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RESEARCH ARTICLE

Paving the Pathway: An Entropy-Based Combined Compromise Solution Approach to Facilitate the Indian Plastic Industry's Transition Toward a Circular Economy

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ABSTRACT

The traditional "take-make-use-dispose"-type economic pattern has led to severe environmental challenges, particularly in the plastic industry, where waste generation and resource inefficiency are of utmost concerns. Transitioning to a circular economy (CE) requires strategic supplier evaluation to ensure sustainable sourcing. However, CE implementation in emerging economies remains underexplored, and no established framework exists for circular supplier selection (CSS) in the plastic industry. This study addresses a practical CSS problem faced by a leading Indian plastic manufacturer (the case organization) aiming to partner with an ideal supplier for developing innovative circular products. Through a Delphi study, eight key evaluation criteria were identified and validated. A multi-criteria decision-making (MCDM) framework integrating the entropy method (for criteria weighting) and the combined compromise solution (COCOSO) method (for supplier ranking) was applied. The findings reveal that "total consumption of toxic substances" and "reduction in workplace hazards through employee wellbeing activities" are the two most influential CSS criteria. Based on the ranking, the most suitable supplier was recommended to the case organization. This research reinforces supplier selection models by integrating social, environmental, and economic dimensions within a CE context. The novel entropy-COCOSO framework further improves decision-making by reducing subjectivity and improving ranking accuracy. Practically, the study provides managers and policymakers with a robust decision-support tool to facilitate CE adoption in the plastic industry, guiding sustainable procurement strategies.

1 | Introduction

Plastic is among the most significant industrial innovations ever, which fosters the efficacy of contemporary economic activity because it is portable, malleable, durable, chemically inert, and, most importantly, inexpensive. However, its excessive production, improper disposal, and accumulation of waste have led to severe environmental and health concerns, including global warming, marine degradation, chemical exposure, and biodiversity loss (Slunge n.d.). Plastic consumption has nearly doubled in the last half-century and is likely to double again in the next 20 years (Chowdhury et al. 2022). Thus, plastics manufacturing has exploded due to this high demand, outpacing the production of most man-made items. The global annual production of plastic surged to 390.7 million metric tons in 2021 and is expected to nearly double by 2035 and almost quadruple by 2050, representing a 4% yearly rise (Evode et al. 2021; Al Qahtani et al. 2022). However, the current process for making, using, and disposing of most plastic products fails to reap the economic benefits of an extracircular approach and results in substantial environmental damage (Johansson 2023; Ncube, Mtetwa, et al. 2023). Furthermore, the genesis of plastic waste is gaining considerable attention worldwide as it imposes a significant policy challenge in developed and developing nations (Tuuri et al. 2023; Chowdhury et al. 2022). Plastic abandoned waste might persist in the ecosystem for hundreds or even thousands of years (Héry and Malenfer 2020). Given the nondegradability of plastic products, its accumulation is more destructive to the environment than its creation (Maione et al. 2022). The plastic waste accumulation has reached a juncture, and prompt action is required to prevent plastic leakage into the surrounding environment (Kibria et al. 2023).

In contrast, circular economy (CE) approaches in the plastic industry are intended to ensure that plastic never becomes waste or enters the ecosystem, preventing as much as possible from ending up in landfills and damaging the environment (Jayarathna et al. 2023). By considering various environmental and socioeconomic issues, the CE model has emerged as a new business paradigm to maximize material circularity, minimize the requirement of virgin materials, and eradicate detrimental impacts on the environment (Ethirajan et al. 2021). Governments and industries worldwide are implementing policies to encourage CE adoption, particularly in sectors with high environmental impact (Diaz et al. 2022). According to Govindan et al. (2020), the first and foremost step in implementing CE is procuring eco-friendly and reusable raw materials and collaborating with circular suppliers who focus on reducing waste in their supply chains (SC). In the plastic industry, CSS plays a crucial role in ensuring that raw materials and production processes align with CE principles (Haleem et al. 2021). Previous CSS studies have concerned different industries, such as the cement industry (Prosman and Sacchi 2018), the automobile industry (Feng and Gong 2020; Münch et al. 2022), the construction industry (Tushar et al. 2022), and petrochemical industry (Alavi et al. 2021; Mina et al. 2021). Unfortunately, no adequate research on CSS in the plastic industry was found, especially in the context of emerging economies.

Although the existing CSS studies encompass environmental and economic aspects, they largely overlook social aspects, indicating a need for criteria that are not only environmentally and economically relevant but also socially significant. Prior research (e.g., Khalili Nasr et al. 2021; Alavi et al. 2021) often overlook or treat social criteria as secondary. This knowledge gap leads to a great challenge to attaining "SDG 3," that is, "good health and well-being," and "SDG 8," that is, "decent work and economic growth" (The 17 goals n.d.). This lack of established set of criteria for CSS in the plastic industry leads to the foundation of the first research question (RQ) (Research Question 1):

Research Question 1. *What are the critical evaluation criteria for CSS in the plastic industry in emerging economics?*

Apart from environmental and economic criteria, this research focuses on two social criteria: "investment in corporate social responsibility activities" and "reduction in workplace hazards through employee wellbeing activities." To the authors' knowledge, this is the first evaluation of circular suppliers that aid the achievement of SDGs 3, 8, 9, 12, and 13 by considering environmental, economic, and social aspects simultaneously. This study also seeks to refine the criteria set to incorporate triple bottom lines of sustainability, thereby providing a more holistic approach to CSS. The Delphi method was employed to achieve this refinement, as Dey et al. (2020) recommended, for its effectiveness in achieving consensus among experts. To this end, the second RQ (Research Question 2) is propounded as follows:

Research Question 2. *How can the evaluation criteria be refined based on their relevance to the plastic industry?*

Existing literature (Ghosh et al. 2021c; Menon and Ravi 2022) suggests that traditional supplier evaluation methods may not fully capture the nuances of CE practices. The review emphasized the necessity of integrated approaches to manage the complexity of MCDM within a CE context. This prompted the development of Research Question 3, which centers on creating and utilizing a robust MCDM framework to effectively assess and rank suppliers based on their levels of CE implementation.

Research Question 3. *How can suppliers be prioritized based on their level of involvement in CE practices implementation?*

To address the stated RQs, this study proposes an integrated framework that merges two distinct MCDM techniques (entropy and COCOSO) for CSS in the plastic industry, paving the path toward a CE. In the proposed framework, the criterion weights were calculated using the entropy approach, and the performance of each supplier was subsequently determined using the COCOSO method, and the suppliers were ranked accordingly. Despite several advantages of the integrated entropy-COCOSO methodology (Dwivedi and Sharma 2022a), it was rarely used in SC studies, especially to solve SS problems. To validate the proposed framework, a real-world CSS problem in a prominent Indian plastic manufacturing company was solved, and four potential suppliers were evaluated based on their involvement in CE practice implementation. This study targets the Indian plastic industry because it is one of the country's leading industrial sectors, contributing significantly to the Indian economy and employment rate (Sundaram et al. 2023). However, the sector remains one of the major polluters in India and lacks the necessary knowledge and infrastructure to aid the shift toward a CE (Neo et al. 2021). As the country's plastic demand is expected to rise by several million tons by 2030 (Neo et al. 2021), the India-based plastic manufacturing organizations must immediately adopt CE principles not only to reduce contamination and waste but also to create fresh possibilities for innovation and expansion (Pillai 2021). This study aims to lay the foundation and equip managers with suitable decision-making framework to facilitate this transition.

The structure of this article is as follows: Section 2 offers an extensive review of the literature on various aspects of CE and CSS. Section 3 outlines the research design, describing the proposed framework and the methodology used in this study. Section 4 presents the framework's application to a real-world CSS case, including its results and validation. Section 5 provides a thorough discussion of the findings. Section 6 examines the research implications. Section 7 depicts the practical implementation challenges. Section 8 concludes the study by addressing its limitations and suggesting directions for future research.

2 | Prior Art

The prior art section is divided into four parts based on the scope of this study. The first section explores the concept of CE. The second section sheds light on CE in the plastic industry. The third section reviews the existing CSS methods and criteria. Finally, the fourth section exposes the research gaps.

2.1 | CE

The growing waste accumulation in our environment is a clear indicator of the current global economic system, which largely depends on the "take-make-dispose" model, also referred to as the linear economy. A CE rethinks current patterns of production and consumption in such a way that business growth promotes assured economic, social, and environmental benefits across SC, from raw material selection to product/service design to manufacturing and distribution to end-user consumption, disposal, and recovery (Chen et al. 2023). By design, a CE is reparative and regenerative, indicating that materials are continuously used in a "closed-loop" system instead of being used only once and then discarded (Ghosh et al. 2023c). A CE model aims to minimize any superfluous inputs and leakages from the system (Horbach and Rammer 2019). To attain this objective, a variety of strategies are followed, such as extending product life cycles to maximize resource utilization, redesigning products with end-of-life considerations, refurbishing solid waste for reuse, increasing recycling, and developing a market for recycled goods (Ghosh et al. 2023; Oliveira et al. 2021; Prieto-Sandoval et al. 2019).

2.2 | The Need for CE in the Plastic Industry

2.2.1 | Environmental Impacts of the Plastic Industry

The plastic industry is a major contributor to environmental pollution, driven by its high production volume and the long-lasting nature of plastic waste. Studies such as Simon (2019) and Chowdhury et al. (2022) highlight the extensive environmental impact caused by plastic production and disposal, including global warming, marine degradation, and biodiversity loss. The environmental hazards posed by plastic waste are well documented. Ncube, Mtetwa, et al. (2023) discuss the life cycle of plastic, from extraction to disposal, highlighting the substantial greenhouse gas emissions and water consumption associated with plastic production. The improper disposal methods, such as landfilling and incineration, exacerbate environmental degradation by releasing toxic substances and greenhouse gases (Evode et al. 2021). The persistence of plastic in ecosystems, potentially lasting hundreds to thousands of years, underscores the need for sustainable alternatives (Maione et al. 2022). The linear "take-make-use-dispose" model traditionally employed by the plastic industry results in significant waste generation and resource depletion (Bodar et al. 2018). According to Al Qahtani et al. (2022), the global annual plastic output projection indicates a steep rise to double by 2035 and nearly fourfold by 2050. This unsustainable growth highlights the critical need to shift to a CE model focused on reducing waste and maximizing resource use.

2.2.2 | Current State of CE in the Plastic Industry

In the era of CE, plastic should no longer be regarded as "waste" but rather as a renewable resource that must be properly disposed of (Jayarathna et al. 2023). Plastic CE solutions include manufacturing plastics from alternative non-fossil fuel feedstocks (Chowdhury et al. 2022); reusing plastic scraps as a resource (Al Qahtani et al. 2022); re-engineering plastic production processes and designing products to improve durability, reusability, and waste mitigation (Ncube, Mtetwa, et al. 2023); alliance between companies and customers to foster recycling and elevate the economic worth of plastic items (Héry and Malenfer 2020); developing solid data structures to support circular solutions (Neo et al. 2021), adopting fiscal and legislative changes, and promoting sustainable business models that promote plastic goods as amenities as well as promote sharing and leasing (Sundaram et al. 2023). According to a recent report by the Asian Development Bank (2020), the following approaches can facilitate the adoption of in the plastic industry: (i) increase expenditures in infrastructure and efficient unified solid waste management systems; (ii) increase the viability of government legislation, laws, and pledges to a circular plastics economy; and (iii) increase involvement of stakeholders and commitments throughout the value chain to reduce plastic pollution and implementCE practices. Despite its potential advantages, the adoption of CE in the plastic industry is still in its embryonic stages in many emerging economies. Research by Khalili Nasr et al. (2021) indicates that while growing awareness of CE, practical application and comprehensive frameworks for CSS are lacking. This underscores the need for empirical studies and decision-making tools to support the transition to a CE in the plastic industry.

2.2.3 | CE Practices in the Indian Plastic Industry

The Indian plastic industry is vital to the nation's economy but encounters significant challenges due to its dependence on the conventional linear production model. Transitioning to a CE is essential to address these challenges and foster sustainable growth. Acknowledging this need, the Indian government has implemented various policies to promote CE practices. For example, the "Plastic Waste Management Rules (2016, amended in 2021)" focus on extended producer responsibility (EPR), encouraging manufacturers to oversee the entire life cycle of their products.

Additionally, the "Swachh Bharat Abhiyan" (Clean India Mission) focuses on improving waste management infrastructure and recycling initiatives nationwide (Ministry of Environment, Forest and Climate Change 2021). Industry-led initiatives have also contributed significantly to CE practices. The Alliance to End Plastic Waste (AEPW), a global coalition, collaborates with local governments and industries in India to implement sustainable solutions, particularly in waste collection, sorting, and recycling in urban areas (AEPW 2022). Companies like Ramky Enviro Engineers and Rudra Environmental Solutions are leading efforts in recycling, with innovative solutions such as integrated waste management facilities and pyrolysis technology to convert plastic waste into fuel (Ramky Enviro Engineers 2022; Rudra Environmental Solutions 2022). Collaborative efforts between the public and private sectors have further advanced CE initiatives. The India Plastics Pact, launched in 2021 by the Confederation of Indian Industry (CII) and WWF India, focuses on eliminating problematic plastics, ensuring all packaging is reusable or recyclable, increasing recycling rates, and incorporating recycled content in new packaging (Confederation of Indian Industry (CII) and WWF India 2021).

Several Indian companies are also setting examples in adopting CE practices. UFlex Ltd., the country's largest flexible packaging company, recycles multilayered plastic waste and develops biodegradable packaging solutions. Similarly, Reliance Industries has created a PET recycling ecosystem to produce eco-friendly products using recycled PET (UFlex Ltd 2021; Reliance Industries 2021). Nevertheless, factors like low awareness, insufficient infrastructure, and financial limitations obstruct the widespread implementation of CE practices. Nonetheless, growing regulatory pressures and increasing consumer awareness offer significant opportunities. Technology, infrastructure, and education investments will be key to accelerating the transition toward a CE.

2.2.4 | Need for Further CE Research in the Context of Indian Plastic Industry

India is one of the largest producers of plastic waste, generating approximately 3.4 million tons per year, with only about 30% being recycled. The low recycling rate underscores the inefficiency of existing waste management practices and the pressing need to adopt CE principles. Recent studies emphasize the severe environmental impact of plastic waste in India, including pollution of land and water bodies, which further supports the need for innovative solutions like CE. While there is a growing awareness of CE in India, practical application remains limited, particularly in the plastic industry. CE practices can significantly benefit the Indian plastic industry by reducing environmental impact, creating economic opportunities, and enhancing social welfare (Ethirajan et al. 2021). Studies by Neo et al. (2021) and Sundaram et al. (2023) indicate that the Indian plastic sector lacks the necessary infrastructure and knowledge to support a shift toward CE. This gap underscores the need for comprehensive frameworks that can guide organizations in implementing CE practices effectively.

