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S.I. : OR FOR SUSTAINABILITY IN SUPPLY CHAIN MANAGEMENT

Migration to the quadruple bottom line framework for achieving sustainable development goals: the 4Ps of sustainability

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Abstract
The topic of sustainability has been of great interest for the past decades. Many governments have taken action to incentivize firms to reduce negative environmental and social impacts. It is unclear, however, how successful policymakers have been in reducing sustainability threats. This obscurity raises the question of how they can play a fundamental role in helping businesses become more sustainable while complying with entrepreneurs' and investors' expectations. This study reviews recent academic directions and projects centered on the convergence of supply chain management and sustainability development. To this end, this research adopts an operations management perspective to study the existing sustainable supply chain management literature. This study provides a novel taxonomy of the literature, comprising nine primary research directions, and offers promising future research. We analyze how each research direction aligns with the United Nations' Sustainable Development Goals to identify extensively explored areas and pinpoint those requiring further attention. Based on this literature review, we primarily present evidence corroborating a worldwide trend toward implementing sustainability-driven regulations. This finding helps us develop a new theory in the context of sustainability development and introduce the quadruple bottom line framework as an extension of the classical triple bottom line model.

Keywords Environment and climate change · Sustainability · Supply chain management · Sustainable regulation · Sustainable development goals · Literature review

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1 Introduction

The classical four-element perception in Ancient Greece included earth, water, air, and fire, which were simplistic substances explaining the nature of all matter. While modern scientific investigations have proven that such a system was incorrect, humans still believe that the next generations deserve to take advantage of the best form of these resources.

Industrialization has created prosperous economies along with ecological problems. The Intergovernmental Panel on Climate Change (IPCC) reports that "*even if the concentrations of all greenhouse gases and aerosols had been kept constant at the levels in 2000, a global warming of approximately 0.1 centigrade per decade would be expected.*" More specifically, the public has been demanding improved performance in the consumption of natural resources. The best evidence in support of this argument comes from sustainability-sensitive initiatives of the United Nations in the last 40 years. Their World Commission on Environment and Development (WCED) in 1987 defined sustainability development as "a practice that meets the needs of the present without compromising the ability of future generations to meet their own needs." To reduce global greenhouse gas (GHG) emissions, the Kyoto Protocol was consequently adopted in 1997, under which many countries and multi-national unions agreed to legally binding targets for their regional emissions. In alignment with the aforementioned initiatives, both researchers and practitioners have actively pursued the fundamental pillars of sustainable development. This commitment is often framed within the Triple Bottom Line (TBL) framework (Elkington, 1997), emphasizing the interconnections of economic, environmental, and social pillars.

Furthermore, guided by a long-term vision to forge a better world for succeeding generations, the United Nations has formally delineated 17 Sustainable Development Goals (SDGs). It envisions the attainment of these goals by all nations, irrespective of economic standing, by the end of 2030. The SDGs represent a compelling global agenda, necessitating every nation's swift and concerted effort to strike a constructive balance within the TBL framework. In response, the business world has developed strategies to attain the United Nations' SDGs (Serafini et al., 2022). Companies actively strive to formulate sustainable business models regardless of their size or industry focus. This commitment plays a pivotal role in propelling the implementation of the SDGs through substantial investments in technological innovation and active participation in collaborative partnerships (Di Vaio et al., 2020). Despite the ongoing sustainability transition, challenges persist. Many professionals have underscored a notable gap in understanding the role of businesses in addressing the SDGs and their intrinsic relevance for sustainable development (Mio et al., 2020). Major hurdles encompass insufficient financial contributions from the private sector, Inadequate collaboration among stakeholders, lack of accurate data, absence of adequate regulatory frameworks, and disparities in development between nations (Barua, 2020). Serafini et al. (2022) assert that higher education institutions and academic research projects play a crucial role in advancing the SDGs, contributing significantly to a socially equitable and environmentally protected world.

At the micro-level of business dynamics, decision-makers aim to optimize organizational operations for long-term efficiency (Shepherd & Günter, 2006), which may jeopardize the preservation of natural resources. In the contemporary world, academics and practitioners have a growing consensus to integrate sustainability aspects into business models. Cetinkaya et al. (2011) assert that various strategic business failures are linked to an exclusive focus on financial objectives in corporate visions. Within the TBL context, stakeholders collectively aim to create competitive value by taking into account essential considerations of the

economy (profit), the environment (planet), and society (people), also known as the 3Ps of sustainability. In effect, safety, equal opportunities, public health, and human rights appear obligatory from the perspective of socially responsible decision-makers, along with environmental concerns about preserving freshwater resources, fossil fuels, climate, lands, and forests. Kleindorfer et al. (2005) list motivators driving this paradigm as scarcity and cost of materials and energy, public and regulatory pressure for social and environmental responsibility, awareness of TBL issues, and NGO-oriented activities. Although the TBL definition of sustainability development is of prevalent interest in the literature, different attempts at defining sustainability in the context of supply chain management have been made (see Ahi & Searcy, 2013, where the authors conduct a review on 34 definitions.) In this study, we adopt the definition proposed by Hassini et al. (2012): "*sustainable supply chain management (SSCM) is the management of supply chain operations, resources, information, and funds to maximize the supply chain profitability while at the same time minimizing the environmental impacts and maximizing the social well-being.*" Such a perspective concerns the operational drivers of profitability and their effects on the people and the planet. It is worth pointing out that green supply chain management (GSCM) is the other line of research that most closely links sustainability and supply chain disciplines. We note that our perspective of SSCM encompasses that of GSCM, which mainly accounts for economic and environmental facets of business operations, exploring the possibility of essentially eliminating anthropogenic destructive impacts.

In this paper, we review trends that have shaped the field of SSCM. We attempt to detect the operational and tactical problems restricting our review scope to recent publications in 14 leading operations journals. We aim to contribute to the literature by offering a comprehensive classification of research questions and directions, ranging from sustainability-conscious regulations to eco-efficient energy technologies to humanitarian logistics investigated in top-ranked operational journals. Our review differs from previous research in that it provides a detailed list of quantitative and qualitative approaches applied in the reviewed materials. We examine the growing body of literature centered on sustainable legislation and provide evidence demonstrating global attention to the interaction between policy-making and SSCM efforts. This existing intersection allows us to introduce a new framework for SSCM practices – the 4Ps of sustainability – reflecting a holistic approach to decision-making beyond TBL considerations. Additionally, we explore recent publications that form the context of sustainable supply chain management.

We adopt a systematic content analysis, a method known for its rigor in literature reviews (Seuring & Müller, 2008). The four-step content analysis approach employed in this study ensures a rule-governed process, integrating the collection and analysis phases of the review. Our study involves an extensive review of 5,160 articles published in 14 influential operations management journals. From this vast collection, we focus on 715 items that we believe are particularly interesting to researchers and practitioners. Our research stream is inherently multidisciplinary, and given the global interest in this area, we feel compelled to present a new taxonomy of the literature. This taxonomy consists of nine primary research directions, which we believe will greatly interest academics seeking a broad overview of the SSCM field. In this study, we also evaluate the potential contributions of each proposed research direction to the United Nations' SDGs outlined in "Transforming Our World: The 2030 Agenda for Sustainable Development." Accordingly, we identify the SDGs that have garnered significant attention within the operations management community.

The remaining sections of the paper are structured as follows. Section 2 furnishes a concise summary of pertinent studies delving into sustainable supply chains. Section 3 traces the review's objectives and methodology, providing insight into the review approach adopted.

The pivotal outcomes of our comprehensive analysis are expounded upon in Sect. 4, where a comprehensive taxonomy is presented, encompassing nine principal classes of research topics within the SSCM context. We elaborate on how these topics contribute to attaining the United Nations' SDGs in Sect. 5. Lastly, Sect. 6 encapsulates the study's conclusions, offering valuable insights gleaned from the exploration, and proposes a prospective research agenda to stimulate further inquiry into this critical domain.

2 Research context

In the Rio+20 Summit of 2012, the concept of formulating the United Nations' SDGs took shape. These goals, endorsed by the Heads of Government in 2015, denote a significant global endeavor to steer the world toward more resilient pathways and fight extreme poverty. Caiado et al. (2018) present an innovative framework designed to guide researchers, practitioners, community leaders, and entrepreneurs, offering insights on how to address the barriers and challenges associated with the implementation of the United Nations' 2030 Agenda. Their review underscores the need for co-creative practices to foster collaboration between developed and developing countries, the application of Industry 4 technologies in logistics and resource distribution across high-income and low-income countries, and the globalization of the circular economy through inter-country networks, thereby adding value to the least affluent nations. In a more recent study, Pizzi et al. (2020) conduct a mapping of knowledge generated by management scholars delving into the role of businesses, corporations, and for-profit organizations in advancing the SDGs. Their findings unveil four prominent research themes: technological innovation, firms' contributions in developing countries, non-financial reporting, and education. They observe that policies solely aimed at improving corporate reporting on sustainability are insufficient to increase the willingness of business players and academic scholars to adopt TBL initiatives.

Prior research has also systematically explored applications of SSCM that were reported in different academic outlets since the 1990s. Ciliberti et al. (2008) address the management of the supply chain from a cross-functional perspective with a focus on social responsibility. By analyzing non-financial reports of a sample of companies, the authors introduce a taxonomy of 47 sustainable practices classified based on five areas: corporate social responsibility, sustainable transportation, sustainable packaging, sustainable warehousing, and reverse logistics. Providing a background discussion on GSCM, Sarkis et al. (2011) categorize the literature under nine broad research opportunities and directions. Using organizational theories, they summarize future research directions applied to GSCM under the umbrella of complexity theory, ecological modernization, information theory, institutional theory, resource-based view, resource-dependence theory, social network theory, stakeholder theory, and transaction cost economics. Hassini et al. (2012) review the literature on SSCM through the introduction of a framework considering performance measures. Analyzing two collections of references, where one includes 707 papers and the other focuses on a subset of 87 articles, the authors cover important sustainability topics and specifically list nine hurdles for the development of reliable metrics inherent to the nature of supply chains. These challenges include the difficulty in deciding on which environmental indicators to use, reaching necessary agreements among different players, the incompatibility between intra-organizational and inter-organizational measures, the absence of a supervisory entity ensuring compliance throughout the supply chain, the lack of trust in the relationships, managing conflicting strategies adopted by dif-

ferent players, difficulties in the coordination of competencies, problems in streamlining the various types of supply chain parties, and coping with the dynamic nature of supply chains.

