly articles focus on the conceptualization of the green perspective as a unique characteristic. The idea of "green" is a multifaceted construct that pertains to various business issues such as sales, environmental concerns and other concerns; it is also applicable to supply chains. This section has seven sub-themes: (1) Introduction to green and sustainable supply chain management, (2) Survey and framework development, (3) Categorization and mapping of literature, (4) Operational procedures and performance, (5) Environmental sustainability framework, (6) Third-party logistics and environmental sustainability and (7) Sustained competitive advantage.

- **Introduction to green and sustainable supply chain management:** The first sub-theme of this cluster is the introduction to green and sustainable supply chain management. These papers discuss the concept of sustainability in the context of supply chain management and highlight the interactions between environmental, sociocultural and economic performance. Carter and Rogers (2008) develop conceptual theories in this area. Rao and Holt (2005) examine possible connections between green concepts and supply chain management.
- **Survey and framework development:** The second sub-theme focuses on surveying the literature and developing conceptual frameworks for sustainable

supply chain management. Seuring and Müller (2008) survey 191 studies on sustainable supply chain management and provide a conceptual framework for summarizing the research in this area.

- **Categorization and mapping of literature:** This sub-theme discusses the categorization and mapping of the literature on green supply-chain management. Srivastava (2007) categorizes the literature on green supply-chain management based on the issue context in the supply chain's most important areas and the technique and strategy used. The research also maps and demonstrates the various mathematical tools/techniques used in the literature in relation to the settings of green supply-chain management.

- **Operational procedures and performance:** The fourth sub-theme discusses the links between operational procedures and performance in green supply-chain management strategies. Zhu *et al.* (2005) and Zhu and Sarkis (2004) elaborate on the links between operational procedures and performance among early adopters of green supply-chain management strategies in Chinese manufacturing companies.

- **Environmental sustainability framework:** The fifth sub-theme discusses the development of an environmental sustainability framework with a particular emphasis on businesses engaged in the logistics and transportation industries. Colicchia *et al.* (2013) developed this framework to discover environmental sustainability efforts.

- **Third-party logistics and environmental sustainability:** Lieb and Lieb (2010) aim to document the degree to which third-party logistics (3PL) organizations have adopted environmental sustainability objectives.

- **Sustained competitive advantage:** Barney (1991) and Hart (1995) elaborate on a firm's resources to generate sustained competitive advantage, including value, uniqueness, imitability and substitutability. This perspective can help firms develop sustainable green supply chain management practices to enhance their competitive advantage.

- Cluster Four: Drivers and barriers of reverse logistics and the circular economy

The articles in this collection discuss the drivers and obstacles of reverse logistics and the circular economy. This cluster can be divided into the following sub-themes.

- **Circular economy and eco-innovation:** de Jesus and Mendonça (2018) focus on the eco-innovation pathway towards a circular economy and attempts to consolidate existing but fragmented results addressing how "transformative innovation" might facilitate this transition while reducing barriers to sustainability. Govindan and Hasanagic (2018) analyze the drivers, impediments and practices that impact the adoption of the circular economy in the context of supply chains. To examine the degree of implementation of the circular economy, the authors link stakeholder viewpoints with drivers, impediments and practices. Ormazabal *et al.* (2018) develop an empirical analysis that enables the authors to investigate the potential for implementation of the circular economy in small and medium-sized enterprises (SMEs), as well as the barriers and opportunities that may exist. Rajput and Singh (2019) aim to comprehend the hidden relationship between the circular economy and Industry 4.0 within the framework of the supply chain. Rosa *et al.* (2020) try to begin with hybrid categories such as Circular Industry 4.0 and digital circular economy perspectives, as an innovative framework highlighting the connections between Industry 4.0 and the circular economy. The authors also discuss future research fields that have been developed in the circular economy research agenda.

- **Industry 4.0 and sustainable manufacturing:** de Sousa Jabbour *et al.* (2018) argue for the integration of two industrial waves that have the potential to reshape present production and consumption patterns: Industry 4.0 and environmentally-sustainable manufacturing. Yadav *et al.* (2020) establish a unique set of 28 concerns in sustainable supply-chain management and 22 solution measures. In addition, the scenario of an automobile case is used to evaluate the applicability of the created framework using a hybrid best–worst method (BWM) – ELimination and Choice Expressing Reality (ELECTRE) technique.
- **Obstacles and drivers of the circular economy:** Kirchherr *et al.* (2018) report the first large-N-study on impediments to the EU circular economy (208 survey respondents, 47 expert interviews). Businesses and policymakers think the most significant obstacles to the circular economy are cultural hurdles, including an absence of interest on the part of consumers and a lack of understanding by a cautious corporate culture. Tura *et al.* (2019) present a framework of obstacles and drivers with seven main categories: economic, environmental, political, social and institutional, technical and informational, supply chain and organizational aspects.
- Cluster Five: Business models for sustainable logistics and the circular economy

This cluster has 103 papers; scholars primarily aim to assess novel business models. This cluster focuses on empowering and enhancing the sustainability of the logistics industry, as well as addressing the circular economy. This cluster has four sub-themes.