The extant literature on green and sustainable supplier selection is extensive; however, research specifically focused on CSS in the Indian plastic industry is scarce. Tushar et al. (2022) noted that while there are studies on CSS in various industries, the plastic sector in India has not been adequately explored. This gap is significant, as supplier selection is crucial for the effective implementation of CE practices. Despite its benefits, empirical studies validating CE models in real-world contexts, especially in emerging economies like India, remain scarce. As Al Qahtani et al. (2022) noted, the practical viability of CE business models needs to be demonstrated through case studies and empirical research. Our study seeks to address these gaps by designing a customized CSS framework for the Indian plastic industry, offering practical insights and validation.

2.3 | Circular Supplier Selection Process

Collectively, suppliers and manufacturers create the most environmental impact. The CE compels suppliers to produce raw materials that are practically restorative, recoverable, and regenerative while also being environmentally friendly (Kannan, Mina, et al. 2020). Thus, aCE-based SS increases network efficiency, minimizes cost, and decreases environmental harm while conserving natural resources and promoting the circularity of discarded materials (Mina et al. 2021). A handful of research on CSS is available in the literature carried out by previous authors in various industrial domains. For example, Moktadir et al. (2020) identified challenges in selecting sustainable suppliers in circular supply chains (CSC) and emphasized integrating Industry 4.0 technologies to improve decision-making in sustainability contexts. Similarly, Xie et al. (2023) proposed an MCDM framework using entropy and COPRAS methods, focusing on balancing economic, environmental, and social criteria to optimize CSS. Moreover, a study by Ncube, Mtetwa, et al. (2023) emphasized the importance of recent innovations in SS methods to support resilient CE, noting that criteria such as technological adaptability and eco-design have become crucial in emerging SC. These recent insights highlight the need for industry-specific, empirically tested frameworks that address these new priorities within CSS models, reinforcing the novelty of this study within the context of the plastics industry.

Table 1 displays a few noteworthy CSS studies. Relevant criteria and appropriate selection methods are essential for effective SS (Tushar et al. 2022). These two variables are mutually beneficial; ignoring one would lead to an inefficient evaluation. It is worth mentioning that the business setting significantly impacts the selection of appropriate criteria and the most effective method. As a result, the two fundamental issues in SS problems are “Which criteria are to be considered for the effective SS process?” and “Which method yields the most effective result in a CSS process?” Accordingly, the literature review depicted in this section comprises the following two subsections.

2.3.1 | Criteria Used in the Supplier Selection Process

The majority of CSS criteria may be classified into three categories: economic, environmental, and social, based on the triple bottom line (TBL) concept (Yadav et al. 2020). Some of the frequently used environmental criteria are “environmental management system,” “carbon emissions,” “use of environmentally-friendly materials,” “pollution control initiatives,” and “resource consumption.” Economic criteria that are commonly used in the SS problems are “cost,” “total transportation and disposal cost,” “recycling cost,” “and financial capability.” The most used social criteria include “creating job opportunities,” “occupational health and safety management system,” “information disclosure,” and “the rights

TABLE 1 | A few pioneer works in the domain of CSS.

Authors	Country context	Target industry	Criteria considered	Dimensions covered					No. of suppliers assessed	Methods applied	Limitations/ remarks
				Environmental	Social	Economic	Circular	Traditional			
Muneeb et al. (2023)	France	Refurbishing management system	"Quantity of returned products, carbon emission in transporting a single product, carbon footprint by the production of a refurbished product, total transportation and disposal cost, recycling cost, flexibility, aggregate demand, price of a unit ordered from supplier"	√		√	√	√	8	"Goal programming," "weighted sum method (WSM)"	Specific crucial SS criteria might have been disregarded, particularly when considering a circular context
Münch et al. (2022)	Germany	Automotive industry	"Environmental related certifications, green procurement, research and development, green image, eco-friendly packaging, eco-friendly materials, environmental standards, eco-design, clean technologies, eco-friendly transportation, pollution, waste generation, resource consumption"				√		NA	"FDEMATEL"	It only addresses circular variables and ignores economic and social factors that may influence SS
Tushar et al. (2022)	Bangladesh	Construction industry	"Cost, on-time delivery, reliability, rejection rate, after-sales service, quality management system, use of green technology, green packaging, response toward environmental regulations and standards, use of environmental-friendly and recyclable raw materials, green research and development, environmental certification, pollution control initiatives, corporate reputation, timeliness, responsiveness, return of goods, technical capability, product diversity"	√			√	√	5	"Preference ranking organization method for enrichment evaluation (PROMETHEE)," "weighted aggregated sum product assessment (WASPAS)," "FAHP"	The supplier ranking depended on the subjective judgments of domain experts, which could introduce potential bias
Wang et al. (2021)	Taiwan	Bicycle manufacturers	NA	√	√	√			2	"Mathematical programming," "hypothesis testing"	The proposed technique can only access one product attribute

(Continues)

TABLE 1 | (Continued)

Authors	Country context	Target industry	Criteria considered	Dimensions covered: Environmental	Social	Economic	Circular	Traditional	No. of suppliers assessed	Methods applied	Limitations/remarks
Mina et al. (2021)	Iran	Petrochemical industry	"Delivery reliability, on-time delivery, quality control system, after-sale service, previous customer satisfaction, sustainability longevity, GHG emissions from production and recycling activities, environmental regulations and standards, green packaging, eco-friendly and recyclable raw material, clean technology, technology capability, production facility and capacity, financial capability, flexibility, research and development"				√	√	6	"Fuzzy-analytic hierarchy process (FAHP)," "Fuzzy-Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS)", "FIS"	The findings may not corroborate SSS principles as no social criteria was considered in this study
Alavi et al. (2021)	Persian Gulf	Petrochemical industry	"Cost, quality, on-time delivery, reputation, flexibility, technological capacity, R&D, responsiveness, financial capability, productivity, service efficiency, risk, energy consumption in production and recycling, air pollution in production, production using recyclable raw materials, utilizing clean and green technology, eco-friendly packaging materials, environmental standards and regulations, waste management, environmental management system, managing returned products, reverse logistics, human rights, occupational health and safety management system, information disclosure, social commitment, ethical issues, employment practices, social management, attention to child and forced labor problem"		√	√	√		10	"FBWM," "fuzzy inference system (FIS)"	There is a lack of effort to ascertain whether SSS should consider environmental issues alone or alongside economic and social factors.

(Continues)

TABLE 1 | (Continued)

Authors	Country context	Target industry	Criteria considered	Dimensions covered: Environmental	Social	Economic	Circular	Traditional	No. of suppliers assessed	Methods applied	Limitations/remarks
Khalili Nasr et al. (2021)	Iran	Garment manufacturing and distribution industry	"Quality, reputation, on-time delivery, flexibility, technology capability, after-sales service, eco-friendly and recyclable raw materials, recyclable packaging materials, design for reuse, environmental management systems, air pollution, hazardous waste management, environmental certifications, clean technologies, green R&D and innovation, creating job opportunities, information disclosure, occupational health, and safety systems, the interests and rights of employees"	√	√	√	√		5	"FBWM," "multi-objective mixed-integer linear programming (MOMILP)"	With disruption concerns, the network investigated in this research could be expanded to perishable items
Kannan, Mina, et al. (2020)	Iran	Wire-and-cable industry	"Cost, quality, delivery, reputation, technology, flexibility, occupational health and safety systems, the rights of stakeholders, the interests and rights of employees, job creation, information disclosure, air pollution, utilizing eco-friendly and recyclable raw materials, environmental standards and regulations, clean technologies in production and recycling products, using recyclable materials in packaging products"		√	√	√	√	6	"Fuzzy-best worst method (FBWM)," "multi-criteria optimization and compromise solution method (VIKOR)"	As a weighting mechanism, it does not consider the criteria's mutual dependency
Govindan et al. (2020)	Iran	Automotive timing belt manufacturer	"Air pollution, environmental standards, eco-friendly raw materials, eco-design, eco-friendly packaging, eco-friendly transportation, clean technology, quality control system, previous customer satisfaction, qualities of after-sales service, on time and efficient production, time management, delivery time"				√	√	6	"Fuzzy-analytic network process (FANP)," "fuzzy-decision making trial and evaluation laboratory (FDEMATEL)"	"Environmental," "social," and "economic" criteria were overlooked

(Continues)

TABLE 1 | (Continued)

Authors	Country context	Target industry	Criteria considered	Dimensions covered					No. of suppliers assessed	Methods applied	Limitations/remarks
				Environmental	Social	Economic	Circular	Traditional			
Feng and Gong (2020)	NA	Automobile manufacturing industry	"Quality, cost, delivery reliability, flexibility, technology, and green development capabilities, green image, production management and resource consumption, carbon emissions, green innovations and products"	√			√	√	5	"Linguistic entropy weight method", "multi-objective programming"	Although the evaluation criteria need to be distinct, multiple indicators in this study might overlap
Prosman and Sacchi (2018)	Sweden, Germany, Great Britain, Denmark	Cement industry	"Nature occupation, mineral extraction, human toxicity, global warming, eco-toxicity, acidification, ozone layer depletion, eutrophication"	√					4	"Consequential life cycle assessment (CLCA)"	The exactitude of results obtained from this study is influenced by different degrees of unpredictability

of stakeholders." However, researchers have incorporated circular, environmental, social, and economic criteria in their recent studies. The commonly used circular criteria are "using recyclable materials in packaging products," "utilizing eco-friendly and recyclable raw materials," "design of products to reuse," "waste management," and "reverse logistics." Furthermore, some of the criteria utilized in the GSS process may be found in some CSS research. The most frequently used CSS criteria in recent years are shown in Table 1.

2.3.2 | Methods and Techniques Used in Supplier Selection Process

SS is commonly viewed as an MCDM problem that considers multiple conflicting criteria (tangible and intangible) and obtains alternative preferences. Various SS and assessment approaches have been developed and effectively applied by many researchers in recent years: AHP (Mina et al. 2021), FTOPSIS (Mina et al. 2021), DEMATEL (Ghosh et al. 2023c), FDEMATEL (Münch et al. 2022), FBWM (Kannan, Govindan, and Rajendran 2020; Alavi et al. 2021, Khalili Nasr et al. 2021), PROMETHEE (Tushar et al. 2022), WASPAS (Tushar et al. 2022), and VIKOR (Kannan, Mina, et al. 2020). Each MCDM approach has advantages and disadvantages.

To take advantage of the benefits of stand-alone MCDM approaches while avoiding their limitations, researchers have attempted to combine two or more MCDM techniques into a hybrid model. These hybrid MCDM methods frequently use one method to determine the criteria weight and then employ that estimated weight to rank the alternatives using another MCDM method. A few commonly used hybrid MCDM methods include entropy-TOPSIS (Ghosh et al. 2021c), entropy-complex proportional assessment (COPRAS) (Ghosh et al. 2023b), FAHP-FTOPSIS (Ghosh et al. 2022a), and FBWM-VIKOR (Kannan, Mina, et al. 2020).

In addition to combining two MCDM approaches to handle SS issues, authors started utilizing more than two MCDM approaches. For example, a combination of FAHP-FTOPSIS- FIS (Mina et al. 2021), FAHP-PROMETHEE-WASPAS (Tushar et al. 2022), and entropy-TOPSIS-COPRAS-gray relational analysis (GRA) (Ghosh et al. 2022b).

Apart from the MCDM methods, various mathematical and statistical methods are also used for SC problems, such as integrated MCDM and multivariate analysis (Ray et al. 2021; Ghosh et al. 2021a, 2021, 2023d), combined robust design-based MCDM (Ghosh et al. 2022), entropy-multiobjective programming (Feng and Gong 2020), integrated goal programming and WSM (Muneeb et al. 2023), and mathematical programming (Wang et al. 2021).

2.4 | Research Gaps

i. Table 1 shows that previous CSS studies were mainly conducted in developed country contexts, particularly Western ones. There is still a scarcity of CE-related research in emerging economies such as India.

ii. A handful of research on CSS has been conducted in various industrial contexts such as the cement industry (Prosman and Sacchi 2018), the automobile industry (Feng and Gong 2020; Münch et al. 2022), construction industry (Tushar et al. 2022), and petrochemical industry (Alavi et al. 2021; Mina et al. 2021). While plastic industry has a major contribution to the global waste generation and CE adoption is gaining traction in the plastic sector in recent times, unfortunately, no research attempt has been made to select circular supplier in the plastic industry till date.

iii. Recent research has continued emphasizing CSS practices, particularly in industries with complex SC. For instance, Tuuri et al. (2023) highlight the ongoing complexities of managing hazardous waste and toxic substance usage in recycling processes, which impedes circularity efforts. Similarly, Ncube, Cunningham, and Horbach (2023) investigate how toxic additives in plastic production complicate recycling, reinforcing the need for criteria that consider environmental and human health impacts in supplier selection models. These studies emphasize a critical gap: Although frameworks for CSS exist, there is hardly any study applying them within the plastics industry or examining their specific impact on achieving a zero-waste economy in emerging markets. This research employs COCOSO method as a robust ranking mechanism to select the most suitable supplier within the plastic industry. This approach fills the gap in existing CSS frameworks by enhancing accuracy and applicability in real-world decision-making.

iv. Previous studies used a wide variety of selection criteria, most of which are qualitative in nature. The application of quantitative criteria in SS problems is very rare. Previous authors seldom consider multiple dimensions when evaluating suppliers. Not many CSS studies concurrently consider environmental, social, and economic factors while choosing criteria. To this end, this study integrates expert validation (Delphi method) to refine the set of evaluation criteria. This structured approach ensures rigor in addressing the problem.

v. Many criteria examined in earlier research primarily pertain to productivity, profitability, and life cycle–oriented perspectives. While these criteria, such as "procurement cost," "resource efficiency," "energy consumption," "eco-design," "material recovery," and "transportation cost," offer utility, they fall short of comprehensively assessing the CE performance of suppliers. This limitation arises from their predominant focus on tangible factors, neglecting significant intangible aspects like "CSR activities," "employee wellbeing," "generation of hazardous waste," and "consumption of toxic substances," which indirectly impact CE performance. Furthermore, incorporating social criteria—such as workplace safety and employee wellbeing—into CE frameworks, is particularly relevant in high-risk production sectors like plastics. These insights have informed our inclusion of social criteria in this study, specifically "reduction in workplace hazards through employee wellbeing activities."

vi. Additionally, it has been discovered that most current MCDM-based SS models use subjective weights that do not accurately reflect real-world circumstances. To address this gap, this study employs an integrated entropy-COCOSO methodology. The entropy method ensures an objective evaluation of supplier selection criteria by minimizing subjectivity.

vii. As most of the CE business models presented in earlier research have not been verified or proven through real-world applications, their relevance to the plastic industry will be called into doubt. Thus, developing and applying an empirical model for CSS in the plastic industry to intensify its practical viability is the need of the hour.

