



Research article

Environmental resilience: transition to regenerative supply chain management

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Abstract: Global supply chains face mounting pressures for sustainability, necessitating a shift from Green Supply Chain Management (GSCM) towards regenerative supply chain management (RSCM) to address environmental concerns and enhance Resilience. This transition addresses environmental concerns while improving and supporting Resilience within supply networks. My aims were twofold: (1) To assess the resilience-enhancing mechanisms during the transition to RSCM through a comprehensive review process, and (2) to uncover critical factors and themes of the RSCM. The study employed qualitative interviews as the primary method to collect data using a structured questionnaire. The study adopted snowball sampling based on the referral and recommendation of the respondents. The study investigated vital strategies and challenges for adopting RSCM, explicitly focusing on environmental sustainability. The results indicated that the transition emphasizes a shift from harm reduction to ecosystem restoration, highlighting the importance of environmental restoration in RSCM. Additionally, RSCM places a pronounced emphasis on resilience-building strategies compared to GSCM, underscoring the need for more comprehensive integration of Resilience within supply chains during this transition, particularly in an environmental context. I also developed a framework illustrating the transition from GSCM to RSCM, emphasizing environmental considerations. Additionally, this study contributes novel insights into the dynamic landscape of sustainable supply chain management, emphasizing the importance of resilience-building strategies, particularly in an environmental context, during the shift to RSCM.

Keywords: regenerative supply chain management; green supply chain management; resilience-enhancing mechanisms; environmental resilience

1. Introduction

Regenerative supply chain management (RSCM) has revolutionized sustainability practices within the broader supply chain management framework. It stems from acknowledging merely minimizing negative impacts (as in green supply chains). More is needed; the focus shifts toward actively restoring and enhancing ecosystems and environmental upgrades while conducting business operations [1,2]. The term "regenerative" emphasizes replenishing natural resources, enhancing biodiversity, and fostering ecosystems' Resilience. It seeks to go beyond reducing harm to improving environmental and social conditions [3–5]. The concept of regenerative practices draws inspiration from various disciplines, including ecology, biology, and sustainable development. It aligns with circular economy principles, biomimicry, and cradle-to-cradle design [6,7].

Rooted in understanding natural systems, regenerative supply chain management aims to mimic nature's processes, emphasizing closed-loop systems, renewable energy sources, waste reduction, the utilization of sustainable materials, and pro-environmental practices [8,9]. This approach views supply chains as integral parts of larger ecosystems and envisions businesses as catalysts for positive environmental and social change. The study focuses on the transformative shift from green supply chain management to regenerative supply chain practices through resilience-enhancing mechanisms [10–12]. Additionally, the study aimed to analyze the theoretical underpinnings and practical implications of this paradigm shift in the context of modern business operations. So, it explores how companies are transitioning towards regenerative practices, their challenges, and the potential benefits for businesses, the environment, and society at large [11,13].

Existing literature on regenerative supply chain management needs a cohesive integration of the 'Resilience-Enhancing Mechanisms' construct within the framework [14–16]. Prior studies have emphasized the significance of Resilience in sustainable supply chains; however, they have yet to sufficiently explore its specific role and influence in transitioning from GSCM to RSCM [14,17]. In the same way, theoretical recommendations from past research highlight the crucial need to delineate and examine how resilience-enhancing mechanisms, such as adaptive capacity, robustness, and flexibility, interact within the framework of RSCM strategies [18,19]. Similarly, [17,20] recommends that the understanding and influence of these mechanisms on the successful implementation of regenerative practices still needs to be explored, creating a distinct theoretical gap that requires focused investigation. Addressing this gap is vital to establishing a comprehensive theoretical foundation, providing businesses with actionable insights into fostering Resilience within their supply chains while adopting regenerative strategies [20–22].

Based on the above-cited literature, the study explores the question, "How can organizations enhance environmental resilience during the transition to regenerative supply chain management? Thus, I aim to investigate RSCM to enhance Resilience within supply chains and facilitate sustainable business practices. Specifically, the study aims to explore the transition from GSCM principles and identify strategies to optimize RSCM practices, focusing on fostering Resilience, mitigating challenges, and maximizing benefits within contemporary business operations.

The study contributed to the existing body of knowledge in RSCM and its distinctive contribution to addressing a specific theoretical gap. Previous research has highlighted the importance of Resilience in sustainable supply chains; however, the study focuses on the integration of 'Resilience-Enhancing Mechanisms' within the RSCM framework. This targeted exploration provides a novel perspective on the transition from GSCM to RSCM, offering insights beyond the current theoretical landscape. Thus,

the study contributes to advancing sustainable and resilient business practices by providing a nuanced understanding of how adaptive capacity, robustness, and flexibility interact within the context of RSCM.

The paper is structured as follows: Initially, it maintains an introduction and gaps followed by a comprehensive literature and theoretical review. In the third section, a detailed methodology for the study is given. In the subsequent section, findings from the interviews are mentioned in narrative and thematic form, followed by a discussion, conclusion, and recommendations.

2. Literature review

Fostering Resilience within supply chains through optimizing RSCM while transitioning from GSCM principles is multifaceted [6,23]. RSCM's optimization for resilience enhancement involves several interconnected elements and strategies, primarily focusing on reshaping supply chain processes, emphasizing adaptive capacities, enhancing robustness, and fostering flexibility [14,24].

