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Bridging Academic Research and Business Practices at the Crossroad of Circular Economy and the SDGs

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ABSTRACT

The global shift toward sustainability has amplified interest in the Circular Economy, which aims to optimize resource use and minimize waste. In parallel, the Sustainable Development Goals (SDGs) provide a universal framework for addressing social, environmental, and economic challenges. This study bridges academic research and corporate practice by mapping how Circular Economy strategies and SDG priorities are articulated across domains. By identifying who leads on what and where convergence occurs, it seeks to guide cross-fertilization, foster mutual learning, and support more aligned sustainability transitions. While prior research highlights the transformative potential of circularity frameworks, few studies examine how these ideas are unevenly adopted across institutional settings. To address this, we conduct a comparative textual analysis of 919 academic articles and the sustainability reports of the top 50 Fortune 500 firms for the period 2015–2024, using computational linguistic methods to trace links between circular strategies and SDGs targets. The findings reveal a more nuanced landscape than a simple academia–industry divide. Although their fourth priorities differ, “Repurpose” for academia and “Repair” for firms, both domains emphasize upstream circular strategies such as “Refuse”, “Rethink”, and especially “Reduce”. Convergence also emerges around SDG 7 (clean energy), SDG 12 (responsible consumption), and SDG 13 (climate action). The study reframes the academia–industry gap as a dynamic relationship and proposes a map of Circular Economy SDG alignments to guide future collaboration.

1 | Introduction

Over the past decade, the Circular Economy (CE) has gained momentum as a promising framework for addressing environmental degradation and unsustainable resource use (Geissdoerfer et al. 2017). By replacing linear “take–make–dispose” models with regenerative principles, CE promotes strategies such as reuse, repair, remanufacturing, and recycling (Kirchherr et al. 2017). Industries ranging from manufacturing to fashion have begun integrating CE principles, reflecting a growing shift

away from profit-centric models toward more sustainable value creation (Merli et al. 2018).

In parallel, the United Nations’ Sustainable Development Goals (SDGs) have emerged as a global agenda to address interconnected socio-environmental challenges (UN 2015). With 17 goals addressing issues ranging from poverty and inequality to climate change and responsible production, the SDGs serve as a normative and strategic framework. For businesses, aligning with the SDGs offers opportunities for innovation, reputation building, and risk

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mitigation (European Commission 2015), while for academia, the SDGs have become a lens for analyzing systemic change, sustainability metrics, and multi-level interventions (Aluchna et al. 2023).

Despite shared ambitions, academia and industry pursue sustainability through different logics. Academics often emphasize systems thinking and long-term transformation, whereas businesses prioritize operational feasibility and short-term performance (Bocken et al. 2014). As a result, both sectors may invoke terms such as “circularity” or “sustainability”, yet their interpretations and implementations diverge significantly (Prieto-Sandoval et al. 2018).

This divergence is often evident in sustainability discourse. Academic publications call for radical redesign and deep innovation, while businesses often favor incremental improvements aligned with quarterly targets (Lieder and Rashid 2016). Academic tools such as lifecycle assessments and circularity indicators (Elia et al. 2017) contrast with corporate reliance on financial metrics such as Return on Investment (Lewandowski 2016).

Although the literature is rich on CE strategies (Bocken et al. 2016) and SDG implementation (Alonso-Almeida et al. 2017), comparative evidence remains limited on how academia and industry conceptualize, prioritize, and operationalize CE strategies and SDG goals. Shared terminology often masks substantive differences in priorities, evaluation methods, and desired outcomes (Kirchherr et al. 2017). In particular, it remains unclear whether corporate commitments to CE and the SDGs represent substantive action or primarily serve branding and communication purposes (Juin et al. 2025).

Another underexplored area concerns how organizational barriers shape this divergence. Although research highlights constraints such as fragmented supply chains and regulatory uncertainty (Urbinati et al. 2017), little is known about how these obstacles affect cross-sector dialogue and mutual learning (Lozano et al. 2015). Bridging this divide requires addressing the “valley of death” between research and practice, where promising ideas fail to scale or sustain themselves (Pieroni et al. 2019).

This study is motivated by three core drivers. First, the urgency of climate change and social inequality demands sustainability solutions (Agyemang et al. 2019). CE must move beyond conceptual traction to organizational uptake and impact (Cramer 2020). Second, global governance bodies increasingly position private-sector actors as central to achieving the SDGs (European Commission 2015). Third, although CE is widely discussed in academic circles (Nazir and Doni 2024), its uptake in business remains uneven (Aranda-Usón et al. 2020). Identifying where priorities converge or diverge can inform more actionable, context-sensitive sustainability frameworks (Dyllick and Muff 2016).

Against this backdrop, this paper seeks to answer the following research question:

Where do academia and industry diverge and converge in shaping the agenda for Circular Economy strategies and Sustainable Development Goals?

To address this question, we conduct a computational text analysis using topic modeling of 919 academic articles and the sustainability reports of the top 50 Fortune 500 companies (2015–2024). Drawing on Natural Language Processing (NLP), we examine how each domain articulates key CE strategies and SDG priorities and how these articulations evolve (Grimmer and Stewart 2013; Ferjančič et al. 2024).

Specifically, our objective is to (1) compare CE “R-strategy” hierarchies and SDG salience across the two corpuses, (2) map where SDGs and circular strategies co-occur, and (3) identify areas of convergence and divergence that can support cross-sector learning and foster cooperation between academia and industry.