Given the lack of established CSS frameworks in the plastic industry, this study adopts a structured multiphase methodology. The Delphi study refines the evaluation criteria, mitigating subjectivity in supplier selection. The entropy method assigns objective weights to criteria, ensuring unbiased prioritization. Finally, the COCOSO method ranks suppliers based on a comprehensive evaluation of environmental, economic, and social dimensions, bridging the gaps in prior research.

3 | Research Design

This study utilized a case study-based approach to meet its research objectives. The methodological framework follows a three-phase design, namely, the preparation phase, the weight determination phase, and the evaluation phase, as depicted in Figure 1.

In the first phase of this three-phase approach, all the critical CSS criteria were identified through an extensive literature survey. Subsequently, distinguished experts from the case organization and related fields were invited, and an expert committee was formed based on their willingness to participate in the evaluation process. The expert committee was approached to review and finalize the previously short-listed criteria through a literature survey. Furthermore, a Delphi study was carried out to adjust (add or omit) and refine the ultimate list of selection criteria. Subsequently, a questionnaire was created, and essential data and information were gathered through expert interviews for this study. In the next phase, the entropy method was applied to determine the criteria weights, which the expert committee subsequently validated. The final and third phases included using the COCOSO method to rank suppliers based on their performance scores. Next, a sensitivity analysis was performed to validate the robustness of the results derived from the integrated entropy-COCOSO method, culminating in identifying the optimal supplier.

This study adopted an MCDM technique called the entropy method to determine the criteria weights. Various MCDM approaches can be found in the literature to weigh the criteria, such as AHP, DEMATEL, and BWM (Ghosh et al. 2023c; Giri et al. 2022). Out of these methods, AHP is the most commonly used and convenient tool for weighting the criteria due to its ease of use and scope of consistency checking. The significant shortcomings of AHP include its subjectivity and reliance on experts' perceptions to be translated into numerical ratings, as well as the additional effort and time required for a more significant number of pairwise comparisons, even for a small problem. However, the entropy method offers a quantitative appraisal

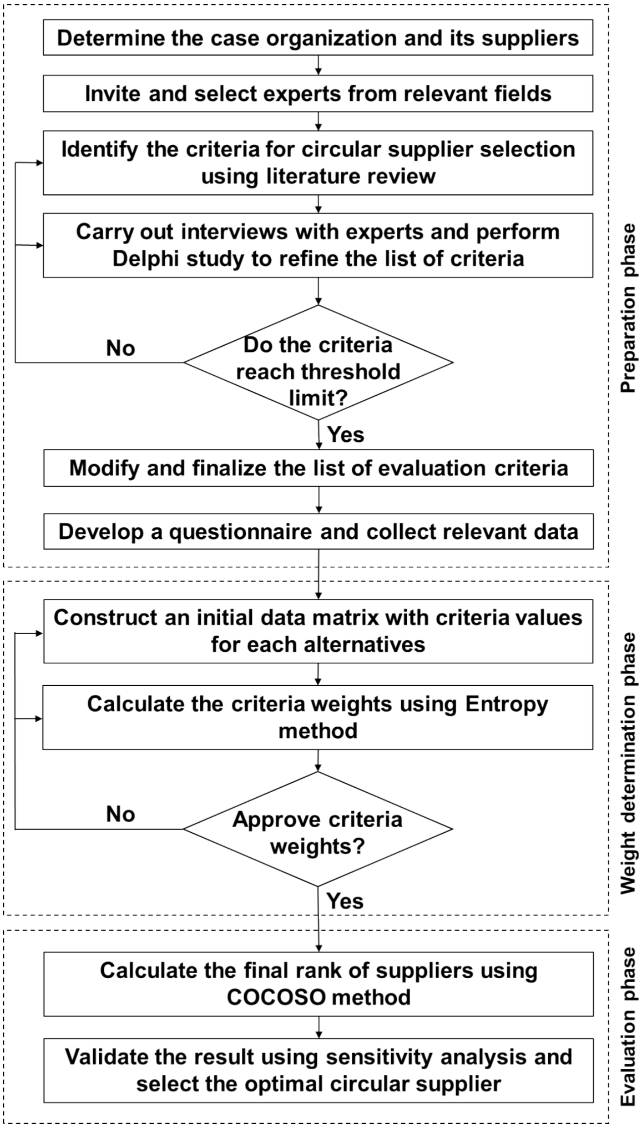

FIGURE 1 | Proposed research framework.

of criteria weight by utilizing the amount of information provided by various criteria. Thus, it minimizes subjective bias and provides higher accuracy than AHP. The entropy method does not consider the decision-maker's (DM's) preferences and may be used to assess the uncertainty of variables and how the controlling factors impact the outcome. Entropy is fundamentally a measure of the information content related to the data variability that a singular event can provide. A higher entropy value for a specific criterion indicates lower discrimination in the decision-making process.

Unlike AHP, which relies on expert judgments that can introduce subjectivity, the entropy method uses the inherent variability in the data to determine the weights. This approach ensures higher accuracy and objectivity, particularly important for complex decision-making problems involving multiple criteria.

On the other hand, the COCOSO method (Dwivedi and Sharma 2022b) was employed in this research to prioritize the suppliers. Previous authors developed and applied numerous MCDM methods to rank the alternatives. Among those, TOPSIS (Menon and Ravi 2022), COPRAS (Ghosh et al. 2023b), VIKOR (Kannan, Mina, et al. 2020), GRA (Ghosh et al. 2022b), ELECTRE (Zhong and Yao 2017), and PROMETHEE (Tushar et al. 2022) are popular. However, when used for MCDM problems, these algorithms may produce significantly different rankings due to variations in the criteria weight distributions. In other words, these approaches cannot deliver reliable and stable outcomes. To overcome this problem, applying the COCOSO method can be beneficial. The COCOSO method was initially developed by Yazdani et al. (2019). It buckles the principles of methods such as "simple additive weighting (SAW)" (Afshari et al. 2010), "weighted aggregated sum product assessment (WASPAS)" (Zavadskas et al. 2012), and "multiplicative exponential weighting (MEW)" (Zanakis et al. 1998), incorporating aggregation strategies. Despite this, it yields credible outcomes when compared to these methods. This integration enhances the robustness and reliability of alternative rankings by leveraging the strengths of the individual methods. DM can obtain a "multi-faceted compromise solution" through this method, aligning with solutions generated by other MCDM approaches. The optimal solution obtained through the COCOSO method remains robust against changes in criteria importance or the inclusion/exclusion of alternatives, highlighting its reliability and ensuring stable, accurate decision-making outcomes. Additionally, COCOSO demonstrated superior performance in generating consistent and stable results across various applications, making it well suited for our study's objective of identifying the optimal supplier forCE practices in the plastic industry.

In the literature, the combined entropy-COCOSO method was used in a few studies for different purposes such as "evaluation of anti-tank guided missiles" (Erdal et al. 2023), "selection of the most appropriate engineering sustainability components" (Dwivedi and Sharma 2022a), and "analyze the performance of SDGs" (Dwivedi and Sharma 2022b). However, the use of the integrated entropy-COCOSO technique in CSS is rare. Thus, this study sought to integrate these two MCDM approaches and apply them to solve a real-world CSS problem.

The various methodological procedures and steps of entropy and COCOSO methods are described below.

3.1 | Steps of the Entropy Method

Step 1: In this step, an initial data matrix (B) was constructed, which consisted of a alternatives and c criteria (Equation 1). Each element (b_{ij}) in the matrix implies the measure of performance of i^{th} alternative corresponds to j^{th} criterion.

$$B = \left[b_{ij}\right]_{a\times c} = \begin{bmatrix} b_{11} & \cdots & b_{1c} \\ \vdots & \ddots & \vdots \\ b_{a1} & \cdots & b_{ac} \end{bmatrix}, (1 \le i \le a; 1 \le j \le c) \quad (1)$$

Step 2: Equation (2) was used to convert matrix (B) into a normalized matrix (D) as shown below.

$$D = \left[d_{ij}\right]_{a\times c} = \frac{b_{ij}}{\sum_{i=1}^{a} b_{ij}} \quad (2)$$

where b_{ij} expresses j^{th} criterion's normalized value corresponds to i^{th} alternative.

Step 3: Equation (3) was used to determine the j^{th} criterion's entropy (s_j).

$$s_j = -f\sum_{i=1}^{a} d_{ij}.\log_e d_{ij} \tag{3}$$

f is a constant term known as the "entropy constant," which is equal to $\frac{1}{(\log_e a)}$.

Step 4: Equation (4) was used to compute the "degree of diversification" (l_j) of the j^{th} criterion.

$$l_j = 1 - s_j \tag{4}$$

Step 5: Equation (5) was used to calculate the "entropy weight" of the j^{th} criterion (q_j).

$$q_j = \frac{l_j}{\sum_{j=1}^{c} l_j} = \frac{1 - s_j}{\sum_{j=1}^{n}(1 - s_j)} \tag{5}$$

where $\sum_{j=1}^{c} q_j = 1$.

3.2 | Steps of the COCOSO Method

Step 1: An initial data matrix (B) was developed as shown in Equation (1). However, this matrix remains the same as that of the entropy method.

$$\mathrm{B} = \left[\mathrm{b_{ij}}\right]_{\mathrm{a \times c}}$$

Step 2: Equations (6) and (7) were used to convert matrix (B) into a normalized matrix (R) as shown below:

$$\mathrm{R} = \left[\mathrm{r_{ij}}\right]_{\mathrm{a \times c}}$$

$$r_{ij} = \frac{b_{ij} - min(b_{ij})}{max(b_{ij}) - min(b_{ij})} \text{ for benefit criteria} \tag{6}$$

$$r_{ij} = \frac{max(b_{ij}) - b_{ij}}{max(b_{ij}) - min(b_{ij})} \text{ for cost criteria} \tag{7}$$

Step 3: Equations (8) and (9) were used to compute the "sum of weighted comparability matrix (T_i)" and "power of weighted comparability matrix (E_i)" for each alternative, respectively.

$$T_i = \sum_{j=1}^{c} q_j r_{ij} \tag{8}$$

$$E_i = \sum_{j=1}^{c} (r_{ij})^{q_j} \tag{9}$$

Step 4: Equations (10), (11), and (12) were used to calculate the aggregation of appraisal ratings K_{ia}, K_{ib}, and K_{ic}, respectively.

$$K_{ia} = \frac{E_i + T_i}{\sum_{i=1}^{a}(E_i + T_i)} \tag{10}$$

$$K_{ib} = \frac{T_i}{min(T_i)} + \frac{E_i}{min(E_i)} \tag{11}$$

$$K_{ic} = \frac{\beta(T_i) + (1-\beta)(E_i)}{[\beta.max(T_i) + (1-\beta).max(E_i)]} \tag{12}$$

where

$(0 \le \beta \le 1)$ and the cutoff value of β is usually taken as 0.50.

K_{ia} is the "arithmetic mean" of aggregates of "WPM" and "WSM" ratings.

K_{ib} is the "sum of relative ratings" of "WSM" and "WPM" when compared to the best.

K_{ic} is the "balanced compromise" of "WSM" and "WPM" ratings.

Step 5: Equation (13) was used to determine the relative performance score (K_i) and rank the alternatives in the "decreasing order" of K_i.

$$K_i = [(K_{ia} \times K_{ib} \times K_{ic})^{\frac{1}{3}} + \frac{1}{3}(K_{ia} + K_{ib} + K_{ic})] \tag{13}$$

4 | An Empirical Case Study

Because India is in the early stages of adopting CE practices in its plastic sector, the accuracy of the proposed CSS framework is demonstrated through a case study in the Indian plastic industry. The following subsections illustrate the case study.

4.1 | Timeframe Chosen for the Case Study

The timeframe for our study spans from 2017 to 2023. This period was chosen for several reasons. Firstly, the concept of CE has gained considerable attention in recent years. The period from 2017 onward marks a critical phase during which CE principles began to be widely recognized and adopted in various industries, including the plastic industry. Secondly, the chosen timeframe guarantees the inclusion of the most recent and pertinent research, capturing the latest developments, innovations, and challenges in implementing CE practices. This helps to capture current trends and provides a contemporary understanding of the topic. Most importantly, significant policy changes and initiatives promoting CE have been introduced globally and in India during this period. For example, the amendment of the "Plastic Waste Management Rules" in India and the launch of the India Plastics Pact occurred within this period, making it highly relevant to our study.

4.2 | Selection of the Case Organization and Problem Statement

The CSS framework proposed in this research was implemented on "Company XYZ," a distinguished plastic manufacturing firm with a 37-year business tenure. As one of the leading plastic companies in India, Company XYZ is recognized for producing robust and durable products that enjoy widespread popularity in the domestic market. The firm continually exploits its brand by expanding its distribution network and releasing new items, increasing its financial gains. Beyond financial performance, the company is dedicated to achieving sustainable performance by embracing various environmentally friendly and socially viable practices in its latest initiatives. Table 2 shows details of the case organization.

In producing plastic components, a substantial volume of waste is generated, leading to environmental pollution and a depletion of natural resources. On the contrary, according to government legislation and the country's law, recovering, reusing, and recycling manufacturing waste are vital from the sustainability viewpoint. Currently, there is no recycling facility in the manufacturing units of Company XYZ to retain the value from recovered waste components. However, the company remains unable to balance financial profits and ecological footprints. There has recently been a drive among strategic managerial levels to implement CE practices in their SC operations and shift toward the CE systematically. Apart from these, the company also conducts regular supplier engagement and environmental audit programs. The company is seeking suppliers/vendors to supply raw materials and subassemblies for a new component designed by its R&D engineers. Therefore, a CE-focused SS is the best answer for its requirements. Four suppliers with a prior affiliation with the company are considered potential alternatives. All of these suppliers possess the capability to manufacture the required components. Consequently, the executives of Company XYZ have consented to participate in this research.

4.3 | Formation of Experts' Committee and Demographic Profile

Experts were selected based on their specialized knowledge, organizational hierarchy level, and years of professional experience. Careful consideration was given to ensuring that the chosen experts were familiar with the basic concept of CE and had prior involvement with CE activities in their corporate roles, academic/research pursuits, or administrative duties. Initially, 18 management professionals spanning the company's strategic, tactical, and operational levels were invited, and 12 experts expressed eagerness to participate in the research. Additionally, four emeritus professionals from diverse industrial domains, four distinguished educators from reputable technology universities/colleges, and five high-ranking government officials (both state and central) were approached, all of whom agreed to contribute. As a result, a DM committee consisting of 25 experts was established. Each expert held a diploma-level qualification and had at least 10 years of combined industry and academic experience, ensuring they possessed the necessary expertise for the research. The experts were engaged through telephone conversations, site visits, and emails. They were asked to provide their demographic information, as presented in Table 3.