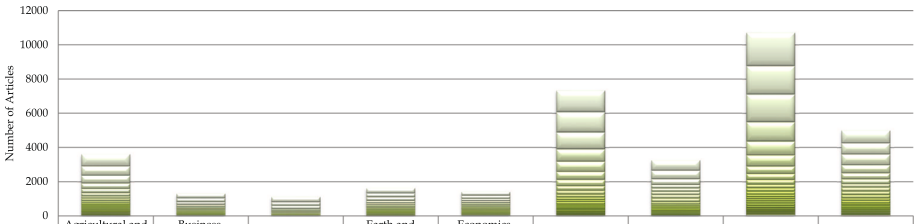
As the circular economy gains prominence, traditional supply chains are evolving into circular supply chains (CSCs) to enhance sustainability performance. In a systematic literature review, Sudusinghe and Seuring (2022) investigate the role of collaboration in enhancing sustainability performance in implementing circular practices. Their findings indicate that CSCs primarily emphasize improvements in environmental and economic aspects, with less focus on social performance. In their review of green network design literature, Waltho et al. (2019) concentrate on models and methodologies that explicitly incorporate carbon emissions and environmental policies. The study examines the major sources of emissions within the supply chain, revealing that transportation constitutes approximately one-third, trailed by power-intensive processes such as manufacturing, storage, and warehousing. Additionally, they note that the impact of emissions on demand is seldom taken into account. Other studies that have reviewed the broad literature of SSCM and GSCM include Brandenburg and Rebs (2015), Fahimnia et al. (2015b), Punj et al. (2023), and Xu and Li (2012).

Ranjbari et al. (2021) provide valuable insights for governments, authorities, practitioners, and policy-makers to mitigate the pandemic's adverse impacts on sustainability and take advantage of the potential opportunities for sustainability transition in the post-COVID-19 era. Moreover, the impact of Industry 4 and evolving communication technologies on supply chain performance is a crucial area of research for both practical and academic communities. In this context, it is essential to understand how smart supply chains transform with the support of advanced technologies and the impact of Industry 4.0 on these chains. In a recent review, Zhang et al. (2023) emphasize the need to consider the sustainability of supply chains in future research initiatives and the importance of establishing and reconfiguring a network based on real-time information, which is central to the continued advancement of smart supply chains, utilizing advanced technologies to interconnect processes across diverse partners to form an intelligent and interconnected system.

The present literature review systematically examines the intersection of sustainability and supply chain management, aiming to make significant contributions to the field. First, we identify and elaborate on nine key research threads within this domain. Second, we introduce a novel framework representing a noteworthy shift in the future trajectory of SSCM literature. Our observation underscores a crucial transformation from the traditional triple bottom line (TBL) framework to a more comprehensive quadruple bottom line (QBL) paradigm encompassing Profit, Planet, People, and Policy-the "4Ps of Sustainability." Lastly, our paper conducts a thorough analysis of the contributions made by previous research in SSCM to Sustainable Development Goals (SDGs). We identify specific SDGs that warrant further attention in future research within the operations and supply chain management community. This study thus provides valuable insights and directions for advancing the understanding and practice of sustainability in the context of supply chain management.

3 Review methodology

From a broad perspective, we observe evidence of an increasing trend, indicating an interest growth in the investigation of sustainability development. This observable trend underscores a collective acknowledgement of the critical importance of sustainability in various domains, reflecting a concerted effort toward understanding, implementing, and advancing practices that foster long-term ecological, social, and economic well-being. Substantiating this obser-



	Agricultural and Biological Sciences	Business, Management, and Accounting	Chemical Engineering	Earth and Planetary Sciences	Economics, Econometrics, and Finance	Energy	Engineering	Environmental Science	Social Sciences
2023	713	269	305	312	230	1,269	621	1,951	752
2022	544	225	204	225	173	1,182	493	1,659	651
2021	454	153	196	212	129	985	325	1,617	619
2020	310	117	78	138	121	717	207	1,129	476
2019	247	82	59	112	97	589	199	805	353
2018	191	41	45	83	70	470	180	651	270
2017	130	60	29	74	55	362	201	436	214
2016	134	39	22	45	46	272	215	347	225
2015	110	36	14	62	84	221	136	276	204
2014	96	28	14	32	60	169	85	216	198
2013	65	29	4	27	33	158	90	194	143
2012	70	21	8	33	39	112	74	167	150
2011	74	22	11	29	27	147	95	149	99
2010	60	24	7	26	18	97	48	129	63
2009	56	25	13	37	27	83	45	121	97
2008	50	15	12	28	25	83	27	122	79
2007	56	11	19	17	38	73	34	134	70
2006	54	14	12	22	28	80	28	130	60
2005	35	20	9	19	21	65	26	102	60
2004	30	8	12	19	14	49	27	78	38
2003	35	9	11	27	12	44	25	75	45
2002	28	21	4	21	15	33	27	71	39
2001	25	17	5	12	19	25	23	68	38
2000	37	14	9	12	20	39	20	74	49

Fig. 1 The number of English-written articles published during 2000–2023 identified by the search keys of "sustainability" or "sustainable development" in the titles, abstracts, and keywords fields on ScienceDirect in Novermber 2023

vation is the statistical evidence provided in Fig. 1. Drawing from an extensive collection of articles on ScienceDirect spanning the period between 2000 and 2023, Fig. 1 illustrates a growing emphasis on this paradigm in research articles. This emphasis appears to respond to heightened public awareness of climate change issues in the 1990s. The figure distinctly showcases the interdisciplinary nature of sustainability, with the dataset curated using the search keys of "sustainability" or "sustainable development" in the titles, abstracts, and keywords fields of English-written publications. Notably, the recent surge in the research activity of the 23,682 articles found is particularly evident in the subject areas of environmental, energy, social, and agricultural sciences.

The primary purpose of our review is to revisit the latest research projects centered on SSCM from an operational and tactical perspective. In this study, we utilize a systematic literature review methodology employing content analysis, a rule-governed tool for analyzing a sample of research documents (Seuring & Gold, 2012). Our four-step analysis procedure involves: (1) material collection; (2) descriptive analysis; (3) category selection; and (4) material evaluation. Our research focuses on developing a conceptual framework instead of conducting an exhaustive literature review in the context of sustainability. Toward the end of characterizing the dimensions of our review scope and highlighting the associated research gaps, we concentrate on a list of selected operations journals and their recent research directions. We expressly review the literature from 14 influential journals in the operations management field listed in Table 1, drawing on the journal rankings proposed by Fry and Donohue (2013), Olson (2005), and Xu et al. (2011).

Table 1 Alphabetically ordered journal titles reviewed in this study

Journal title	ID	Publisher
Annals of Operations Research	AOR	Springer
Decision Sciences	DS	Wiley
European Journal of Operational Research	EJOR	Elsevier
IIE Transactions	IIE	Taylor & Francis
International Journal of Production Economics	IJPE	Elsevier
Journal of Operations Management	JOM	Elsevier
Management Science	MS	Informs
Manufacturing & Service Operations Management	MSOM	Inform
Naval Research Logistics	NRL	Wiley
Omega	OMEGA	Elsevier
Operations Research	OR	Informs
Operations Research Letters	ORL	Elsevier
Production and Operations Management	POM	Wiley
Transportation Science	TS	Inform

In this literature review, we consider a unit of analysis as a single technical article written in English. Our initial keyword search is not limited to work that specifically applies quantitative methods. This approach enables us to gather a broad range of papers exploring the sustainability field, from which we can subsequently identify those applied to SSCM frameworks. To collect the relevant articles, we conducted a structured keyword search. We first employed the keywords "Sustainable", "Sustainability", "Green", "Climate", "Environment", "Environmental", or "Social" in the abstract field of the target journals to search target publications between 2007 and 2023. The most recent date of material collection was on September 1st, 2023. We focus on that this time frame to investigate how the United Nations World Commission on Environment and Development (WCED) has influenced sustainability awareness within the operations management community in the two decades since its implementation.

The initial sample comprises 5,160 articles. In the subsequent step, we scrutinized the collected material's title, keywords, and abstract, applying exclusion criteria agreed upon by all co-authors. Specifically, we eliminate calls-for-papers in special issues, introductions of proceedings, technical reports, literature review papers, and short notes identified in the previous search phase. To concentrate on the operational and tactical decision-making in the present paper, we also restrict our attention by excluding work that conceptually investigated sustainability development or centered on the strategic importance of green organizational practices. This deliberate narrowing of the scope aims to enhance the relevance of our study to the SSCM dimensions to be pursued in future research projects. After this initial screening step, we review the full text of the 715 references that remained in our literature pool (see Appendix) to identify prior work applying quantitative methods to SSCM initiatives. To ensure the reliability of our review, we adhere to the principle proposed by Seuring and Müller (2008), requiring all authors to be consistently involved in the review process.

In this study, a descriptive evaluation of the literature pool is conducted to characterize the distribution of SSCM publications over time and across journals. Figure 2 illustrates the distribution of the reviewed materials by source. It is worth noting that three journals account

