

## Article

# Investigating the Nexus between Green Supply Chain Practices and Sustainable Waste Management in Advancing Circular Economy

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**Abstract:** While examining the potential synergies between green supply chain management (GSCM) and sustainable waste management (SWM), we aim to investigate the relationship between sustainable waste management and green supply chain practices to promote a circular economy as a strategy for achieving sustainability. To address a gap in our understanding, this study will examine how GSCM and SWM relate to one another and their effect on CE deployment's long-term survival. The research utilized a cross-sectional design with a sample size of 50 respondents from manufacturing firms. The companies were selected using purposive sampling based on varying industry sizes and operations. The findings demonstrate considerable positive correlations among GSCM practices, SWM techniques, and CE adoption, making it evident that comprehensive sustainability methods are required. Stakeholder participation, circular business models, and better governmental frameworks to promote circularity are among the many recommendations. By providing empirical evidence for the connections between GSCM, SWM, and CE, this study contributes to the current body of knowledge. It emphasizes the value of all-encompassing sustainability strategies for reaping financial and environmental benefits.

**Keywords:** sustainable waste management; green supply chain management; circular economy; sustainability; environment



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## 1. Introduction

The term “circular economy” (CE) is becoming more popular as a new way of thinking about businesses that prioritize reusing and recycling items instead of throwing them away [1]. The pollution and depletion of natural resources caused by conventional linear models of production and consumption are becoming increasingly apparent concerns for both the economy and the environment [2]. The CE proposes an alternative “closing the loop” method by maximizing resource utilization, reducing waste, and extending product lifecycles [3].

Green supply chain management (GSCM) and sustainable waste management (SWM) are two pillars of the CE framework. To reduce the adverse environmental effects of supply chains, GSCM employs sustainable materials, optimizes logistics, and uses energy-efficient techniques [4]. The primary goals of solid waste management (SWM) are to decrease waste production, promote recycling and reuse, and divert garbage from landfills; efficient collection and treatment technologies support these goals [5].

Although GSCM and SWM are recognized as significant CE drivers, the combined benefits could be even more excellent [4]. Both Seuring, S. and Müller, M. demonstrate the potential for combining GSCM and SWM to reduce resource use, pollution, and greenhouse gas emissions. More than that, it can boost competitiveness, improve resource utilization, and turn waste into value.

Despite the growing popularity of GSCM and CE, the literature needs comprehensive information regarding how these approaches might be combined to maximize their

environmental sustainability. Although several studies have examined GSCM and CE independently, very few have examined their joint promotion of the circular economy [6].

This research addresses this gap by investigating the nexus between GSCM practices and sustainable waste management in advancing the circular economy. Specifically, the study will explore the following questions:

*How can integrating green supply chain management practices and sustainable waste management strategies contribute to implementing and advancing the circular economy?*

The outcomes are critically important for both organizations and other stakeholders of the circular economy. By utilizing cost-effective strategies and boosting resource efficiency, businesses can leverage these insights to their advantage in the circular economy scenario. Policymakers should use their expertise to establish effective incentives for firms to embrace circular practices, which might hasten the transition to a more sustainable future. Researchers can go even further in this essential domain with a deeper understanding of the circular economy and its driving forces. This study can potentially deliver “significant advantages,” including driving economic growth, sustainable waste management, and maximizing resource efficiency by aligning with the objectives of promoting sustainability and the circular economy.

## 2. Literature Review

Waste disposal is one of the most effective ways to combat pollution and is considered a real global, national, and local challenge for ecosystems [7]. Companies can gain an advantage in the market by adopting a zero-waste approach, which goes against the industry’s natural inclination toward efficiency. In recent times, “more with less”—the optimization of raw material use—has superseded “competence of work” and “capital.” As a result, zero waste has emerged as a new standard for modern companies to meet when evaluating employee performance and new product inclusion [8]. However, the circular economy cannot exist without abandoning the linear, fossil fuel-based paradigm that has ruled since the Industrial Revolution. Globally, this approach has boosted economies and advanced technology, but at the expense of ecosystems on Earth [9].

For the Sustainable Development Goals (SDGs) outlined in the Paris Climate Agreement to be realized by 2030, there must be a significant change in economic and social expectations. If we care about the environment, there should not be a direct rivalry between food production and bio-based materials and products. To get to zero waste, we need to eliminate systems that produce garbage, thus making better use of second-generation biorefineries, which can make clean consumer goods on a larger scale [9]. Moreover, when valuable commodities serve their purpose in society, recovery technologies also allow for reuse, recycling, and recovery, ultimately benefiting the economy [10]. Producers and consumers can spread biodiversity to help the economy and the environment [11]. Ellen MacArthur Foundation (EMF) research indicates that a shift toward a circular economy can significantly mitigate environmental degradation and the effects of climate change [12]. Proper regulation and oversight are necessary to prevent the circular economy from becoming another meaningless sustainability concept [13]. Some measures that can help promote healthier circular economies are deregulating trash trading, tax incentives for circular products, and awareness initiatives [14].