First, optimizing RSCM requires a fundamental reconfiguration of supply chain processes. This encompasses integrating closed-loop systems, which emulate natural processes, facilitating waste reduction and resource efficiency [25]. It is natural that when loops are closed in the supply chain processes, the process will upgrade and minimize the waste. It also helps develop sustainable materials and encourages the reuse and recycling of the material. These practices bolster Resilience in supply chain processes to external disruption and ensure a reliable energy supply chain against energy-disrupted supply [26,27]. At the same time, these processes and practices reconfigure renewable energy resources and sustainable practices, reducing wastage and environmental footprint [28,29].

Secondly, adaptive capacity practices must be incorporated to foster Resilience in supply chains. It involves developing a mechanism to respond to unforeseen contingencies and disruption [7,30]. Similarly, agile and flexible structures must be implemented to reconfigure and respond to market changes (supply and demand), natural disasters, and any other contingencies, emergencies, or crises. However, it needs strategic partnerships, advanced technology, and diversified sources [31]. Likewise, advanced data analytics can process accurate data and respond accordingly to changing structures [32,33].

Additionally, for the optimization of the RSCM and bolstering Resilience, there is a need to improve the robustness of supply chain management processes [22]. Robustness is the ability to reduce disturbance and manage all the operations most desirably. It focuses more on eliminating interruptions. To come up with robustness and optimization, the companies need to bring drastic changes in the process and develop a better mechanism, which should have, but not be limited to, backup plans, buffer zones, or safety stocks to accommodate disruption. Moreover, it involves constantly evaluating and minimizing vulnerabilities [34,35]. Reduction in dependencies on a single/sole source, market, supplier, and region can affect the robustness of the supply chain processes. In the same way, implementing risk management strategies can enhance robustness and add to the resilience mechanism in RSCM [36,37].

Last, flexibility in RSCH processes emerges as a critical element in enhancing or optimizing RSCM for Resilience in the supply chain. Flexibility enhances the processes from an inside perspective and develops a responsive mechanism for changing market, environmental, and regulatory conditions without compromising efficiency [15,38]. A range of flexibility strategies, like modular design, can

easily configure products and processes and contribute to innovation and continuous improvement [31,39].

The above-cited debate confirms that multifaceted mechanisms are needed to increase Resilience in RSCM. It can minimize disruption and its associated impacts [40]. At the same time, it increases sustainability and competitive advantage in volatile markets [36,41]. Moreover, businesses need to be aligned with sustainable business practices so that companies can positively contribute to environmental preservation, social responsibility, and long-term economic validity [42,43]

In a nutshell, the literature proclaims that optimizing the implementation of RSCM to foster Resilience within supply chains while transitioning from GSCM principles necessitates a holistic approach. It involves reconfiguring supply chain processes, emphasizing adaptive capacities, enhancing robustness, and fostering flexibility. The outcomes of this optimization extend beyond mitigating disruptions, encompassing sustainability and competitive advantage while contributing to environmental and social well-being. Table 1 compares GSCM and RSCM based on the literature cited above.

Table 1. Comparison of GSCM and RSCM.

Items	GSCM	RSCM
Focus	Minimize negative environmental impacts	Actively restore and enhance ecosystems
Objective	Reduce harm to the environment	Improve environmental and social conditions
Inspiration	Sustainability and eco-efficiency	Principles of circular economy, biomimicry, and cradle-to-cradle design
Approach	Emphasizes reducing waste and emissions	Mimics nature's processes, closed-loop systems, renewable energy, sustainable materials
View of Supply Chains	As separate entities from ecosystems	Integral parts of larger ecosystems
Business Role	Mitigating environmental impact	Catalyst for positive environmental and social change
Strategy	Focus on sustainable sourcing and production	Closed-loop systems, waste reduction, sustainable materials
Goals	Decrease environmental footprint	Enhance biodiversity, replenish natural resources
Fundamental Principle	Eco-efficiency and waste reduction	Restoration, Resilience, and improvement of ecosystems
Long-term Vision	Environmental sustainability	Environmental and social improvement

3. New perspective of the RSCM

RSCM represents a paradigm shift from traditional supply chain models, aspiring to sustain and rejuvenate ecosystems. Central to RSCM is adopting a systemic thinking approach, acknowledging supply chains as interconnected components within broader socio-ecological systems [44]. This

transformative perspective underscores the importance of Resilience in addressing systemic challenges, enabling organizations to navigate complexities and uncertainties more effectively [12,45]. Moreover, RSCM has its roots in nature's design principles. It employs biomimicry to create closed-loop supply chains to minimize waste and optimize resource utilization. By incorporating nature's modularity, diversity, and adaptability strategies, RSCM enhances sustainability and fosters innovation and efficiency [46]. At the same time, RSCM goes beyond operational practices to embrace regenerative business models and prioritize long-term sustainability and collaboration among stakeholders. It also encourages inclusive societies and promotes fair labour practices. These RSCM practices contribute to building resilient communities capable of surviving socio-economic challenges [47–49].

Furthermore, RSCM recommends diversification, flexibility, and scenario planning to ensure business continuity in the face of disruptions [50]. Last, RSCM develops comprehensive metrics to evaluate frameworks and assess ecological, social, and economic indicators. These indicators give organizations insights to drive continuous improvement and regenerate supply chain sustainability [51]. Its synthesis is presented in Table 2.

Table 2. Emerging aspects of RSCM.