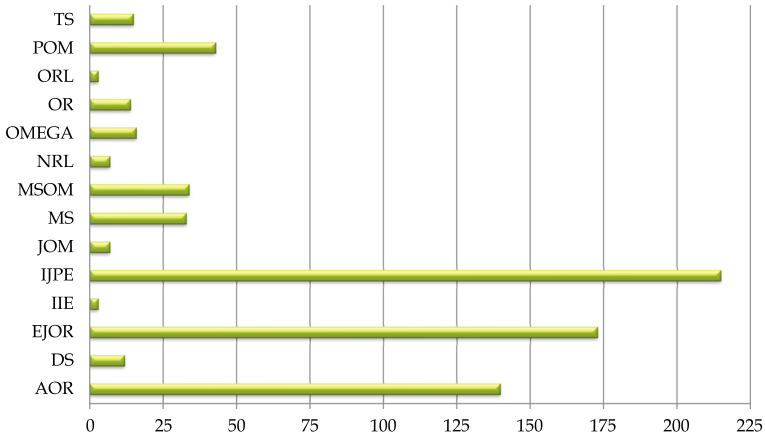


Fig. 2 Distribution of the reviewed articles by the journal title

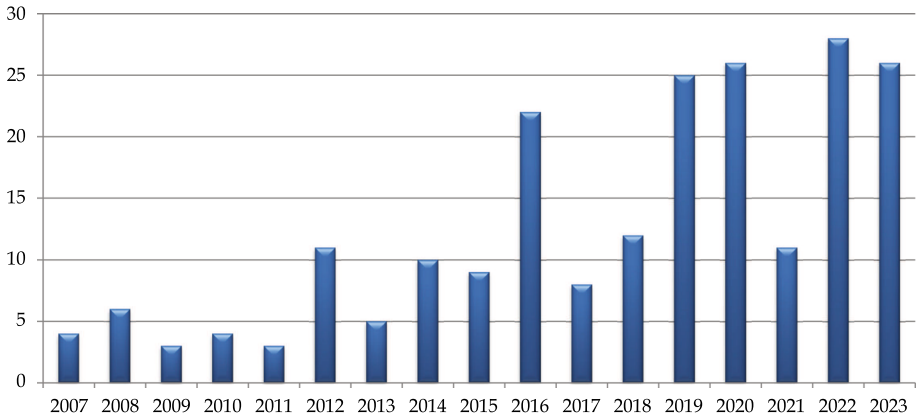


Fig. 3 Distribution of the reviewed articles by the publication year and the social pillar

for about 73% of the reviewed literature. Figure 3 provides an overview of the social pillar explored in each year, indicating a growing attention to this aspect over time. Conversely, Fig. 4 illustrates the distribution of our literature pool across the TBL pillars. Due to the filtering criteria in this review, none of the reviewed papers exclude the economic pillar. Notably, there are approximately six times more studies integrating the economic and environmental pillars than those integrating the economic and social pillars. Further, only 18% of the articles have unified a comprehensive sustainability-conscious framework in their SSCM studies. This indicates that socially-driven concerns may not have received the attention they deserve. The existing literature confirms that enforcing social compliance throughout the supply chain is more challenging than environmental measures that are more often associated with governmental regulations (Barbosa-Póvoa et al., 2018; Hassini et al., 2012).

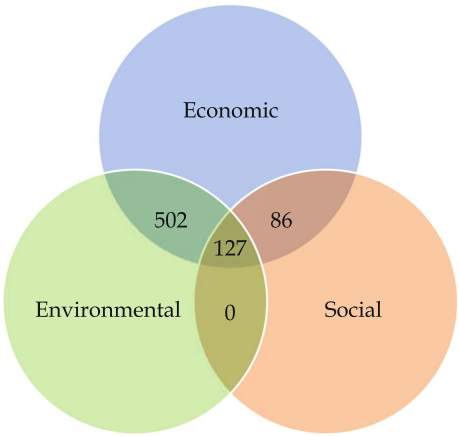


Fig. 4 Distribution of the reviewed articles by the sustainability pillars

4 Research streams of the SSCM literature

In Appendix, we provide a complete list of the reviewed articles, categorized based on their sustainability pillars, research methodology, modeling approaches, and SSCM applications. Examining the solution techniques applied in the literature reveals a dominance of optimization models and game-theoretic analytics in the reviewed field. Additionally, other widely adopted quantitative methods include stochastic optimization and statistical learning, highlighting the significance of decision-making under uncertainty and the role of big data analytics in our rapidly changing world.

It is noteworthy that the literature extensively focuses on sustainability performance measurement methods, with data envelopment analysis playing a substantial role in prior research. From a research methodology standpoint, most studies prioritize analytical approaches, while a significant portion focuses on data-driven frameworks and case studies. This concentration on quantitative techniques aligns with the primary objective of our study, which is centered on operations management journals. In the regulatory facet of SSCM, the literature reflects a notable concentration on green technology investments, environmental taxation policies, emissions trading schemes, and carbon offset strategies. This emphasis underscores the multidimensional nature of sustainability considerations within the broader context of supply chain management.

In the following, we group the recent developments and directions of the SSCM literature into nine categories: sustainability-based performance measurement; sustainability regulation; closed-loop supply chain; corporate social responsibility; humanitarian logistics; sustainability-conscious lot-sizing; sustainable transportation and facility location; sustainable procurement; and sustainable farming, fisheries, and forestry.

4.1 Sustainability-based performance measurement

Sustainability-driven performance measurement, a strategic framework for evaluating organizational success, strongly aligns with SDG 8: "Decent Work and Economic Growth." By incorporating sustainability considerations into performance metrics, this approach ensures that economic growth is inclusive, promoting fair labor practices and creating employment opportunities that prioritize the well-being of workers. Sustainability-based performance

measurement not only contributes to the specific targets outlined in SDG 8 but also supports the overarching goal of fostering sustainable economic growth that benefits individuals and communities.

The literature on assessing SSCM practices has proliferated over the last years (Sudusinghe & Seuring, 2022; Tajbakhsh & Hassini, 2015). This line of research aims to analyze sustainability-driven metric systems and improve value drivers among supply chain partners. On the other hand, the literature provides insights showing that empirical research lacks theoretically developed measurement scales in SSCM (Chan et al., 2016). A significant portion of our review scope (including 150 articles of all 715 reviewed items) is associated with performance measurement in SSCM. While fully recognizing the abundance of interest in assessing environmental performance (including 141 articles of all 150 items under consideration here), researchers have occasionally looked at the efficiency of social practices (conducted in 56 pieces of the reviewed articles). Within the socially-driven studies, it is noteworthy that over 32% of the articles have been published since 2020, indicating a discernible shift towards case-based investigations in response to the requirements imposed by the COVID-19 pandemic. In their recent study in the agriculture sector, Zhu et al. (2023) investigate the associations between inefficiency and socio-economic factors. They employ a bootstrap regression model to explore the underlying factors contributing to differences in inefficiency scores among dairy farms. The study reveals that farms exhibit relatively poorer performance in the environmental dimension compared to the economic and social dimensions. The findings indicate that the intensity of advisory services and the number of entrepreneurs are linked to lower environmental inefficiency. Farm size and the share of households in total labor are positively related to environmental inefficiency. On the other hand, social inefficiency is negatively associated with the debt ratio and government support.

From the perspective of assessment methods applied for performance measurement in the presence of multiple attributes, the literature presents applications of different parametric and non-parametric techniques in our review. Data envelopment analysis (DEA) has been the most popular tool applied in 33% of the studies. The popularity of this method in the intersection of performance measurement and operations management is due to its independence from determining factor weights by decision-makers while being capable of calculating efficiency scores based on optimization models. To enhance the health system response to pandemics in low- to middle-income communities, Haeri et al. (2022) expand upon a DEA model tailored for designing a health service network under conditions of uncertainty. In a commitment to social responsibility, their extended model incorporates two measures: job creation and balanced development. This inclusion aims to address the surge in patient numbers and disaster victims seeking healthcare facilities, tackling the economic challenges and preserving livelihoods during a crisis.

Analytic network process (AHP) and life cycle assessment (LCA) stand out as two other popular assessment procedures frequently employed in the reviewed literature. For instance, Brent et al. (2007) integrates both methods in their infection-risk minimization framework, applying this approach to optimize healthcare waste management in two African case studies. Validi et al. (2020) introduces an AHP-integrated bi-objective model aimed at minimizing CO_2 emissions and total costs across a three-echelon network. García-Melón et al. (2016) offers potential investors, regardless of their financial knowledge, a ranking of mutual funds based on their contribution to social responsibility practices. They note that this proposed ranking aims to complement traditional financial rankings to benefit investors rather than to replace them. Applying an LCA approach, Esenduran et al. (2016) model the environmental impacts of three legislative scenarios: no take-back legislation, legislation with collection targets, and legislation with both collection and reuse targets. By doing so, they analyze

how different levels of legislation influence manufacturing, remanufacturing, and collection decisions. This method enables them to quantify the effects of legislation on consumer surplus and manufacturer profits and identify situations where total welfare decreases due to legislative interventions.

Consistent with the scope of this review, we have identified diverse applications of mathematical programming in sustainability measurement, encompassing metaheuristic approaches (Roozbeh Nia et al., 2023; Validi et al., 2014) and exact solution procedures (Chen & Delmas, 2012; Esenduran et al., 2016; Mallidis et al., 2020; Sueyoshi & Goto, 2013). Deterministic optimization has been a focal point, evident in 51 instances among the 150 articles reviewed in this section. This includes diverse applications such as mixed-integer programming models (Mallidis et al., 2020), dynamic optimization scenarios (Shi et al., 2016), goal programming cases (Mahdiloo et al., 2015), and game-theoretic frameworks (Esenduran et al., 2016). Furthermore, researchers have delved into performance measurement under uncertainty, integrating diverse methodologies such as stochastic programming (Ben Abdelaziz et al., 2020), robust optimization (Homayouni et al., 2023), stochastic processes (Sarkis & Dhavale, 2015), simulation analysis (Melkonyan et al., 2020), and fuzzy Logic (Kazana et al., 2020). Finally, it is worth highlighting that a significant portion of the reviewed articles in the context of performance measurement incorporates applications of statistical learning techniques and artificial intelligence frameworks (Flammer, 2015; Montabon et al., 2007; Muthulingam et al., 2013; Yousefi & Mohamadpour Tosarkani, 2022).

4.2 Sustainability regulation

Sustainability regulations represent a focal point within one of the leading research streams aligned with SDG 16: "Peace, Justice, and Strong Institutions." This research emphasizes the critical role of effective, transparent regulations in promoting environmental and social sustainability. By addressing global challenges and contributing to responsible governance, sustainability regulations emerge as a key focus area within the broader context of achieving the objectives outlined in SDG 16. The problem of environmental pollution occurs when emissions from industrial facilities are sufficiently high to cause devastating damage to properties, ecosystems, human health, and aesthetics. Production units may discharge pollutants irresponsibly when there is no attached cost to such behavior or incentive for reducing such emissions. In recent years, various policy instruments (both socially and environmentally sensitive legislation) have been introduced to curb pollution, reuse durable components, promote human rights in the workplace, make urban areas safer for inhabitants, and preserve natural resources. Toward this end, governments and international institutions have launched practical initiatives. The Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) and the Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment are two successful cases in Europe.

Figure 5 indicates that such a mechanism-oriented perspective has significantly attracted researchers. We note that out of the 715 articles reviewed, 371 articles incorporate regulations and legislation into sustainability practices, amounting to 492 applications. This context has been particularly interesting over the last years, showing an accelerating publication trend after 2012. Our observation highlights a vital research shift in the SSCM literature in the near future, from the mentioned triple bottom line framework (Profit–Planet–People) into a quadruple bottom line (QBL) paradigm (Profit–Planet–People–Policy). We call this framework "the 4Ps of sustainability," depicted in Fig. 6.