If the circular economy is to be implemented, renewable energy sources must reduce waste and eliminate toxic substances [15]. When applied to the design of resources, products, systems, and operations, this paradigm seeks out and creates possibilities for a cradle-to-cradle transition. Decoupling economic expansion from exploiting natural resources is an increasingly common strategy for reducing environmental costs and improving economic growth [16]. While the idea of a circular economy has been around in other European Union projects, such as waste data and resource efficiency, it has only gained traction [17].

Within the broader literature on sustainable management practices during the last 30 years, supply chain management has emerged as a critical discipline [18]. Businesses

and communities can benefit from sustainable supply chain management (S-SCM) since it aims to assist them in responding to external incentives and demands that impact their consumption and production habits [19]. People from the community, environmental and social groups, government agencies, and consumers are all examples of these outside groups. According to [20], sustainable supply chain management can be described as “the management of material, information, and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental, and social, into account.”

Governments, banks, and corporations must all work together to address the pressing global issue of sustainable consumption and production [21]. The Circular Economy Action Plan of the European Union and the Circular Economy Promotion Law of China both show that legislators have recently given the concept of a circular economy more weight [22]. The possibility of synergies between the circular economy and supply chain management has also been the subject of increased academic investigation since 2017 [23].

Since the United Nations endorsed the 2030 Agenda for Sustainable Development in 2015, centered on 17 Sustainable Development Goals (UN SDGs) [24], the number of S-SCM publications has increased. According to multiple publications, S-SCM and circular economy practices like recycling are essential for companies to become more sustainable [25]. Businesses should set standards for interacting with suppliers to address many social and environmental issues. Waste reduction and management, water management, gas emissions, skill development, and workplace safety are all part of this [26,27]. Furthermore, reverse logistics can encourage responsible consumption through recycling and other circular economy strategies [28].

Several theoretical frameworks, including biomimicry, cradle-to-cradle design, and industrial ecology [29], provide a foundation for the circular economy concept. Industrial ecology, for example, attempts to reduce waste by optimizing the material and energy flows in industrial systems. The cradle-to-cradle design principles proposed by [30] aim to reduce or prevent waste by making products and materials that can be safely reused or recycled.

The circular economy can be studied and put into practice by employing existing approaches such as life cycle assessment (LCA), input–output analysis (IOA), and material flow analysis (MFA) [31]. A product or service’s ecological impacts in its entire lifecycle can be evaluated using life cycle assessment (LCA) results, which are highly beneficial for eco-design and waste management approaches. MFA and IOA analyze material movements across and within economies to identify bottlenecks and maximize efficiency.

According to RBV theory, organizations well-versed in eco-design, waste management, and sustainable supply chain practices may find it easier to execute circular economy methods [32]. This is relevant to efforts toward a more sustainable and circular economy. As per [33], the natural resource-based view (NRBV) clarifies and broadens the RBV theory to include environmental factors; organizations may gain an edge over others by using their ecological management expertise.

Following the RBV theory, empirical studies frequently follow the following pattern: identify critical resources and abilities, quantify them, and then assess their ability to generate competitive advantages. Researchers may accomplish this using qualitative techniques, such as interviews and case studies, or quantitative methods such as surveys and structural equation modeling (SEM) [34].

Various institutional pressures, such as regulations, industry standards, societal expectations, and stakeholder demands, may emerge in sustainability and the circular economy [35]. Businesses may feel constrained to adopt sustainable practices and participate in circular economy programs to maintain credibility and accreditation [36].

Scholars studying institutional theory about sustainability and the circular economy usually use qualitative approaches, such as case studies and interviews, to better understand the factors influencing organizational behavior [32]. However, quantitative methods like surveys and structural equation modeling (SEM) can also be employed to evaluate

the impact of institutional forces on adopting sustainable practices and verify hypotheses derived from institutional theory.

### 2.1. Green Supply Chain Management

Research studies like [37,38] have shown that GSCM approaches can cover various processes, including organizational supply chains and global and industrial networks. An organization's product life cycle process is typically where GSCM definitions begin. Among the many components of these processes [39] are reverse logistics, internal environmental management (IEM), and external environmental management from suppliers. Prior research [40] has defined and confirmed the five main components of GSCM practices: Green Purchasing (GP), Eco-design or design for the Environment (ECO), Investment Recovery (IR), Customer Cooperation for Environmental Concerns (CC), and Internal Environmental Management (IEM). A recent publication [41] further supports and summarizes these components. We use these five GSCM practices—explained further on—to guide our evaluation of the literature and theoretical foundations. The goal of IEM is to improve an organization's environmental performance. It includes cleaner production, an EMS, buy-in from senior management, ISO14001 certification [42], and knowledge exchange initiatives [43].

According to [44], one objective of ECO is to attain eco-efficiency while simultaneously satisfying stakeholder demands. Suppliers are integral to GP's selection, monitoring, and control procedures [45]. Essential procedures include conducting environmental audits, exchanging data, and obtaining eco-labels. Many efforts to improve environmental performance are part of customer collaboration. Coordinating with third-party logistics providers, recycling initiatives, encouraging environmentally responsible consumption, and working with clients to recycle products are essential duties [46].