- **Definition and significance of business models:** This facet concerns defining the concept of a business model as a blueprint for value-generating methods, distribution methods and capture methods used by commercial entities. The core of a business model lies in how an organization provides value to customers, induces their willingness to pay and translates those payments into profit. Teece (2010) explores the relevance of business models and their relationship with corporate strategy, economic theory and innovation management.
- **Circular and sustainable business models:** Antikainen and Valkokari (2016) propose a process for innovating circular and sustainable business models, which involves recognizing trends and stakeholders' value and evaluating the consequences of sustainable practices and circularity. Boons and Lüdeke-Freund (2013) present normative requirements for environmentally friendly business models, while Geissdoerfer *et al.* (2018) explore sustainability objectives in circular business models and supply networks. Linder and Williander (2017) discuss the potential negative impacts of return flow management in circular business models and Urbinati *et al.* (2017) propose a classification system for circular economy business models based on their level of circularity adaptation.
- **Archetypes of sustainable business models:** Bocken *et al.* (2014) propose archetypes of sustainable business models to facilitate the development of sustainable practices in the logistics industry. These archetypes provide a common language for stakeholders to accelerate the process of creating sustainable business models.
- **Product design and business model tactics:** Bocken *et al.* (2016) examine the product design and business model tactics necessary for transitioning from a linear to a circular economy in the logistics industry.
- Cluster Six: Transportation problems in sustainable green logistics

This section presents the results of an analysis of the transportation issues in green logistics for sustainability. This cluster can be further divided into the following sub-categories.

- **Pollution-routing problem (PRP):** Bektaş and Laporte (2011) propose the PRP, which considers emissions of greenhouse gases, fuel use, travel durations and costs in addition to trip length. Demir *et al.* (2012) provide a heuristic method for solving the PRP and a speed-optimization algorithm to reduce fuel and driver costs. Demir *et al.* (2014b) present an adaptive large-neighborhood search algorithm along with a speed-optimization strategy to solve the bi-objective PRP.
- **Freight-transportation vehicle emission models:** Demir *et al.* (2011) evaluate and compare various freight-transportation vehicle emission models and analyze their results in connection with field research. The integration of these models into existing optimization strategies is required to reduce emissions during the transportation-route design process. Demir *et al.* (2014a) give an overview of studies on green road freight transportation.
- **Green vehicle routing problem (VRP):** Erdoğan and Miller-Hooks (2012) create a green VRP and develop solution methodologies to assist businesses with vehicle fleets powered by alternative fuels in overcoming obstacles caused by a restricted driving range and limited refilling infrastructure.
- **Time-dependent vehicle routing problem (TDVRP):** Kuo (2010) presents a model for predicting total energy consumption for the TDVRP, which takes into account changes in travel speed and duration depending on the time of day. The fuel use also considers the weight of the load, which is often ignored in relevant research.
- **Fuel consumption rate consideration in capacitated vehicle routing problem (FCVRP):** Xiao *et al.* (2012) develop a simulated annealing algorithm with a hybrid exchange rule to solve the FCVRP, which takes into account fuel consumption rates. The technique achieves satisfactory results for both classic CVRP and FCVRP.
- Cluster Seven: Digitalization of logistics and supply chain management

There is a concern regarding the potential oversight of emerging trends in scientific research for papers that are not included in bibliographic coupling and co-citation networks. It is improbable that a considerable number of contemporary academic articles receive citations from colleagues. Nevertheless, these papers hold significant value as they have made noteworthy contributions to the latest research discoveries. Therefore, we have analyzed the top ten papers published from 2021 to April 2023, as cluster seven, in order to identify and understand the prevailing trends.

The papers within this cluster prominently address the interconnections among digitalization concepts, especially the Industry 4.0 technologies and logistics and supply chain management. We structure this cluster as follows.

- **Adoption of Industry 4.0 technologies in sustainable supply chain management:** In the studies by Kouhizadeh *et al.* (2021) and Bag *et al.* (2021a), the researchers utilized theoretical frameworks such as the technology-organization-environment framework, practice-based view and dynamic capability view to investigate the barriers and impact of Industry 4.0 adoption on sustainable supply chain management. In Bag *et al.* (2021b), institutional theory and resource-based view theory were employed to elucidate how automotive firms configure tangible resources and workforce skills to drive technological enablement and improve sustainable manufacturing practices and to develop circular economy capabilities. The researchers also used statistical validation through data collection using online surveys and structured questionnaires in Bag *et al.* (2021a).