The sample size for our study was determined based on several considerations, including the nature of the research, the methodologies employed, and precedents set by similar studies in the field. The sample size of 25 experts ensures a diverse and representative group, incorporating various perspectives from different levels of the organization (strategic, tactical, and operational) and external experts from academia and government. This diversity helps capture a comprehensive view of the criteria relevant to CSS in the plastic industry. A sample size of 25 experts was considered adequate for this study, given its exploratory nature and reliance on expert judgment within the context of MCDM frameworks and Delphi studies, where smaller but well-qualified expert panels are typical and often recommended. Studies indicate that expert panels ranging from 10

TABLE 2 | Business profile of the case organization.

Size of the business		Large scale
Industrial segment		Manufacturing
Origin		North-eastern India
Number of employees		3500
Operating revenue for the financial year 2023		INR 150 cr. to 430 cr.
Types of products manufactured		Engineering molded furniture, material handling crates, travel luggage accessories, dining tables and chairs, PVC pipes and fittings, plastic sheets, and disposable containers
No. of manufacturing facilities		10
No. of retail outlets		500
Market share	Organized market	15%
	Unorganized market	> 50%
Certifications		ISO14001; ISO 9001

TABLE 3 | Demographic profile of experts.

Particulars	Affiliation/levels	Designation/job roles	Qualification	Gender	Experience (years)
Intraorganizational experts	Strategic level of Company XYZ	Managing director	MBA	M	35
		Personnel manager (HR)	MBA	F	30
		Chief financial officer	CA	F	28
		Head marketing officer	MBA	F	32
		Planning executive	Ph.D.	M	28
	Tactical level of Company XYZ	Chief supervisor	M.Com.	M	27
		Project manager	M.Tech.	M	25
		Operations manager	MBA	M	21
	Operational level of Company XYZ	Procurement head	BBA	M	20
		Maintenance supervisor	B.Tech.	M	20
		Quality control engineer	B.E.	M	18
		Line staff	Diploma	M	12
Interorganizational experts	Sole proprietorship business	Chairman and managing director cum entrepreneur	M.A.	M	10
	Multinational corporation	Senior technical officer	Ph.D.	M	17
	Freight consultancy agency	Logistics consultant	MBA	F	14
	A large-scale service organization	Head of 'research planning and business development'	Ph.D.	F	15
Academician and/or research community	Central technology university	Professor in production engineering (with specialization in operations and supply chain management)	Post Doc.	M	23
	State engineering college	Associate professor in Industrial engineering (with specialization in ergonomics)	Ph.D.	F	16
	"Central leather research institute"	Principal scientist and Honorary faculty	D.Sc.	F	26
	"Central building research institute"	Group Leader (Polymers, Plastics and Composites)	M.Sc.	M	14

(Continues)

TABLE 3 | (Continued)

Particulars	Affiliation/levels	Designation/job roles	Qualification	Gender	Experience (years)
Public sector officials and government employees	"Council of scientific and industrial research (Govt. of India)"	Chief scientist of central chemical research institute	Post Doc.	F	29
	A public sector undertaking company	Assistant executive engineer	M.Tech.	F	11
	"The ministry of micro, small, and medium enterprises (Govt. of India)"	Joint economic advisor	M.Com.	M	24
	Public service commission (Govt. of West Bengal)	Industrial development officer	B.Tech.	F	19
	"Central board of pollution control (the ministry of environment, forest, and climate change, Govt. of India)"	Executive director (Operations)	M.Sc.	M	18

to 30 participants are generally adequate when experts possess specialized knowledge, and the aim is to capture a well-rounded, in-depth perspective on complex issues (Hasson et al. 2000; Okoli and Pawlowski 2004). The Delphi method, employed to refine and validate the criteria for CSS, relies on iterative feedback from a panel of experts. A sample size of 25 is adequate to facilitate multiple rounds of surveys and achieve consensus while also allowing for a manageable data collection and analysis process. Studies by Linstone and Turoff (2002) suggest that the Delphi method's effectiveness is more influenced by the expertise and engagement of the participants rather than the sheer size of the panel. By carefully selecting experts with substantial experience and knowledge in CE and the plastic industry, we ensured the quality and reliability of the feedback. Additionally, for MCDM studies, the effectiveness of decision-making and criteria validation does not necessarily increase with a larger sample size as long as the panel includes experts with high domain relevance and experience (Hsu and Sandford 2007).

Similar studies in supplier selection and CE have employed comparable sample sizes. For instance, studies by Govindan et al. (2020) and Kannan, Govindan, and Rajendran (2020) employed similar sample sizes to assess expert perspectives on sustainability criteria within supplier selection contexts. These studies demonstrate that in-depth insights from a selected panel of knowledgeable experts can be sufficient to establish robust decision frameworks, particularly when applying structured methodologies like the Delphi approach. Khalili Nasr et al. (2021) used a sample of 20 experts in their Delphi study on sustainable supplier selection. Alavi et al. (2021) also utilized a panel of 22 experts to research supplier selection in the petrochemical industry. These studies support the adequacy of our sample size. Ghosh et al. (2022d) conducted a study on green supplier selection using a sample size of 18 experts, demonstrating that our sample size of 25 is consistent with established practices in the literature. By selecting a sample size of 25 experts, we ensured a balance between diversity and manageability, enabling us to gather comprehensive and high-quality data for our study. This sample size is supported by the methodological requirements of the Delphi method and aligns with precedents set by similar research in the field.

4.4 | Identification and Validation of the Evaluation Criteria

4.4.1 | Initial Screening of Criteria

The assessment criteria for CSS were determined through a comprehensive literature review. The inclusion criteria are as follows:

i. Date of publication: Articles published between 2017 and 2023 were included to ensure the study is grounded in the most recent and relevant research.

ii. Relevance to CE: Studies that explicitly address CE concepts, frameworks, and practices, particularly in the context of the plastic industry, were considered. A comprehensive search of scholarly articles from reputable international journals was conducted, utilizing keywords such as "circular economy," "circular economy performance evaluation," and "circular supplier selection," along with "plastic industry."

iii. Focus on SS: Research that discusses SS, MCDM methods, and sustainability criteria in the context of CE was considered. Furthermore, an in-depth review of various contemporary topics such as "closed-loop supply chain," "reverse logistics," "green supply chain management," and "sustainable supply chain management" was undertaken, given the overlapping principles of these concepts with CE.
iv. Geographical relevance: Articles that focus on emerging economies, particularly India, were considered to provide context-specific insights and relevance.
v. Peer-reviewed sources: Only peer-reviewed journal articles and reputable industry reports were considered to ensure the reliability and validity of the included research. The following web platforms were browsed for the extraction of relevant articles: IEEE Xplore (https://ieeexplore.ieee.org/Xplore/home.jsp), Wiley Online Library (https://onlinelibrary.wiley.com/), Springer (https://link.springer.com/), Taylor & Francis Online (https://www.tandfonline.com/), Emerald Insight (https://www.emerald.com/insight/), and Elsevier (https://www.elsevier.com/en-in). Searches were conducted on Google Scholar (https://scholar.google.com/) and ResearchGate (https://www.researchgate.net/) to supplement the initial findings.

On the other hand, the exclusion criteria are as follows:

i. Non-English publications: Articles not published in English were excluded to avoid translation biases and ensure clarity in understanding the research context.
ii. Irrelevant topics: Studies that do not focus on CE, SS, or the plastic industry were excluded to maintain the focus and relevance of the literature review.
iii. Duplicate studies: Articles that were redundant or did not add new insights beyond what was already included were excluded to avoid repetition.
iv. Gray literature: Unpublished reports, working papers, and non-peer-reviewed sources were excluded to ensure the credibility and academic rigor of the literature.

Applying these inclusion and exclusion criteria ensured a comprehensive and focused review of the most relevant and recent literature, providing a rigid base for our study. Considering all these sources, a total of 76 scholarly articles, chosen after screening over 150 publications, were considered, encompassing the most recent and highly cited works in the aforementioned areas. After going through these papers, 10 critical evaluation criteria were determined. Because there has been no study into developing an appropriate set of qualitative criteria for CSS, the proposed criteria in this research were derived from the notion of two or more similar qualitative criteria and verified by the experts afterward.

4.4.2 | Refinement and Finalization of Criteria Using a Delphi Study

After the evaluation criteria were screened, they were presented to the DM committee, and the Delphi method was used to refine and finalize them based on their relevance and importance for implementing CE practices in the plastic industry. The Delphi process was conducted through three evaluation sessions using Google Forms. After each round, the experts received a detailed summary of the collective results and feedback from anonymous experts.

The inaugural phase of the Delphi study commenced with a brief survey on the concept of the CE approach to establish a uniform perspective among experts from the outset of the research. Subsequently, the experts were briefed on the progression of CE knowledge within the research framework through an accessible and interactive documentary. It was crucial to have this level of understanding of the subject to respond more accurately, avoid misinterpretation, and draw rational conclusions. The experts were requested to assess the applicability of the chosen criteria in the second session by only marking "Yes" as relevant and "No" as irrelevant. Furthermore, based on their expertise and experience, experts were asked to propose any additional criteria pertinent to CSS. Following that, two experts proposed three more criteria: "total emissions from logistics operations," "increase in scrap recycling rate," and "total consumption of toxic substances."

At the end of the second Delphi session, 13 criteria were retained for the final session. In the last stage, experts were asked to assess the individual importance of each criterion of the CE-based supplier evaluation problem. To gather their input, a set of structured questionnaires was designed and distributed to the experts for their individual responses. The questionnaire included provisions for assigning numeric ratings to each of the 13 criteria based on a "5-point Likert-type" scale. On this scale, a rating of 5 indicates that the criterion is extremely important, whereas a rating of 1 suggests that the criterion is not important at all. The remaining values (2, 3, and 4) denote intermediate levels of importance.

Subsequently, the responses from individual experts were collected, compiled in a Microsoft Excel datasheet, and synthesized using MINITAB software. Descriptive statistics analysis, including parameters such as "mean," "median," and "standard deviation (SD)," was conducted in MINITAB. Following the guideline, Ghosh et al. (2023c) mentioned that "the threshold of mean and median should not be less than 4 to get approved by the Delphi study," criteria with mean and median values exceeding 4 were approved, but others were rejected. The descriptive analysis for the Delphi study is presented in Table 4. Out of the 13 criteria, five failed to surpass the threshold limit for both mean and median and were consequently rejected. Therefore, eight criteria were ultimately accepted as evaluation criteria.

After multiple adjustments and discussions with the DM committee experts, the final set of criteria was determined. Table 5 displays the final criteria, including their notations, sources, units, type, dimensions, and relevance to CE adoption in the plastic industry.

4.5 | Framing of Instrument and Data Curation

In this study, a set of structured questionnaires was utilized to gather essential data and information. The questionnaire comprised three parts with standardized questions and fixed objectives. The first part focused on obtaining preliminary details of

TABLE 4 | Descriptive analysis for the Delphi study.

No.	Criteria	Mean	Median	SD	Accepted/rejected?
Initial criteria (extracted from the literature review)					
1	"Investment in corporate social responsibility activities"	4.6000	5	0.547720	Accepted
2	"Reduction in workplace accidents and risks by adopting employee wellbeing activities"	4.2000	5	1.207120	Accepted
3	"Reduction in hazardous waste generation"	4.1428	4	1.715170	Accepted
4	"Investment in research and development"	3.6666	5	1.799470	Rejected
5	"Percentage reduction in electricity consumption"	4.5333	5	0.743223	Accepted
6	"Returns from sale of recycled waste products"	4.2666	5	0.883715	Accepted
7	"Waste water treatment capacity"	2.6000	3	0.54772	Rejected
8	"Total raw material consumption"	4.0714	4	0.813250	Accepted
9	"Increase in cost for purchasing environment-friendly material"	3.4000	3	1.055600	Rejected
10	"Investment in research and development"	3.3333	3	1.234430	Rejected
Additional criteria incorporated (derived from experts' recommendations)					
1	"Total emissions from logistics operations"	4.1333	4	0.990430	Accepted
2	"Increase in scrap recycling rate"	3.8000	4	0.836666	Rejected
3	"Total consumption of toxic substances"	4.0666	4	0.798809	Accepted

the experts, including designations, job roles, fields of expertise, years of experience, and other basic information. The second section addressed questions related to the research scope, whereas the final part covered various topics, including constraints to CE practice implementation, suggestions, improvement measures, and strategies. To guide the experts, the questionnaire provided concise explanations for each criterion and its relevance to the CSS process.

Before data collection began, the questionnaire was pilot-tested with members of the DM committee and five supply chain management (SCM) professionals from a reputable multinational company (MNC) who were not part of the DM committee to identify potential areas for improvement. The questionnaire was revised three times based on expert feedback to ensure content validity and minimize bias. The printed and electronic versions of the questionnaire were distributed to each DM committee member. Before data collection, the research objectives were explained to the management representatives of the case organization, along with an outline of how the collected data would be used. To reduce expert bias in the data collection process, individual face-to-face interviews were scheduled with each of the 12 experts from the case organization. The responses from these experts were compiled, and secondary data were also gathered from corporate websites, annual reports, and historical databases.

4.6 | Application of Integrated Entropy-COCOSO Methodology

Upon gathering the necessary data, analysis and methodological calculations were conducted using Microsoft Excel. Table 6 presents a data matrix outlining the criterion values for each alternative. The data matrix was developed by compiling performance data for each criterion across the four suppliers considered in the study. This matrix forms the basis for implementing the entropy-COCOSO methodology to assess each supplier's engagement in CE practices.

Each entry in the matrix represents the value of a specific criterion for a given supplier based on quantitative data gathered through expert interviews and the company's historical database/records. For example, consider the value **35.36** under "Supplier B" for the criterion "Investment in corporate social responsibility activities" (C1). This value represents the monetary investment (in Lakhs INR per year) Supplier B allocates to CSR initiatives related to environmental protection, job creation, and community welfare. This information was obtained through the following process:

Firstly, data were gathered from Supplier B's CSR reports, corporate websites, and financial disclosures. Additionally, input from Supplier B's representatives was solicited through structured questionnaires and follow-up interviews, which helped confirm the reported CSR investments and verified that these figures were relevant to CE-related activities. Secondly, because the reported CSR investments might vary in format or currency, all monetary data were standardized to Lakhs INR per year to ensure uniformity across all suppliers. Finally, the gathered value was validated by cross-referencing it with external data sources, including industry benchmarks for CSR spending in similar organizations within the plastics sector. This value, therefore, captures a precise, validated measure of Supplier B's commitment to CSR, reflecting their level of investment

TABLE 5 | Final set of evaluation criteria for CSS.