In closed-loop supply chains, IR is carried out by the 3Rs: reduction, recycling, and reuse. Vital processes include reverse logistics, product take-back initiatives, recycling infrastructure, and selling excess materials [47]. All five GSCM approaches are used to improve overall performance, even if their effects on the economy and the environment are different. After CC, ECO, and GP, the most significant noticeable improvement in economic performance comes from IEM. ECO comes on top when comparing environmental performance improvements, followed by GP, CC, and IEM. IR, which comes in last, endures, relative to other strategies for improving economic and environmental performance.

### 2.2. Circular Economy

Given its origins in the late 1970s, the "Circular Economy" has piqued the curiosity of numerous scholars and businesses [48]. The modern economic system views natural resources as essential commodities, with production and consumption acting as inputs and waste as outputs. According to this idea, these systems are not linear and cannot be sustained indefinitely. Drawing on [49] an assertion that Earth is a closed, circular system with a limited absorption capacity, other authors have examined the relationship between the economy and the environment. A more sustainable and regenerative economic paradigm is sought to be launched by the Circular Economy, which tries to mimic natural ecosystems and strive to limit waste, pollution, and resource depletion [23]. The methodology of the Circular Economy has evolved from several principles and components that facilitate closed-loop systems in commercial and industrial activities. These ideas include but are not limited to, biomimicry, regenerative design, industrial ecology, the blue economy, cradle-to-cradle, ecological principles, looping and performance economies, etc. Circular economies (CEs) have become popular over the last decade as a viable alternative to the exploitative take-make-dispose financial model. There was a 600% increase in the number of publications about the Circular Economy in 2012 due to the initiatives of the Ellen MacArthur Foundation, which substantially raised the concept's profile [50]. The overarching purpose of firms and sectors offering services is to contribute to the Circular Economy's common economic platform that prioritizes capital and the environment [51].

Promoting sustainable growth through reducing emissions, energy leakage, and resource input/waste is the goal of the growing concept known as the Circular Economy [52]. Repair, maintenance, recycling, remanufacturing, reuse, and long-term design are some ways this goal can be achieved. Various attempts at describing the unique word “Circular Economy” have resulted in as many as 124 different descriptions. To supplant the linear “end-of-life” paradigm, the Circular Economy is a body of academic writing that focuses on minimizing, reusing, recycling, and recovering resources and materials through production, distribution, and sustainability.

Environmental stewardship, economic growth, and social equity are the pillars of sustainable development that benefit current and future generations [53]. Scales ranging from the micro to the macro include products, businesses, consumers, eco-industrial parks, cities, regions, countries, and beyond. Technological progress, ethical consumers, and innovative business practices are paving the way for the Circular Economy paradigm to materialize. One goal of CE is to reduce the linear flow of energy and materials by integrating renewable energy flows into society’s production and consumption processes [27]. By increasing the resale value of waste and decreasing consumption, the Circular Economy promotes better and more sustainable resource management. This encompasses not just company concepts but also product, material, and system design and can lead to a more regenerative and recycled economy [54].

### 2.3. Sustainable Waste Management Strategies

Sustainable waste management in its current state seeks to construct a circular economy that emphasizes recycling and reuse of materials rather than merely disposing of waste. This shift necessitates new strategies that surpass the status quo. Important factors that will influence SWM in 2023 are the following:

Waste management works best when waste is still in its early stages. This includes choosing products with lengthy lifespans and repair capabilities, reducing wasteful packaging, and encouraging responsible consumption [40]. An increasing number of enterprises include modularity and disassembly into their product designs to make reusing and repairing components easier. To reduce waste [55], we suggested using reusable water bottles and grocery bags.

When producers are made to pay for the disposal of their products, they are more likely to create eco-friendly products and set up efficient mechanisms for recyclables and returns. According to this “cradle-to-cradle” approach, closed-loop systems that transform trash into new products should be implemented.

Most organic waste, including leftover food and yard trimmings, ends up in landfills, releasing harmful methane levels. Recycling them into nutrient-rich soil amendments through composting helps reduce greenhouse gas emissions. It keeps it out of landfills [56]. Biogas is another alternative energy source that can be produced from organic waste through anaerobic digestion.

Recyclability is especially problematic when dealing with electronic waste and other forms of plastic. New technologies for decomposing these materials into component elements enable the manufacturing of new items [57]. This significant development is critical for reducing the need for new resources and completing the life cycle of challenging materials.

### Circular Economy Business Models: Rethinking Ownership

Beyond the traditional “take-make-dispose” paradigm, businesses are embracing circularity initiatives. Since the producer retains ownership in product-as-a-service models, ref. [43] states that this strategy increases product longevity and upkeep while decreasing waste. Platforms for sharing, repairing, and upcycling are now available to further aid in product longevity and waste reduction.