- **Circular economy practices in supply chain management:** In the studies by Sarkar *et al.* (2022a) and Yu *et al.* (2022), the researchers investigated the relationship between circular economy practices and supply chain capability to improve firm performance. Sarkar *et al.* (2022a) developed a model to nullify food waste in the supply chain and used an algebraic procedure to obtain a globally optimum solution. Yu *et al.* (2022) collected cross-sectional data from 286 respondents through a closed-ended questionnaire to examine the role of Industry 4.0 in circular economy practices and supply chain capabilities. Bag and Rahman (2023) explored the relationship among engagement and alliance capability, data analytics capability, sustainable supply chain flexibility and circular economy-target performance.
- **Environmental sustainability and waste reduction in supply chain management:** In Hina *et al.* (2022), the researchers performed a systematic literature review on circular economy business models to critically analyze and appraise prior findings. In Rusch *et al.* (2023), the researchers provided a comprehensive overview of digital technologies' current and potential applications in sustainable product management. Kurniawan *et al.* (2023) investigated how to strengthen the waste recycling industry in Malang (Indonesia) using a digitalization-based circular economy and utilized lessons learned from Nanning's[8] experiences in digitalizing waste recycling.

For a further comprehensive analysis of the papers in each cluster, please refer to Appendix D in the supplementary file.

6. Discussion, implications and directions for future research

Based on content analysis, the majority of the SGLR literature has been covered by the seven clusters listed earlier: the circular economy facets; decarbonization of operations to nurture a climate-neutral business; green sustainable supply-chain management; drivers and barriers of reverse logistics and the circular economy; business models for sustainable logistics and the circular economy; transportation issues in sustainable green logistics; and digitalization of logistics and supply chain management. All of these central themes are moving toward and encouraging green concepts and sustainability. This comprehensive literature review and bibliometric analysis has two implications. First, by analyzing seven distinct clusters, it is possible to understand the logical and theoretical framework of SGLR literature; moreover, by describing the thematic evolution of SGLR, it is possible to comprehend research gaps and derive novel research ideas, some of the most prominent of which are listed below. Second, for each cluster, the prevailing logic, objective, methodology and conceptual boundaries have been described. This study provides professionals with credible perspectives and practical insights for using SGLR to meet objectives in sustainable development. The bibliometric, thematic, network and content analyses and literature classifications have identified academic gaps and inadequacies. Consequently, based on these outcomes that are highlighted in Figures and Tables, there are multiple opportunities for future research. Some of the significant gaps found, as well as future research objectives and ideas, are outlined below. In addition to the explanations that are provided in Section 5 of this review as answers to the research questions (RQ1-RQ3), further elaborations are presented for these answers in the propositions that follow. The suggestions for future directions are structured based on discussed results and the elaborated clusters with a total of **three** future streams as follows:

(1) Digitalization of SGLR

The domain of digitalization offers several promising avenues for research, including the exploration of digital twin (DT), physical Internet (PI), AI, simulation and optimization driven by big data and the integration of IoT, blockchain and Industry 4.0 technologies for the strategic implementation and management of SGLR. As an illustration, within the technologies previously mentioned, a DT is the technology that incorporates the majority of the aforementioned technologies into its operational framework. The process involves the utilization of sensors and network technologies to create a digital representation of a tangible entity. Several research studies have investigated the potential benefits of implementing a digital logistics/supply chain twin to digitize logistics and supply chain networks. However, to date, no scholarly inquiry has explored the use of a DT in remanufacturing systems. The incorporation of technology within a DT has the potential to provide visual representations, simulations and diagnostic capabilities for monitoring the current state of SGLR systems in real-time. The application of digitalization on SGLR can be divided into two potential parts:

Firstly, the utilization of state-of-the-art technologies in SGLR is restricted, particularly with regards to gauging performance, and the present state of affairs is further compounded by the uncertainties and elevated risks linked to disturbances such as pandemics. The present circumstance poses a challenge to the optimization of logistics and remanufacturing procedures, potentially leading to escalated expenses, diminished efficacy and adverse environmental consequences.

Notwithstanding these obstacles, there exist noteworthy advantages to the implementation of state-of-the-art technologies in the realm of SGLR. The amalgamation of AI and sophisticated analytics has the potential to facilitate instantaneous monitoring and analysis of logistics and remanufacturing procedures, thereby expediting the response to disruptions and enhancing the efficiency of operations. The implementation of robotics and IoT technology can potentially automate numerous manual processes, thereby mitigating the likelihood of errors and enhancing overall efficiency.

In order to surmount the present constraints in this domain, scholarly inquiry is imperative to ascertain the most auspicious technologies and formulate tactics for their execution. Furthermore, there is a requirement to augment the capabilities of performance measurement and analysis, which can facilitate decision-making and facilitate advancement towards sustainability objectives. The incorporation of advanced technologies and evaluation of performance in SGLR has the potential to yield substantial ecological and financial advantages, rendering it a pivotal domain for prospective investigation and advancement. This prompts us to propose the subsequent research propositions that highlight critical aspects necessary for enhancing this facet.

- Identify and evaluate the effectiveness of the engineering and algorithmic solutions such as IoT, AI, big data and blockchain in building smart SGLR.
- Exploring the backbones and architectures needed for high-tech companies using cutting-edge data-driven tools and technologies and targeting sustainable green logistics.
- Develop and apply two-stage stochastic methodologies and robust optimization algorithms to reduce the volatility, uncertainty, complexity and ambiguity (VUCA) (Nikseresht *et al.*, 2022) in green logistics and remanufacturing adoptions.
- Investigate the use of evolutionary game theory techniques for competitive SGLR.
- Design state-of-the-art transportation solutions that are directly related to logistics and carbon footprint.