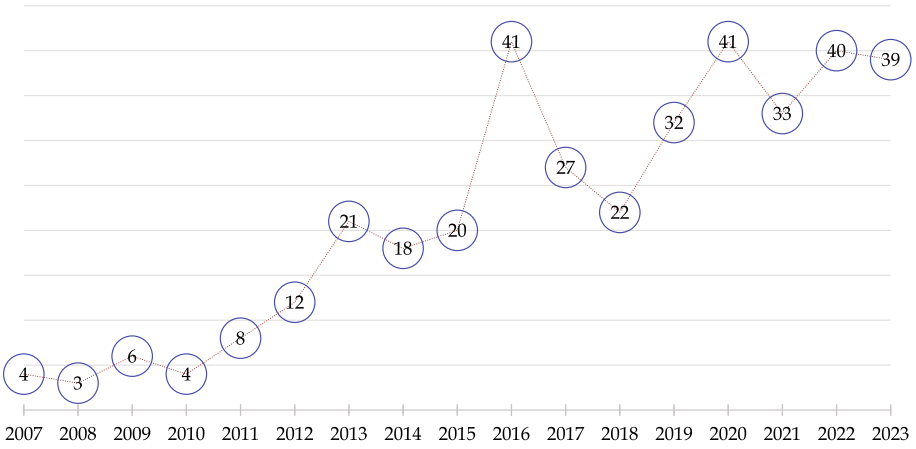


Fig. 5 Distribution of the regulation-based applications by publication year

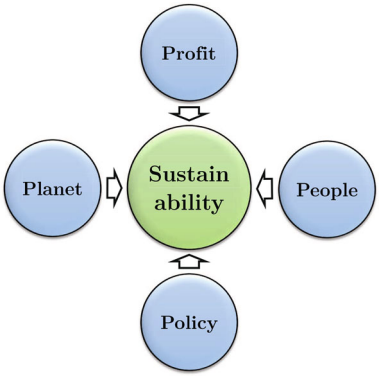


Fig. 6 The 4Ps of sustainability: the QBL framework

A class of sustainable regulation includes policies established to encourage supply chain partners to comply with sustainability disclosure programs. André et al. (2011) investigate a public disclosure program revealing the environmental record of firms to the public in the hope of creating goodwill and ultimately enhancing profit. Analyzing the company's optimal policies regarding emissions, pricing, and advertising, the authors show that advertising serves as a complementary tool to pricing. They also examine the conditions under which emissions increase goodwill, a case where the firm can afford to pollute more. Additionally, André et al. (2011) compare such a setting with scenarios of developing a corporate incentive setup, targeted pollution control, as well as environmental footprint taxation. Through an empirical study conducted in a collaboration of multinational corporations requesting such information from thousands of suppliers in 49 countries, Jira and Toffel (2013) identify several factors associated with vendors' willingness to follow disclosure schemes. Interestingly, they show that suppliers share this information when buyers appear committed to using the information or when suppliers are in more profitable industries. In a different pattern, Kim (2015) explores the interplay between inspections performed by a regulator and noncompliance disclosure by a production firm. Contrary to common belief, the author finds that a random schedule of inspections carried out by the regulator is not necessarily optimal compared to the development of a series of periodic investigations according to a set schedule. On

the other hand, Heugues (2014) revisits variations of international environmental agreements through the use of a non-cooperative game when countries' strategies to control pollution are complementary. The author demonstrates that stable agreements can consist of half of the countries involved in the negotiation, where the equilibrium number of attendees is also derived.

Our literature review exposes the multifaceted landscape of sustainable regulation, indicating a shift towards proactive measures to prevent harmful impacts rather than simply reacting to the costs associated with emissions and ecological risks. A compelling example of this proactive stance is evident in the study by Kraft et al. (2013b), which investigates the decisions of an NGO working to eliminate a potentially hazardous substance from commercial use. This case represents a paradigm where regulatory efforts are directed towards precluding harm, showcasing a distinctive approach within this regulatory category. Furthermore, our exploration of sustainable regulation uncovers a separate yet equally significant dimension that emphasizes natural resource conservation. In practical terms, this translates into diverse applications such as government regulations governing farmland use to strike a balance between food and energy production (Bai et al., 2016). Forest management policies (Cerdá & Martín-Barroso, 2013; Könnyű & Tóth, 2013) exemplify another facet, demonstrating how regulatory frameworks can be employed to ensure sustainable practices in crucial ecosystems. The implementation of environmental policy reforms to enhance farms' productivity (Bokusheva et al., 2012) is yet another instance where regulatory measures extend beyond reactive control to shape sustainable outcomes actively. Similarly, initiatives addressing the provision and conservation of drinking water (Buratto & D'Alpaos, 2015; Udías et al., 2014) underscore the versatile applications of sustainable regulation, touching on essential resources and their responsible management. This diversified approach in regulatory strategies reflects a nuanced understanding of sustainability that goes beyond mitigating harm to actively promoting and preserving ecological integrity.

Apart from the above-mentioned preventive mechanisms, there are two main streams of monetary-based sustainable regulation to curb the environmental impacts of the discharged emissions: (*i*) environmental subsidy and (*ii*) environmental taxation. The context of environmental subsidy includes two major formats of policies: consumer incentive setup and corporate incentive configuration. Under the consumer incentive frameworks, environmentally friendly customers are offered rebate options, monetary subsidies, and tax credits (Glerum et al., 2013; Krass et al., 2013). As exemplified by Cohen et al. (2016), the U.S. government granted a tax credit to consumers who purchased electric vehicles under the American Recovery and Reinvestment Act of 2009. Accordingly, each electric vehicle purchased in the United States in or after 2010 is eligible for a federal subsidy of up to $7500 in the form of an income tax credit (Huang et al., 2013). To enhance supply–demand alignment in the US influenza vaccine supply chain, Arifoğlu and Tang (2022) introduce a budget-neutral incentive program. Their two-sided approach proposes individual vaccination incentives on the demand side and transfer payments between the social planner and manufacturer on the supply side. During periods of high vaccine supply, the program stimulates demand by providing positive incentives, making vaccination more affordable and eliminating positive externalities. This nuanced program addresses the complexities of supply and demand, demonstrating a proactive strategy for dynamic population needs while ensuring budget neutrality.

The corporate incentive policies, however, provide proper (fixed vs. proportional, individual vs. jointly, forward-logistics-based vs. reverse-logistics-based) incentives for manufacturing firms and service renderers to make the correct technology choices (André et al., 2011; De Giovanni & Zaccour, 2014; Ding et al., 2016; Esenduran et al., 2015; Sheu & Chen, 2012). Out of the 715 reviewed articles, we find 45 applications of corporate-level incentive

programs, where more than 50% of the work has been published since 2020. In a recent study, Jin et al. (2022) investigate the influence of government support on the production and green investment of a manufacturing firm with financial requirements, employing two forms of support: loan guarantee and interest subsidy. Their findings indicate the effectiveness of both policies in augmenting production volume and economic performance. However, the study reveals that the loan guarantee policy falls short in stimulating green investment. Moreover, the comparative success of the loan guarantee policy over interest subsidy is contingent on consumers' green awareness, green investment efficiency, environmental value, and the bank's risk attitude.

In the category of environmental taxation, however, there are three primary classes of policies: targeted pollution control (emission-cap policy), environmental footprint reduction and taxation, and emissions trading scheme (cap-and-trade scheme). Applications of targeted pollution control use a restricting lens that requires a substantial reduction of emissions. Such models can help decision-makers identify when and how much pollution should be reduced to achieve the objectives of environmental standards (Gouda et al., 2016; Sun & Li, 2020; Xu & Masui, 2009). In adopting an emission-cap policy, violating the agreed-upon emissions threshold requires the polluter to pay a sufficiently large tax fee to the regulator. Ba et al. (2013) list practical instances in which regulators impose stringent requirements on emissions volume, including the Energy Independence and Security Act in the United States. However, such mandatory mechanisms are not necessarily optimal in all cases. For example, regulated environmental limits may induce firms to increase their planned stock levels, presumably leading to greater environmental risks (Chen & Monahan, 2010). This complexity has motivated researchers and practitioners to consider alternative policies, such as environmental footprint reduction and taxation. Such a framework is designed in the hope of engendering a rich opportunity for reducing pollution levels, where the polluter incurs a (voluntarily or exogenously government-imposed) tax rate per unit of emissions (Cachon, 2014; Chen & Monahan, 2010; Homayouni et al., 2023; Nagurney & Yu, 2012; Rosič & Jammernegg, 2013; Zakeri et al., 2015). As explained by Park et al. (2015), governments and public institutions have successfully imposed this class of policies in practice, such as a carbon tax at \$30 per metric ton of CO_2 in British Columbia, Canada, as well as a cost of carbon emissions to the society at \$80 per metric ton of CO_2 proposed by IPCC. In a similar vein, Fahimnia et al. (2015a) analyze an Australian case study and propose a carbon tax of \$23 per ton of emissions to achieve the decision-maker's objectives. One drawback of this policy structure is that prominent industries may afford to pollute irresponsibly because the environmental tax per unit produced can be negligible compared to the profit per unit produced. In their analytical examination, Bian and Guo (2022) examine the impact of emission abatement policies on a market where manufacturers invest in green technology to reduce emissions. Their findings suggest that a combination of environmental taxation and subsidy mechanisms serves as a potent strategy for emission reduction, leading to substantial industry profits. However, concerning social welfare, the subsidy policy alone results in lower social welfare and environmental performance compared to the taxation policy when the emission abatement cost is sufficiently considerable.