By implementing these strategies, we can create the groundwork for a future where waste is minimized, resources are recovered and reused abundantly, and the circular



economy thrives. Building ethical and resource-efficient futures requires robust policy frameworks, stakeholder collaboration, and constant innovation.

#### 2.4. Theoretical Underpinning

Based on the Circular Economy Theory, which proposes a shift in economic paradigm toward models with regenerative capacities more akin to natural ecosystems, the study is structured. This method is founded on the principle that economic systems should mimic natural cyclical patterns. Its beliefs include reducing waste, conserving resources, and closing material loops. The circular economy is based on the arguments [43] about how Earth functions as a closed system [40]. It brought attention to the importance of reducing environmental damage while promoting economic growth, which helped spread the idea and make it well-known. As per [25], businesses can maximize resource utilization, decrease waste, and support sustainable development by adopting circular economy principles, including closed-loop systems and cradle-to-cradle design. This theory posits that governments and corporations should embrace circular processes to boost sustainability and secure their financial futures.

### 3. Methodology

This study aimed to investigate how Sustainable Waste Management (SWM) and Green Supply Chain Management (GSCM) practices impact the utilization of Circular Economy (CE) principles. A causal research design was employed to manipulate the independent variables (GSCM and SWM practices) and observe the dependent variable (CE implementation) to determine if there is a cause-and-effect relationship. Through experimental manipulation and control, we can analyze how changes to GSCM and SWM procedures affect businesses' adoption and integration of CE concepts. Using this method, we can better understand the factors that motivate sustainable activities and their potential impact on circular economy initiatives [58].

The study on sustainable waste management, green supply chain management, and the circular economy utilized a purposive sampling method, selecting a group of fifty individuals from the manufacturing sector. Although the sample size may appear small, it was chosen based on practical constraints and available resources. Despite potential limitations on generalization, this approach enables an in-depth examination of study variables in the manufacturing industry. Using a purposeful sampling technique reinforces the study's external validity, ensuring representation from various sectors, sizes, and geographic regions of six businesses by selecting 50 respondents from each sector. This methodology provides a comprehensive understanding of the interconnections between these issues. The findings hold significance for both academics and businesses equally.

According to [59] a purposive sample, the strategy was used to select six waste and supply chain management businesses. Analyzing green supply chain practices and waste management is simplified by focusing on six firms, including in-depth recruitment of 50 participants from each department, sector, and geographic location. This approach increases the likelihood that the findings will have external validity and apply to a larger business population, as the selected organizations represent a variety of industries, sizes, and locations. Our target audience consists of firms of varying sizes and in various sectors so that we can ensure an extensive understanding of the matter. The availability and willingness of firms to participate will determine the study's sample.

Online surveys with predetermined questions were the primary tool for gathering data. The survey quantified environmentally friendly supply chain methods, sustainable waste management procedures, and attitudes toward the principles of the circular economy [60]. This strategy simplifies the process of reaching out to multiple businesses. The findings from the research are likely to be reliable despite the limited audience. This deliberate approach ensures that the results will be applicable in various contexts and provide valuable insights into green supply chain strategies and waste management.

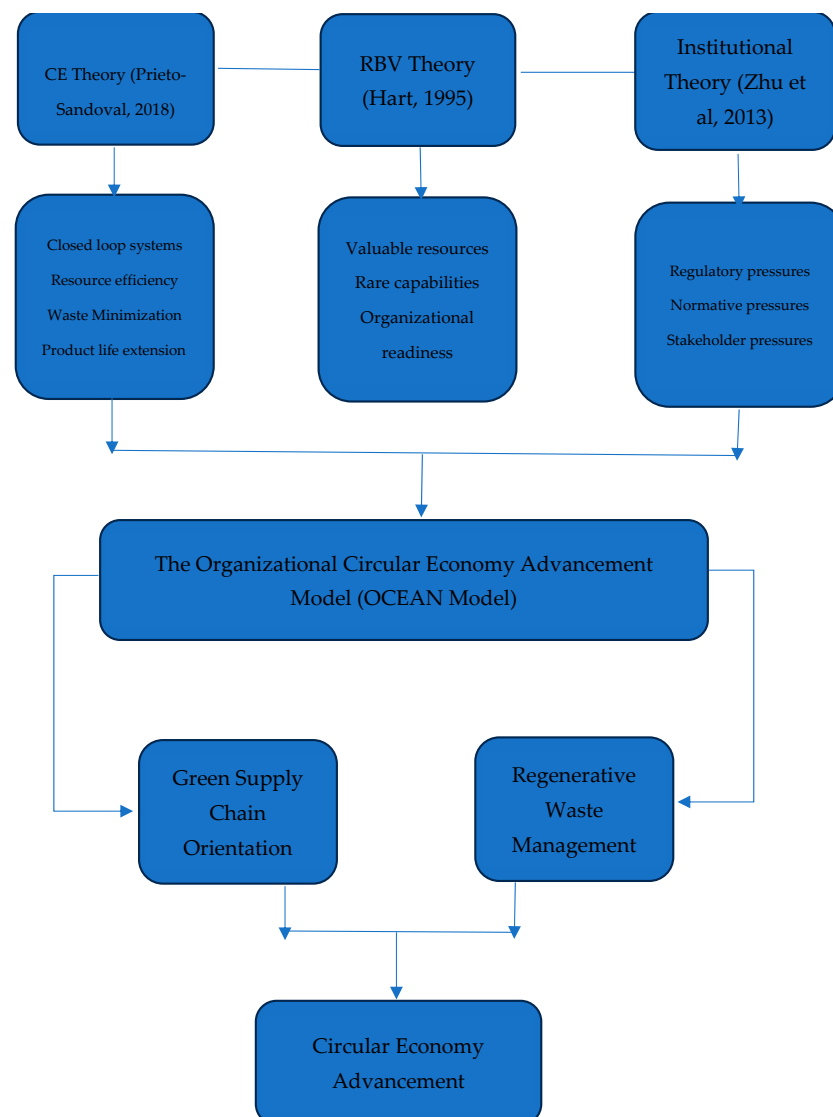
The Organizational Circular Economy Advancement Model (OCEAN Model)