- Analyze the potential environmental and economic benefits of integrating remanufacturing into the circular economy and explore the role of digital technologies in enabling closed-loop supply chains.
- Implement novel forecasting tools to predict various SGLR outcomes.
- Develop cutting-edge environmental metrics and measurements that quantify the effectiveness of each green logistics and remanufacturing strategy.
- Develop sustainable development solutions for SMEs via cutting-edge technologies.
- Using virtual and augmented reality with computer vision for remanufacturing disruption analysis.
- Boosting SGLR via robotics and 3D printing.
- Simulation of carbon-neutral logistics and supply chains for climate neutrality.
- Developing decision support systems for sustainable production processes.

The **second** part of recommendations for future research on digitalizing SGLR involves consumers. Although consumers' increasing concern about the environment has led them to search for products that emit less carbon, many research articles on SGLR do not consider consumers as a significant aspect of managing these activities. This is despite the fact that consumers generate scheduling, quality and quantity uncertainties associated with the adoption of green and sustainability concepts. This may be due to a lack of interdisciplinary collaboration between logistics and marketing, as well as a lack of data on customer behavior and preferences in relation to sustainability. This lack of attention to consumers may result in missed opportunities to optimize logistics and remanufacturing processes, as well as a failure to fully leverage the potential benefits of sustainable practices. By developing a wide range of emission contracts, several research studies have investigated the impacts that green consumer preferences have on the rate of carbon-emission reduction (e.g., revenue-sharing contracts and cost-sharing contracts). Despite this, there continue to be certain limitations on what can be done. First, most current studies did not partition the market; nevertheless, given that there are distinct results in various markets (for example, regular customers and green users), operational decisions under market segmentation conditions need more investigation. Second, many of the publications made the assumption that customers pay the same price for items that are comparable. However, research has found that certain consumers are more inclined than others to pay a higher price for environmentally friendly products. Third, there is a need for more investigation into the incorporation of low-carbon options into production decisions, as well as the procurement of low-carbon technological investments. Among the approaches that can help both the practitioners and scholars in achieving the relevant goals here, solving the issues and filling the gaps are Industry 4.0 and 5.0 and digitalization concepts in general. For instance, big data and social media analytics can be real saviors here. However, there is a lot in improving these approaches. We outline the following proposed research concerning the previous points:

- Exploring the challenges in analyzing textual information and customer footprints using natural language processing: a text mining approach for determining the drivers of green and remanufacturing concepts acceptance.
- Integrating system dynamics, causal inference, city logistics and consumer behavior to enhance SGLR.
- Forecasting customer behavior in SGLR using social media data and customer footprint.

- Ensuring traceability and privacy in SGLR using Blockchain, DT and PI assistantships.
- Assessing the social and ethical dimensions of SGLR: implications for stakeholders.
- Understanding consumers' inclination rate towards green products and low-carbon technological investments: an empirical study.

(2) Enhancing scopes, sectors and industries in the context of SGLR

SGLR possess the capacity to substantially augment the range, domains and fields with regards to ecological sustainability, financial feasibility and societal accountability. The implementation of sustainable practices by logistics and manufacturing companies can result in a reduction of their environmental impact, optimization of their supply chains and enhancement of their financial performance.

The circular economy presents a promising avenue for improvement, as it entails a paradigm shift in which waste is regarded as a valuable resource that can be repurposed, reused, or recycled. The restoration of used products to their original specifications, which reduces the need for new production and minimizes waste, is a crucial element of the circular economy known as remanufacturing.

Apart from the ecological advantages, remanufacturing has the potential to generate economic benefits through the establishment of fresh business prospects and employment opportunities. Remanufacturing firms may opt to specialize in the refurbishment of particular products or components, thereby carving out a distinct market segment that has the potential to yield significant profits. Additionally, the process of remanufacturing has the potential to decrease expenses by limiting the requirement for primary resources and diminishing energy usage, resulting in heightened profitability and competitiveness.

The transportation industry has the potential for improvement through the implementation of sustainable green logistics practices. This can effectively mitigate the environmental impact of transportation activities, including emissions and energy consumption. The implementation of fuel-efficient vehicles, optimization of transportation routes and utilization of renewable energy sources are potential methods to attain this objective. Furthermore, the implementation of green logistics practices has the potential to enhance transportation safety and dependability, thereby resulting in heightened levels of customer satisfaction and allegiance.

Furthermore, the implementation of SGLR has the potential to augment the corporate social responsibility of firms through the advancement of ethical and sustainable procedures. The prioritization of sustainability by companies has the potential to enhance their reputation and brand image, resulting in heightened customer loyalty and the attraction of investors who are environmentally conscious. Further research can be conducted to investigate the potential advantages of SGLR in diverse sectors, including electronics, automotive and construction. The research endeavors can delve into the technical, economic and social dimensions of embracing sustainable methodologies in various sectors, while also scrutinizing the possible impediments and catalysts for execution. Furthermore, there is scope for further research to investigate the prospective policy and regulatory structures that may encourage and streamline the implementation of sustainable methodologies across diverse sectors.