In doing so, the study contributes to both sustainability scholarship and corporate strategy by clarifying how CE and the SDGs are navigated differently yet often in parallel, and how collaboration between the two spheres can accelerate progress toward shared climate and development goals.

2 | Theoretical Background

2.1 | Overview of Relevant Literature

The research landscape on CE and the SDGs has expanded considerably over the past decade (Pal et al. 2025). Scholarly work in this domain often examines the multifaceted nature of sustainability transitions, covering topics such as resource efficiency, product-service systems, policy interventions, and technological innovations (Tukker 2015). Early discussions on CE highlighted the shortcomings of the linear model and argued for regenerative resource use (Ghisellini et al. 2016). Building on these insights, scholars have introduced frameworks such as the “butterfly diagram” of the Ellen MacArthur Foundation, which conceptualizes material loops, and the 9R Framework put forth by Potting et al. (2017), which details strategies such as “reduce”, “reuse”, “refurbish”, and “recycle”. These frameworks aim to provide systematic ways to retain resource value across the entire product lifecycle and reduce negative impacts (Reike et al. 2018).

In parallel, the United Nations’ 2030 Agenda for Sustainable Development offers 17 goals as a global blueprint for addressing issues ranging from poverty and hunger to climate action and responsible consumption (United Nations General Assembly 2015). Researchers have examined the synergies between CE objectives and the broader social, economic, and environmental ambitions articulated in the SDGs (European Commission 2015). Recent work also highlights how climate commitments and development priorities shape regionally differentiated interpretations of the SDGs (Savin et al. 2025). Moreover, the business literature has begun to focus on sustainable business models (Bocken et al. 2014), environmentally informed product design (Bocken et al. 2016), and supply chain optimization for closed-loop systems (Govindan and Hasanagic 2018). Despite the diverse perspectives offered, there is a growing consensus that achieving global sustainability targets requires concerted efforts by multiple categories of actors (Cramer 2020).

While both academia and industry recognize the urgency of sustainability challenges, companies tend to prioritize feasibility, cost-effectiveness, and short to medium-term performance (Bocken et al. 2014; Aranda-Usón et al. 2020), whereas academic research focuses on systemic analysis and frameworks for long-term transformation (Geissdoerfer et al. 2017). This tension has prompted calls for approaches that better align conceptual ambition with organizational feasibility (Pieroni et al. 2019).

2.2 | Key Theories and Concepts

Several theories and concepts underpin the current discourse on CE and the SDGs. A key concept is Circular Business Models, which embed circularity into value creation and capture processes. Rather than adding sustainability to existing models, these models require redesigning business logic to align profitability with resource regeneration and stakeholder value (De Angelis 2024). These models typically involve innovations across the supply chain, aiming to achieve sustainability goals by aligning business success with the principles of circularity and the SDGs (Nayal et al. 2022).

The 9R Framework (Potting et al. 2017), detailed in Appendix A, is widely cited in academic literature (Kirchherr et al. 2017; Munoz et al. 2024; Nazir and Doni 2024) and in corporate practice. It conceptualizes CE strategies that preserve higher levels of resource value (Reike et al. 2018) as a hierarchy of actions spanning a product's life cycle, from highly circular to more linear practices. At one end, strategies such as Refuse (R0), Rethink (R1), and Reduce (2) represent the most circular approaches by avoiding or radically reducing resource use, while at the other end, Recycle (R8) and Recover (R9) reflect more linear logics focused on end-of-life treatment rather than prevention. Between these extremes, the framework orders strategies from R3 to R7—Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), and Repurpose (R7)—providing a structured lens to assess how organizations shift from linear to increasingly circular modes of value creation. While academically robust, the framework can pose challenges for corporate adoption, particularly when firms lack the technological, financial, or organizational capacity to implement higher-value creation strategies (Evans et al. 2017).

Alongside these CE-specific models, the SDGs mapped in Appendix B provide a broader normative framework for integrating social and environmental targets into policy and organizational strategies (United Nations General Assembly 2015). For example, SDG 12 (Responsible Consumption and Production) aligns directly with CE objectives, while SDG 9 (Industry, Innovation, and Infrastructure) emphasizes fostering resilient systems that can accommodate new forms of circular production. Together, CE frameworks and the SDGs increasingly serve as complementary reference systems that guide sustainability-oriented decision-making (Alonso-Almeida et al. 2020).

2.3 | Gap in the Literature

Despite a rich and rapidly expanding body of research, the lack of a unified understanding of the CE often leads to “conceptual stretching”, which complicates both academic theorizing and

practical implementation (Kirchherr et al. 2017; Prieto-Sandoval et al. 2018).

Evidence suggests that academia and industry often move in parallel but disconnected directions on both the CE and SDG agendas. While researchers tend to focus on systemic change and conceptual clarity, companies often emphasize operational goals and short-term outcomes. This study addresses this divergence by examining where academia and industry diverge and converge in advancing CE strategies and SDGs. By comparing academic and corporate perspectives, this work explores where they align and how greater synergy might be achieved to support a more cohesive sustainability transition.

3 | Methodology

3.1 | Data Collection Methods

3.1.1 | Academic Literature—Database Search

The academic articles were sourced exclusively from the Scopus database, a large, multidisciplinary, and widely used repository that provides extensive coverage of journals in the social sciences, management, and sustainability domains central to CE–SDG research (Mongeon and Paul-Hus 2016).