Aspects of RSCM	Description
Transformative Approach	RSCM transcends traditional supply chain models, aiming to restore ecosystems sustainably. It adopts a system thinking approach, fostering Resilience to systemic challenges.
Nature's Design Principles	RSCM leverages biomimicry to create closed-loop supply chains, minimizing waste and maximizing resource use.
Regenerative Business Models	RSCM prioritizes long-term sustainability and collaboration across stakeholders, fostering inclusive societies.
Resilience and Risk Management	RSCM emphasizes diversification, flexibility, and scenario planning to ensure business continuity.
Social Equity and Inclusive Value Chains	RSCM promotes fair labour practices and economic prosperity, contributing to resilient societies.
Metrics and Evaluation Frameworks	RSCM advocates for comprehensive metrics assessing ecological, social, and economic indicators.
Transformative Approach	RSCM transcends traditional supply chain models, aiming to restore ecosystems sustainably. It adopts a system thinking approach, fostering Resilience to systemic challenges.

4. Theoretical support of the study

There are many theories related to the study. The study incorporated the resilience theory, complex adaptive systems theory, and transition management theory in detail and later presented its synthesis in the context.

4.1. Resilience theory (RT)

RT is more to the core context of supply chain management. It explores the capacity of supply chains to withstand and recover from disturbances while maintaining functionality [52,53]. It

originates from various disciplines, including ecology, psychology, and engineering, and focuses on understanding how systems can absorb disturbances, adapt to change, and maintain their functions and structures [28,54]. Initially developed in ecological sciences, resilience theory gained traction for its applicability in various complex systems, including supply chains. It has evolved and has been widely adopted in fields concerned with managing complex systems [41,55]

It emphasizes the need to design and manage supply chains that can adapt swiftly to disruptions, ranging from environmental changes to economic shifts or unexpected natural disasters [36]. Resilience theory suggests that by integrating flexibility and learning mechanisms into supply chain strategies, organizations can enhance their ability to respond effectively to unforeseen challenges, minimize disruptions, and maintain operational continuity [56,57].

One of the main focuses of resilience theory is to increase the systems' capacity to face challenges and disruption. It absorbs shocks and recovers quickly after disturbances [28]. Moreover, it proposes to develop and adopt a robust system to manage and mitigate risks and uncertainties [12,58]. It involves understanding for both, i.e., responding to predictable changes and unexpected events. These events may vary in intensity; however, through developing robust mechanisms, uncertainties like natural disasters, market fluctuations, or disruptions in the supply chain can be handled in the best possible and optimal ways [15,54].

Various mechanisms can help develop Resilience from a supply chain perspective. It starts with developing redundancies and making backup plans to handle unexpected and unwanted situations. Similarly, flexibility should be incorporated into the system, and alternatives should be considered to handle the disruption [7]. This leads to a diversity of resources, processes, and transportation, reducing risks and enhancing Resilience [59]. This principle is logical and natural in that diversifying the resources, processes, methods, and models reduces the risk and enhances Resilience [7,12,54].

At the same time, resilience theory also looks for learning and adaptability. Through active monitoring, assessing, and analyzing, another crucial aspect of resilience theory in supply chains is the ability to learn and adapt. This involves monitoring, analyzing, and learning from past disruptions to improve future responses [34]. It includes developing capabilities for rapid decision-making and response during crises and fostering a culture of continuous improvement and innovation within supply chain operations [39]. Resilience theory supports reducing negative impacts and enhancing supply chains' adaptive capacity [13].

4.2. Complex adaptive systems theory (CAST)

CAST focuses on understanding how complex and interconnected systems of supply chain management work as a dynamic entity to respond to complex situations. At the same time, it also ensures the system can self-organize itself in response to disruption [16,39]. Moreover, it exhibits emergent behaviours and recognizes supply chains as networks comprising interconnected agents, processes, and interactions. CAST also highlights that all these systems operate well-connectedly, where small process changes can lead to significant changes in some other processes or products [60].

Moreover, this CAST also recognizes the importance of the decentralized nature of the supply chain. All individual entities should be able to adjust their behaviours according to the changing circumstances [52,61]. At the same time, it provides a framework to understand how supply chains dynamically evolve and how they self-organize and innovate in response to the shift toward regenerative practices [11,15,62]. Consequently, these practices of emergent behaviours, feedback loop

mechanisms, and decentralized decision-making shape supply chains' ability to enhance Resilience during the transition phase [19,52,63].

4.3. Transition management theory (TMT)

As the name indicates, the theory's core is to manage and facilitate the transition from one state to another [64]. In the field of supply chain management, it provides a comprehensive framework and guidelines for the change of processes from one state to another [7,65]. It recommends deploying better and flexible governing mechanisms and flexible and adaptive strategies, and it seeks the involvement of all stakeholders to effectively transition from one process to a better-optimized one [33]. This theory acknowledges the involvement of multiple factors and actors in the transition process, with some support and some negation. However, it recommends starting with optimal ones to assess the transition in progressive form and extend it to the whole system [7,66]. Similarly, all the factors and actors are accommodated comprehensively to transition from tradition to a regenerative supply chain [67,68]. The theory helps in developing and enhancing resilience mechanisms to face the challenges, accordingly, propose strategies and action plans, and offer new insights to bolster Resilience in supply chain management processes and practices [1,33]