The possible advantages of SGLR are noteworthy, spanning across economic, environmental and social aspects. Through the adoption of sustainable practices, corporations have the potential to not only augment their competitive advantage, but also make a valuable contribution to the worldwide endeavors aimed at promoting sustainability and circular economy.

Based on the above discussions regarding the enhancement of scopes, sectors and industries in the context of SGLR, research propositions can be divided into three potential parts as below:

Firstly, the current state of academic research on waste management following remanufacturing in the context of sustainable green logistics is deficient in terms of social, economic and geographical considerations. The dearth of research in this area is noteworthy as it constrains our comprehension of the plausible ramifications of SGLR on societies, financial systems and the ecosystem.

The possible cause of this disparity could be attributed to the fact that the majority of studies in the domain of SGLR tend to concentrate on technical facets such as the management of supply chain, manufacturing procedures and the mitigation of waste. Although sustainable logistics and remanufacturing are crucial elements, they fail to encompass the complete spectrum of waste management in terms of social, economic and geographical aspects that follow the process of remanufacturing. The following propositions reflect this facet of the enhancement of scopes, sectors and industries in the context of SGLR:

- Optimal location analysis for trash and recycling centers: a multi-criteria decision-making approach.
- Balancing globalization and localization in SGLR facilities: a social and economic perspective.
- Restructuring global supply networks during pandemic periods: a risk management perspective.

Secondly, it can be observed that SGLR entail the involvement of intricate sectors that exhibit interconnections and multifaceted characteristics. The aforementioned industries encompass transportation, manufacturing, waste management and energy, among various other sectors. The amalgamation of these domains is imperative in attaining a viable and cyclical economy.

The resolution of sustainability and circular economy challenges in these sectors necessitates an interdisciplinary methodology that integrates technical, economic, social and environmental viewpoints. Numerous research studies tend to concentrate on a particular sector or discipline, resulting in a fragmented comprehension of sustainability predicaments and feasible remedies. Prospective research endeavors may consider employing a multidisciplinary and systems thinking methodology to examine the sustainability predicaments and possibilities within these industries. In addition, scholars have the ability to create uniform metrics and assessment instruments capable of capturing the intricacy and interdependence of sustainability facets. The following research propositions reflect and expand on this aspect of the enhancement of scopes, sectors and industries in the context of SGLR:

- A system thinking approach to investigating sustainability challenges and opportunities in the transportation and logistics sectors.
- Multi-dimensional approaches to addressing sustainability challenges in the logistics and transportation sectors.
- Supply chain collaboration and partnership as enablers of sustainable and green logistics and remanufacturing practices.
- Implementing climate-neutral logistics practices by SMEs in different sectors and countries.

Thirdly, the impacts of various policies set by the government regarding the SGLR implementations are of high importance, however, they have been neglected in research. The following proposition can be considered for future research directions:

- Analyzing the impact of government policies and regulations (e.g., carbon pricing, extended producer responsibility) on the adoption of SGLR practices in different regions and industries (e.g., Does environmental regulation influence corporate environment-related decision-making and responsibility?).

(3) Developing more efficient and effective climate-neutral and climate-change-related solutions and promoting more environmental-related and sustainability research concerning SGLR

One of the current focus areas of sustainable development and climate-friendly process development is achieving carbon neutrality, which means achieving net zero carbon emissions by balancing the amount of carbon emitted with an equivalent amount sequestered or offset. In comparison, climate neutrality, which is known as net zero or zero emissions, goes beyond carbon to include all greenhouse gases and other drivers of climate change. Carbon neutrality is a part of climate neutrality.

Establishing climate neutrality in logistics and supply chains is a complex, challenging task that involves major efforts from a variety of stakeholders such as politicians, corporations and consumers. One possible strategy for reaching climate neutrality is the creation of carbon-neutral logistics and supply chains, which entails lowering greenhouse gas emissions and offsetting the residual emissions via the use of renewable energy and other carbon-neutral technology.

However, there are obstacles that must be overcome to attain carbon neutrality in logistics and supply chain networks. First, there is a lack of common measures for quantifying carbon emissions across various sectors, making it difficult to evaluate emissions-reduction initiatives. Second, there is a lack of knowledge and awareness among consumers and enterprises about the environmental effect of logistics and supply chain operations, resulting in a lack of investment in sustainable methods. Third, there are technological difficulties in creating and deploying carbon-neutral innovations such as electric cars and renewable energy sources, which may be expensive and require substantial infrastructure expenditures.