Regarding the practical and theoretical concerns listed above, the literature introduces emissions trading schemes (ETSs). The underlying logic behind an ETS is that pollution permits adopt a value and place an environmental price on the right to pollute based on imposed authority limitations (Chevallier et al., 2009). This scheme manages allowable pollution concentrations at a set of geographical points, where a set of polluters aim to satisfy their customer requirements. The initial allocation of the pollution licenses is free of charge and depends on the sum determined by a central decision-maker for each receptor point. Addi-

tionally, each polluter can purchase extra permits at controlled prices per unit in a pollutant market. At the end of production, if the polluter discharges emissions beyond its collective cap (assigned initially and purchased in the market), a sizeable tax is imposed for every additional emitted unit (Abdallah et al., 2013; Choudhary et al., 2015; Kroes et al., 2012; Luo et al., 2016; Zhao et al., 2010). Moreover, companies are authorized to sell excess allowances in the market to less green firms (Sheu & Li, 2013). Such a market-based mechanism has been implemented in several parts of the world. The European Union Carbon Dioxide Emissions Trading Scheme (EU-ETS) is an example of this policy category (Hong et al., 2016). We recall that the emissions cap in targeted pollution control represents the maximum limit of the polluter's discharged emissions, whereas the cap in a cap-and-trade scheme indicates the total initial emissions allowances assigned to all the polluters to manage their permit trades in the market (Hong et al., 2016). Fang and Ma (2021) dissect an optimization model of technology adoption with heterogeneous agents. They propose a trading mechanism under uncertain carbon prices, where agents with varying market shares seek to identify optimal technology adoption for their respective portions of the entire system. Their numerical results highlight that implementing the carbon emission trading mechanism proves to be an effective strategy for promoting technology adoption and reducing carbon emissions.

From an environmental standpoint, we also find another essential configuration of sustainability regulatory policies, examined extensively in the literature, known as take-back legislation. Such mechanisms ensure that producers are responsible for remanufacturing and recycling their sold products (Atasu et al., 2009; Esenduran & Kemahlıoğlu-Ziya, 2015; Karakayali et al., 2007; Linton et al., 2007; Toso & Alem, 2014; Vadde et al., 2011; Weraikat et al., 2016). Xerox is a successful example of a firm that was ahead of most of its competitors in realizing profits from remanufacturing and recycling in the 1990s (Galbreth et al., 2013). The WEEE Directive is a well-established piece of extended producer responsibility (EPR) legislation that has been the basis of many academic discussions. The United States, Japan, Brazil, and China have recently approved ERP programs as well to reduce the amount of electronics waste sent to landfills (Atasu & Van Wassenhove, 2012; Gui et al., 2016; Toso & Alem, 2014). The solid livestock waste regulation in Andalusia, Spain, concerning activities in incineration plants, is another example in this category (Caballero et al., 2007). Safe disposal of leftover medications in the pharmaceutical industry has also been of interest from the perspective of environmentally friendly regulators (Weraikat et al., 2016). This part of the literature presents two widely used classes of regulations: a collective compliance scheme with recovery cost allocation by partners' market share and an individual compliance scheme (Esenduran & Kemahlıoğlu-Ziya, 2015). With such environmental regulations, the critical question is whether an original equipment manufacturer should collect and reuse its products at product recovery facilities or outsource this service to a collector-driven channel (Karakayali et al., 2007). Another taxonomy on take-back legislation is based upon when and how the disposal fee is paid, which introduces fee-upon-sale and fee-upon-disposal sub-categories (Plambeck & Wang, 2009).

It is worthwhile to note that several researchers have sought policy-making mechanisms that potentially explore a socially desirable perspective, grouped into corporate social responsibility legislation and sustainable transportation legislation. In the first category, the literature documents governmental tax deductions for charitable contributions (Arya & Mittendorf, 2015) and modifications to break scheduling requirements aimed at restricting employees' work hours (Kok et al., 2010; Mirzapour Al-E-Hashem et al., 2013). The second category addresses challenges related to pollution, noise disturbance, vibrations, traffic congestion, safety issues, and socio-environmental risks in freight transportation. Solutions involve the development of urban time-window policies (Akyol & Koster, 2013; Quak & de Koster,

2009), the promotion of convenient short-distance and affordable long-distance shopping alternatives (Cachon, 2014), the enforcement of emission-free logistics regulations (Schneider et al., 2014), the selection of appropriate transportation options for nuclear waste (Chen et al., 2008), and the reporting of air quality emissions inventories at airports (Sherry, 2015). In the presence of globally growing pressure concerning sustainability development, academic research on sustainable regulation still needs to be conducted. Examples of recently proposed policies include a carbon offset scheme (Bian & Guo, 2022; Dye & Yang, 2015; El Ouardighi et al., 2020), a feed-in-tariff and menu pricing mechanism (Ata et al., 2012; Möst & Keles, 2010; Qi et al., 2016), a renewable portfolio standard (Omrani et al., 2019; Ritzenhofen et al., 2016; Siddiqui et al., 2016), a RoR regulation scheme (Islegen & Reichelstein, 2011), and a liberalized electricity market (Möst & Keles, 2010), which could lead to the emergence of new areas of study in the future.

4.3 Closed-loop supply chain

The integration of closed-loop supply chain (CLSC) practices aligns seamlessly with SDG 12: "Responsible Consumption and Production." This sustainable business approach emphasizes minimizing waste, optimizing resource efficiency, and promoting environmentally conscious practices. A closed-loop supply chain, which prioritizes the reuse, refurbishment, and recycling of materials, directly contributes to the broader objectives of achieving sustainable management and efficient utilization of natural resources outlined in SDG 12. By embracing closed-loop principles, organizations play a vital role in fostering a circular economy and advancing the global agenda for responsible and sustainable consumption and production.

Growing attention on CLSC applications originated with public awareness in the 2000s, particularly as a response to the WEEE Directive which principally aims to resolve issues linked to end-of-life and end-of-use products. CLSC combines both forward and reverse flows into a supply network to boost economic productivity and improve environmental performance from the point of consumption to the point of origin (Guide & Van Wassenhove, 2006a, b). In our review, we find numerous CLSC-oriented studies (210 articles out of 715 reviewed items) that take into consideration the areas of (*i*) green design and technology selection and (*ii*) reverse logistics (RL). The RL field focuses on the environmentally conscious exploitation of used products during collected reusables' in-use and post-use life. We note that RL and CLSC may be used interchangeably in some articles. However, we consider environmentally desirable practices under the green design and technology selection umbrella as part of the initiatives that pursue the CLSC objectives. We assume that developing environmentally friendly products, improved energy consumption, and green technologies lead to durable deliverables with longer life cycles. Since the literature reports different interpretations for similar sustainability-driven terms, we depict our definitions on the CLSC scope in Fig. 7. In the context of CLSC, the life cycle assessment is a systematic tool that allows decision-makers to efficiently determine how to design a product for the environment and improve the procurement process to minimize unfavorable impacts over the product's useable life and beyond (Raz et al., 2013). It is important to note that sustainable regulatory initiatives have actively promoted CLSC-centered practices.

We also find that a considerable portion of the policies discussed in Sect. 4.2 have imposed or incentivized business players to consider adopting more sustainable production processes or the reusability value of durable products (Besiou et al., 2012; Buratto & D'Alpaos, 2015; Caballero et al., 2007; Toyasaki et al., 2014; Walther et al., 2008; Weraikat et al., 2016). In the realm of green design and technology selection, researchers have explored diverse

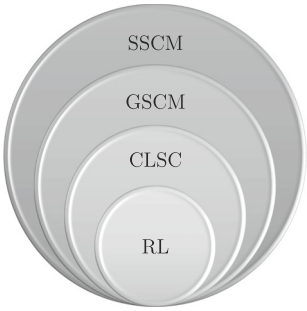


Fig. 7 The relationship between the scope of RL, CLSC, GSCM, and SSCM in the present study

applications, including design improvement and clean-tech investment (Bastian-Pinto et al., 2010; Gouda et al., 2016; Pinto et al., 2015; Raz et al., 2013; Sueyoshi & Goto, 2012; Zhu et al., 2008), energy efficiency enhancement and energy technology development (Doukas, 2013; Doukas et al., 2007; Gahm et al., 2016; Soleimani et al., 2022; Wu et al., 2015; Yazan et al., 2011), hazardous substance replacement (Kraft et al., 2013a), and the implementation of environmental management systems (Castka & Balzarova, 2008b; Curkovic & Sroufe, 2007; González-Benito & González-Benito, 2008; Narasimhan et al., 2015). The last category follows the growing interest in the adoption of environmental standards developed by the International Organization for Standardization (ISO), such as the ISO 14000 family of standards.

RL, on the other hand, plays a vital role once the product is produced and delivered to the ultimate consumer. Drawn on customer relationship management necessities, it concentrates on environmentally desirable efforts to reuse collected products during or after their usable life. Our review scope of RL includes take-back legislation, returning policies, collection channels, disassembly procedures, core-part harvesting opportunities, repairing initiatives, refining processes, resorting phases, reconditioning methods, reusing operations, and remarketing strategies. In this study, we group such scenarios into two principal streams: high-value reusability (known as remanufacturing) and low-value reusability (referred to as recycling). Accordingly, examples of remarketing are reusing outputs of remanufacturing, reselling outputs of recycling, leasing programs, salvaging low-value reusables in a secondary market, and environmentally friendly distribution of clean water.

The main trade-off in remanufacturing is to decide whether a direct remarketing strategy or an upgrading procedure is optimal. As a result, two formats of remanufacturing can be explored: restoring collected products to their original functionality versus upgrading them with incremental innovations (Agrawal et al., 2012; Galbreth et al., 2013; Govindan et al., 2015; Yalabik et al., 2014; Yan et al., 2015; Zarbakhshnia et al., 2020). Notably, the main trade-off in recycling low-value reusables is developing sustainable treatment strategies versus adopting less eco-efficient disposal procedures (sanitary landfill, ocean dumping, and incineration). The literature has extensively explored various recycling strategies, including end-of-life (EoL) recovery (Bi et al., 2015; Govindan et al., 2023; Mohan & Amit, 2020; Sbihi & Eglese, 2010; Sheu, 2016), by-product synergy (BPS) (Govindan et al., 2015; Linton et al., 2007; Srivastava, 2008), waste to energy (Ata et al., 2012), indispensable waste incineration (Caballero et al., 2007), and waste disposal (Asefi et al., 2019; Brent et al., 2007; Inghels et al., 2016; Schuwirth et al., 2012; Weraikat et al., 2016). Notably, BPS cases involve the conversion of a waste stream into a saleable by-product, creating value both financially and ecologically. We also note that EoL recovery practices aim to convert low-value reusables to recycled materials and reused core parts while disposing of zero-value wastes. Additionally,

the literature reports few instances of recycling the most crucial recyclable substance on Earth, clean water (Pinto et al., 2015).