The circular economy model suggests a more restorative and regenerative economic structure than the “take-make-waste” design that underlies conventional economics [30]. It centers on restoring, recycling, and reusing products to increase life cycles, minimize waste, and close material loops.

By resource-based theory, firms may possess a sustained competitive advantage by utilizing valued, distinctive, rarer, irreplaceable, and hard-to-imitate resources and skills. Companies with the necessary sustainability knowledge [31], including sustainable design, waste management, and supply chains, may be advantageous when implementing circular economy programs.

From the institutional theory perspective, the business’s institutional foundation regulates law, norms, and cultural-cognitive environment. External factors, including regulations, standards, consumers’ preferences, and the expectations of various stakeholders, could force businesses to introduce sustainability in their operations and strategies [33].

Based on these theoretical underpinnings, researchers have proposed the following framework to investigate the relationships between green supply chain practices, sustainable waste management, and the advancement of the circular economy indicated in Figure 1.



**Figure 1.** The Organizational Circular Economy Advancement Model (OCEAN Model) [30,32,38].

#### Circular Economy Paradigm Shift:

- Replace the traditional 'take-make-waste' approach with an advanced cyclical closed-loop manufacturing framework.
- Implementing a circular economy by minimizing waste, maximizing product lifespan, and optimizing resource use.
- Consistency in environmental efforts and achieving sustainability goals.

#### Institutional and Stakeholder Drivers:

- Regulators pressure various aspects of businesses, such as environmental laws, policies, and standards.
- Legitimate concerns, societal expectations, and industry norms all contribute to the creation of normative pressures.
- Stakeholders pressure firms, including customers, investors, and community members.

#### Organizational Readiness and Capabilities:

- Shifting toward a sustainable and circular economy is becoming a critical economic priority.
- Effective collaboration among different departments and integrating sustainable practices into business activities.
- Financial support for initiatives to create a sustainable and environmentally friendly economy.
- Acquiring specialized knowledge to implement eco-friendly methods.

#### Collaborative and Restorative Supply Chain Management:

- "Ensuring ethical sourcing of materials and adopting sustainable purchasing practices."
- "Sustainable architecture emphasizes reuse, recycling, disassembling, and accessibility."
- Implementing reverse logistics and closed-loop supply chains can create a sustainable future by reducing waste, reusing materials, and minimizing the environmental impact of our supply chain.
- "Building solid relationships with suppliers, buyers, and recycling centers is critical to creating a sustainable and successful business that benefits everyone involved."

#### Regenerative Waste Management Strategies:

- "Smarter processes and products can enhance efficiency and cut down waste."
- "Waste valorization" refers to converting trash into something useful.
- "Circular systems" refer to the processes that recover and recycle materials to reduce waste and promote sustainability.
- "Sustainable energy can be generated by recovering energy from biological waste."

#### Enabling Technology and Innovation:

- Making use of technology that is reliable and sustainable.
- Electronic systems for tracking and monitoring the flow of materials.
- Revolutions in product design, manufacturing processes, and eliminating waste mechanisms.

#### Continuous Improvement and Adaptive Governance:

- Systematic approaches to data collection and performance monitoring.
- Provide regular comprehensive reviews and comparisons with circular economy objectives.
- By incorporating feedback loops, adaptive leadership enables policy modification.
- The decision-making process includes community members and stakeholders.

#### Circular Economy Advancement and Impact:

- Resources and conservation advantages.
- Decreased ecological impact and emissions of greenhouse gases.
- Economic benefits and new business concepts.
- Industries that engage in the circular economy contribute to economic growth and create social benefits and new employment opportunities.



- The preservation of lasting sustainability and resilience of a community.

This proposed framework encompasses the essential components and motivators for building the circular economy by integrating sustainable waste management strategies with green supply chain practices. It emphasizes the importance of stakeholders' and institutions' roles and the need for a paradigm change toward circular economy concepts.