Criteria name with notations	Qualitative attributes from which the criterion was derived	Relevance to the CE adoption in the plastic industry	Source	Unit	Type	Dimension
Investment in corporate social responsibility activities (C1)	• Social commitment • Ethical issues • Green research and development • Environmental protection activities • Creating job opportunities • Social wellbeing • Poverty eradication • Health and wellbeing • Social responsibilities • Food security • Gender equality • Child and forced labor issues	The issue lies not with plastic but with the need for businesses and individuals to undergo reform. Businesses must balance environmental and social responsibilities with revenue goals. In addition to leveraging technology for efficient plastic waste reuse, recovery, and recycling, there is an urgent need for widespread education on proper plastic use and disposal through CSR initiatives. Companies should embrace a strategic approach to formulate impactful CSR and sustainability initiatives, promoting them to enhance brand visibility and cultivate a positive perception among consumers	Dey et al. (2020); Ethirajan et al. (2021); Kannan, Govindan, and Rajendran (2020); Khalili Nasr et al. (2021); Mina et al. (2021); Oliveira et al. (2021); Münch et al. (2022); Tushar et al. (2022)	Lakhs INR/Year	Benefit	Social/economic
Reduction in workplace hazards through employee wellbeing activities (C2)	• Stakeholders' interests and rights • Human rights and ethical issues • Occupational health and safety measures • Staff empowerment and motivation • Accident reduction • Decent labor condition • Predictive maintenance • Resilient infrastructure	In contrast to the plastic industry, there is practically little emphasis on employees, suppliers, dealers, retailers, and vendors. Plastic manufacturers operating in the modern era mainly emphasize customer-related initiatives such as customer feedback, engagement, and outreach programs. On the other hand, employee-related initiatives are very rare and are mostly limited to training and meetings. However, concerning occupational health and safety, workplace hazards, and the risk of accidents, companies should be more proactive and take preventive measures	Dey et al. (2020); Ethirajan et al. (2021); Kannan, Govindan, and Rajendran (2020); Yadav et al. (2020); Alavi et al. (2021); Khalili Nasr et al. (2021); Oliveira et al. (2021); Diaz et al. (2022)	Percentage	Benefit	Social

(Continues)

TABLE 5 | (Continued)

Criteria name with notations	Qualitative attributes from which the criterion was derived	Relevance to the CE adoption in the plastic industry	Source	Unit	Type	Dimension
Reduction in hazardous waste generation (C3)	• Managing byproducts and waste • Hazardous waste management • Waste reduction • Waste generation • Recycled waste, water, or materials • Hazardous substances • Using environmentally friendly and recyclable goods • Selection of biodegradable items • Lean practices • Eco-design • Clean technologies in the production and recycling of products	Reducing hazardous waste is critical for building a CE. Disposing of plastic waste poses numerous environmental challenges, such as (i) incineration, which emits toxic gases into the atmosphere; (ii) contaminated plastics may leak dangerous substances into the ground, which may subsequently seep into surrounding water sources; (iii) the reckless dumping of plastic garbage on land renders it infertile. These actions harm human health and the environment and accelerate climate change. To mitigate these issues, companies must devise strategies to use and reuse resources, keeping as much as possible from going to waste and damaging the environment	Horbach and Rammer (2019); Prieto-Sandoval et al. (2019); Dey et al. (2020); Govindan et al. (2020); Hussain and Malik (2020); Kannan, Mina, et al. (2020); Moktadir et al. (2020); Haleem et al. (2021); Khalili Nasr et al. (2021); Münch et al. (2022); Diaz et al. (2022)	Tons	Benefit	Environmental
Percentage reduction in electricity consumption (C4)	• Reduction in energy consumption • Cost reduction • Use of renewable or alternative energy sources • Sustainable energy sources for production • Energy-efficient design	The plastic industry is distinguished by diverse energy flows at various temperature levels, with electricity as its primary source. This energy consumption in plastic processing is associated with the following utilities: heating and melting, cooling via HVAC systems and chillers, and powering auxiliary equipment like grinders, compressors, pumps, driers, and blowers. Plastic molding is an energy-intensive process, and as wasting energy has negative financial and environmental consequences, it does not make any sense to waste it. Thus, the potential for energy savings in the plastics industry is relatively high and may be achieved through the use of key corrective measures	Horbach and Rammer (2019); Prieto-Sandoval et al. (2019); Dey et al. (2020); Hussain and Malik (2020); Haleem et al. (2021); Diaz et al. (2022)	Percentage	Benefit	Economic

(Continues)

TABLE 5 | (Continued)

Criteria name with notations	Qualitative attributes from which the criterion was derived	Relevance to the CE adoption in the plastic industry	Source	Unit	Type	Dimension
Returns from sale of recycled waste products (C5)	• End-of-life returns • Reverse logistics practices • Recycling cost • Improved recycling of products after use • Cooperation with customers to retrieve products • Return on investment • Resale value • Material recovery • Managing returned products • Return of goods • Quantity of returned products	CE aims to prolong the useful life of items and increase their chances of resale. This approach directly reduces natural resource consumption and promotes recycling waste into secondary raw materials. However, the recycling industry is emerging as an ancillary industry that can provide millions of job opportunities and generate substantial revenue. Plastic food containers, baggage, clothing, furnishings, benches, flooring, pipes, tables, and fencing may be made from recycled plastic containers.	Horbach and Rammer (2019); Prieto-Sandoval et al. (2019); Dey et al. (2020); Ethirajan et al. (2021); Hussain and Malik (2020); Moktadir et al. (2020); Alavi et al. (2021); Haleem et al. (2021); Tushar et al. (2022); Muneeb et al. (2023)	Lakhs INR/Year	Benefit	Economic
Total raw material consumption (C6)	• Sustainable resource management • Resource efficiency • Scarcity of resources • Extended product life • Recovery of resources • Product service life • Sustainable material selection • Design for repair and remanufacture • Resource consumption • Natural resource depletion • Design of products to reuse	The physical building blocks of the economy are material resources. Economic growth typically entails rising demand for raw materials that, if improperly handled, become waste. Using raw materials derived from natural resources and associated production and consumption processes impacts the environment, economy, and society. Plastics are manufactured from raw materials like crude oil, natural gas, coal, cellulose, and salt. CE in the plastic industry introduces an innovative production and consumption model to foster sustainable growth. It achieves this by advocating resource optimization, minimizing raw material consumption, and promoting waste recovery through recycling and reusing	Horbach and Rammer (2019); Prieto-Sandoval et al. (2019); Dey et al. (2020); Ethirajan et al. (2021); Moktadir et al. (2020); Yadav et al. (2020); Haleem et al. (2021); Khalili Nasr et al. (2021); Oliveira et al. (2021); Diaz et al. (2022)	Tons	Cost	Environmental

(Continues)

TABLE 5 | (Continued)

Criteria name with notations	Qualitative attributes from which the criterion was derived	Relevance to the CE adoption in the plastic industry	Source	Unit	Type	Dimension
Total emissions from logistics operations (C7)	• Reduction in carbon emission • Air pollution • Eco-friendly transportation • Development of a sustainable logistics system • Carbon offsetting • Optimization of logistics • Pollution control initiatives • Carbon emission in transporting a single product	Logistics ties exist between resources and goods and between products and customers. Heavy trucks and freight vehicles contribute approximately half of all GHG emissions in plastic production, particularly when transporting raw materials and finished products. CE establishes a closed loop of material flows within the plastic SC, incorporating logistics activities. This approach seeks to optimize resource utilization and minimize environmental impacts across the entire life cycle of plastic products. It also helps reduce the environmental footprint of logistics and delivery processes by cutting waste, costs, and carbon emissions from the first mile to the last	Prieto-Sandoval et al. (2019); Dey et al. (2020); Yadav et al. (2020); Haleem et al. (2021); Münch et al. (2022); Tushar et al. (2022); Muneeb et al. (2023)	Tons	Cost	Environmental
Total consumption of toxic substances (C8)	• Reduction in the usage of toxic materials • Hazardous substances • Eco-friendly raw material • Clean technology • Toxic additives and substances • Eco-toxicity • Human toxicity potential • Eutrophication	Making products with less harmful chemicals simplifies recycling, protects the environment, and is essential to establishing a CE. Recycling harmful chemical-containing plastics is not recommended. These toxic compounds may re-emerge into waste-derived end-products, posing serious threats to humans and the environment. The compounds may potentially represent unknown hazards due to differences in exposure and environmental emission paths from new waste management techniques instead of standard treatment	Prosman and Sacchi (2018); Horbach and Rammer (2019); Hussain and Malik (2020); Maione et al. (2022); Münch et al. (2022)	Tons	Cost	Environmental

in sustainability-oriented activities that align with CE goals. Similarly, the remaining values were obtained. After creating the initial data matrix, the integrated entropy-COCOSO approach was applied for further analysis.

4.6.1 | Calculating Relative Weights of Criteria Using Entropy Method

In this step, the entropy method was employed to compute the objective weights of the criteria. Initially, a data matrix with four alternatives (suppliers) and eight criteria was created, as illustrated in Table 6. Subsequently, the data matrix was normalized using Equation (2) and is presented in Table S1 (*refer to Annexure A*). After that, for entropy (s_j) and degree of diversification (l_j), the entropy weights of each criterion were computed using Equations (3) and (4), respectively, and are detailed in Table S2 (see Annexure A). Then, the entropy weights of the criteria were computed using Equation (5), as shown in Table 7.

Based on the objective weights obtained from the entropy method, the criteria are ranked as follows: $C8 > C2 > C4 > C1 > C5 > \; C6 > C3 > C7$. Figure 2 shows the weight distribution among the evaluation criteria through a radar chart. Therefore, C8 can be entitled as the most influential criterion for CSS.

4.6.2 | Calculating Performance Scores and Ranking the Alternatives Using the COCOSO Method

In this step, the COCOSO method was employed to calculate the performance scores of supplier organizations and rank them accordingly. The initial data matrix (B) remains the same as that of the entropy method, that is, Table 6. Subsequently, the data matrix was normalized using Equations (6) and (7) and is presented in Table S3 (*refer to Annexure A*). Thereafter, the "sum of weighted comparability matrix (T_i)" and "power of weighted comparability matrix (E_i)" for each alternative were calculated using Equations (8) and (9), respectively, and shown in Tables S4 and S5, respectively (*see Annexure A*). Then, the aggregation of appraisal ratings (K_{ia}, K_{ib}, and K_{ic}) were calculated using Equations (10), (11), and (12), respectively. The alternatives were ranked based on K_{ia}, K_{ib}, and K_{ic} values separately and shown in Table 8. Finally, the relative performance score (K_i) of each alternative was calculated using Equation (13), and final ranking of the alternatives was done based on the descending order of K_i values as shown in Table 8.

Table 8 shows that supplier organizations were ranked on K_{ia}, K_{ib}, K_{ic}, and K_i values individually, and in all the cases, results yield the same ranking: Supplier A > Supplier C > Supplier B > Supplier D. Figure 3 compares the rankings of supplier organizations across different cases, with Supplier A consistently achieving the top position.

4.7 | Sensitivity Analysis

A sensitivity analysis was performed to evaluate the robustness of the results, examining how small changes in input parameters affect the output variable in a given scenario. In this research, the sensitivity model proposed by Ghosh et al. (2023b)

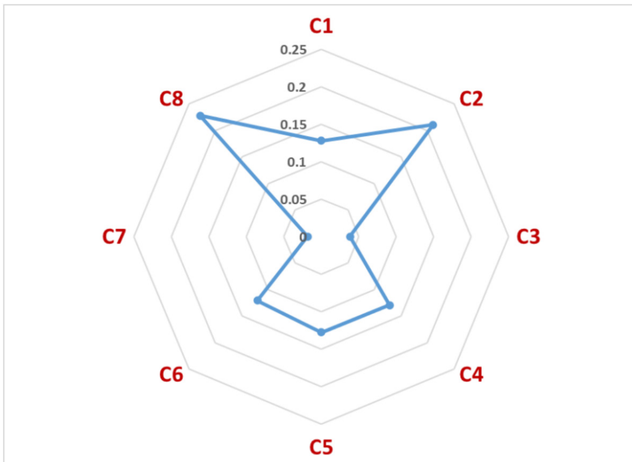

FIGURE 2 | Radar chart of criteria weights.

TABLE 6 | Initial data matrix (B).

Criteria Alternatives	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*
Supplier A	27.75	17.86	1074	25.00	21.60	50,491	19,968	1550
Supplier B	35.36	14.30	977	16.34	28.87	68,377	22,998	1336
Supplier C	18.60	23.90	1248	13.39	35.50	48,966	20,600	1421
Supplier D	22.75	32.23	879	21.89	19.53	85,096	17,865	2789

TABLE 7 | Entropy weights of criteria (q_j).

Criteria	C1	C2	C3	C4	C5	C6	C7	C8
Weights (w_j)	0.12774	0.21059	0.03804	0.12908	0.12748	0.12041	0.01825	0.22841
Ranking	4	2	7	3	5	6	8	1

TABLE 8 | Ranking of the supplier organizations.