4.4 Corporate social responsibility

Corporate social responsibility (CSR) extends its impact across various SDGs, contributing to goals such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production). As a comprehensive business approach, CSR reflects a commitment to building a more equitable and sustainable global economy, addressing both social and environmental dimensions of corporate impact. In addition to environmentally friendly considerations over the last several years, social issues have been (willingly through the adoption of corporate policies or involuntarily due to binding legislation) integrated into business decision-making by several institutions and governments (Eccles et al., 2014). Hassini et al. (2012) define business sustainability (BS) as "*the ability to conduct business with a long-term goal of maintaining the well-being of the economy, environment, and society.*" Occasionally, CSR and BS are used interchangeably in the literature, while CSR is frequently viewed as a two-fold paradigm monitoring the balance between economic and social objectives (see Dahlsrud, 2008, where the authors conduct a systematic review on 37 definitions of CSR). In this study, we adopt the latter perspective and rely on the definition proposed by the World Business Council for Sustainable Development: "*CSR is the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large.*"

In practice, we observe severe cases in which the poor red-flag actions against employees (by upstream partners of prominent firms such as Apple, Disney, Marks & Spencer, Zara, and Walmart) can seriously injure the organizational reputation. Without comprehensive law enforcement, such businesses mainly focus on building a strong brand image through auditing suppliers that exert CSR practices that merit further investigation. In our review, we find that such a trend is gradually prevailing in academic research projects (Chen et al., 2014, 2008; Galbreth & Ghosh, 2013; Huang et al., 2022; Sarkis & Dhavale, 2015; Wei et al., 2012). In our review, we identified numerous studies (117 out of 715 reviewed items) that focus on CSR considerations. Aligning with socially favorable practices, researchers have explored specific applications of CSR, promoting worker rights and concerns (Devika et al., 2014; Kok et al., 2010; Xia et al., 2015), considering indigenous people (Narasimhan et al., 2015), developing rural communities (Henao et al., 2012; Pourmohammadi et al., 2023; Rouse & Chiu, 2009), sharing corporate social investments (Hsueh, 2014; Hsueh & Chang, 2008), incentivizing corporate social initiatives (Letizia & Hendrikse, 2016; Liu et al., 2022b; Porteous et al., 2015), penalizing corporate social violations (Guo et al., 2016; Plambeck & Taylor, 2015; Porteous et al., 2015), enhancing consumer social responsibility (Ballestero et al., 2012; Pigors & Rockenbach, 2016; Popkowski Leszczyc & Rothkopf, 2010), and following social responsibility standards (Castka & Balzarova, 2008b, a; Sartor et al., 2016).

Concerning the last CSR research stream, we note that Social Accountability 8000 (SA8000), established by the Social Accountability International, is a commonly used standard aiming at the promotion of business solutions concerning child labor, health and safety, freedom of association and the right to collective bargaining, discrimination, disciplinary practices, working hours, remuneration, and management system. Analyzing 56 academic articles and addressing key components of SA8000, SA8000, Sartor et al. (2016) provide a useful comparison with ISO 9000 and ISO 14,000 standards. Following this strategic demand,

ISO has also initiated the ISO 26000 standard on CSR. Basically, ISO 26000 aims to help organizations translate CSR principles into effective action and share best global practices (Castka & Balzarova, 2008a).

4.5 Humanitarian logistics

Humanitarian logistics (HL) that coordinates supply chain initiatives in crisis response is closely aligned with SDG 3: "Good Health and Well-being." In times of humanitarian crises, HL plays a pivotal role in ensuring the timely and efficient delivery of essential medical supplies, vaccines, and healthcare resources to affected populations. By facilitating the rapid response and deployment of healthcare services, humanitarian logistics directly contributes to achieving SDG 3's objective of promoting good health and well-being for all. Effective logistics management in humanitarian operations becomes a critical enabler for mitigating the impact of crises on public health and bolstering the resilience of communities facing emergencies. The literature of HL explores the economic and social implications of humanitarian recovery procedures, given the ample evidence showing that the adverse impacts of disasters are increasing. We rely on the definition proposed by the International Federation of Red Cross and Red Crescent Societies: "*HL comprises acquiring and delivering requested supplies and services, at the places and times they are needed while ensuring the best value for money. In the immediate aftermath of any disaster, these supplies include items vital for survival, such as food, water, temporary shelter and medicine, among others.*" Major disasters and catastrophic events such as the Indian Ocean Tsunami in 2004, Hurricane Katrina in 2005, the Haitian Earthquake in 2010, and the Tohoku Tsunami in 2011 illustrate how HL problems can be crucial in response to tragic events (Holguín-Veras et al., 2012). From a planning horizon standpoint, HL addresses long-term humanitarian assistance as well as post-disaster short-term recovery activities. Consequently, different strategies may be adopted in the case of catastrophes (where high-consequence events generate widespread impacts on society) and non-catastrophic events (in which the local population and authorities cope with significant casualties.)

Holguín-Veras et al. (2012) investigate the differences between HL and commercial logistics. Accordingly, the objectives being pursued are the main differences, where HL concentrates on total social costs integrating logistics and deprivation costs. The authors identify key areas characterizing these two lines of research: the objectives being pursued, the origin of the commodity flows to be transported, knowledge of demand, the decision-making structure, the periodicity and volume of logistic activities, and the state of the social networks and support systems. Additionally, they group HL-driven activities into mitigation, preparedness, response, and recovery, where the first two items are actively performed before the disaster (such as practice drills related to relief distribution, pre-positioning of critical supplies, and building codes). Similarly, Holguín-Veras et al. (2013) endeavor to define how to harmonize conflicting economic and social goals. They identify three key factors: the economic impacts on the relief agency that incurs the logistical costs associated with the delivery of relief aid, the reduction of the deprivation costs for the individuals who receive assistance, and the opportunity cost of the delivery strategy.

Various applications of HL in the operations management context are identified in our review, with 22 instances among the 715 reviewed articles. Noyan et al. (2015) present a distribution network design problem focused on determining the locations and capacities of relief distribution points in the last-mile network. This model considers demand- and network-related uncertainties in post-disaster environments, addressing the critical concerns

of relief organizations in designing last-mile networks to provide accessible and equitable service to beneficiaries. Two supply allocation policies are examined, and a hybrid version is proposed, considering their different implications for equity and accessibility. In a related context, Chakravarty (2014) emphasize the importance of timely and adequate arrival of relief supplies. They highlight the complexity of coordination in a relief chain due to uncertainties associated with disaster intensity, strike probability, infrastructure disruption, and actual damage. Their recommendation emphasizes adjusting the response quantity and time based on imputed social value, accounting for different disaster intensities, cost structures, and community contexts.

Large-scale natural disasters present humanitarian supply chains with myriad challenges, ranging from acute supply shortages and uneven distribution to logistical limitations and conflicting objectives among decision-makers. The complexity of post-disaster scenarios introduces unique considerations that complicate the process of optimal decision-making. Recovery characteristics vary across response phases, shaped by the dynamic interplay of evolving relief demand patterns and persistent supply constraints. In light of these challenges, our review has delineated distinct research streams within the HL field, each aimed at addressing the complexities inherent in managing affected supply chains: humanitarian transportation (Besiou et al., 2014; Chakravarty, 2011; Moreno et al., 2018), humanitarian inventory allocation (Cao et al., 2021; Pérez-Rodríguez & Holguín-Veras, 2016; Zhang et al., 2022), humanitarian material supply (Chakravarty, 2014; Liang et al., 2012), humanitarian asset transfer (Bhattacharya et al., 2014), humanitarian housing reconstruction (Matopoulos et al., 2014), humanitarian emergency evacuation (Fry & Binner, 2016), and humanitarian recovery from floods (Sodhi & Tang, 2014). Future investigations in these research streams can contribute significantly to enhancing the resilience and effectiveness of humanitarian supply chains in the face of diverse challenges.

4.6 Environmentally- and socially-conscious lot-sizing

Environmentally and socially conscious lot-sizing, an inventory management approach that integrates environmental and social considerations, strongly aligns with SDG 12: "Responsible Consumption and Production." By adopting this approach, businesses contribute to the sustainable use of resources and the reduction of waste. Many businesses have focused on the physical processes involved in pursuing emissions reduction efforts. They, however, may neglect a significant source of emissions that can be reduced through momentous lot-sizing decisions. Our review identifies 38 studies out of 715 articles focusing on sustainability-conscious lot-sizing. We observed several variations of the economic order quantity model developed to consider GHG emissions. (Battini et al., 2014; Fahimnia et al., 2015c; Yan et al., 2017). In the earliest study falling within our review scope, Mitra (2009) looks into inventory management in the context of product take-back and reusability activities. Motivated by the growing demand for remanufacturing and recycling, the author develops a two-echelon inventory system, first under a deterministic setting for demand and return rates and second by the use of a stochastic model. Sazvar et al. (2014), Tahirov et al. (2016), and Hong et al. (2016) also explore the integrated perspective of lot-sizing decisions in the presence of CLSC initiatives. The latter, in particular, stems from a scenario under which an ETS-centered regulator is also under consideration. Similar combinations of sustainability-driven legislation and lot-sizing problems have been adequately investigated in the literature (Absi et al., 2013; Chen et al., 2013; Diabat & Al-Salem, 2015; Hovelaque & Bironneau, 2015; Li & Gu, 2012; Wahab et al., 2011; Wang & Choi, 2015).

In a comprehensive framework, Mirzapour Al-E-Hashem and Rekik (2014) consider a multi-product, multi-period inventory routing problem. Over a finite planning horizon, it is assumed that the demand associated with each product is deterministic, where the network addresses an interrelationship between the transportation cost and the GHG emissions level. Notably, the objective is to identify the best configuration of the vehicle types, routes, pickups, deliveries, and trans-shipments in each period to minimize inventory holding and transportation costs. Stenius et al. (2018) propose a model designed for the sustainable management of a one-warehouse-N-retailer inventory system featuring time-based shipment consolidation. The model incorporates the option to reserve intermodal transportation capacity alongside on-demand truck transports. Continuous inventory reviews are conducted, and shipments from the warehouse are consolidated for groups of retailers before being dispatched periodically. This innovative approach facilitates the integration of realistic volume-dependent freight cost structures and transportation emissions into the model. The research derives probability mass functions for the number of units on each shipment and optimizes the reorder levels, shipment intervals, and capacity reservation quantities jointly to minimize total expected costs. Through a different formation, Bouchery et al. (2012) revisit classical inventory methods in the context of SSCM. They use an interactive procedure that allows decision-makers to identify the best options under environmentally friendly policies and through social necessities. Nematollahi et al. (2017) advocate for a collaborative model synchronizing CSR investment and order quantity in a two-echelon supply chain with stochastic demand. The model aims to maximize the profitability of the entire supply chain, leading to Pareto improvement for all supply chain members. By incorporating costs associated with product shortages and surpluses, the model not only incentivizes supply chain members to engage in collaborative planning but also promises to elevate the overall network's profit and CSR performance.