Importantly, relying on a single database reflects a methodological choice. NLP-based analyses using pre-trained Large Language Models (LLMs), such as BERTopic, are highly sensitive to inconsistencies in metadata structure, document formatting, and indexing practices. Integrating multiple databases (e.g., both Scopus and Web of Science) may increase coverage (Echchakoui 2020), but it also introduces substantial heterogeneity in metadata and text extraction processes. Prior methodological research has shown that such differences systematically affect downstream analytical outcomes (Zupic and Čater 2015; Harzing and Alakangas 2016).

In text-based and semantic analyses, this heterogeneity risks producing artifacts driven by database-specific features rather than by genuine patterns in scholarly discourse. For this reason, the study prioritizes semantic consistency, replicability, and internal validity. Although this design choice entails a trade-off in coverage, it ensures the robustness and interpretability of the subsequent NLP-based analysis.

The search terms combined references to the SDGs and CE concepts to capture articles that explicitly mention or discuss both domains. Specifically, the following query was used: *TITLE-ABS-KEY (sdg OR “sustainable development goals”) AND circular**. The first 10 outlets, ranked by the number of articles published on the subject, accounted for 20% of the corpus, as shown in Appendix C.

3.1.2 | Initial Screening and Filters

As shown in Figure 1, the initial query returned 2258 documents. The results were filtered to include only English-language documents, reducing the count to 2208. Next, non-peer-reviewed

publications were excluded, yielding 1985 items. This exclusion was intended to improve the quality and reliability of the data corpus.

A title and abstract screening was conducted to exclude articles that did not address the intersection of circularity and the SDGs, reducing the set to 928. Finally, the researchers excluded articles published in 2025 to focus on full calendar years, resulting in a final sample of 919 articles.

3.1.3 | Rationale for Inclusion

These articles were selected for their explicit mention of the CE and the SDGs. The final pool spans a broad range of research fields, from engineering and environmental sciences to

management and policy, ensuring a diverse set of academic perspectives for the analysis (Geissdoerfer et al. 2017).

3.1.4 | Corporate Sustainability Reports—Fortune 500 Selection

To capture the corporate perspective, the study targeted the top 50 companies (listed in Table 1) from the Fortune Global 500 (2024). This sampling strategy reflects the role these firms play in shaping global sustainability practices, as leading corporations are often subject to greater public and investor scrutiny, prompting more comprehensive sustainability reporting (Lozano et al. 2015). Fortune 500 companies also have greater resources to invest in sustainability initiatives, making them valuable case studies (Amini et al. 2018).

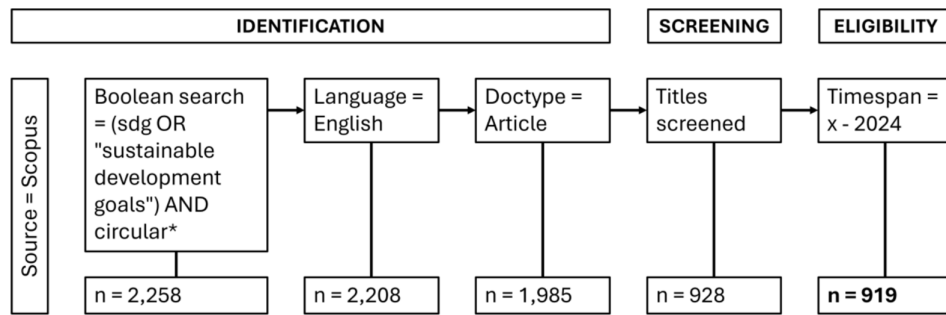


FIGURE 1 | PRISMA diagram of the systematic literature review.

TABLE 1 | List of the top 50 Fortune Global 500 Ranking companies in 2024 (source fortune.com).

1	Walmart	11	Volkswagen	21	JPMorgan Chase	31	Samsung Electronics	41	BMW
2	Amazon	12	Exxon Mobil	22	Industrial & Commercial Bank of China	32	Hon Hai Precision Industry	42	Mercedes-Benz Group
3	State Grid	13	Shell	23	TotalEnergies	33	Cigna	43	China Railway Construction
4	Saudi Aramco	14	China State Construction Engineering	24	Glencore	34	Agricultural Bank of China	44	Baowu China Steel Group
5	Sinopec Group	15	Toyota Motor	25	BP	35	China Railway Engineering Group	45	Citigroup
6	China National Petroleum	16	McKesson	26	Microsoft	36	Ford Motor	46	Centene
7	Apple	17	Alphabet	27	Cardinal Health	37	Bank of China	47	JD.com
8	UnitedHealth Group	18	Cencora	28	Stellantis	38	Bank of America	48	Home Depot
9	Berkshire Hathaway	19	Trafigura Group	29	Chevron	39	General Motors	49	Electricité de France
10	CVS Health	20	Costco Wholesale	30	China Construction Bank	40	Elevance Health	50	Marathon Petroleum

TABLE 2 | Distribution of sustainability reports available on the internet (2015–2024).

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
N° reports	31	39	43	44	43	46	47	45	48	18

These leading corporations typically publish annual or biennial sustainability or non-financial reports that detail their environmental and social performance, goals, and strategic initiatives (European Commission 2015). Thus, focusing on this sample aligns with common sustainability research methods that use industry leaders to signal broader trends (Stead and Stead 2000).

3.1.5 | Data Collection

For each of the top 50 Fortune 500 companies (T-50), the 10 most recent publicly available sustainability or non-financial reports were downloaded. This 10-year timeframe was deliberately chosen to enable a longitudinal analysis of how corporate discourse has evolved, particularly since the adoption of the SDGs in 2015 (Dyllick and Muff 2016). Although these non-financial reports are primarily communication tools and may be subject to self-presentation bias, they remain the primary channel through which corporations articulate their sustainability strategies and performance to stakeholders (Aluchna et al. 2023).

