Circular Supply Chains in the textile and apparel sector: an overview of promising practices

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***Abstract* – Circular Supply Chain (CSC) management is increasingly recognized as essential for the textile and apparel sector, yet the operationalization of circularity — particularly for pre-consumer waste — remains poorly understood. This paper presents a systematic literature review of 34 studies, following the PRISMA framework, to identify promising CSC practices for pre-consumer textile revalorization. The analysis reveals two dominant analytical lenses in the literature — a waste-oriented perspective distinguishing pre-consumer from post-consumer flows, and a logistics-oriented perspective integrating forward logistics and reverse logistics — which are rarely bridged in existing studies. Four primary short-loop revalorization pathways are identified (reuse, rework, remake, and recycling), structured within a cascading hierarchy of value retention. Key findings highlight an imbalance between conceptual and real-world applicable contributions, a fragmented treatment of recovery practices, and the emerging role of digital technologies and local configurations as enablers of CSC implementation. This review provides a conceptual foundation for designing operational CSCs for the textile and apparel sector in Quebec (Canada) and other countries.**

Keywords — Circular Economy, Supply Chain, textile, Logistics, revalorization.

1. Introduction

CSC management refers to the integration of Circular Economy (CE) thinking into the management of the Supply Chain (SC) and its surrounding industrial and natural ecosystems [35]. Since a few years now, there is an emergence of terms like Closed-Loop SC, Green SC, Sustainable SC, and CSC based on the corporate social responsibility concept [35]. However, despite this growing interest, these concepts are not yet widely or systematically applied in the textile sector, rather, their adoption is currently described as being in a nascent stage [2], [17], [22]. In fact, research in major textile hubs, including India, Bangladesh and Turkey, indicates that circular practices are still in their early stages [15], [20], [22]. Therefore, it is essential to understand that a CSC is not merely about recycling but is a fundamental integration of CE thinking, as mentioned earlier, it aims to systematically restore technical materials and regenerate biological resources within a zero-waste paradigm by fostering system-wide innovation across business models and SC functions, from product design to end-of-life management, while engaging all stakeholders throughout the product lifecycle [35]. CSC management has a systemic perspective that promotes cross-sector collaboration and coordination among diverse stakeholders, creating opportunities to reduce resource consumption and waste at a larger scale [35]. However, such an expanded scope inevitably increases logistical complexity compared to traditional linear SCs that are structured around a unidirectional flow from production to consumption. A circular SC introduces recursive flows, whereby materials reaching obsolescence are reintroduced into the system for subsequent lifecycles, and the successful implementation of this recursive logic depends fundamentally on the existence of a robust, integrated, and efficient logistics infrastructure [2], [9], [20], [22], [35]. This issue has been identified within an initiated collaborative research project with the Commercial Development Corporation (Société de Développement Commercial - SDC) of Central District of Montreal (CDM), a major textile industrial cluster in the province of Quebec, Canada. Local firms have expressed interest in increasing the use and revalorize textile fibers (PreC), particularly through the "shortest loop" of circularity. However, uncertainties and lack of knowledge regarding CSC practices, logistical feasibility, and economic viability continue to constrain its adoption. Companies require clearer guidance on how the revalorization of non-conform PreC material can be integrated into their existing SC configuration as a first step prior to a full system overhaul.

This study presents a systematic literature review (SLR) on CSC practices for PreC materials. The remainder of this paper is organized as follows: Section 2 describes the literature search and article selection methodology. Section 3 presents the analysis of the selected studies. Section 4 discusses the implications of the findings, and finally, Section 5 provides conclusions and some future research avenues.

2. Literature search and selection methodology

The methodological process began with the identification of the goals and operational needs of the CDM following multiple information-gathering workshop and meetings involving various stakeholders in the textile industry (Quebec, Canada), including industrial partners, sector representatives, consultants and researchers. These discussions led to the development of a project framing document outlining the district's priorities regarding the integration and revalorization of "still usable" PreC textile fibers within existing SCs and their potential transition toward CSC configurations. The document was subsequently presented and discussed among project partners to ensure alignment between research objectives and industrial expectations. This preliminary stage clarified the project objectives: (i) identifying promising CSC practices, as well as their limitations; (ii) determining associated CSC design possibilities; (iii) assessing the benefits and limitations of these

CSCs through mathematical modeling and scenario analysis; (iv) and, providing decision-oriented insights for companies of the CDM and other actors in the textile sector seeking to transition from linear SCs to CSCs.