4.7 Sustainable transportation and facility location

Sustainable transportation and facility location strategies within the supply chain align significantly with several SDGs. Specifically, these practices contribute to SDG 9: "Industry, Innovation, and Infrastructure" by emphasizing efficient and environmentally responsible logistics networks. In the supply chain context, sustainable transportation directly addresses SDG 13: "Climate Action" by reducing carbon emissions and fostering climate-resilient practices. By integrating sustainability into transportation decisions and strategically locating facilities, businesses contribute to the broader SDG agenda, fostering innovation, resilience, and responsible consumption within the industrial ecosystem.

Until recently, the literature on transportation and facility location problems has mainly focused on cost minimization. However, with an increasing worldwide concern for the environment, logistics providers and distribution decision-makers have started paying more attention to negative externalities (i.e., pollution, accidents, noise, resource consumption, land use deterioration, and climate change risk) of their operations through sustainability-driven location, routing, and scheduling decisions, supported by 162 applications in the 715 reviewed articles (Abdullahi et al., 2021; Akyol & Koster, 2013; Caballero et al., 2007; Cachon, 2014; Fukasawa et al., 2016; Haass et al., 2015; Micheli & Mantella, 2018; Pan et al., 2013; Pati et al., 2008; Rouse & Chiu, 2009). Fattahi (2020) presents a data-driven stochastic model designed to derive robust decisions from a defined ambiguity set, considering all possible distributions based on the moments of available data. This approach is particularly applicable when the exact distribution of random parameters is unknown, but data related to these parameters is accessible. Their study delves into a network design prob-

lem within the power generation sector, focusing on the utilization of municipal solid waste generated by various sources such as shops, hotels, households, offices, and restaurants. Liu et al. (2022a) highlight the increasing attention on autonomous delivery robots (ADRs) as eco-friendly alternatives for last-mile delivery compared to traditional van fleets. However, ADRs' low efficiency, resulting in few orders per trip, limits their applicability in practice. The study aims to minimize transportation costs and emissions by addressing an extended two-echelon vehicle routing problem. Their model considers load-dependent unit transport costs and unit emissions, incorporating mixed vehicles and multiple depots. They offer valuable insights for transportation managers and operators, aiding in efficient planning and a deeper understanding of adopting ADRs' economic and environmental benefits, especially when considering load-dependent costs and emissions.

The density, size, and location of stores in a network (long consumer travel given the presence of few stores versus short shopping trips within a dense network) are of interest to both retailer and customer partners. This topic is critical from the perspective of SSCM because the Environmental Protection Agency (EPA)'s reports show that the transportation sector accounts for 30% of annual CO_2 emissions in the United States, for which 65% of this amount is discharged by personal vehicles (Cachon, 2014). With that being said, it is essential to note that the remaining 35% still play a significant role in sustainable development.

Many researchers have developed sustainable transportation models that address significant contributions in mode selection. These encompass urban logistics (Akyol & Koster, 2013; Fontaine et al., 2023; Pérez et al., 2015; Quak & de Koster, 2009; Savelsbergh & Van Woensel, 2016), road transportation (Demir et al., 2014; Haass et al., 2015; Kelle et al., 2019; Pan et al., 2013; Soysal et al., 2014; Validi et al., 2014), railroad transportation (Lam & Gu, 2016; Rosell et al., 2022), and marine transportation (Mallidis et al., 2020; Park et al., 2022; Verma et al., 2013). These models address environmental concerns (e.g., consuming fossil fuels, GHG emissions, and shipping hazard materials) and social risks (fatal accidents, city noise, employee health conditions, drivers' human rights, and the presence of trucks in residential areas). There are also interesting applications of sustainable operations management in the fields of aviation transportation (Aktürk et al., 2014; Chen & Solak, 2015; Sherry, 2015; Sheu & Li, 2013) and aircraft ground routing (Guépet et al., 2016). In the last case, the problem consists of scheduling aircraft movements on the ground between runways and parking positions. As Guépet et al. (2016) discuss, such actions play a vital role in airport emissions (e.g., 54% of emitted NO at London Heathrow airport in 2009). Another operational problem in this area is associated with decisions on transportation speed control. Accordingly, the benefits of a variable-speed strategy can be compared to a fixed-speed policy to show significant improvements from a GHG emissions perspective (Aktürk et al., 2014; Berling & Martínez-de Albéniz, 2015; Kramer et al., 2015). Public bike-sharing systems deployed in hundreds of cities worldwide also fall into this category. In addressing a two-stage problem aimed at enhancing mobility with social equity and environmental sustainability, Alvarez-Valdes et al. (2016) estimate the unsatisfied demand, considering factors like the lack of free lockers or bicycles at each station for a specific future period and various possible initial bicycle counts. Subsequently, these estimates guide redistribution algorithms. Recent discussions on applications of ride-sharing platforms are presented by Guo et al. (2023), Naumov and Keith (2023), and Zhao et al. (2023).

Furthermore, green vehicle innovation offers a promising direction for future research in the SSCM field. Closely connected with CLSC models, applications of green vehicles, such as electric vehicles (EVs), have been proposed as part of a massive emissions reduction in the transportation sector (Mak et al., 2013). As discussed in Sect. 4.2, government subsidies and tax deductions have successfully incentivized consumers to consider the benefits of EVs in

comparison with internal combustion engine vehicles. This growing interest has led to various interdisciplinary research projects on EV supply chains. (Avci et al., 2014; Cohen et al., 2016; Kieckhäfer et al., 2014; Mak et al., 2013; Schneider et al., 2014). In a study by Gao and Leng (2021), the competition between an EV manufacturer and an internal combustion vehicle manufacturer is analyzed. Their analysis is conducted under a government subsidy program that offers either a per-unit subsidy to the EV manufacturer or a price discount subsidy to EV consumers. Their proposed framework recommends that the government adopt the per-unit subsidy scheme to achieve the same amount of EV sales and social welfare while requiring a smaller total subsidy. Furthermore, their findings suggest that if the environmental impact of EV production is high, the government should increase its subsidy when the EV manufacturer enhances the driving range on a single charge. However, if the cost of the battery is significantly high, a longer driving range for the EV may hinder its adoption. This holds regardless of the subsidy scheme employed.

Even though remarkable attention has been given to the transportation and facility location problems examined under sustainable legislation (Akyol & Koster, 2013; Buratto & D'Alpaos, 2015; Chen et al., 2008; Diabat & Al-Salem, 2015; Konur, 2014; Qi et al., 2016; Quak & De Koster, 2007), future research will uncover other drivers of such an integration. In addition, several other future research opportunities exist in this context, such as customized distribution decisions on water infrastructure (Bravo & Gonzalez, 2009; Pinto et al., 2015; Roozbahani et al., 2015; Zhao et al., 2013), transmission networks (Möst & Keles, 2010; Qi et al., 2016), and waste transport (Inghels et al., 2016; Pati et al., 2008; Sbihi & Eglese, 2010).

4.8 Sustainable procurement

Sustainable procurement, a strategic approach that integrates environmental, social, and ethical considerations into sourcing decisions, strongly aligns with the principles of SDG 12: "Responsible Consumption and Production." By incorporating sustainability criteria into procurement practices, organizations contribute significantly to fostering responsible and sustainable sourcing patterns. This approach reduces the supply chain's environmental impact and promotes fair labor practices and ethical business conduct, addressing the social dimensions of sustainability. As the green movement spreads globally, organizations are under pressure to reduce emissions across their supply network. Accordingly, companies and their decision-makers must consider sustainability-related issues in their administrative activities.

One of the most essential decisions in SSCM is the commitment to environmental and social causes while cutting costs throughout procurement processes. Based on our review of 715 articles, we have found 38 applications that consider such a standpoint. The literature includes several pivotal research questions on sustainable procurement, among which are how supply chains should strategically and optimally design their supplier selection and supplier evaluation procedures (Bai & Sarkis, 2010; Govindan & Sivakumar, 2016; Mohammed et al., 2019; Sarkis & Dhavale, 2015), how they can build a long-term prosperous relationship through the use of supplier empowerment (Bai et al., 2016; Dou et al., 2014; Huppmann, 2013; Kim et al., 2021), and how they ensure the success of all partners involved through proper supply coordination (El Ouardighi et al., 2016; Feng et al., 2022; Liu et al., 2012; Rosič & Jammernegg, 2013)

The literature also encompasses prior studies focusing on sustainability-oriented policy development (Kalkanci & Plambeck, 2020; Kim et al., 2021; Rosič & Jammernegg, 2013), implementations of CLSC (Govindan et al., 2019; Hsu et al., 2014; Sheu, 2016), and different

approaches to CSR practices (Chen et al., 2020; Orsdemir et al., 2019; Sarkis & Dhavale, 2015). These investigations collectively seek to improve procurement efficiency while aligning with environmentally and socially responsible practices.

4.9 Sustainable farming, fisheries, and forestry

Sustainable farming, fisheries, and forestry practices embody a commitment to different SDGs, most notably SDG 15: "Life on Land" and SDG 14: "Life below Water." In alignment with SDG 15, these practices prioritize responsible land use and forest management, contributing to biodiversity conservation and protecting terrestrial ecosystems. Simultaneously, by adopting sustainable fishing techniques, these practices directly support SDG 14's goal of conserving and sustainably using the oceans, seas, and marine resources. Sustainable farming, fisheries, and forestry underscore the interconnected relationship between land and water, emphasizing the need for holistic and environmentally responsible approaches to ensure the health and vitality of both terrestrial and marine ecosystems. Our review of the SSCM literature reveals that farm management, fisheries management, and forest management have garnered particular attention, constituting 55 applications within the 715 articles we have reviewed. We call these viable research avenues the 3Fs of sustainability, for which researchers and regulators aim to preserve lands and natural resources and sustainably manage livestock supply.