The framework highlights supply chain management's vital and collaborative nature, focusing on green sourcing, sustainable design, reverse logistics, and connections. Using regenerative waste management systems includes waste prevention, valorization, energy recovery, and closed-loop recycling.

Stakeholder involvement, adaptive governance, methods for continuous development, and enabling technology and innovation are all recognized as essential facilitators.

The primary goal of the framework is to promote the advancement of the circular economy, which will boost efficiency in the use of natural resources and energy, minimize our adverse effects on the environment, and have positive effects on society and the economy while bringing us one step closer to our sustainable development objectives.

Businesses can use this framework as a foundation for new ideas, research, and theories for integrating circular economy principles into their waste management and supply chain procedures.

The adopted research methodology used a structured questionnaire to evaluate participants' perceptions of sustainability issues. The regulatory environment is also considered. The questionnaire was developed with intense caution. It leveraged the renowned Likert 5-point scale to provide extensive responses in the four main sections. The first section dealt with Green Supply Chain Management (GSCM) practices related to environmental management systems, green procurement policies, and the process of reverse logistics. Next, respondents assessed sustainable waste management (SWM) approaches, determining how the parameters of waste reduction, recycling programs, and waste treatment systems align with the legal frameworks. CE principles like resource efficiency and material loop closure were also included in the questionnaire to determine participants' attitudes toward the regulatory constraints on it. Lastly, demographic factors were collected to provide the context of the findings, covering the industry sector, the company size, geographical location, and regulated context. The strategy provided a structured data collection system, allowing quantitative analysis to be carried out to clarify participants' perspectives on sustainable business practices in this regulatory environment.

Proper statistical analysis was conducted on the quantitative information obtained from online surveys. Descriptive statistics were used to summarize the sample's characteristics. Sustainable waste management, green supply chain management, and circular economy practices are all studied about one another using correlational analysis, such as Pearson's correlation coefficient. Regression analysis allows a more thorough examination of the variables' possible predictive relationships.

Ethical and data security considerations aside, the study asked all participants to sign an informed consent document outlining the purpose of the research, the fact that their participation is entirely voluntary, and the steps to be taken to guarantee their anonymity. The data are stored securely and will only be accessible to those on the research team. This guaranteed that the participants' identity and confidentiality were protected. The study followed all ethical standards and obtained the necessary permissions from appropriate ethics committees or institutional review boards to protect participants' rights and reduce the possibility of bias.

## 4. Results

### 4.1. Descriptive Statistics

Table 1 presents descriptive statistics for the variables included in the study: The application of Green Supply Chain Management (GSCM), Sustainable Waste Management (SWM), and Circular Economic (CE) principles. For the study of GSCM Practices, the mean score is 3.92 with a relatively high standard deviation of 0.634, showing the widespread

adoption of GSCM among participants chosen for the sample. Likewise, SWM Strategies exhibited the most significant adoption, proven by a mean score of 4.24 and a low standard deviation of 0.431 compared to GSCM practices. CE Implementation mean score is 4.24, and the variance is 0.591; CE Implementation mean score indicates a moderate amount of implementation. The distribution of the variables is closer to normality, as demonstrated by the small values we obtain from the skewness and kurtosis test. The results presented above indicate that the surveyed group is inclined toward GSCM, SWM, and CE, thus providing the ground for further research.

**Table 1.** Descriptive Statistics of the GSCM, SWM Strategies, and CE.

Descriptive Statistics										
	N Statistic	Minimum Statistic	Maximum Statistic	M Statistic	Std. D Statistic	Var. Statistic	Skewness		Kurtosis	
GSCM Practices	50	3	5	3.92	0.634	0.402	0.063	0.337	−0.407	0.662
SWM Strategies	50	4	5	4.24	0.431	0.186	1.256	0.337	−0.443	0.662
CE Implementation	50	3	5	4.24	0.591	0.349	−0.105	0.337	−0.378	0.662
Valid N (listwise)	50									

#### 4.2. Correlations

Table 2 displays the correlation matrix among the variables: Efficient Green Supply Chain Management (GSCM) Processes, Holistic Waste Management (SWM) Strategies, and the implementation of the Circular Economy (CE). Spearman's Rho coefficients demonstrate how the variables are firmly connected and whether they are positively or negatively correlated.

**Table 2.** Correlations Between GSCM, SWM Strategies, and CE.

Correlations					
			GSCM Practices	SWM Strategies	CE Implementation
Spearman's rho	GSCM Practices	Correlation Coefficient	1.000	0.259	0.464
		Sig. (2-tailed)	.	0.029	0.003
		N	50	50	50
	SWM Strategies	Correlation Coefficient	0.259	1.000	0.488 *
		Sig. (2-tailed)	0.029	.	0.042
		N	50	50	50
	CE Implementation	Correlation Coefficient	0.464	0.488 *	1.000
		Sig. (2-tailed)	0.003	0.042	.
		N	50	50	50

\* Correlation is significant at the 0.05 level (2-tailed).