The present SLR focuses specifically on addressing the first objective. In other words, it aims to identify and synthesize existing knowledge on CSC practices relevant to the revalorization of PreC textile materials, as well as the limitations and promising perspectives influencing their implementation. The findings derived from this review will provide the conceptual foundation for the subsequent project objectives. The research methodology used is a SLR combined with the snowballing technique. This combined approach ensured both methodological rigor in the literature search process and the inclusion of relevant studies. A SLR is defined as a structured synthesis of evidence in which studies are systematically identified, selected, and critically analyzed to address a specific topic. SLRs reduce bias by relying on predefined inclusion criteria and transparent procedures, thereby enhancing the replicability and reliability of the review process [29]. To ensure transparency and methodological consistency, this study follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework [29]. The PRISMA guidelines were designed to help systematic reviewers clearly reporting the methodology and findings of their review [27]. PRISMA structures systematic reviews into four main stages: identification, screening, eligibility, and inclusion [27]. The definition of keywords was conducted iteratively. Initial keywords were derived directly from the project framing document and refined progressively as preliminary searches revealed dominant terminologies in the literature. As presented in table 1, three main keywords were selected: (i) Circularity/Revalorization; (ii) Supply Chain; and (iii) Textile/Apparel. Then, synonymous keywords for each main term were defined. The primary databases used was Scopus for its multidisciplinary and vast pool of articles.

Table 1 - Keywords used in the search process

Main keywords	Synonymous keywords
Circularity/ Revalorization	Circular*, *loop, Reval*, Remanufactur*, Rework, Recover*, Pre-consum*, Repair, Reuse, Refurbish*, Reutiliz*, Reintegrat*, Repurpose, Reverse, Recursive, Upcycl*, Recycl*, Transform*, Non-conform*, Off-spec, Default, Defective
Supply Chain	Supply Chain*, Operation*, Production, Logistic*
Textile/ Apparel	Fashion, Garment

Multiple search formulas were tested iteratively before identifying the query that provided the most relevant results. The article identification and selection process followed the principles of the PRISMA as mentioned earlier. As illustrated in Figure 1, the iterative refinement of the search query, combined with subject area restrictions and database filters, ensured the identification of studies addressing both CSCs and revalorization practices within the textile sector. From 1,572 records screened on title and abstract, 44 articles were retained for full-text assessment, of which 10 were excluded following two criteria: recycling-only focus that did not engage the broader portfolio of pre-recycling revalorization practices (EC1), and material-only focus that limited transferability to pre-consumer textile waste revalorization more broadly (EC2). The final corpus comprises 34 articles.

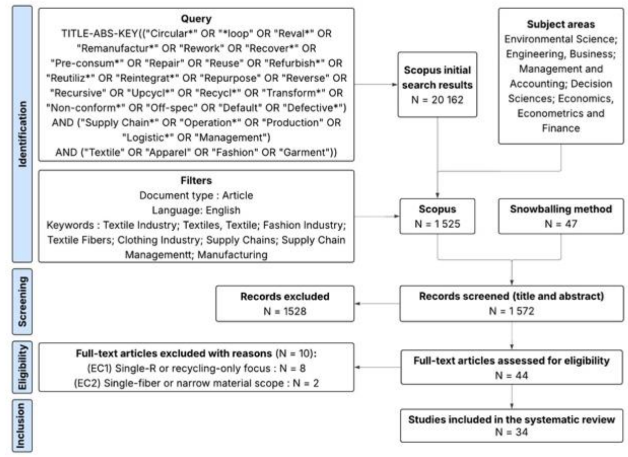

Figure 1 - Selection process performed following PRISMA model

3. RESULTS ANALYSIS

As presented in figure 2, the geographical distribution of the selected studies (34 in total) highlights a strong concentration in specific regions, with Italy and the U-K emerging as the most represented countries, followed by India and other Asian countries. This distribution also indicates multiple collaborations between countries, indicating growing cross-continental research efforts in the field, such as Md. Shamsuzzaman et al. (2025) article. The temporal distribution of publications, illustrated in figure 3, shows a clear increase of research in the field over recent years, with a noticeable peak in 2023. This trend reflects a growing academic interest in CSC practices within the textile and apparel sector. As shown in figure 4, the distribution of articles across journals reveals a strong presence of publications in sustainability operations-oriented journals, such as *Journal of Cleaner Production*, *Sustainability*, and *Sustainable Production and Consumption*. The diversity of publications highlights the interdisciplinary nature of the topic, bridging environmental, operations, and strategic perspectives. As illustrated in figure 5, the literature is mostly oriented toward conceptual frameworks, while some studies address operations optimization and the practical implementation of CSC strategies, particularly in the context of PreC textile and apparel revalorization. Conceptual framework studies typically adopt a systemic perspective, covering a wide range of practices across the entire product lifecycle, from pre-consumer to post-consumer stages. In contrast, the operations optimization-based studies rely on quantitative models to support decision-making, often focusing on cost minimization or multi-objective optimization, like Masoudipour et al. (2017) article. Studies focusing on revalorization practices tend to address specific waste streams and emphasize the technical implementation of recovery actions such as reuse, rework, and recycling. However, only a limited number of studies explicitly adopt a cascading perspective, in which these practices are hierarchically organized to maximize value retention. This perspective will be further elaborated later in this section. Finally, a limited number of studies focus on enabling technologies, highlighting the role of data, traceability, and information sharing in supporting circularity across textile and apparel lifecycle.