Future studies might concentrate on standardizing carbon measures and reporting systems, as well as enhancing education on sustainable logistics and supply chain practices, in order to address these issues. Moreover, research might investigate novel technologies and business models that minimize emissions and enhance the sustainability of logistics and supply chain operations. Last, research may investigate the legislative and regulatory frameworks required to support the development of carbon-neutral logistics and supply chains, including incentives and laws that promote sustainable behaviors and investments. Alongside the mentioned points, there are further important propositions concerning this stream of research that can be categorized into two sub-themes, i.e., (1) Investigating the benefits, risks, cost and price concerns and decisions of SGLR concerning society and (2) Detection of drivers, motivators and barriers of adopting climate-neutral (e.g., low-carbon) practices concerning SGLR.

First, it can be stated that the facets of SGLR encompass significant methodologies that commercial enterprises can adopt to mitigate their ecological footprint and foster social welfare. When evaluating these practices, it is imperative to consider various factors such as advantages, disadvantages, expenses and pricing considerations. The existing body of literature has indicated a deficiency in addressing the aforementioned facets. This is some proposed research that can aid in filling the relevant gaps:

- A comprehensive analysis of sustainable development dimensions in green logistics and remanufacturing can provide more effective and inclusive solutions.
- Investigating the role of circular economy principles in promoting SGLR practices and developing new business models.
- Determining the uncertainties and barriers to the adoption of green logistics and remanufacturing and developing solutions to overcome them.
- Evaluating the practical, social and environmental impacts of green logistics, remanufacturing and circular economy practices.
- Developing a methodology for calculating external costs through ecosystem services to enable the decarbonization of operations and the development of climate-neutral supply chains.
- Optimizing costs, reducing risks and enhancing benefits through SGLR practices for public and private organizations.
- Analyzing the potential of the food-sharing economy in promoting sustainable logistics practices.
- Integrating disassembly, remanufacturing and reassembly processes to improve cost-efficiency, demonstrate better results and promote sustainable production and consumption.

Secondly, in a general sense, researchers can investigate and try to detect novel drivers, motivators and barriers of adopting climate-neutral (e.g., low-carbon) practices concerning SGLR. Here are some possible avenues for research:

- Theoretical systematization says that the concepts of barriers and motivators of low-carbon supply chains and logistics should be used to broaden empirical and quantitative investigations, resulting in valuable generalizations.
- The application of organizational theories as analytical tools should be considered to comprehend the drivers and obstacles to the adoption of low-carbon products, logistics and supply chains. The theories in question encompass the resource-based view, ecological modernization theory, institutional theory and the stakeholder theory.
- The methodologies of life-cycle analysis (LCA) and input-output analysis are frequently used in order to measure the carbon footprint of products in logistics and supply chains. The practice of LCA poses significant challenges in identifying drivers, motivators, barriers and scopes; additional challenges are selecting organizational boundaries and allocating aggregated carbon-inventory data.
- In several instances of multi-criteria decision-making methodologies, sensitivity analysis was not conducted. The study of sensitivity analysis involves examining the effects of modifying criteria weights on the drivers, motivators and barriers for the selection of a supplier with the most favorable climatic and environmental performance. The aforementioned task is achieved by modifying the relative importance of different criteria in diverse experiments. Therefore, it is imperative that future multi-criteria decision-making methodologies incorporate this aspect.
- Examine the impact of diverse national contexts on the implementation of low-carbon supply chain practices. Additionally, try to analyze how these contexts can either facilitate or hinder the development of motivators and barriers to the adoption of these practices.

- Examine potential variations in the responses of private multinational corporations and domestic companies to the motivators and barriers associated with low-carbon supply chains.
- Investigate the subject of business and climate change strategies, with a focus on the incentives driving the implementation of low-carbon operational practices. Additionally, the analysis can be broadened to encompass logistics and supply chains.
- Analyze and compare the obstacles and incentives encountered by companies in the implementation of management practices for low-carbon logistics and supply chains, comparing companies based on their participation in voluntary carbon-disclosure programs.

Table 11 summarizes the proposed research studies regarding each of the three research streams, the insights of this review's figures and tables and the content analysis with regard to the identified clusters, research gaps and opportunities. Appendix E has a list of points concluded from the analyzed papers that provide additional directions for proposed research.

7. Conclusions

Sustainable green logistics and remanufacturing are critical components of mitigating the negative effects of climate change. The implementation of these practices can significantly reduce carbon emissions, pollution and waste, leading to a more sustainable future for all. Additionally, green logistics and its combination with sustainability, remanufacturing and other sub-topics provide smart winning logistics and supply chain management in a world where tracking of performance implications for supply chain management under explicit climate neutrality objectives has become a necessity. Over time, a growing number of scholarly studies corroborate this idea. The link between logistics, sustainability, green ideas and remanufacturing is investigated via a thorough literature review. The literature on the integrated topics is examined using bibliometric, network, thematic and content analyses, as well as categorization, in order to integrate the results and contribute to the present state. Figure 2 presents a comprehensive listing of all the procedures undertaken for this article. Moreover, two conceptual models (Figure 1) concerning the SGLR concepts and clime-neutral strategies and implementations are developed by the authors that help both the scholars and practitioners. The most important findings and contributions of this study are shown in Figure 7 as well as in Sections 5 and 6's explanations, elaborations and recommendations.