A total of 404 reports were found out of 500 (50 companies × 10 years). While over 90% of reports were available for the period 2017–2023, the years 2015 and 2016 reached only 70%, and the year 2024 was below 40% because organizations publish their reports at different times of year+1, as detailed in Table 2.

3.2 | Sampling Techniques

3.2.1 | Academic Articles

A purposive sampling approach was used to identify peer-reviewed journal articles that explicitly addressed both CE and the SDGs (Kirchherr et al. 2017). Unlike purely random sampling, this method ensures that all articles in the final set are contextually relevant. The multi-step filter, covering language, document type, and content screening (e.g., title and abstract, where needed), further refined the sample to those most pertinent to the research question (Bocken et al. 2014).

3.2.2 | Corporate Reports

For the corporate data, the study adopted a judgmental sampling strategy, limiting the scope to the T-50. This subset was chosen for two reasons: (1) large corporations often face significant scrutiny from investors, consumers, and regulators, which may spur more comprehensive sustainability reporting (Lozano et al. 2015), and (2) these entities have greater capacity to implement novel sustainability initiatives, making them instructive case studies for examining the incorporation of CE and SDG

language. The 10-year span allows observation of how sustainability communication has evolved alongside growing global attention to climate change and responsible production (Dyllick and Muff 2016).

3.3 | Data Analysis Procedures

3.3.1 | Lexicon Development

Two distinct lexicons were used: one for the CE, developed from scratch using the logic of the 9R framework, and another for the SDGs, which had already been published. The 9R framework was chosen for its comprehensive, hierarchical structure, widely recognized in academic literature and policy circles (Munoz et al. 2024; Nowicki et al. 2023).

CE 9R Lexicon. Based on Potting et al. (2017), the lexicon was developed as follows. First, for each “R” category (Refuse, Reduce, Reuse, etc.), a generative AI tool (GPT 4.o) generated a list of 50 related words. Next, the resulting lists were sent to 40 academics, practitioners, and policy advisors for review. The survey ran from December 2024 to February 2025 and received 16 responses (40% response rate) from participants in eight countries. A simple set of acceptance/removal rules was applied using a 25% threshold (Janse van Rensburg et al. 2023). The final CE lexicon based on the 9R framework is presented in Appendix D.

SDG Lexicon. Based on the framework proposed by Amel-Zadeh et al. (2021), the SDG lexicon maps keywords associated with each of the 17 goals, including “clean energy”, “responsible consumption”, and “infrastructure innovation”. Although some lexical overlap across CE strategies is unavoidable, our analytical pipeline does not rely on rigid keyword–category assignments. Instead, semantic relevance is assessed using contextual embeddings, which derive term meaning from surrounding text rather than isolated tokens, thereby mitigating misclassification risks in overlapping CE categories (Grimmer and Stewart 2013; Grootendorst 2022). Accordingly, terms that may technically relate to multiple R-strategies (e.g., recycled components discussed in remanufacturing contexts) were classified based on their dominant contextual function within paragraphs, rather than on their nominal association with a single R-category.

3.3.2 | NLP Pipeline for Mapping Sustainable Disclosure

To systematically analyze textual content on sustainability themes, this study implements a computational NLP pipeline. This approach, as introduced in Figure 2 and increasingly prevalent in sustainability research (Ferjančič et al. 2024), ensures

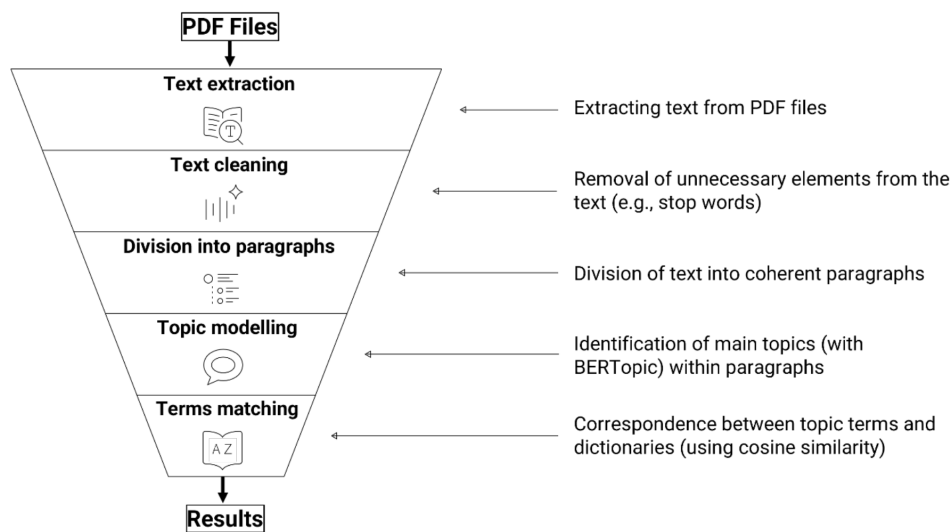


FIGURE 2 | NLP pipeline to extract and analyze sustainability-related content.

both objectivity and replicability and facilitates the identification of nuanced semantic patterns at scale. The NLP workflow, summarized in Appendix E, proceeds through four principal stages:

1. **Text Extraction and Preparation:** Source documents (academic and corporate PDFs) are converted to raw text, cleaned of extraneous elements, and segmented into paragraphs to preserve logical context. Each paragraph is transformed into a numerical vector (an embedding) that captures its contextual meaning using the advanced Sentence-BERT transformer model (Reimers and Gurevych 2019).
2. **Dominant Theme Identification:** Using the BERTopic framework (Grootendorst 2022), paragraphs with similar semantic content are automatically clustered into coherent topics. It combines contextual embeddings with a class-based TF-IDF procedure to assign the most dominant theme to each paragraph. This controlled strategy enhances thematic clarity and reduces topic dilution (Mohammadrezaei et al. 2024).
3. **Alignment with Sustainability Frameworks:** The identified topics on the SDGs and the CE are mapped to established sustainability taxonomies using semantic matching. This is done by computing the cosine similarity between the vector representations of the topic keywords and the pre-encoded lexicons. A conservative similarity threshold of 0.7 is applied to balance precision and recall, retaining only robust semantic alignments. Robustness checks using higher and lower cosine similarity thresholds yield qualitatively consistent results, indicating that the findings are not driven by the specific threshold choice. The choice of a 0.7 threshold reflects a conservative balance between semantic specificity and inclusiveness and avoids over-fragmentation of the mapping while limiting noisy alignments.
4. **Methodological Rationale:** The BERTopic framework, which leverages contextual embeddings, was selected over traditional topic models for its ability to generate semantically

coherent, contextually relevant topics (Grootendorst 2022). Comparative evaluations show that embedding-based topic models such as BERTopic outperform classical probabilistic approaches (e.g., LDA) in semantic coherence and stability, particularly for heterogeneous corpora (Gan et al. 2023). This approach offers greater interpretability and transparency in modeling complex sustainability discourse (Mohammadrezaei et al. 2024). The methodology aligns with emerging best practices in computational sustainability analysis, as evidenced by successful applications in SDG discourse analysis (Invernici et al. 2025) and in green AI research (Raman et al. 2024).

Rather than relying on a single analytical technique, the study adopts a multi-layer NLP pipeline. Semantic topic modeling (BERTopic), a cosine-similarity-based framework alignment, SDG-R co-occurrence analysis, and longitudinal trend analysis serve as complementary lenses, enabling methodological triangulation and mitigating the risk of biased pattern detection inherent in single-method approaches (Grimmer and Stewart 2013; Ferjančič et al. 2024; Raman et al. 2024; Invernici et al. 2025).

3.3.3 | Reliability and Validity

To ensure the reliability and validity of the analysis, the lexical dictionaries underwent an iterative validation process, a critical step in computational text analysis (Grimmer and Stewart 2013). Both authors manually reviewed the same document sample and compared their results to confirm that the automated text mining accurately captured the intended concepts. When misclassifications occurred—often due to the misuse of synonyms or context-specific terms—the dictionaries were refined by adding, removing, or modifying terms. The analysis was rerun to maintain consistency across the entire corpus (Nazir and Doni 2024). This iterative refinement ensures that the data accurately reflect the underlying constructs being studied (Short et al. 2010) and aligns with established best practices for dictionary-based content analysis (Krippendorff 2018).

To deepen this comparison, cross-tabulation was used to assess co-occurrence patterns (Pal et al. 2025; Ferraz and Pyka 2023). This analysis identified which Rs are most frequently associated with specific SDGs. Finally, a trend analysis over the 10-year period tracked changes in references to specific SDGs and Rs across datasets, highlighting evolving sustainability priorities (Murray et al. 2017). Reliability is further strengthened through triangulation that combines semantic clustering, dictionary-based validation, co-occurrence analysis, and temporal comparison (Grimmer and Stewart 2013).

4 | Results

4.1 | The SDGs

The visibility and prioritization of the SDGs will be examined in two key domains of sustainability discourse: academic literature and T-50 sustainability reports. Drawing on Figures 3 and 4, which track the volume of SDG mentions in academic sources from 2015 to 2024 and in corporate reporting from 2015 to 2023 (2024 is only partial as of mid-2025), we examine not