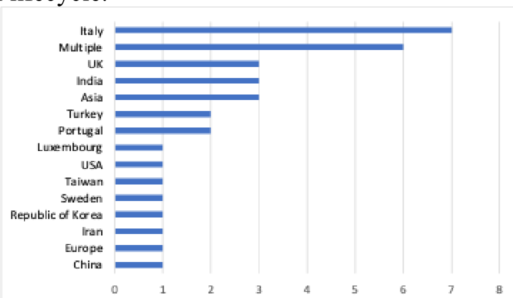

Figure 2 - Distribution of publications by country (N = 34)

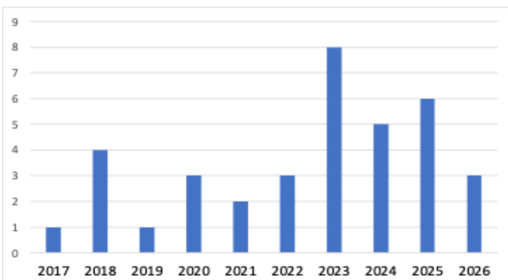

Figure 3 - Distribution of publications per year (N = 34)

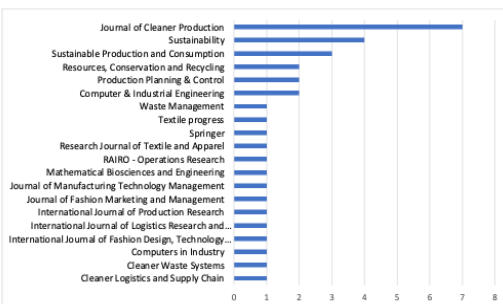

Figure 4 - Distribution of articles across publication journals

Figure 5 - Articles primary contribution distribution

After a more in-depth analysis, two complementary but distinct perspectives emerged. First, many studies identify pre-consumer (PreC) or post-industrial (PI) and post-consumer (PC) stages as the main typologies of textile waste [1], [18], [21]. Authors use this distinction to categorize the textile waste streams and define the appropriate waste management methods. PreC waste is typically described as materials generated during manufacturing processes, such as textile scraps, defective garments, or unsold inventory, whereas PC waste refers to garments discarded by consumers after their useful life [9], [23]. Several studies highlight that PreC waste is generally easier to collect, sort, and recycle due to higher material homogeneity and traceability, while PC textiles pose greater challenges because of fiber blends, chemical finishes, and contamination [1], [15], [19]. Other contributions emphasize the diversity of recovery channels associated with these waste streams [9], [12]. In their framework, PreC waste corresponds to materials generated during production processes or unsold products returned before consumer use. From a CSC perspective, several authors note that textile revalorization systems can rely on both sources, combining production by-products from PreC flows and used garments from PC flows [28], [29]. Second, several studies analyze circular textile systems through the integration of Forward Logistics (FL) and Reverse Logistics (RL) within the SC. In this perspective, FL refers to the traditional forward movement of products from suppliers to consumers, whereas RL involves the return flow of used products or materials from consumers back to producers for reuse, recycling, or remanufacturing [17], [18], [33]. RL is therefore often considered a mechanism for closing the SC loop (Closed-Loop SC), enabling material reintegration and reducing reliance on virgin raw materials [17]. Based on the reviewed literature, the waste-oriented perspective (PreC vs. PC) and the logistics-oriented perspective (FL vs. RL) are generally treated as distinct approaches. On the one hand, several studies emphasize that FL optimization remains dominant, while RL is underdeveloped or insufficiently integrated in traditional systems [14], [18]. On the other hand, much of the previous literature has investigated reverse SCs separately from revalorization practices, pointing to the need for more integrated frameworks that include both material streams and waste revalorization [13]. The short-loop revalorization of PreC "clean waste", occurring within the manufacturing and distribution stages, typically follows a sorting process that acts as an operational decision node. This stage determines the most appropriate recovery pathway based on material characteristics such as size, quality, and composition [32]. As illustrated in figure 6, based on the sorting outcome, PreC materials are directed toward four primary revalorization pathways: *reuse, rework, remake, recycle*. *Reuse* primarily concerns unsold inventory or minimally defective garments, which are redistributed without significant transformation [18]. *Rework* involves restoring defective products to their original quality standards, enabling their reintegration into standard distribution channels [16]. *Remake* refers to the reconstruction of products from rejected items that still contain high-value components, allowing partial material recovery and transformation into new products or inputs [23]. Finally, *recycle* is a recovery stage for materials that are unsuitable for higher-value pathways and involves their transformation into secondary raw materials or alternative applications [1]. These pathways illustrate a hierarchical structure of value retention, where higher-value recovery options are prioritized before lower-value ones, reflecting a cascading logic of resource utilization, such as the 3R, 6R and 10R frameworks.