This paper started with the identification and mapping of publications from a range of journals, institutions, authors, and nations in this field. Second, the combination of bibliometric and network investigations resulted in a thorough literature search for the articles and added methodological value to this study. During the third phase, present and future study topics are chosen, and fresh insights are extracted from previously discovered research themes. The fifth section provided the foundation for multiple proposed future research objectives and endeavors; seven clusters have been found within the study topic. The combination of SGLR is expected to attract experts from other fields. It is anticipated that they will use sustainability and green principles to find fresh academic topics associated with logistics, remanufacturing and the circular economy. When commencing research on this topic, academics should consider citing the critical articles included in this review. Various software programs have been used to graphically map the findings and confirm the conclusions produced from the Scopus database. Using the aforementioned data and technologies, the existing correlations between the parameters of the author co-citation network, the keyword co-occurrence network, the topic analysis and the institution cooperation network can be easily understood and shown. Our literature review, like all

Table 11.
Summary of gaps, challenges and research opportunities

Future direction	Potential research gap/Challenge	Category	Potential future research directions
Digitalization of SGLR	Not using cutting-edge technologies (related to Industry 4.0 & 5.0) and performance measurements, especially under the uncertainties and high risk of disruptions (such as pandemics)	Methods and approaches	Identification and use of engineering and algorithmic solutions such as IoT, AI, big data and blockchain to build smart SGLR Backbones and architectures needed for high-tech companies using cutting-edge data-driven tools and technologies and targeting sustainable green logistics Using two-stage stochastic methodologies and robust optimization algorithms to reduce the VUCA in green logistics and remanufacturing adoptions Evolutionary game theory techniques for competitive SGLR
		Perspective of research areas	Designing state-of-the-art transportation solutions that are directly related to logistics and carbon footprint Analyzing the potential environmental and economic benefits of integrating remanufacturing into the circular economy and exploring the role of digital technologies in enabling closed-loop supply chains Implementation of novel forecasting tools to predict various SGLR outcomes Developing cutting-edge environmental metrics and measurements that quantify the effectiveness of each green logistics and remanufacturing strategy Sustainable development solutions for SMEs via cutting-edge technologies Using virtual reality, augmented reality and computer vision to foresee and better understand the remanufacturing effects of disruptions and vice versa Boosting SGLR processes via robotics and 3D printing One possible strategy for reaching climate neutrality is the creation of carbon-neutral logistics and supply chains, which entails lowering greenhouse gas emissions and offsetting the residual emissions via the use of renewable energy and other carbon-neutral technology. Researchers can develop and try to simulate such technologies and report the outcomes Creating a decision support system to increase the energy savings of sustainable production processes at the process scheduling and planning levels
	The majority of articles did not include consumers as a significant aspect of managing sustainable green logistics, remanufacturing, and operations activities, despite the fact that customers generate scheduling, quality, and quantity uncertainties associated with green and sustainability concept adoptions	Methods and approaches	There might be a misinterpretation in analyzing textual information and customer footprints (e.g., social media data) using natural language processing. Major drivers associated with high acceptance of green and remanufacturing concepts must be determined correctly via text mining Focusing on the combination of system dynamics, causal inference, city logistics, and consumer behavior
		Perspective of research areas	Understanding and forecasting customer behavior via social media data and customer footprint Blockchain, DT, and PI assistantships in monitoring and tracing the status of remanufactured goods without compromising consumer confidentiality Investigating the social and ethical dimensions of SGLR practices and assessing the potential impacts on stakeholders (e.g., employees, customers, local communities) Consumers' inclination rate towards green products and low-carbon technological investments

(*continued*)

Table 11.

Future direction	Potential research gap/Challenge	Category	Potential future research directions
Enhancing scopes, sectors, and industries in the context of SGLR	Few articles examined the social, economic, and geographical aspects of waste management following remanufacturing	Perspective of research areas	The optimum location for establishing trash and recycling centers Globalization vs. localization plus social and economic considerations for putting up SGLR facilities Provide critical restructuring steps for global supply networks during pandemic periods that are of high risk and unpredictability
	Few papers study complex sectors	Perspective of research areas	Multi-echelon supply chain management, multi-level structures, multi-channel logistics, on-premise activities mixture with online platforms, and fossil-fuels-based firms and high-tech industries' issues should be considered Systems thinking approach adoption to investigate the merits and garner the possible existing opportunities Investigating the role of supply chain collaboration and partnerships in promoting SGLR practices across different tiers of the supply chain Investigating the implementation of climate-neutral logistics practices by SMEs in different sectors and countries
	The impact of government policies on SGLR implementations	Perspective of research areas	Analyzing the impact of government policies and regulations (e.g., carbon pricing, extended producer responsibility) on the adoption of SGLR practices in different regions and industries (e.g., Does environmental regulation influence corporate environment-related decision-making and responsibility?)
Developing more efficient and effective climate-neutral and climate-change-related solutions, and promoting more environmental-related and sustainability research concerning SGLR	Few papers addressed the benefits, risks, cost, and price concerns and decisions of SGLR concerning society	Perspective of research areas	Examine more than one facet of sustainable development concerning green logistics and remanufacturing to have better and more general-purpose offerings with benefits Investigating the role of circular economy principles in promoting SGLR practices (e.g., resource efficiency, closed-loop supply chains, product design for disassembly), and new business models for sustainable production and consumption Discover the uncertainties regarding the adoption of green logistics and devise solutions Investigation of practical, public-related, and environmental impacts of green logistics, remanufacturing, and the circular economy Decarbonization of operations via external-cost calculation through ecosystem services and development of climate-neutral supply chains Investigate the reduction of risk, optimization of costs, and enhancement of benefits in parallel with SGLR for the public Food-sharing economy analysis regarding sustainable logistics Integration of disassembly, remanufacturing, and reassembly to reduce costs, demonstrate better results and show the results better