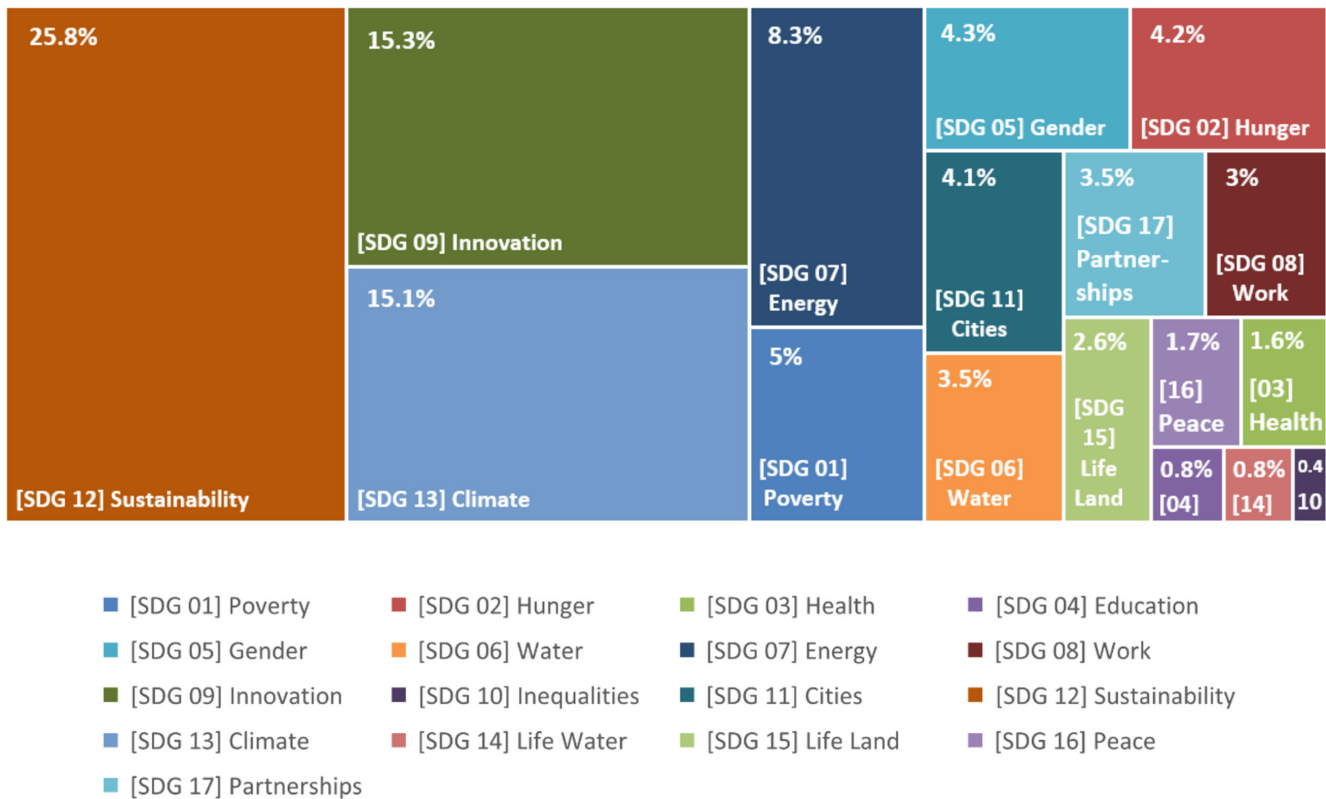


FIGURE 3 | SDGs distribution across 2015–2024 in academic sources.

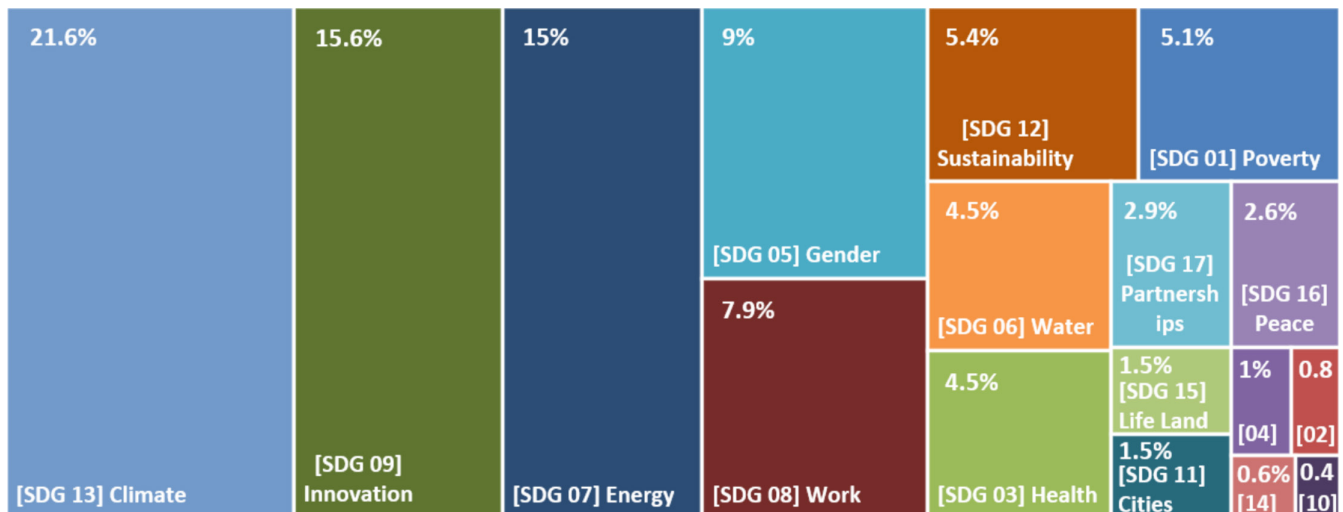


FIGURE 4 | SDGs distribution across 2015–2023 in corporate reporting.

only the scale of adoption over time but also the variation in goal-specific focus.

4.1.1 | The SDGs in Academia

Academic research has progressively and substantively embraced the SDG framework over the past decade. From 2015 to 2019, the number of SDG mentions in sampled academic publications remained relatively low, at 271, reflecting limited engagement following the SDGs' launch. The sharpest increase occurred from 2020 onward, coinciding with mounting policy focus on the CE and sustainability transitions worldwide. In 2024 alone, as shown in Figure 5, total SDG mentions had climbed to 1499, representing one-third of the total for the entire 10-year period in a single year.

Within this broader growth, several SDGs have emerged as dominant reference points. SDG 12 (Responsible Consumption and Production) was the most cited, rising from 10 mentions in 2017 to 417 in 2024, reflecting growing interest in circular practices,

life-cycle thinking, and production–consumption loops. SDG 9 (Industry, Innovation and Infrastructure) also grew sharply, from two mentions in 2017 to 234 in 2024. SDG 13 (Climate Action) followed a similar trend, focusing on decarbonization and transition strategies.

Illustrative of the SDG 12 trend, one academic paper published in 2020 stated, “In recent years, there has been an increasing focus on circularity in construction [...] to design products and processes that limit and compel the use of finite resources [...]” (Alkhani 2020, 6) highlighting how research emphasizes the importance of SDG 12 for sustainable transitions.