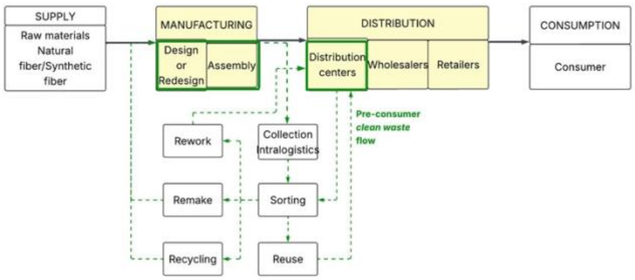

Figure 6 – RL in SCs and positioning of PreC waste flow

The 3R framework consists of the traditional principles used to implement circularity: Reduce, Reuse, and Recycle [29]. The 6R framework extends the foundational 3Rs to include Redesign, Remanufacture, and Repair [3]. While the 10R framework provides a detailed hierarchy of circular solutions, prioritized by their level of circularity [32]. The higher an option is in the hierarchy, the more sustainable and preferable it is considered. The components include Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover [32]. Table 2 structures the selected studies along four dimensions derived from the review's research question: (i) the waste flow addressed (PreC vs. PC); (ii) the CSC practices considered, which could be one of the R-frameworks, a logistics network configuration, and/or a technology implemented; (iii) the organizational scope, which distinguishes internal-focused operations from multi-actor coordinated operations (intra- vs. inter-firm); and (iv) the performance aspects pursued (e.g., cost and waste reduction).

4. Discussion

The objective of this SLR is to consolidate what the existing literature offers regarding the CSC practices, relevant to the revalorization of PreC textile materials and limitations. A first promising practice is the structuring of revalorization within a cascading framework that prioritizes value retention, where higher-value options such as reuse, rework, or remake precede lower-value material recycling [11]. This integrative logic is visible in the corpus: single-R and 3R contributions remain predominantly intra-firm, while 6R, 10R, and 60R ([6], [17], [22], [36]) articulate revalorization across inter-firm configurations, suggesting that broader R-frameworks are more feasible when deployed at the inter- rather than intra-firm level. A major gap lies in the fragmented treatment of R-frameworks. Many studies focus on single-R recovery options, such as reuse or recycling, without considering how these practices can be integrated within a cascading framework that prioritizes value retention. As a result, the literature often overlooks the hierarchical structuring of recovery pathways, where higher-value options such as reuse, rework, or remake should be prioritized before lower-value material recycling [11]. A second promising practice is the joint design of manufacturing and logistics operations, since coherent CSCs require simultaneously considering the nature of materials manufactured and the structure of logistics networks [36]. The growing preference for local and short-loop configurations [9], [11] reinforces this orientation, indicating that operational viability depends as much on spatial proximity and network design as on the choice of R-framework itself. A third promising practice concerns the coordination mechanisms that enable multi-actor materials revalorization. The literature points to inter-firm orchestration as a means of aligning incentives, managing information flows, and coordinating logistics activities across fragmented partners [13], complemented by digital technologies such as Digital Product Passports (DPPs), blockchain, and hyperconnected logistics systems (i.e., IoT), that recur as enablers of transparency and coordination [2], [7], [11], [36]. These mechanisms are most impactful when integrated rather than deployed in isolation, though the literature does not yet indicate their accessibility or implementation criteria or requirements for small and medium enterprises (SMEs). However, a major gap lies in the imbalance between conceptual and real-world applicable contributions. While there is a growing body of research on CSCs, many existing frameworks are conceptual lacking tangible guidance or structured roadmaps for actual industrial implementation [36]. Most conceptual frameworks tend to linger on high-level recommendations and general ecosystem views, failing to provide specific guidelines for operations/logistics management supporting CSC configuration.