(*continued*)

Future direction	Potential research gap/Challenge	Category	Potential future research directions
	Drivers, motivators, and barriers of adopting climate-neutral (e.g., low-carbon) practices concerning SGLR	Methods and approaches	Theoretical systematization motivates us that the concepts of barriers and motivators in low-carbon supply chains and logistics should be utilized to broaden empirical and quantitative investigations, resulting in valuable generalizations
			The application of organizational theories as analytical tools should be considered to comprehend the drivers and obstacles to the adoption of low-carbon products, logistics and supply chains. The theories in question encompass resource-based view, ecological modernization theory, institutional theory and the stakeholder theory
			The methodologies of LCA and input-output analysis are frequently utilized in order to measure the carbon footprint of products within logistics and supply chains. The practice of LCA poses significant challenges in identifying drivers, motivators, barriers, scopes, selecting organizational boundaries and allocating aggregated carbon inventory data
			In several multi-criteria decision-making methodologies instances, sensitivity analysis was not conducted. The study of sensitivity analysis involves examining the effects of modifying criteria weights on the drivers, motivators and barriers for selection of a supplier with the most favorable climatic and environmental performance. The aforementioned task is achieved by modifying the relative importance of different criteria in diverse experiments. Therefore, it is imperative that future multi-criteria decision-making methodologies incorporate this aspect
		Perspective of research areas	To examine the impact of diverse national contexts on the implementation of low-carbon supply chain practices. Additionally, try to analyze how these contexts can either facilitate or hinder the development of motivators and barriers to the adoption of these practices
			To examine potential variations in the responses of private multinational corporations and domestic companies to the motivators and barriers associated with low-carbon supply chains
			To investigate the subject of business and climate change strategies, with a focus on the incentives driving the implementation of low-carbon operational practices. Additionally, the analysis can be broadened to encompass logistics and supply chains
			Analyze and compare the obstacles and incentives encountered by companies in the implementation of management practices for low-carbon logistics and supply chains, comparing companies based on their participation in voluntary carbon-disclosure programs

Source(s): Developed by the authors

Table 11.

others, is subject to some limitations. This is owing to the fact that only the finest and most valuable screened research publications are taken into account. This research used logistics, green ideas, sustainability, remanufacturing, reverse logistics and circular economy among its most important terms. Multiple search words or phrases might form a heterogeneous cluster that can be interpreted in a variety of ways. In addition, the construction of a classification system for sample articles based on individual tastes is purely subjective. Future study may broaden search strings to include other views, emphasizing the variety of term selection. In addition, more study on a specific route may be based on the explanations given by figures and tables, the characteristics supplied by the discovered clusters and notably the insights and recommendations included in Section 6.

Notes

1. For brevity, only a handful of papers' analyses and investigations (summarized versions) are mentioned here. The complete, detailed explanations are provided in Appendix A of the supplementary file.
2. The diagram is developed by the authors. However, it is inspired by multiple sources and more important ones are (Bag *et al.*, 2021a; David B Grant and Wong, 2017; Di Vaio *et al.*, 2023; Domagala *et al.*, 2022; Li and Wang, 2018; McKinnon, 2018; Piecyk, 2015)
3. The diagram is developed by the authors. However, it is inspired by multiple sources and more important ones are (Bickel and Friedrich, 2005; McKinnon, 2018; Piecyk, 2015; Shaharudin *et al.*, 2019).
4. For the discussions and reported results relevant to the importance of remanufacturing, please refer to Appendix A of the supplementary file.
5. https://charteredabs.org/academic-journal-guide-2021/
6. https://abdc.edu.au/research/abdc-journal-quality-list/
7. Meso-level research often refers to a population size that falls between the micro and macro levels, such as a community or an organization. This population size falls somewhere in the middle. On the other hand, the term "meso-level" may also be used to refer to research whose objective is to discover links between the micro- and macro-levels.
8. As a miniature of China's sustainable waste management, nanning represents a model of smart city that applies resource recovery paradigms using digitalization.

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Appendix

The supplementary material for this article can be found online.

Corresponding author

Davood Golmohammadi can be contacted at: davood.golmohammadi@umb.edu