Suppliers	Rank based on K_{ia}		Rank based on K_{ib}		Rank based on K_{ic}		Rank based on K_i	
	K_{ia} value	Rank	K_{ib} value	Rank	K_{ic} value	Rank	K_i value	Rank
Supplier A	0.32087	1	3.616206	1	0.996967	1	2.694435	1
Supplier B	0.249341	3	2.974881	3	0.774724	3	2.16437	3
Supplier C	0.261809	2	3.293358	2	0.813461	2	2.344701	2
Supplier D	0.16798	4	2	4	0.521927	4	1.45635	4

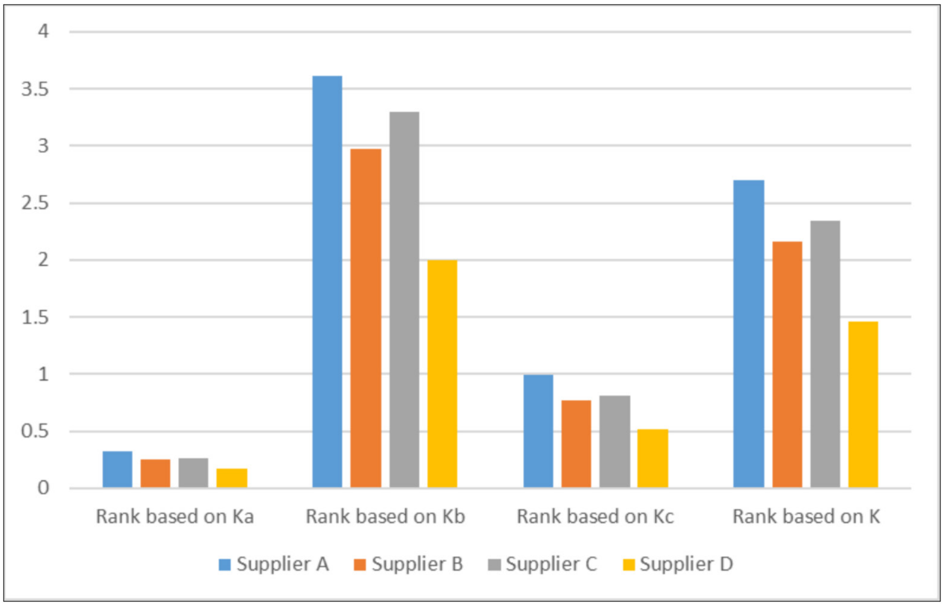

FIGURE 3 | Comparison in the ranking of alternatives.

was adopted. The following governing equations were utilized to formulate a selection index (SI_i) for each supplier organization (alternative) in this model.

$$SI_i = \alpha \times SFM_i + (1 - \alpha) \times OFM_i \tag{14}$$

$$OFM_i = \left[OFCM_i \times \sum_{i=1}^{n} OFCM_i^{-1}\right]^{-1} \tag{15}$$

In Equation (14), SI_i is the output variable, and SFM_i, α, and OFM_i are input variables.

SFM_i refers to the "subjective factor measure" of the i^{th} alternative, derived from the relative performance scores (K_i) of alternatives, as shown in Table 8.

OFM_i denotes the "objective factor measure" of the i^{th} alternative, representing the contribution margin of various alternatives. In Equation (14), α ($0 \le \alpha \le 1$) represents the DM's attitude, reflecting their preference for a specific criterion (j^{th} criterion). The DM's perspective is crucial in selecting the optimal alternative. However, existing sensitivity models often neglect the DM's preferences regarding evaluation criteria. This research integrated the DM's attitude to the sensitivity model. In Equation (15), $OFCM_i$ represents the "objective factor contribution margin" of the i^{th} alternative, calculated based on the performance measure (x_{ij}) of i^{th} alternative for the j^{th} criterion. Thus, SFM values remain unchanged, and α and OFM values vary when the DM's preference for a criterion is adjusted. The alternative with the higher SI value is preferred and selected as the optimal alternative. The sensitivity model proposed in this study predicts the change in SI value resulting from any alteration in the α value. Figure 4 shows the selection priority of supplier organizations to variations in the α value, highlighting the most influential criterion (C8) the DM perceives.

Figure 4 illustrates that within the α range of 0 to approximately 0.09, the ranking order is Supplier B > Supplier C > Supplier A > Supplier D. A break-even point occurs at $\alpha \approx 0.09$, where the selection priority is Supplier B = Supplier C = Supplier A > Supplier D, indicating any of these three suppliers can be chosen over Supplier D. For α values between 0.09 to 1.00, the ranking shifts to Supplier A > Supplier C > Supplier B > Supplier D. Excluding the break-even point as α approaches 1, the ranking aligns exactly with the results from the integrated entropy-COCOSO methodology. This affirms that the sensitivity analysis's outcome maintained the results' robustness.

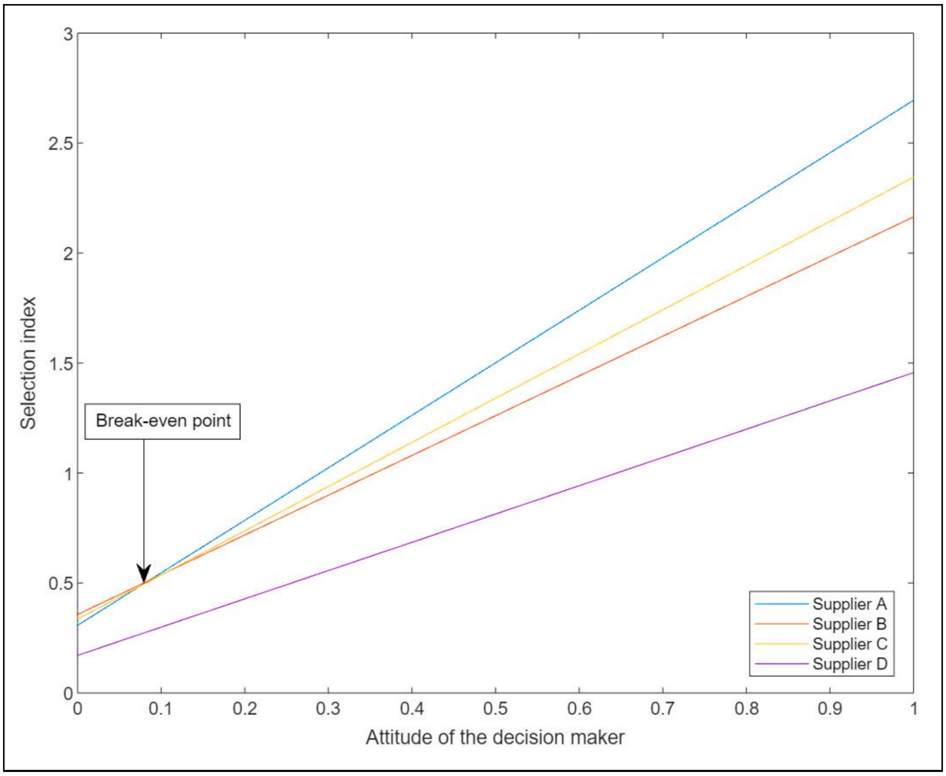

FIGURE 4 | Sensitivity plot.

5 | Discussion on Findings

This study shows some resemblances with a few of the recent research, such as Mina et al. (2021), Tushar et al. (2022), and Feng and Gong (2020), in which the authors assessed and selected circular suppliers in different contexts. The scarcity of effective, unified, and objective CE performance indicators within CSS decisions has emerged above all in the existing knowledge base. The proposed framework, consisting of eight influential criteria and three prime dimensions of sustainability (environmental, social, and economic), can aid in selecting appropriate suppliers from a CE viewpoint. The proposed framework was then applied to an Indian plastic manufacturing company, with input from 25 reputed professionals aided by the integrated entropy-COCOSO methodology, to evaluate and rank four potential suppliers regarding their degree of involvement in CE practice implementation.

The empirical findings of this research are presented in Table 8.

Table 7 shows that the top two evaluation criteria that gained relatively higher weights than others include "total consumption of toxic substances (C8)" with a weight of 0.22841 and "reduction in workplace hazards through employee wellbeing activities (C2)" with a weight of 0.21059. Other four criteria, namely, "percentage reduction in electricity consumption (C4)," "investment in corporate social responsibility activities (C1)," "returns from the sale of recycled waste products (C5)," and "total raw material consumption (C6)" secured 3rd, 4th, 5th, and 6th positions with relative weights of 0.12908, 0.12774, 0.12748, and 0.12041, respectively. The remaining two criteria, namely, "reduction in hazardous waste generation (C3)" and "total emissions from logistics operations (C7)," held the last two positions (i.e., 7th and 8th) in the ranking with weights of 0.03804 and 0.01825, respectively. C8 was the most influential criterion among these eight criteria because a CE cannot coexist with toxic substances. The common conception of the CE is flawed because most resources and products use toxic chemicals. These cannot be recycled and are perpetually involved in the recycling process. During recycling, poisonous chemicals remain in the loop. As most of these substances are not biodegradable, they build up and accumulate in the environment, where they could pose a threat to ecosystems (Tuuri et al. 2023). This implies that even if recycling is done with 100% efficiency, toxic substances will still be reconstituted. This has to change since recycling is useless if we continue to use toxic substances. So, to effectively implement CE, poisonous substances should be removed from the products and replaced with nontoxic alternatives. Therefore, organizations should prioritize this criterion to achieve higher CE performance.

The top two evaluation criteria are of environmental and social dimensions. This underscores a noteworthy observation that, despite financial gain being the primary concern for the industrial sector in developing countries, criteria associated with the environment and society are garnering significant attention from experts, managers, and industry practitioners in recent times. This is a substantial and intriguing finding from this study. Table 8 depicts the performance scores of the four potential suppliers with their respective rankings. The final ranking shows that Supplier A outperformed other suppliers with a K_i value of 2.694435 (the more significant, the better). Suppliers C, B, and D follow, respectively. Therefore, Supplier A is the top supplier and can be recommended to the Indian plastic manufacturing company for contracting/collaborating. However, it can be suggested that other suppliers consider Supplier A as a benchmark organization and adhere to its strategies to improve their performance. Some of this research findings support the claims/arguments of previous scholars, and some findings differ from the earlier research outcomes, which underpins the novelty of this research. A concise comparison of the current findings with those from previous studies is presented in Table 9, highlighting the notable results.

6 | Research Implications

6.1 | Theoretical Contributions

The two most important issues for modern SCM are SS and CE, but typically, these two topics are viewed separately. This study fills this gap by advocating SS in a CE environment, which seems more reasonable given recent advancements and the pressing need to move toward CE. The case illustrated in this research addresses a common and contemporary problem in SCM, which interests industry practitioners and researchers. As no prior studies have addressed CSS in the plastic industry, this research fills a significant gap in the literature. To the best of the authors' knowledge, it represents the first empirical effort to evaluate and identify circular suppliers in the plastic sector, particularly in emerging economies like India, where the industry is crucial for economic growth and environmental sustainability. The proposed framework concurrently accounts for the TBL of sustainability, catalyzing comprehensive environmental, economic, and societal development. Ultimately, the findings divulged that the "Total consumption of toxic substances" emerges as the most influential criterion for CE performance. This aligns with previous research, which indicates that toxic substances utilized in the production process can lead to visible harm and a substantial decline in sustainability performance.

6.2 | Managerial Insights

Suppliers are essential to every organization's pursuit of its CE goals. Hence, for the managers and DM to effectively implement CE practices to gain competitive advantages, they must be well versed in various criteria. This research represents one of the initial endeavors to compile influential criteria. Eight influential criteria for CSS were introduced in this study, which are essential to managers of the case organization and helpful for other organizations seeking CE practices. Nevertheless, these criteria are advantageous from the suppliers' perspective. Suppliers can utilize these criteria to build a more CE-based strategy for manufacturing parts. Those suppliers may improve their performance outcomes against each criterion by formulating a necessary action plan. This, in turn, will assist them in becoming a more sustainable organization that adheres to CE principles. Furthermore, the framework may be utilized to assess and select suppliers in the present context and other contexts, such as an SSS and GSS. The findings of the study could assist suppliers in improving their performance in areas where they may be lacking. DMs or purchasing managers may consider implementing supplier development initiatives for capable suppliers, such as those ranked second and third, in consultation with senior management. As a result, management may assist such suppliers in improving their performance and, as a result, create a strategic alliance with circular suppliers.

6.3 | Potential Attainment of SDGs

The proposed CSS framework in the plastic industry helps to achieve five SDGs ("SDG 3," "SDG 8," "SDG 9," "SDG 12," and "SDG 13") out of 17 SDGs. Through the implementation of the proposed CSS model, the company would be able to attain "SDG 3.9 (reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination)" by controlling emission levels and reducing total consumption of toxic substances during production process, resolving hygienic issues, and ensure healthy lives; "SDG 8.8 (protect labour rights and promote safe and secure working environments for all workers)" by reducing risks, hazards, and accidents in the workplace and ensuring healthy and safe working ambience; "SDG 9.1 (develop quality, reliable, sustainable and resilient infrastructure to support economic development and human well-being)" through providing various CSR and employee–wellbeing activities; "SDG 9.4 (upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency)" by adopting cleaner and environmentally-friendly technologies; "SDG 12.2 (sustainable management and efficient use of natural resources)" by reducing raw/virgin material usage; "SDG 12.4 (environmentally sound management of chemicals and all wastes throughout their life cycle)" by eliminating hazardous waste and reducing the consumption of toxic substances; "SDG 12.5 (reduce waste generation through prevention, reduction, recycling and reuse)" by enhancing recycling rate; and "SDG 13.2 (integrate climate change measures into national policies, strategies and planning)" by minimizing GHG emissions from both production and logistics operations.

7 | Practical Implementation Challenges

While this study provides a structured framework for CSS in the plastic industry, real-world implementation poses several challenges that industry practitioners must navigate. These challenges include:

i. Data availability and reliability: Effective implementation of the proposed methodology requires accurate and comprehensive supplier data. However, many suppliers, especially in emerging economies, may not have robust tracking systems for CE metrics such as waste reduction, energy consumption, and toxic substance usage. Companies can implement standardized data collection protocols, leverage digital tools such as blockchain for supply chain transparency, and encourage suppliers to adopt environmental reporting frameworks.

ii. Resistance to change: Traditional SS criteria often prioritize cost and delivery efficiency over environmental and social factors. Many procurement managers may resist adopting CSS frameworks due to concerns over increased costs or disruptions to established SCs. Organizations should integrate awareness programs and training to educate procurement teams on the long-term benefits of CSS,

TABLE 9 | Analysis of key findings in the shed of previous research findings.