4.4. Theoretical framework of the study

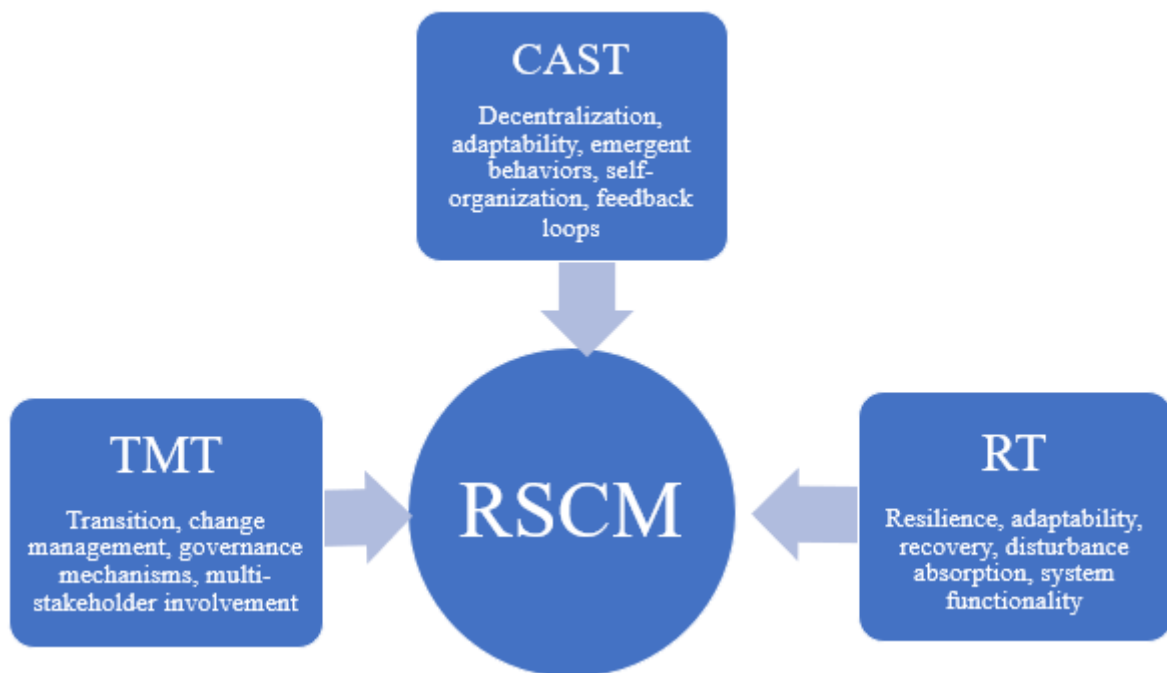
The above-cited theories provide a comprehensive framework for assessing and developing Resilience in the supply chain management processes and practices, especially in the context of RSCM. RT focuses on and aligns environmental resilience with RSCM. It recommends having a robust mechanism to understand how the supply chain can adopt, adapt, recover, and maintain functionality in disruptions [41,57]. It also integrates flexibility, redundancy, and learning plans to boost Resilience in supply chain processes and practices, which is the core of RSCM [62]. Moreover, RT aims to enhance the adaptive capacity of the supply chain, facilitate rapid response to unforeseen situations, and foster regenerative processes and practices to contribute to environment restoration and enhancement [62] actively.

While CAST and TMT offer valuable insights into the dynamic nature of supply chains and managing transitions, they may not address the intricacies of environmental resilience and regenerative practices as comprehensively as RT [40,44]. However, integrating elements of CAS, such as emergent behaviours and self-organization, and strategies from TMT, such as multi-stakeholder involvement and governance mechanisms, alongside RT could provide a holistic approach to navigating the transition to RSCM while enhancing environmental resilience within supply chains [49,61].

In Table 3 and Figure. 1 summarize the above-cited theories and compare them logically and coherently.

Table 3. Synthesis of the theories.

Theory	Identify Key Concepts	Comparison and Evaluation
RT	Resilience, adaptability, recovery, disturbance absorption, system functionality	It focuses on the system's ability to bounce back after disturbances, adapt to changes, absorb shocks, and maintain functionality.
CAST	Decentralization, adaptability, emergent behaviours, self-organization, feedback loops	It focuses on decentralization, adaptability, emergent behaviours, self-organization, and feedback loops.
TMT	Transition, change management, governance mechanisms, multi-stakeholder involvement	It focuses on transition, change management, governance mechanisms, and multi-stakeholder involvement.

**Figure 1.** Theoretical framework for the study.

5. Methodology

The study adopted a qualitative approach. For this, in the first phase, a comprehensive review was conducted to explore the regenerative supply chain management concept, and its comparison was made with green supply chain management. In the second phase, a structured qualitative interview was conducted to explore the phenomenon of interest in more detail. Qualitative structured interviews were found suitable to get the explicit and empirical experiences of concepts and constructs [4,69]. Interviews are a better measure to collect in-depth insights regarding phenomena of interest. The questions for the interview were developed and discussed with the academicians and language experts for face and content validity. Each interview took almost 40 to 45 minutes. The interview was recorded,

and transcription was also taken, which was shared with the respondents for confirmation. After aggregative response development, the theme was also shared with the respondents for confirmation in the second round. The authors themselves conducted all the interviews in person. The interview started with formal questions (attached in Appendix A) supported by other formal queries, depending on the respondents' responses. The main open-ended questions were “How can organizations enhance environmental resilience during the transition to regenerative supply chain management? This question was divided into sub-questions to formally get the answer and building blocks for the thematic analysis.