Several open questions arise from this consolidation. Among them, how firms should select among the revalorization pathways for a given PreC waste stream? What economic, logistical, and regulatory conditions are required for local CSC configurations ensuring their viability in a context such as Quebec? And, which digital technology-based enablers (e.g., DPPs, blockchain, and hyperconnected logistics) are most realistic for SMEs? The literature reviewed here does not provide definitive answers to these questions. However, the preliminary findings will provide some conceptual foundations for the subsequent project objectives.

5. Conclusion

This SLR allowed us to analyze 34 publications and synthesize CSC practices relevant to the revalorization of PreC textile materials. The findings reveal that, while academic interest in textile circularity is growing rapidly, the literature remains mostly conceptual, with limited operational guidance for logistics network design and stakeholder coordination. Two perspectives — waste-oriented and logistics-oriented — coexist largely in isolation and bridging them is necessary for designing coherent CSC configurations. The review also highlights the importance of cascading recovery hierarchies, digital traceability tools, and geo-local short-loop systems as key levers for effective PreC waste valorization. These insights establish the groundwork for subsequent phases of our collaborative research project with the CDM. Future work should prioritize revalorization cascading frameworks that integrate both logistics configuration and technology implementation within industrial cluster contexts.

Table 2 - Classification of Circular Supply Chain practices in textile

Ref.	Waste flows		CSC practices			Scope		Performance aspect(s)
	PreC	PC	R-framework	Logistics configuration	Technology implementation	Inter-firm	Intra-firm	
[1]	X	X	Multi-R	N/A	N/A	X		Environmental impact
[2]	X		Multi-R	N/A	DPP, blockchain	X		Traceability; transparency
[3]	X	X	Multi-R	CLSC	N/A	X		Cost reduction; circularity
[4]	X	X	Multi-R	CLSC	N/A	X		Environmental impact
[5]	X		Single-R	N/A	N/A	X	X	Cost reduction; waste reduction
[6]	X	X	Multi-R	CSC concept	N/A	X		Increase material utility
[7]		X	Multi-R	N/A	DPP	X		Cleaner production
[8]	X	X	Multi-R	CLSC	N/A	X		Waste reduction; circularity
[9]	X	X	Multi-R	RL	N/A	X		Local-vs-global design
[10]		X	Single-R	PreC loop	N/A	X		N/A
[11]		X	Multi-R	N/A	N/A	X		Increase material utility
[12]	X		Single-R	N/A	N/A		X	Material efficiency; waste reduction
[13]	X	X	Multi-R	SC orchestration	N/A	X		N/A
[14]		X	Multi-R	RL	Simulation	X		Cost-environment trade-off
[15]	X		Single-R	N/A	N/A		X	Environmental, economic impact
[16]	X		Single-R	2-stage SC	N/A	X		Increase profit
[17]	X	X	Multi-R	CSC concept	N/A	X	X	N/A
[18]		X	3R	RL	N/A	X		N/A
[19]	X	X	Single-R	N/A	N/A	X		Waste valorization
[20]	X	X	Multi-R	CSC barriers	N/A	X		N/A
[21]		X	Multi-R	N/A	N/A		X	Waste valorization
[22]	X	X	Multi-R	CSC framework	N/A	X		Strategic alignment
[23]		X	Multi-R	CLSC	N/A	X		Cost reduction; quality recovery
[24]		X	Single-R	RL	Genetic algorithm	X		Maximize design fitness
[25]		X	Multi-R	RL	N/A	X		Increase material utility
[26]		X	Single-R	N/A	N/A	X		N/A
[28]	X	X	Multi-R	CSC barriers	N/A	X		N/A
[30]	X	X	Multi-R	CSC orchestration	N/A	X		Waste, carbon emission reduction
[31]	X	X	Single-R	CLSC	N/A			Cost reduction, Waste reduction
[32]	X		Multi-R	N/A	N/A		X	Waste valorization
[33]	X		Single-R	N/A	N/A	X		Cost reduction
[34]	X		Single-R	N/A	automation		X	Time reduction; ergonomic improvement; process reliability
[35]		X	Multi-R	CSC framework	Blockchain	X		Traceability; transparency
[36]	X	X	Multi-R	N/A	Hyperconnectivity	X		N/A

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