Prominent result/ unique aspect of the current study's findings	Source/previous research	Arguments presented by earlier authors	Does this result align with earlier discoveries?	Strategies for improvement adopted by the benchmark supplier/comments
"Total consumption of toxic substances" (C8) emerged as the top influential GSS criteria	Ncube, Cunningham, and Horbach (2023)	The presence of additives, particularly toxic ones, complicates the plastic recycling process in several ways and hinders the development of CE	✓	Reducing non-essential plastics to promote the design and fabrication of toxic-free materials Using efficient chemical segregation techniques, depolymerization, and feedstock recycling methods to oppose the intermixing of toxic substances during recycling It sets out to increase transparency on the use of chemicals in plastics by publicly disclosing information about the synthesis of chemicals related to plastics, their incorporation into plastics, and the concentrations of those chemicals in plastic materials Avoiding poisonous substitutions Updating regulatory testing policy and guidelines
	Bodar et al. (2018)	"Effective material management," "toxic substance reduction," "energy efficiency," and "financial incentives" are four pillars for laying the foundation of a CE	✓	
	Slunge (n.d.)	"If we cannot ensure that recycled plastics are free of toxins, investments in the circular economy are jeopardized"	✓	
	Johansson (2023)	Toxins should not be allowed in the CE because they are primarily nonbiodegradable and accumulate in the environment, causing substantial damage. However, toxic materials remain in the loop during recycling	✓	
	Tuuri et al. (2023)	Making products with fewer toxic chemicals simplifies recycling, protects the environment, and is essential to establishing a CE. However, consumers may be affected by using secondary products from recycled materials contaminated with toxic substances	✓	
The second most important criterion was "Reduction in workplace hazards through employee wellbeing activities" (C2)	Chen et al. (2023)	"The economic, social, and environmental values of CE could decline if safety is not prioritized." The main social concerns of CE implementation are employment, health, and safety	✓	Providing regular training to employees and managerial staff Follow safety guidelines and conduct regular safety audits Adopt proactive maintenance measures and build a resilient supply chain Providing adequate protection equipment Conveying safety precautions transparently Incorporating safety and wellness plans Implementing Kanban and 5S systems Regular risk assessment and monitoring
	Héry and Malenfer (2020)	"The circular economy is likely to challenge work methods and working conditions ... The transition from a linear production to a circular model will only occur gradually. We have seen that the new model will involve a profound change in production organization, particularly in the design and use of (secondary) raw materials. It will be necessary to ensure that these new processes fully account for occupational risk prevention"	✓	

(Continues)

TABLE 9 | (Continued)

Prominent result/unique aspect of the current study's findings	Source/previous research	Arguments presented by earlier authors	Does this result align with earlier discoveries?	Strategies for improvement adopted by the benchmark supplier/comments
Surprisingly, the result found "Reduction in hazardous waste generation" (C3) as one of the least important criteria	Evode et al. (2021)	The genesis of hazardous waste complicates the transition to a CE. Waste mismanagement harms human hygiene and the environment and hastens climate change	✕	Conducting regular plastic audits Utilizing minimum waste generation technology like 3D printing Implementing lean manufacturing principles and JIT system Extracting "refuse-derived fuel (RDF)" and "solid recovered fuel (SRF)" for water heating and waste heat recovery plants Investing in sustainable technologies Partial utilization of robotics and automation
	Kibria et al. (2023)	To eliminate hazards within total production operations and minimize their effects through more effective management, it is necessary to examine them holistically through the lens of wastes, chemicals, and products when looking at such hazards from a circular perspective	✕	
According to the result, "total emissions from logistics operations" is the least criterion	Jayarathna et al. (2023)	Logistics in SC pollute the environment and deplete resources significantly. The negative effects of logistics operations produce interconnected economic, environmental, and social challenges that necessitate more sustainable logistics operations	✕	Employing vehicles with low emissions, such as electric and hybrid models Enhancing vehicle efficiency through adopting fuel-efficient engines, minimizing idle time, and maintaining the fleet appropriately Adopting sustainable and smart packaging to reduce carbon footprint Using root optimization and collaborating with suppliers and customers
	Zarbakhshnia et al. (2023)	"It can be claimed that to actualize the aims of the circular economy by closed-loop supply chain; companies should focus on logistics operations in both forward and reverse flows"	✕	

including regulatory compliance, enhanced brand reputation, and potential cost savings from waste reduction.

iii. Regulatory and policy constraints: Although government policies promoting CE practices are evolving, inconsistencies in regulations across different regions may hinder implementation. For instance, suppliers operating in different states or countries may face varying compliance requirements, making uniform evaluation challenging. Companies should align their SS criteria with global sustainability standards such as ISO 14001 and the Global Reporting Initiative (GRI), ensuring compliance regardless of regional regulatory differences.

iv. Cost and investment concerns: Transitioning to CSC often involves upfront investments in new technologies, infrastructure, and supplier partnerships. Small- and medium-sized enterprises may find it particularly difficult to bear these costs. Organizations can explore collaborative financing models, such as green investment funds or government incentives, to support companies in adopting circular practices. Large corporations can also engage in supplier development programs to help smaller suppliers improve their CE capabilities.

v. Complex supplier evaluation processes: Implementing an MCDM-based approach like entropy-COCOSO requires DMs to handle complex calculations and data-intensive evaluations. Some organizations may lack the necessary expertise or resources to implement such a framework effectively. Developing user-friendly decision-support tools or software that automates the calculation process can help simplify supplier evaluation. Additionally, integrating CE criteria into existing enterprise resource planning (ERP) systems can streamline supplier assessment processes.

By acknowledging these challenges and proactively addressing them, industry practitioners can enhance the feasibility of implementing circular supplier selection frameworks. Future research can further refine these solutions by exploring case studies and best practices from companies successfully transitioning toward circular procurement models.

8 | Conclusion

Nowadays, a CE-focused SS is gaining priority for organizations, especially, manufacturing industries, where production operations and their products, processes, and services negatively impact the environment. CE-based SS has grown vital as businesses compete more fiercely to be the early adopters of this technology. One of the key areas where the SS issue is evident is the plastic industry because a significant portion of its revenue generation, cleaner production, and SC sustainability are inextricably associated with SS. Therefore, establishing partnerships with the wrong suppliers in such industries comes at a cost, causing adverse environmental impacts, reduced chain efficiency, and substantial financial loss. To this end, this research proposes a practical approach for CSS in the plastic industry to attain a zero-waste economy for the first time. The prime objective of this study was to identify, scrutinize, and select the evaluation criteria and, subsequently, rank the supplier organizations within the plastic industry, specifically within an emerging country context.

Through a review of existing literature and expert consultations, eight key criteria were identified across environmental, social, and economic categories. These criteria can all help manage organizational difficulties when making CE-related choices involving suppliers. This study uses the entropy method to present a robust framework that determines the relative importance of evaluation criteria. These weights were then utilized in the COCOSO method to compute performance scores and rank the suppliers. The application of MCDM tools is often useful to aid such strategic decision-making. Many tools have been developed and proposed in earlier studies to facilitate such decisions, yet each has context-specific disadvantages. To overcome some contextual limitations of some MCDM approaches, an integrated MCDM model comprising entropy and COCOSO methods was developed and employed to solve a real-world CSS problem in a plastic manufacturing company in India. Four suppliers were assessed in this research, and 25 experts shared their opinions on the evaluation process. The criterion "Total consumption of toxic substances" surfaced as the most influential, holding the highest importance weight among the eight evaluation criteria. Conversely, the COCOSO method identified Supplier A as the most optimal choice. A sensitivity analysis was then performed to confirm the stability and robustness of these results. The sensitivity analysis's outcome aligned with the actual study findings, affirming that the proposed framework is sufficiently reliable for application in the specific case examined in this research and in analogous cases in other industrial segments. This research can potentially aid DMs and managers within the plastic industry in developing countries in making informed decisions regarding SS from a CE perspective. This, in turn, can expedite the integration of sustainability in this sector and mitigate adverse effects on the environment and society.

8.1 | Limitations and Scope for Future Studies

Although this study provides a structured framework for CSS in the plastic industry, certain limitations must be acknowledged to lay down the foundation for further research. The research is confined to a single industry (plastic) and geographic context (India), which may limit the generalizability of findings. Future studies could extend this framework to industries such as textiles, construction, and electronics, where circularity is equally critical. Additionally, the study employs a static evaluation framework, which does not account for suppliers' dynamic performance changes over time. To improve decision-making adaptability, future studies could integrate dynamic assessment techniques, such as longitudinal tracking of supplier performance, real-time data analytics, or machine learning-based predictive models. A total number of eight evaluation criteria were used in this research. Other criteria may have been overlooked because they were inapplicable in this particular case or because of expert prejudice. In future studies, researchers can adopt the proposed framework to solve similar cases in contexts in other countries, with necessary amendments. Additionally, future research could explore hybrid methodologies that combine quantitative approaches like entropy-COCOSO with qualitative techniques, such as case-based reasoning or expert systems, to refine supplier selection criteria further. By addressing these aspects, future research can build upon the foundation laid in this study, enhancing the robustness and applicability of CSS frameworks in achieving a CE in the plastic industry.

Author Contributions

Sudipta Ghosh: conceptualization, visualization, development and design of methodology, data curation, and preparation of original draft, advanced draft, and final paper. **Rakesh D. Raut:** selection of relevant theories, data analysis, co-writing of the advanced draft, and validation of the final paper. **Naoufel Cheikhrouhou:** providing supplementary materials, synthesizing research data, editing, and evolution of overarching research goals. **Chiranjib Bhowmik:** idea generation, visualization, co-writing of the conception and design. **Amitava Ray:** supervision, project administration, revision of the whole manuscript, and overall investigation.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article.

References

Afshari, A., M. Mojahed, and R. M. Yusuff. 2010. "Simple Additive Weighting Approach to Personnel Selection Problem." *International Journal of Innovation, Management and Technology* 1, no. 5: 511–515. https://doi.org/10.7763/IJIMT.2010.V1.89.

Al Qahtani, S., F. Al Wuhayb, H. Manaa, A. Younis, and S. Sehar. 2022. "Environmental Impact Assessment of Plastic Waste During the Outbreak of COVID-19 and Integrated Strategies for Its Control and Mitigation." *Reviews on Environmental Health* 37, no. 4: 585–596. https://doi.org/10.1515/reveh-2021-0098.

Alavi, B., M. Tavana, and H. Mina. 2021. "A Dynamic Decision Support System for Sustainable Supplier Selection in Circular Economy." *Sustainable Production and Consumption* 27: 905–920. https://doi.org/10.1016/j.spc.2021.02.015.

Alliance to End Plastic Waste (AEPW). 2022. "Projects in India." https://endplasticwaste.org.

Asian Development Bank. 2020. "A Circular Economy for a Sustainable Plastic Future." Asian Development Bank. Accessed May 5, 2023. https://www.adb.org/news/features/circular-economy-sustainable-plastic-future.

Bodar, C., J. Spijker, J. Lijzen, et al. 2018. "Risk Management of Hazardous Substances in a Circular Economy." *Journal of Environmental Management* 212: 108–114. https://doi.org/10.1016/j.jenvman.2018.02.014.

Chen, Z., A. Yildizbasi, and J. Sarkis. 2023. "How Safe Is the Circular Economy?" *Resources, Conservation and Recycling* 188: 106649. https://doi.org/10.1016/j.resconrec.2022.106649.

Chowdhury, G. W., H. J. Koldewey, M. N. H. Niloy, and S. Sarker. 2022. "The Ecological Impact of Plastic Pollution in a Changing Climate." *Emerging Topics in Life Sciences* 6, no. 4: 389–402. https://doi.org/10.1042/ETLS20220016.

Confederation of Indian Industry (CII), and WWF India. 2021. "India Plastics Pact." https://www.india.plasticspact.org.

Dey, P. K., C. Malesios, D. De, P. Budhwar, S. Chowdhury, and W. Cheffi. 2020. "Circular Economy to Enhance Sustainability of Small and Medium-Sized Enterprises." *Business Strategy and the Environment* 29, no. 6: 2145–2169. https://doi.org/10.1002/bse.2492.

Diaz, A., T. Reyes, and R. J. Baumgartner. 2022. "Implementing Circular Economy Strategies During Product Development." *Resources, Conservation and Recycling* 184: 106344. https://doi.org/10.1016/j.resconrec.2022.106344.

Dwivedi, P. P., and D. K. Sharma. 2022a. "Application of Shannon Entropy and CoCoSo Methods in Selection of the Most Appropriate Engineering Sustainability Components." *Cleaner Materials* 5: 100118. https://doi.org/10.1016/j.clema.2022.100118.

Dwivedi, P. P., and D. K. Sharma. 2022b. "Application of Shannon Entropy and COCOSO Techniques to Analyze Performance of Sustainable Development Goals: The Case of the Indian Union Territories." *Results in Engineering* 14: 100416. https://doi.org/10.1016/j.rineng.2022.100416.

Erdal, H., K. G. Kurtay, H. A. Dagistanli, and A. Altundas. 2023. "Evaluation of Anti-Tank Guided Missiles: An Integrated Fuzzy Entropy and Fuzzy CoCoSo Multi Criteria Methodology Using Technical and Simulation Data." *Applied Soft Computing* 137: 110145. https://doi.org/10.1016/j.asoc.2023.110145.

Ethirajan, M., M. Arasu, J. Kandasamy, V. Kek, and S. P. Nadeem. 2021. "Analysing the Risks of Adopting Circular Economy Initiatives in Manufacturing Supply Chains." *Business Strategy and the Environment* 30, no. 1: 204–236. https://doi.org/10.1002/bse.2617.

Evode, N., S. A. Qamar, M. Bilal, D. Barceló, and H. M. N. Iqbal. 2021. "Plastic Waste and Its Management Strategies for Environmental Sustainability." *Case Studies in Chemical and Environmental Engineering* 4: 100142. https://doi.org/10.1016/j.cscee.2021.100142.

Feng, J., and Z. Gong. 2020. "Integrated Linguistic Entropy Weight Method and Multi-Objective Programming Model for Supplier Selection and Order Allocation in a Circular Economy: A Case Study." *Journal of Cleaner Production* 277: 122597. https://doi.org/10.1016/j.jclepro.2020.122597.

Ghosh, S., C. Bhowmik, M. C. Mandal, and A. Ray. 2021. "Green Supplier Selection: An Empirical Investigation." In *Modeling, Simulation and Optimization*, 723–735. Springer Singapore. https://doi.org/10.1007/978-981-15-9829-6_57.

Ghosh, S., C. Bhowmik, S. Sinha, R. D. Raut, M. C. Mandal, and A. Ray. 2023d. "An Integrated Multi-Criteria Decision-Making and Multivariate Analysis Towards Sustainable Procurement With Application in Automotive Industry." *Supply Chain Analytics* 3: 100033. https://doi.org/10.1016/j.sca.2023.100033.

Ghosh, S., M. Chandra Mandal, and A. Ray. 2022. "Exploring the Influence of Critical Parameters on Green Supply Chain Management Performance of Small and Medium-Sized Enterprise: An Integrated Multivariate Analysis-Robust Design Approach." *Cleaner Logistics and Supply Chain* 4: 100057. https://doi.org/10.1016/j.clscn.2022.100057.

Ghosh, S., M. C. Mandal, and A. Ray. 2021a. "Green Supplier Selection Using Statistical Method." In *Lecture Notes on Multidisciplinary Industrial Engineering*, 397–413. Springer Singapore. https://doi.org/10.1007/978-981-15-6017-0_26.

Ghosh, S., M. C. Mandal, and A. Ray. 2021c. "Selection of Environmental-Conscious Sourcing: An Empirical Investigation." *Benchmarking: An International Journal* 28, no. 6: 2130–2155. https://doi.org/10.1108/bij-08-2020-0416.

Ghosh, S., M. C. Mandal, and A. Ray. 2022a. "A PDCA Based Approach to Evaluate Green Supply Chain Management Performance Under

Fuzzy Environment." *International Journal of Management Science and Engineering Management* 18, no. 1: 1–15. https://doi.org/10.1080/17509653.2022.2027292.