5.1. Sample/sampling

The area is new for the researchers and the practitioners. Therefore, the total population was unknown. Thus, the study adopted snowball sampling to approach only those with the related skills, qualifications, and experiences regarding green and regenerative supply chain management. Thus, all the respondents were approached based on this specialized cohort's recommendations, identification, and referral basis. Thus, 17 respondents were approached by different business professionals, university professors (supply chain management), and national and international organizations working on regenerative supply chain practices in the NEOM (A multi-billion project in Saudi Arabia). However, some of the participants did not agree to respond, and some of the respondents gave half the answers (incomplete interview). The study included the responses of eleven (12) respondents, and their details are given in the demographic Table 4.

Table 4. Demographics of the study.

Items		Frequency	Percentage
Type of organization	University	3	25%
	Business Professional	4	33%
	NGO/INGO	5	42%
Gender	Male	7	58%
	Female	5	42%
Marital Status	Married	7	58%
	Un-married	5	42%
Professional experiences	1–10 years	6	50%
	11–20 years	3	25%
	30–40 years	3	25%
Age	30–35	4	33%
	36–40	7	58%
	41–50	1	9%
Job	Full time	12	100%
	Part-time	0	0%

5.2. Ethical considerations

The study strictly adhered to ethical considerations throughout the study, ensuring participant confidentiality and anonymity in data collection and analysis. Informed consent was obtained from all participants, and ethical guidelines regarding research conduct were rigorously followed, prioritizing

the well-being and rights of the individuals involved. The interviews were conducted at the respondent's defined time (allocated time). The study was also faired to give representation to both male and female respondents.

5.3. Data collection

The author approached the interviewee personally. They were contacted and approached, got their consensus for the interview, and then were formally asked/questioned for the framed (attached in Appendix-A) questions. Respondents were asked for help, clarification, explanation, and elaboration. They were also given the freedom to stop the interview at any time. Similarly, codes were developed for the participants instead of using their data.

5.4. Data analysis

In our data analysis phase, the study employed a first narrative analysis and, in the second stage, a thematic analysis approach to distill and interpret the qualitative information gathered from structured interviews with respondents. This method systematically examined the interview transcripts and notes to identify recurring patterns, topics, and significant ideas. Additionally, the study carefully reviewed the collected data, noting common threads, concepts, and key points shared by the participants. Instead of a formal coding process, we focused on organically identifying prevalent themes and patterns in the interviewees' narratives. These emergent themes were then grouped and organized based on their similarities, allowing us to generate a conceptual framework. Moreover, NVIVO-11 was used to generate the word cloud from the interview responses.

6. Findings of the interviews

6.1. Narrative analysis

The first question of the interview was regarding the definition of Resilience in supply chain management. For this question, they (PB1, PIO1, and the SCF1) that *“Resilience within supply chain management refers to the system's capacity to anticipate, adapt, and recover swiftly from disruptions while ensuring continuity in operations. It involves proactive risk management, adaptability, flexibility, and maintaining essential functions during disturbances. They proclaimed that “recycling, reusing resources, or developing closed-loop systems can bolster resilience.”* Similarly, they added to the response of the contribution of RSCM to long-term sustainability goals, *“RSCM contributes positively to long-term sustainability goals. It promotes circularity, reduces waste, and conserves resources. At the same time, it fosters Resilience in the supply chain. Moreover, It aligns business operations with environmental and social considerations. Also, it aims for sustainable growth through minimizing negative environmental impacts.”*

The second question asked by the respondents was about the potential impact of RSCM on enhancing supply chain resilience. The aggregative response from PB1, PIO1, and SCF1 was “

“RSCM presents enhances Resilience in supply chains. Through circularity, waste reduction, and ecosystem conservation, the supply chain becomes more accommodated, flexible, and interconnected. It mitigates risks associated with climate, resource scarcity, and market fluctuations. These also reduce

vulnerabilities and ensure continuity of operation in crises and disruptions. Moreover, it aligns sustainability goals with operations that develop and foster Resilience and innovation."

Similarly, they (PB2, PIO2, and the SCF2) responded to changes or adaptations necessary for RSCM implementation: *"RSCM implementation requires extensive orientation and restructuring inside the organizations. Collaboration with stakeholders and adaptation of innovative technologies are needed for traceability and transparency. Similarly, revamping procurement strategies and establishing clear guidelines for regenerative supply are needed from ethical and organizational perspectives. Additionally, cross-sector collaboration, a culture of knowledge sharing, and support are essential in implementing RSCM."*

In the same way, they (PB3, PIO3, and the SCF3) anticipated barriers and plans to address transitioning from GSCM to RSCM."

"There can be certain challenges to transit from GSCM to RSCM initially. These may include, but are not limited to employees' training and awareness, upgrading technology, onboarding stakeholders, and overcoming communication problems. However, these will bring long-term benefits like stakeholder engagement, industry-wide collaboration, establishing benchmarks and frameworks, which will facilitate the smoother transition and overcome transition."

For the RQ3 regarding the role of stakeholders in RSCM implementation, they responded that.

"Active participation of the stakeholder is crucial for successful RSCM implementation. Their involvement, commitment, and contribution are essential for RSCM practices and processes. It fosters collaboration across industries in the supply chain" in the same way they added to the collaboration with suppliers and stakeholders for the RSCM transition."