The correlation indicates that GSCM practices and SWM strategies have a positive and statistically significant correlation ( $\rho = 0.259$ ,  $p = 0.029$ ). This means a weak to moderate range positive relationship between the two constructs. Furthermore, the GSCM Practices and the CE Implementation processes are positively and significantly correlated ( $\rho = 0.464$ ,  $p = 0.003$ ), showing that they are related to a moderate degree.

In addition, the empirical relationship between SWM Strategies and CE Implementation is also positive and statistically significant ( $\rho = 0.488$ ,  $p = 0.042$ ), which indicates a moderate positive correlation between these constructs.

Correlations show that there are highly significant relationships between Green Supply Chain Management (GSCM) Practices, Sustainable Waste Management (SWM) Strategies, and Circular Economy (CE) Implementation. The positive correlation suggests a relation between a high implementation level of the CE principles and sustainability components mentioned above, i.e., GSCM and SWM. This implies that businesses that adopt a circular economy in both the supply of materials and the management of waste materials are

potentially the leaders in promoting circular economy initiatives. Such findings closely relate GSCM, SWM, and CE, thus highlighting the role of all-encompassing sustainability approaches in turning waste into value to protect the environment.

#### 4.3. Regression Analysis

The results of the regression study indicate that GSCM Practices and SWM Strategies explain roughly 9.7 percent of the variance in CE implementation. (See Table 3). Despite the model's increased complexity (R-squared value: 0.058), CE Implementation has a significant effect ( $p = 0.092$ ) according to the F statistic (2.511). This provides strong evidence that GSCM practices and SWM Strategies substantially drive sustainable behaviors within societies. Although the R-squared values are lower than expected, this model is still effective in understanding the influences on the variables. The research shows that GSCM practices and SWM strategies may need help predicting diversity. Still, they are crucial to advancing sustainability goals and encouraging more sustainable practices in the examined setting.

**Table 3.** Model Summary.

Model Summary										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.311 <sup>a</sup>	0.097	0.058	0.574	0.097	2.511	2	47	0.092	1.335

<sup>a</sup> Predictors: (Constant), SWM Strategies, GSCM Practices.

The ANOVA results show (See Table 4) that the regression model is statistically significant ( $F = 2.511$ ,  $p = 0.092$ ), suggesting that altogether, the principles of sustainable waste management (SWM) strategies and green supply chain management (GSCM) practices have been contributing toward the explanation of variability involved in circular economy (CE) implementation. The total square for the regression model is 1.653, with 2 degrees of freedom, thus generating a mean square of 0.826. The result indicates that a substantial part of the variance in CE Implementation is by the model rather than the residual variance. Moreover, a  $p$ -value greater than 0.05 further indicates its limited significance, thus offering the model's predictive ability to model CE implementation.

**Table 4.** Predictive Ability of CE Implementation Model.

ANOVA <sup>a</sup>					
	Model	SS	Df	Mean Square	Sig.
1	Regression	1.653	2	0.826	0.092 <sup>b</sup>
	Residual	15.467	47	0.329	
	Total	17.120	49		

<sup>a</sup> Dependent Variable: CE Implementation. <sup>b</sup> Predictors: (Constant), SWM Strategies, GSCM Practices.

The coefficients table displays the results of the regression analysis, which investigates the correlation among Green Section Management (GSCM) practices, Sustainable Waste Management (SWM) strategies, and the independent variable of Circular Economy (CE) Implementation. (See Table 5). With a constant term of 6.076, the regression model is intended to approximate the CE Implementation score when neither GSCM Practice nor SWM Strategy is present. The predictors show that good GSCM Practices and CE Implementation scores ( $\beta = 0.111$ ,  $p < 0.001$ ) are positively correlated. Thus, a one-unit increase in GSCM Practices increases the CE Implementation score by 0.111 units. As well as this, (SWM Strategies) and (CE Implementation) show significant positive externalities ( $\beta = 0.309$ ,  $p = 0.032$ ) so that for each one point (SWM Strategies), (CE Implementation) becomes 0.309 points greater.

**Table 5.** Regression Analysis of GSCM, SWM, and CE Implementation.

		Co-Efficient <sup>a</sup>					Collinearity Statistics	
	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Tolerance	VIF
		B	Std. Error	Beta				
1	(Constant)	6.076	0.900		6.751	0.000		
	GSCM Practices	0.211	0.131	0.111	3.082	0.000	0.979	1.022
	SWM Strategies	0.423	0.192	0.309	2.204	0.032	0.909	1.072

<sup>a</sup> Dependent Variable: CE Implementation.

In addition, the (GSCM) Practices and the (SWM) Strategies benefit the CE Implementation. According to the findings, we presume businesses that adopt more sustainable approaches to procurement activities and waste management methodologies have higher to very high CE implementation scores. The opposite is the case in that GSCM is less efficient than SWM because GSCM practices affect relationship size. At the same time, sustainable waste management plays a highly significant role in the implementation of circular economy investments. Notwithstanding, the low correlations among the regressors (tolerance > 0.1, VIF < 10) confirm no occurrence of collinearity among the regressors.