Ghosh, S., M. C. Mandal, and A. Ray. 2022b. "Green Supply Chain Management Framework for Supplier Selection: An Integrated Multi-Criteria Decision-Making Approach." *International Journal of Management Science and Engineering Management* 17, no. 3: 205–219. https://doi.org/10.1080/17509653.2021.1997661.

Ghosh, S., M. C. Mandal, and A. Ray. 2022d. "Strategic Sourcing Model for Green Supply Chain Management: An Insight Into Automobile Manufacturing Units in India." *Benchmarking: An International Journal* 29, no. 10: 3097–3132. https://doi.org/10.1108/bij-06-2021-0333.

Ghosh, S., M. C. Mandal, and A. Ray. 2023. "Investigating the key Performance Parameters of Green Supply Chain Management for Sustainability in tea Processing Firms Using Pareto Analysis." *Journal of The Institution of Engineers (India): Series C* 104, no. 1: 113–122. https://doi.org/10.1007/s40032-022-00888-8.

Ghosh, S., R. D. Raut, M. C. Mandal, and A. Ray. 2023b. "Revisiting the nexus Between Sustainable Supply Chain Management and the Performance of Steel Manufacturing Organizations: A Case Study From an Emerging Economy." *IEEE Engineering Management Review* 51, no. 1: 189–213. https://doi.org/10.1109/emr.2022.3233484.

Ghosh, S., R. D. Raut, M. C. Mandal, and A. Ray. 2023c. "Are the Small- and Medium-Sized Enterprises in Developing Countries Ready to Implement Circular Economy Practices? An Empirical Quest for Key Readiness Factors." *IEEE Transactions on Engineering Management* 71: 7467–7478. https://doi.org/10.1109/tem.2023.3257237.

Giri, B. C., M. U. Molla, and P. Biswas. 2022. "Pythagorean Fuzzy DEMATEL Method for Supplier Selection in Sustainable Supply Chain Management." *Expert Systems with Applications* 193: 116396. https://doi.org/10.1016/j.eswa.2021.116396.

Govindan, K., H. Mina, A. Esmaeili, and S. M. Gholami-Zanjani. 2020. "An Integrated Hybrid Approach for Circular Supplier Selection and Closed Loop Supply Chain Network Design Under Uncertainty." *Journal of Cleaner Production* 242, 118317. https://doi.org/10.1016/j.jclepro.2019.118317.

Haleem, A., S. Khan, S. Luthra, H. Varshney, M. Alam, and M. I. Khan. 2021. "Supplier Evaluation in the Context of Circular Economy: A Forward Step for Resilient Business and Environment Concern." *Business Strategy and the Environment* 30, no. 4: 2119–2146. https://doi.org/10.1002/bse.2736.

Hasson, F., S. Keeney, and H. McKenna. 2000. "Research Guidelines for the Delphi Survey Technique." *Journal of Advanced Nursing* 32, no. 4: 1008–1015. https://doi.org/10.1046/j.1365-2648.2000.t01-1-01567.x.

Héry, M., and M. Malenfer. 2020. "Development of a Circular Economy and Evolution of Working Conditions and Occupational Risks—A Strategic Foresight Study." *European Journal of Futures Research* 8, no. 1. https://doi.org/10.1186/s40309-020-00168-7.

Horbach, J., and C. Rammer. 2019. "Circular Economy Innovations, Growth and Employment at the Firm Level: Empirical Evidence From Germany." *Journal of Industrial Ecology* 24, no. 3: 615–625. https://doi.org/10.1111/jiec.12977.

Hsu, C. C., and B. A. Sandford. 2007. "The Delphi Technique: Making Sense of Consensus." *Practical Assessment, Research & Evaluation* 12, no. 10: 1–8. https://doi.org/10.7275/pdz9-th90.

Hussain, M., and M. Malik. 2020. "Organizational Enablers for Circular Economy in the Context of Sustainable Supply Chain Management." *Journal of Cleaner Production* 256: 120375. https://doi.org/10.1016/j.jclepro.2020.120375.

Jayarathna, C. P., D. Agdas, and L. Dawes. 2023. "Exploring Sustainable Logistics Practices Toward a Circular Economy: A Value Creation Perspective." *Business Strategy and the Environment* 32, no. 1: 704–720. https://doi.org/10.1002/bse.3170.

Johansson, N. 2023. "Recycling Warning! Reconfiguring the Toxic Politics of a Circular Economy." *Sustainability Science* 18, no. 2: 1043–1048. https://doi.org/10.1007/s11625-022-01220-0.

Kannan, D., K. Govindan, and S. Rajendran. 2020. "Vendor Selection in an Automobile Industry Using an Integrated Approach of Multi Criteria Decision Making." *Sustainable Production and Consumption* 8: 177–193. https://doi.org/10.1016/j.spc.2016.09.005.

Kannan, D., H. Mina, S. Nosrati-Abarghooee, and G. Khosrojerdi. 2020. "Sustainable Circular Supplier Selection: A Novel Hybrid Approach." *Science of the Total Environment* 722: 137936. https://doi.org/10.1016/j.scitotenv.2020.137936.

Khalili Nasr, A., M. Tavana, B. Alavi, and H. Mina. 2021. "A Novel Fuzzy Multi-Objective Circular Supplier Selection and Order Allocation Model for Sustainable Closed-Loop Supply Chains." *Journal of Cleaner Production* 287: 124994. https://doi.org/10.1016/j.jclepro.2020.124994.

Kibria, M. G., N. I. Masuk, R. Safayet, H. Q. Nguyen, and M. Mourshed. 2023. "Plastic Waste: Challenges and Opportunities to Mitigate Pollution and Effective Management." *International Journal of Environmental Research* 17, no. 1. https://doi.org/10.1007/s41742-023-00507-z.

Linstone, H. A., and M. Turoff. 2002. *The Delphi Method: Techniques and Applications*. Addison-Wesley.

Maione, C., Y. Lapko, and P. Trucco. 2022. "Towards a Circular Economy for the Plastic Packaging Sector: Insights From the Italian Case." *Sustainable Production and Consumption* 34: 78–89. https://doi.org/10.1016/j.spc.2022.09.002.

Menon, R. R., and V. Ravi. 2022. "Using AHP-TOPSIS Methodologies in the Selection of Sustainable Suppliers in an Electronics Supply Chain." *Cleaner Materials* 5: 100130. https://doi.org/10.1016/j.clema.2022.100130.

Mina, H., D. Kannan, S. M. Gholami-Zanjani, and M. Biuki. 2021. "Transition Towards Circular Supplier Selection in Petrochemical Industry: A Hybrid Approach to Achieve Sustainable Development Goals." *Journal of Cleaner Production* 286: 125273. https://doi.org/10.1016/j.jclepro.2020.125273.

Ministry of Environment, Forest and Climate Change. 2021. "Plastic Waste Management Rules." https://moef.gov.in.

Moktadir, M. A., A. Kumar, S. M. Ali, S. K. Paul, R. Sultana, and J. Rezaei. 2020. "Critical Success Factors for a Circular Economy: Implications for Business Strategy and the Environment." *Business Strategy and the Environment* 29, no. 8: 3611–3635. https://doi.org/10.1002/bse.2600.

Münch, C., L. A. Benz, and E. Hartmann. 2022. "Exploring the Circular Economy Paradigm: A Natural Resource-Based View on Supplier Selection Criteria." *Journal of Purchasing and Supply Management* 28, no. 4: 100793. https://doi.org/10.1016/j.pursup.2022.100793.

Muneeb, S. M., Z. Asim, M. Hajiaghaei-Keshteli, and H. Abbas. 2023. "A Multi-Objective Integrated Supplier Selection-Production-Distribution Model for Re-Furbished Products: Towards a Circular Economy." *Renewable and Sustainable Energy Reviews* 175: 113156. https://doi.org/10.1016/j.rser.2023.113156.

Ncube, A., S. Mtetwa, M. Bukhari, G. Fiorentino, and R. Passaro. 2023. "Circular Economy and Green Chemistry: The Need for Radical Innovative Approaches in the Design for New Products." *Energies* 16, no. 4: 1752. https://doi.org/10.3390/en16041752.

Ncube, F., S. A. Cunningham, and J. Horbach. 2023. "Toxic Additives and Plastic Recycling: Challenges for a Circular Economy." *Waste Management* 167: 231012. https://doi.org/10.1016/j.wasman.2023.231012.

Neo, E. R. K., G. C. Y. Soo, D. Z. L. Tan, K. Cady, K. T. Tong, and J. S. C. Low. 2021. "Life Cycle Assessment of Plastic Waste end-Of-Life for India and Indonesia." *Resources, Conservation and Recycling* 174: 105774. https://doi.org/10.1016/j.resconrec.2021.105774.

Okoli, C., and S. D. Pawlowski. 2004. "The Delphi Method as a Research Tool: An Example, Design Considerations, and Applications."

Information & Management 42, no. 1: 15–29. https://doi.org/10.1016/j.im.2003.11.002.

Oliveira, M., M. Miguel, S. K. van Langen, et al. 2021. "Circular Economy and the Transition to a Sustainable Society: Integrated Assessment Methods for a New Paradigm." *Circular Economy and Sustainability* 1: 99–113. https://doi.org/10.1007/s43615-021-00019-y.

Pillai, J. 2021. "Managing Plastic Waste – What Emerging Economies Like India Can Learn From Developed Nations." *Reinforced Plastics* 65: S8–S11. https://doi.org/10.1016/j.repl.2021.04.011.

Prieto-Sandoval, V., C. Jaca, J. Santos, R. J. Baumgartner, and M. Ormazabal. 2019. "Key Strategies, Resources, and Capabilities for Implementing Circular Economy in Industrial Small and Medium Enterprises." *Corporate Social Responsibility and Environmental Management* 26, no. 6: 1473–1484. https://doi.org/10.1002/csr.1761.

Prosman, E. J., and R. Sacchi. 2018. "New Environmental Supplier Selection Criteria for Circular Supply Chains: Lessons From a Consequential LCA Study on Waste Recovery." *Journal of Cleaner Production* 172: 2782–2792. https://doi.org/10.1016/j.jclepro.2017.11.134.

Ramky Enviro Engineers. 2022. "Waste Management Solutions." https://ramky.com.

Ray, A., S. Ghosh, and M. C. Mandal. 2021. "An Exploratory Assessment of the Sustainability Performance of the Construction Industry." *International Journal of Industrial Engineering: Theory Applications and Practice* 28, no. 3: 329–353. https://doi.org/10.23055/ijietap.2021.28.3.7035.

Reliance Industries. 2021. "PET Recycling Initiatives." https://ril.com.

Rudra Environmental Solutions. 2022. "Pyrolysis Technology." https://rudraenviro.com.

Simon, B. 2019. "What Are the Most Significant Aspects of Supporting the Circular Economy in the Plastic Industry?" *Resources, Conservation and Recycling* 141: 299–300. https://doi.org/10.1016/j.resconrec.2018.10.044.

Slunge, D. n.d. "Scientists Want to Get Rid of Toxic Chemicals in Plastic." University of Gothenburg. Retrieved August 1, 2023. https://www.gu.se/en/news/scientists-want-to-get-rid-of-toxic-chemicals-in-plastic.

Sundaram, J., S. Muniamuthu, C. Rajkumar, J. Udaya Prakash, V. S. Hema Kumar, and S. Ganesan. 2023. "Scope of Waste Plastic to Reuse in India – A Review." *Materials Today Proceedings*. https://doi.org/10.1016/j.matpr.2023.04.156.

The 17 goals. n.d. Sdgs.un.org. Retrieved June 21, 2023, from https://sdgs.un.org/goals.

Tushar, Z. N., A. B. M. M. Bari, and M. A. Khan. 2022. "Circular Supplier Selection in the Construction Industry: A Sustainability Perspective for the Emerging Economies." *Sustainable Manufacturing and Service Economics* 1: 100005. https://doi.org/10.1016/j.smse.2022.100005.

Tuuri, M., J. Korhonen, and H. Kiiskinen. 2023. "Hazardous Waste Management in Circular Supply Chains: Key Challenges and Mitigation Strategies." *Sustainable Production and Consumption* 36: 402–417. https://doi.org/10.1016/j.spc.2023.07.002.

UFlex Ltd. 2021. "Sustainable Packaging Solutions." https://uflexltd.com.

Wang, C.-H., M. H. Ali, K.-S. Chen, Y. T. Negash, M.-L. Tseng, and R. R. Tan. 2021. "Data Driven Supplier Selection as a Circular Economy Enabler: A Taguchi Capability Index for Manufactured Products With Asymmetric Tolerances." *Advanced Engineering Informatics* 47, no. 101249: 101249. https://doi.org/10.1016/j.aei.2021.101249.

Xie, Z., G. Tian, and Y. Tao. 2023. "A Multi-Criteria Decision-Making Framework for Sustainable Supplier Selection in Circular Economy and Industry 4.0 Era." *Sustainability* 14, no. 24: 16809. https://doi.org/10.3390/su142416809.

Yadav, G., S. K. Mangla, A. Bhattacharya, and S. Luthra. 2020. "Exploring Indicators of Circular Economy Adoption Framework Through a Hybrid Decision Support Approach." *Journal of Cleaner Production* 277: 124186. https://doi.org/10.1016/j.jclepro.2020.124186.

Yazdani, M., P. Zarate, E. K. Zavadskas, and Z. Turskis. 2019. "A Combined Compromise Solution (CoCoSo) Method for Multi-Criteria Decision-Making Problems." *Management Decision* 57, no. 9: 2501–2519. https://doi.org/10.1108/MD-05-2017-0458.

Zanakis, S. H., A. Solomon, N. Wishart, and S. Dublish. 1998. "Multi-Attribute Decision Making: A Simulation Comparison of Select Methods." *European Journal of Operational Research* 107, no. 3: 507–529. https://doi.org/10.1016/S0377-2217(97)00147-1.

Zarbakhshnia, N., K. Govindan, D. Kannan, and M. Goh. 2023. "Outsourcing Logistics Operations in Circular Economy Towards to Sustainable Development Goals." *Business Strategy and the Environment* 32, no. 1: 134–162. https://doi.org/10.1002/bse.3122.

Zavadskas, E. K., Z. Turskis, J. Antucheviciene, and A. Zakarevicius. 2012. "Optimization of Weighted Aggregated Sum Product Assessment." *Elektronika ir Elektrotechnika* 122, no. 6: 3–6. https://doi.org/10.5755/j01.eee.122.6.1810.

Zhong, L., and L. Yao. 2017. "An ELECTRE I-Based Multi-Criteria Group Decision Making Method With Interval Type-2 Fuzzy Numbers and Its Application to Supplier Selection." *Applied Soft Computing* 57: 556–576. https://doi.org/10.1016/j.asoc.2017.04.001.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.