Collaboration comes through active partnership based on a shared vision, shared values, knowledge exchange, and joint development of strategies. These practices help facilitate the smoother transition to RSCM and its implementation." Additionally, the respondents answered regarding the strategies for stakeholder alignment during RSCM transition, they proclaimed that *"ensuring alignment involves fostering inclusivity, transparent communication, and stakeholder engagement. Implementing feedback mechanisms, capacity-building programs, and establishing clear roles and responsibilities are crucial for maintaining stakeholder cooperation and alignment throughout the transition."*

In the end, for the last question, RQ4, regarding the measurement of RSCM success within the supply chain, they responded that the *"industry needs to develop success measurement for tracking progress like waste reduction, increased resource efficiency, supplier collaboration, cost savings, and customer satisfaction to gauge the effectiveness of RSCM implementation."* In the same way, for the answer regarding the key performance indicators (KPIs) for RSCM impact evaluation, they proclaimed that *"the Prioritized KPIs aims to evaluate the diverse dimensions of sustainability and Resilience, needed for the RSCM implementation. It includes, but not limited to carbon footprint reduction, waste management, supplier sustainability, resilience indices, and social impact assessments, aiming to evaluate the diverse dimensions of sustainability and Resilience influenced by RSCM."* Similarly, to respond to the query regarding challenges in quantifying benefits of RSCM implementation, they declared that *"there are many challenges regarding the standardizing measurement methodologies, accessing reliable data across the supply chain, attributing causality between RSCM practices and observed impacts, and harmonizing diverse metrics. Addressing these challenges would require*

collaborative efforts, industry-wide standards, and innovative measurement tools to effectively quantify RSCM benefits.”

These responses collectively urge the integral role of Resilience in supply chain operations. It emphasizes proactive measures of adaptability and sustainable practices of RSCM. They proclaim the potential of RSCM in sustaining the supply chain against disruption. The responses also suggest restructuring of the organization, active stakeholder engagement, and technological innovation for the successful implementation of RSCM. Moreover, the experts postulated that in the transition from GSCM to RSCM, there may be some temporary challenges; however, it will bring long-term benefits to the industries.

Similarly, stakeholder recognition and active engagement help identify KPIs for measuring RSCM across the supply chain ecosystem. The study came up with the following major themes extracted from the interview responses, presented in Table 5 and Figure 2. These responses present three major perspectives regarding RSCM.

Table 5. Themes extracted from interviews.

Themes	Professional Businessman	Professional (Sustainable International Organization)	Professor of Supply Chain Management
The Potential impact of RSCM on Supply chain resilience	<ul style="list-style-type: none"> -Bolster supply chain resilience through regenerative practices -Reduce risks related to disruptions -Emphasize circularity and waste reduction 	<ul style="list-style-type: none"> -Fortify supply chain resilience -Mitigate disruptions due to climate change and resource depletion -Focus on holistic sustainability 	<ul style="list-style-type: none"> - Transform supply chain resilience through regenerative practices -Create adaptable systems -Promote proactive risk mitigation
Changes/Adaptations for RSCM implementation	<ul style="list-style-type: none"> -Shift towards collaborative relationships -Invest in technology for traceability - Establish new metrics - Foster a culture of innovation and sustainability 	<ul style="list-style-type: none"> -Holistic reorientation towards sustainable practices - Revamp procurement strategies -Foster collaboration and knowledge sharing 	<ul style="list-style-type: none"> -Comprehensive restructuring of supply chain strategies integration
Barriers/Concerns in transitioning to RSCM	<ul style="list-style-type: none"> -Initial investment for technology upgrades -Resistance/skepticism among stakeholders -Address through communication and training programs 	<ul style="list-style-type: none"> -Shift in mindset and supply chain structures -Address through stakeholder education and collaboration with industry leaders 	<ul style="list-style-type: none"> -Resistance due to operational norms and uncertainties -Address via detailed roadmaps and collaboration with experts
Role of stakeholders in RSCM implementation	<ul style="list-style-type: none"> -Offer support, expertise, and resources -Ensure adoption of regenerative practices throughout the supply chain 	<ul style="list-style-type: none"> -Act as active participants and influencers -Embrace regenerative practices and sustainability principles 	<ul style="list-style-type: none"> -Drive RSCM implementation -Embed regenerative practices and foster collaboration
Collaboration with stakeholders for RSCM transition	<ul style="list-style-type: none"> -Open communication and shared goals -Joint projects and co-development of strategies -Engagement with stakeholders 	<ul style="list-style-type: none"> -Partnerships based on shared values and knowledge sharing -Supplier development and sustainability-focused forums 	<ul style="list-style-type: none"> -Strategic partnerships and co-development of roadmaps -Joint research initiatives and idea-sharing
Strategies for stakeholder alignment during transition	<ul style="list-style-type: none"> -Clear communication channels and stakeholder mapping -Encouragement of participation in decision-making -Offer incentives and resources 	<ul style="list-style-type: none"> -Foster inclusivity and transparent communication -Feedback mechanisms and capacity-building programs 	<ul style="list-style-type: none"> -Establish shared goals and engagement sessions -Continuous communication and empowerment through training and incentives
Measurement of RSCM effectiveness in the supply chain	<ul style="list-style-type: none"> -Track metrics like waste reduction and resource efficiency -Assess cost savings and improved relationships 	<ul style="list-style-type: none"> -Monitor waste reduction and supplier compliance -Measure improvements in well-being and ecosystem health 	<ul style="list-style-type: none"> -Evaluate waste reduction, supplier collaboration, and agility - Assess cost savings and customer satisfaction levels
Specific KPIs for evaluating RSCM impact	<ul style="list-style-type: none"> -Carbon footprint reduction and recycled materials usage -Energy efficiency and supplier compliance -Swift recovery from disruptions 	<ul style="list-style-type: none"> -Biodiversity preservation and emissions reduction -Water conservation and supplier diversity -Swift recovery from disruptions 	<ul style="list-style-type: none"> -Carbon footprint reduction and circularity index -Supplier sustainability ratings and resilience index -Social impact assessments
Challenges in quantifying RSCM benefits	<ul style="list-style-type: none"> -Difficulty in measuring intangible impacts -Establishing benchmarks and consistent data collection 	<ul style="list-style-type: none"> -Standardizing measurement methodologies and accessing reliable data -Attributing causality between practices and impacts 	<ul style="list-style-type: none"> - Data availability and cause-and-effect relationships -Harmonizing diverse metrics across the supply chain