4.1.2 | The SDGs in Industry

In parallel, corporate discourse among the T-50 firms also shows an uptake of SDG language in sustainability reporting, though with a distinct profile. As shown in Figure 6, overall SDG mentions increased by less than a factor of two between 2015 and 2023, rising from 209 to 365.

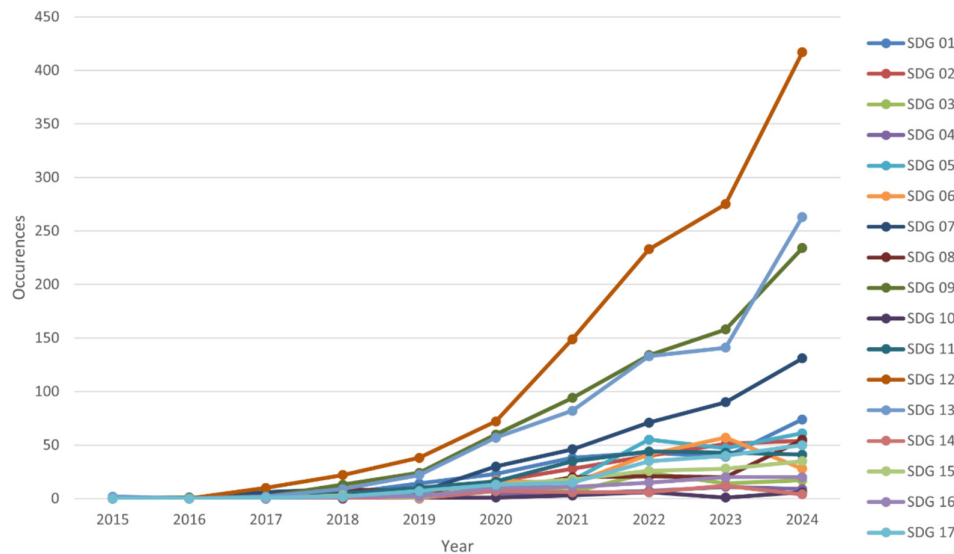


FIGURE 5 | SDGs evolution across 2015–2024 in academic sources.

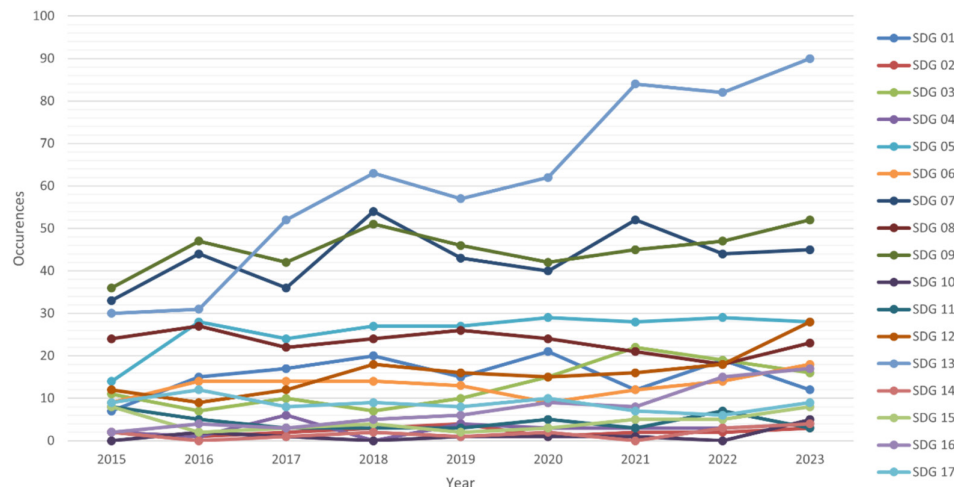


FIGURE 6 | SDGs evolution across 2015–2023 in corporate reporting.

SDG 13 (Climate Action) was the most frequently cited goal in corporate reports, with 90 mentions in 2023. This prominence reflects heightened regulatory scrutiny and investor pressure for climate-risk disclosures. SDG 9 (Industry, Innovation and Infrastructure) ranked second, with 52 mentions in 2023. This result underscores the growing strategic importance of circularity and resource efficiency for firms amid regulatory and reputational expectations.

The predominance of SDG 13 (Climate Action) is illustrated by the following quote from the *EDF Universal Registration Document and Sustainability Statement 2024* sustainability report: “The EDF group can claim to have divided by three its direct Scope 1 emissions since 2015 [...] and by three its carbon intensity [...], while maintaining its title as the largest producer of decarbonized electricity in the world [...]” (EDF Universal Registration Document and Sustainability Statement 2024, 216).

4.1.3 | The SDGs Convergence for Both Academia and Industry

When comparing the two datasets over time, several patterns emerge. First, SDG 7, SDG 9, and SDG 13 rank among the top five goals across both academic and corporate sources. This suggests shared concern for affordable and clean energy, innovation and resource use, and climate resilience.

Apple stated in its 2016 sustainability report: “Innovation is at the heart of everything we do at Apple, and that extends to our commitment to protecting the natural environment [...]. We’re constantly striving to find or invent solutions to important environmental challenges [...]” (Apple Sustainability Report 2016, 3), highlighting how alignment with SDG 9 (Innovation) reinforces its strategic positioning in sustainability.