Under farm management, researchers have pinpointed gaps that need to be filled from an operations management standpoint. Examining the distribution of surface water among farmers, Bravo and Gonzalez (2009) estimate the minimal amounts of surface water and groundwater to be allocated for irrigated farmland in the basin under its jurisdiction. Dos Santos et al. (2010) define the problem of sustainable vegetable crop supply, determining the allocation of arable areas to meet customer demand. Investigating a pig-raising production system focusing on least-cost diet formulation, Dubeau et al. (2011) face challenges due to adverse environmental effects, transforming the problem into a multi-objective framework involving factors like nitrogen and phosphorus excretions. Additionally, several initiatives are related to the agribusiness sector's reverse logistics. Sgarbossa and Russo (2017) lay the groundwork for developing new CLSC models, extending them to recover resources from unavoidable waste in the food sector. They analyze the waste generated from slaughtering processes and repurpose it to create methane gas and purified water. Bravo and Gonzalez (2009) aid public water agencies in allocating surface water among farmers and permits groundwater use for irrigation. Their proposed framework involves a stochastic goal programming approach with two goals, the first related to farm management and the other addressing environmental impact.

There is a growing call for researchers to study, analyzing harvest scheduling models (John & Tóth, 2015), evaluating sustainability in agriculture operations (Gomes et al., 2009; Serra et al., 2014), understanding the performance of bioenergy production chains (Yazan et al., 2011), assessing farm productivity during the implementation of environmental policy reforms (Berre et al., 2013; Skevas et al., 2014), investigating the crop rotation planning problem (Alfandari et al., 2015; Rădulescu et al., 2014), studying the effect of government regulation on balanced farmland use (Bai et al., 2016), exploring the entry and competition of a plant factory supply chain in vegetable markets while using less labor, water, nutrition, and pesticides (Hu et al., 2014), and developing nitrate emissions efficiently (Prabodanie et al., 2014). Nematollahi and Tajbakhsh (2020) conduct a comprehensive review of quantitative studies on sustainable agricultural supply chains and delve into government sustainability-

driven legislation within the crop-based and livestock sectors. Upon recognizing the value of data-driven design in sustainable agriculture, Kamble et al. (2020) analyze the sector's descriptive, predictive, and prescriptive analytics, identifying visibility and network resources as the primary drivers of sustainable performance.

To mitigate research gaps in sustainable forest management, researchers have proposed various models (Bettinger et al., 2007; Cerdá & Martín-Barroso, 2013; Rönnqvist et al., 2015). Álvarez Miranda et al. (2018) put forward a multi-faceted decision-making framework aimed at supporting strategic decisions in forest management. Within their context, uncertainty is addressed by incorporating climate change scenarios. The primary decision involves defining a harvest scheduling strategy that balances economic value, carbon sequestration, water use efficiency for biomass production, and runoff water considerations. Similarly, Kazana et al. (2020) assert the importance of incorporating conflicting objectives of various stakeholders in the assessment of forest resources. They introduce a multi-criteria approach that integrates spatial analysis, analytic hierarchy process, and fuzzy extent analysis to evaluate the sustainability of forest management. With a policy-making perspective, Narasimhan et al. (2015) focus on an emergent standard for sustainable operations management, which is established by the Forest Stewardship Council (FSC). Certified wood, paper, and other forest products are tracked to the consumer through the FSC system. On the other hand, few studies have reviewed the SSCM context in the fisheries management field (Arnason, 2009; Rahman et al., 2021).

We also note that our review presents an integral line of research examining the integration of the 3Fs of sustainability and sustainability-driven policy-making (Bai et al., 2016; Bokusheva et al., 2012; Cerdá & Martín-Barroso, 2013).To safeguard soil quality for sustainable development and bolster farmers' incomes, agricultural enterprises are increasingly developing green and efficient raw materials (GRMs) that enhance crop yields while minimizing soil damage. However, farmers exhibit heterogeneity in both their trust in agricultural information and attitudes toward sustainable development. In a recent investigation, Guo et al. (2022) explore the optimal subsidy policy for the government to encourage the adoption of GRMs, considering the impact of farmer heterogeneity through a government-firm-farmer Stackelberg game. Their analysis suggests that the government should subsidize both farmers and GRM firms when the effectiveness of GRMs is not sufficiently high. While higher trust in agricultural information can enhance their willingness to adopt GRMs, paradoxically, it reduces the farmer surplus.

5 Achieving SDGs through SSCM initiatives

Our literature review reveals diverse findings, providing insights into various aspects of the SSCM landscape, all aligned with multiple United Nations' SDGs. Our primary focus on quantitative frameworks underscores a growing interest in incorporating social indicators into performance measurement, recognizing the significance of the social pillar in recent years alongside environmental considerations. The extensive existence of CSR practices within the reviewed articles notably emphasizes the practicality of SDG 1 (No Poverty) and SDG 2 (Zero Hunger) in the context of SSCM. The literature underscores businesses ' pivotal contribution to advancing a more equitable global economy through CSR initiatives within the context of SDG 8 (Decent Work and Economic Growth) and SDG 11 (Sustainable Cities and Communities). These initiatives span a spectrum from promoting worker rights to addressing concerns related to indigenous communities and actively participating in the

development of rural areas. Aligned with the principles of SDG 17 (Partnership for the Goals), the literature accentuates the importance of collaborations between businesses and regulatory bodies to achieve QBL objectives. Our study identifies and emphasizes what we term the 4Ps of sustainability. This collaborative framework is instrumental in fostering sustainable practices and achieving shared goals. In the context of SDG 3 (Good Health and Well-being), the literature not only reaffirms the significance of CSR but also underscores the critical role of HL initiatives. Especially notable is the role of HL in orchestrating disrupted supply chains, thereby contributing to well-being during crises.

The core of SSCM practices, with a logistical lens, centers on sustainability-driven performance measurement. This focal point aligns with SDG 8 (Decent Work and Economic Growth), substantially contributing to fair labor practices and fostering inclusive economic growth. Our dedicated exploration of quantitative frameworks signals a growing interest in integrating social indicators into performance measurement. This marks a notable shift, acknowledging the growing importance of the social pillar alongside environmental considerations in recent years. Within the SSCM literature, a specific thread investigates the synergy between SDG 9 (Industry, Innovation, and Infrastructure) and SDG 13 (Climate Action). This line of inquiry underscores the pivotal role of sustainable transportation and facility location strategies in promoting green practices, particularly highlighting the nexus between industrial and environmental actions. Furthermore, the SSCM literature reveals a seamless alignment with SDG 12 (Responsible Consumption and Production) through CLSC practices. This alignment underscores a commitment to optimizing material reusability, emphasizing forward and reverse logistics. CSC applications emerge as a central theme, indicating a growing consensus on the need for sustainable practices. The review emphasizes exploring green design and technology selection within this context, suggesting a rich avenue for future research endeavors.

SDG 14 (Life below Water) and SDG 15 (Life on Land) find representation through a variety of applications crafted for the 3Fs of sustainability. These initiatives actively contribute to biodiversity conservation, illustrating the supply chain's potential impact on the ecological well-being of farming, fisheries, and forestry sectors. By incorporating practices that consider terrestrial and aquatic ecosystems, SSCM endeavors align with the global objectives of preserving life for future generations. Furthermore, the discourse on sustainability regulation directly ties into SDG 16 (Peace, Justice, and Strong Institutions). This connection underscores the crucial role of effective legislation in promoting well-investigated environmental sustainability and inadequately-explored social sustainability. By advocating for and adhering to robust institutional frameworks, SSCM practices contribute to fostering long-term justice.

While the SSCM literature has made substantial strides in addressing various SDGs, there appears to be a notable gap in attention toward specific goals. SDGs 4 (Quality Education), 5 (Gender Equality), 6 (Clean Water and Sanitation), 7 (Affordable and Clean Energy), and 10 (Reduced Inequality) have received comparatively less focus in the reviewed literature. This observation underscores a potential area for future exploration and research. To ensure a more comprehensive approach to sustainability initiatives, further investigations are recommended to uncover the potential contributions SSCM can make in addressing these crucial sustainable development paradigms and fostering inclusive sustainability practices.

6 Concluding remarks and research gaps

This study examines the interface of sustainability development and supply chain management and reviews research directions emerging in this field. We identify nine primary research streams and explore their contributions to the United Nations' Sustainable Development Goals (SDGs). Additionally, we highlight the SDGs that demand further attention within the research domain of SSCM. The selection procedure facilitates an in-depth examination of the operational and tactical decision-making. Given that the literature on the SSCM topic is extensive, in this paper, we conduct a keyword-based search drawn on the main concepts and definitions. Reviewing the background of this multidisciplinary research stream and observing worldwide attention to this paradigm, we outline our analysis findings as follows:

- While we acknowledge that all pillars of sustainability need to be considered by researchers and practitioners, more research on the social aspect is necessary. Global pressure on business players has led to an intense concentration on environmental considerations within our review scope. However, we feel that more attention should be given to the social risks of industrialized operations.
- In this paper, we revisit the literature of SSCM from the perspective of a selected list of leading operations journals. As we expected, we find that the reviewed SSCM literature is currently thriving, with research at the convergence of analytical modeling and data-driven analytics. Accordingly, many researchers have sought to develop sustainability-centered optimization models, game-theoretic formations, performance assessment metrics, heuristic solution procedures, and statistical analyses to examine data collected from interviews, questionnaires, and databases. It should be stressed, however, that there is considerable potential for incorporating big data frameworks into SSCM problems.
- Given that in most economies, the requirements of sustainability development have been acknowledged, the reviewed literature on SSCM demonstrates less focus on African, Asian, and South American countries. This finding is not the consequence of the lack of research potential within this geography. For example, poverty, education, and public health issues of African inhabitants, natural disaster vulnerability, refugee catastrophes, and weak economies of Asian governments, as well as environmental considerations of South American countries, provide limitless research opportunities for the SSCM field. Additionally, we believe that it is essential to investigate the exceptional economic growth of China, India, and Brazil (in the presence of socio-environmental concerns in these booming economies) from the perspective of a sustainability-sensitive decision-maker.
- Our examination of the existing literature on the SSCM reveals a notable oversight in addressing specific SDGs. Notably, SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), and SDG 10 (Reduced Inequality) have received relatively limited attention in prior studies, suggesting a discernible gap in the research landscape. To bridge this gap and foster a more holistic approach to sustainability, we recommend further investigation and research to uncover the potential contributions of SSCM in tackling these critical challenges in future studies.

Appendix

In this section, we present a detailed list of the reviewed articles, organized based on their sustainability pillars, research methodology, modeling approaches, and SSCM applications. This online companion features a spreadsheet consolidating our master data on a single sheet, accompanied by nine separate sheets, each summarizing one of the SSCM drivers elucidated in Sects. 4.1–4.9 in electronic supplementry material.

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