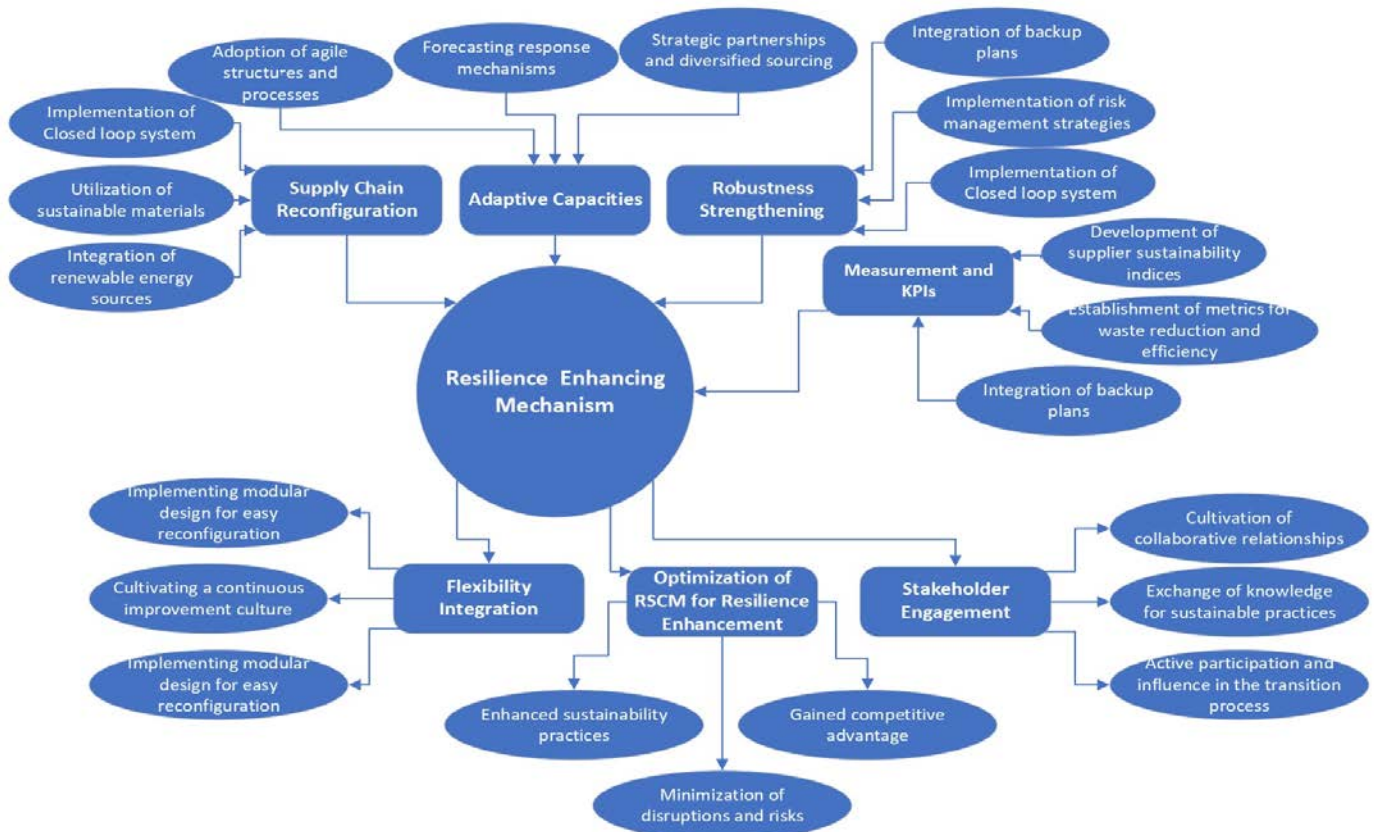


Figure 3. Resilience enhancing mechanism.

In the context of RSCM, the focus shifts towards building Resilience and fostering regenerative practices that contribute to sustainability and positive impacts on the environment and society [14]. Within the RSCM framework, logical planning involves anticipating and mitigating disruptions and aligning strategies with regenerative principles. Contextual considerations extend beyond immediate operational factors to encompass broader ecological and social contexts, ensuring supply chain activities contribute to regeneration rather than depletion [12]. Sectoral insights within RSCM involve tailoring mechanisms to industry-specific risks and opportunities for regenerative practices. A research-based approach includes studying regenerative techniques, circular economy principles, and sustainable innovations [59]. Connectivity is vital for sharing regenerative best practices, collaborating on eco-friendly initiatives, and collectively working towards a regenerative supply chain. So, resilience-enhancing mechanisms within the RSCM framework should fortify against disruptions and actively contribute to the regeneration and sustainability of the supply chain and the ecosystems in which it operates [31,47,66].