#### 4.4. Discussion

The results of this study, when taken into the context of previous research on GSCM, SWM, and their relationship to adopting the circular economy (CE), provide significant support for the claims. Previous research has demonstrated that GSCM approaches can increase resource efficiency and environmental sustainability, for example, refs. [50,53] are only a couple of numerous examples. These methods aim to reduce the ecological effect at every level of the supply chain. They include green purchasing, eco-design, consumer interaction, and investment recovery.

Research from organizations such as the [35,61] provides credence to the notion that SWM methods are pivotal in enhancing circularity and decreasing waste. SWM uses innovative techniques such as anaerobic digestion, recycling, and composting to reduce landfill waste and maximize resource recovery [48]. Consistent with this previous research, the current study found that organizations that use holistic sustainability strategies, such as GSCM and SWM, have a better chance of promoting CE activities.

Furthermore, researchers have identified supply chain approaches that contribute to sustainable consumption and are a component of the circular economy. This infrastructure includes recycling, remanufacturing, refurbishing, maintenance services, and education to change consumer attitudes and behaviors through competitive pricing [61]. To accomplish sustainable consumption, we must build infrastructure that increases consumer awareness, involvement, and accountability and establishes production systems that can support themselves.

The study's findings provide practical insights for organizations seeking to enhance their sustainability initiatives. Since GSCM and SWM contribute to the objectives of the circular economy, companies can utilize this study's results to their advantage when attempting to persuade investors to finance these initiatives. According to [47,62], green procurement methods, logistics optimization, and waste reduction activities may yield financial and environmental benefits.

Furthermore, the study emphasizes collaboration across sectors and the supply chain to foster circularity [47]. We found that expanding sustainable practices and building relationships with stakeholders like suppliers and customers can help companies become more competitive and resilient in the face of environmental issues. This research can help policymakers develop workable regulations and incentives, promoting responsible resource management and sustainable development.

Lastly, the study's findings stress integrating green supply chain management strategies with sustainable waste management methods to progress the circular economy objective. This approach allows companies to reduce their environmental footprint, tap into untapped markets, and contribute to a more sustainable future.

Managers who are looking to develop sustainable businesses may find the findings of the study particularly useful. Policymakers can create policies based on a circular economy (CE) to achieve economic and environmental objectives. Achieving this goal would require innovative, interdependent approaches to product lifecycle management and design that conserve natural resources while reducing waste. One way to reduce the ecological impact is an inclusive framework that encourages sustainable product purchases, more significant supply chain transparency, and the maintenance of closed-loop systems. These tools become even more effective when stakeholders such as suppliers and customers work together. Policymakers can encourage sustainable behavior by providing financial incentives and rebates and implementing supportive regulations. If managers and policymakers embrace these recommendations, the circular economy and sustainability may undergo another paradigm shift.

## 5. Conclusions

The study has revealed that green supply chain management and sustainable waste management help foster the circular economy if applied well. The research on these practices highlights that these practices impact the implementation of circular economy initiatives. Those companies that emphasize sustainability in their supply chains and waste management are expected to look ahead in a timely manner and adopt strategies based on a circular economy. The above findings highlight the necessity of integrated sustainability approaches, which are crucial for environmental goal achievement, and give practical suggestions to businesses and policymakers, pointing to a need for collaborative and investment-type activities in sustainable practices that encourage a circular economy.

This study extends the current body of literature in many aspects. Firstly, it bridges the understanding of the interaction in GSCM, SWM, and CE through their empirical demonstration in the research paper. Secondly, it presents real-life experiences of GSCM and SWM's benefits for business decision-making and the public domain. It gives concrete examples of actual life usage by decision-makers and businesses. Finally, an essential point in the study is the reminder that collaboration and interdependence are crucial in managing the supply chain. This is implied when the overall sustainability approach is critical to successfully managing environmental problems.

Although the present study has made a significant contribution, it still needs to be argued that it has some limitations. Lastly, the subject number of the research was small, and its application results were significant. The next step could be to assess this issue using large-scale studies covering more industries. In addition, the focus was entirely on the quantitative method, which may have neglected the emphasis on every aspect while disregarding the vital qualitative elements. When conducting research, it could be helpful to use qualitative techniques, such as case studies and interviews, to gather data on our growing awareness of the underlying dynamics.

Moreover, the investigation was carried out within a specific geographical area, which may limit the applicability of the findings across other regions with dissimilar socio-economic and environmental conditions. Subsequently, another exciting area for future explorations would be to compare several countries to determine if results could be transposed to different situations.

Furthermore, longitudinal research is necessary to give insights into the causality of GSCM and SWM development strategies on CE adoption. Nevertheless, it is essential to note that this research was conducted at an organizational level. Hence, future research should focus on the government and its policies to determine their role in implementing sustainable processes in supply chains. Lastly, due to the continuous development of

technology and emerging trends in the field of circular economy, there is a need to maintain persistence in this area of research.

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