7. Discussion

The evolution from GSCM to RSCM marks a significant paradigm shift in sustainability practices within the broader context of supply chain management [63]. Prior discussions and comparative analyses from various studies have underscored this transition as a pivotal move from merely minimizing negative impacts to actively restoring and enhancing ecosystems while conducting

business operations [33]. This transformation reflects a departure from the linear and reductionist approach of GSCM towards a holistic and regenerative model rooted in concepts like circular economy, biomimicry, and cradle-to-cradle design [8,54,61]. The debate gathered from previous studies highlights that while GSCM primarily focuses on reducing harm through eco-efficiency, RSCM aims to mimic nature's processes and emphasizes closed-loop systems, renewable energy sources, waste reduction, and sustainable materials. This discussion explored a clear difference between the two approaches and the need for transition to RSCM [53].

Similarly, the comparative analysis found that the GSCM concentrates more on reducing negative impacts by optimizing resource usage and efficiency in the supply chain [31]. However, RSCM recommends minimizing the negative impact and actively focusing on the restoration and improvement of the ecosystem. Moreover, RSCM also aligns its processes and practices with the fundamental principles of circular economy, Resilience, closed-loop systems, renewable energy utilization, and sustainable material practices [16,54]. This comparison admits the need for a more holistic, nature-mimicking approach. Also, it highlighted the need for GSCM in achieving the broader sustainability goals that RSCM is striving for [43].

Moreover, the study also explored commonalities. Both approaches (GSCM and RSCM) observe the critical role of resilience and strive for sustainability [43,65]. However, RSCM seeks more emphasis on developing capacities and raising awareness regarding sustainability, robustness, flexibility, and agility. Moreover, the resilience-enhancing mechanism is the hallmark of RSCM, which demands comprehensive exploration and integration of resilience-building strategies in the supply chain domain. [2,53].

7.1. Theoretical Implications

The study added to the body of knowledge in supply chain management. The merging of the three theories (RT, TMT, and CAST) came with a robust theoretical framework to understand the dynamics of the RSCM. The synthesis of theory provides an understanding of how supply chain management practices and processes proactively contribute to regenerative practices. The framework explored and developed the resilience-building mechanism within RSCM. The adaptive capacity, robustness, and flexibility add to the existing theories. These theories can be aligned practically when shifting from GSCM to RSCM. Moreover, the study bridges the gaps in understanding the specific role of the resilience-enhancing mechanisms in the transformative processes. Additionally, the theoretical framework proposed can serve as a foundational guide for future research endeavours exploring the intersection of sustainability, Resilience, and supply chain management.

7.2. Practical Implications

Besides theoretical contribution, the study also offers actionable insights to the businesses. It advises adopting RSCM practices to reduce waste, enhance robustness, and promote flexibility and agility in their operations and practices. These practices also add to the social impact of the business, where the public starts accepting and adopting. Moreover, these practices bring a tangible matrix for measuring RSCM success.

Moreover, the study also recommends the inclusion of the stakeholders and recognizes their critical role in promoting Resilience and adapting to RSCM processes and practices. Including active

stakeholders brings collaborative relationships, improves transparency, and promotes effective communication and stakeholder engagement. Moreover, the study proclaims that these practices must be exercised beyond internal organizational to broader industry collaborations, emphasizing the importance of cross-sector partnerships and knowledge sharing. Lastly, the study came up with the indicator or key performance indicators, which can be set and promoted to be adopted across industries.

8. Limitations of the study

The study on RSCM and its transition from GSCM has made significant contributions, shedding light on the transformative paradigm shift in sustainability practices within supply chains. However, limitations need to be considered for future research. A more robust approach would involve cross-industry analysis to explore the challenges and opportunities in diverse business contexts. Additionally, while the qualitative insights from expert interviews provide valuable perspectives, future research could benefit from a mixed-methods approach, incorporating quantitative data to bolster the statistical validity of findings. Furthermore, the study's reliance on data up to a specific date may miss recent developments in the dynamic field of sustainability, urging researchers to update their investigations continually. Moreover, the proposed theoretical model can be tested and validated using qualitative or quantitative methods in different domains.

9. Conclusion

The study explored and assessed the evolution from GSCM to the transformative paradigm of RSCM. The interviews' findings admit the critical role of RSCM in bringing and bolstering Resilience in the supply chain. The study debated the fundamental philosophy of RSCM. It explored circular economy principles and biomimicry, which actively contribute to restoring ecosystems while conducting business operations. The study also emphasizes closed-loop systems, renewable energy utilization, waste reduction, and sustainable material adoption.

The study also carries certain limitations, which need to be considered in future studies. The constrained sample size and the qualitative approach, broader industry representation, and diverse methodology can be explored in the future to comprehend better the concept, processes, and implications of RSCM. In the same way, the integration of RSCM principles is a desirable shift towards sustainability and supply chain resilience. In line with the study's findings, future research may focus on diverse sectors, domains, and methodologies. It can also incorporate alternative theoretical models and methods for the multifaceted implementation of RSCM. Furthermore, longitudinal and cohort studies will be beneficial in exploring the behavioural aspects and preferences of the general population regarding RSCM.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The author declares no conflict of interest.

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