4.2 | The Rs Framework of Circularity

The use and evolution of circularity-related terminology in academic publications and corporate sustainability reporting can be analyzed by focusing on the “R” strategies commonly associated with CE frameworks. Figure 7 summarizes the frequency of these Rs in academic literature (2015–2024) and in the T-50 reports (2015–2023). The findings reveal both convergence and divergence, shedding light on the practical and conceptual priorities that drive circularity discourse in each domain.

4.2.1 | The CE Rs in Academia

Academic engagement with the Rs of circularity has intensified substantially over the past decade. The total number of R-related mentions rose from 171 in 2019 to 1155 in 2024 alone, as shown

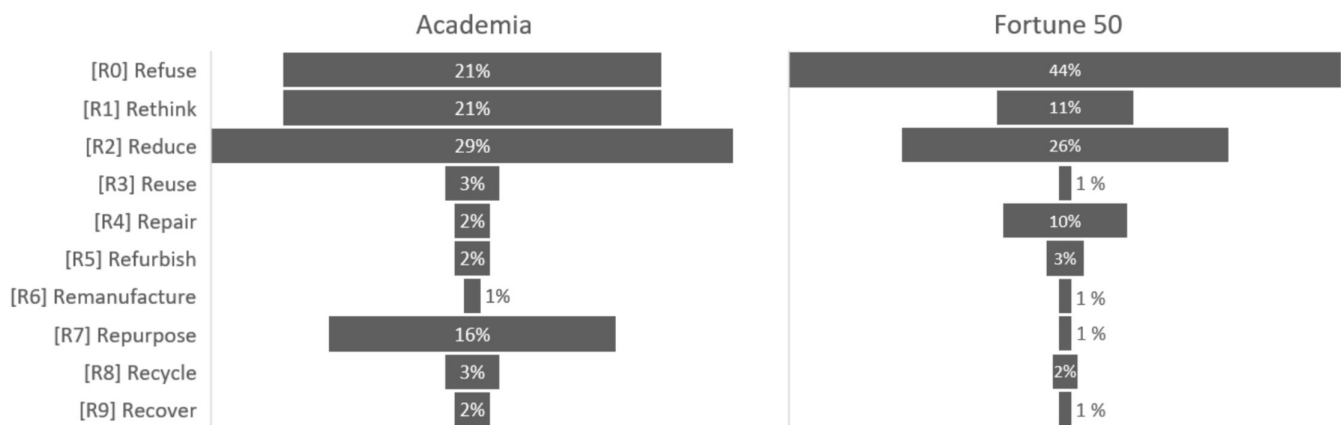


FIGURE 7 | Rs distribution across 2015–2024 in academic sources and corporate reporting.

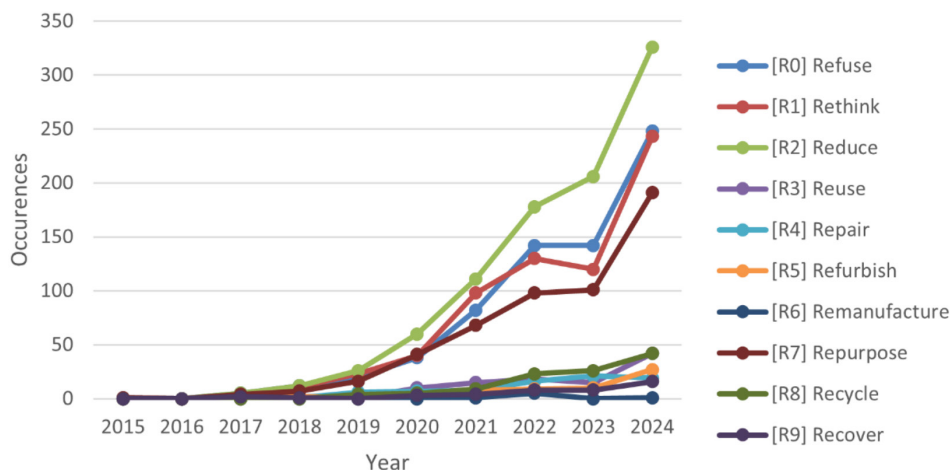


FIGURE 8 | Rs evolution across 2015–2024 in academic sources.

in Figure 8. This steady growth indicates the progressive integration of CE principles into the core of sustainability research.

Among the various Rs, “Reduce” (R2) has been the most frequently referenced term throughout the period, with only 12 mentions in 2018 and 326 6years later in 2024. “Refuse” (R0) and “Rethink” (R1) follow closely. Their growth curves reflect increasing academic interest in upstream strategies (R0 to R2) for smarter product use and manufacturing, and align with recent critical literature advocating a move beyond end-of-pipe solutions. Of particular note is the growing presence of “Repurpose” (R7), which continues to sustain interest in specific downstream strategies of the CE.

As an illustrative academic source noted in 2023, “Aerial photos of ‘bike graveyards’ in China illustrate that you can have too much of a good thing. Bike sharing, in theory, should reduce the number of bikes required; however, when bike sharing is seen as a business opportunity we end up with mountains of excess bikes. [...] ‘Share bike is a great idea ... 10 billion of them is not a good idea’ [...]” (Szto and Wilson 2023, 9). This statement shows that higher-order Rs (R0 to R2), while often positioned as drivers of strategic and behavioral change, can also present counterexamples to currently promoted models in certain contexts.

4.2.2 | The CE Rs in Industry

T-50 firms have also adopted R-based circularity-related language more extensively over time, though we did not observe any major breaks over the 10-year period. Figure 9 shows that the total number of R-strategy mentions in corporate reports doubled from 83 in 2015 to 164 in 2023.

“Refuse” (R0) dominates the terminology landscape in corporate reporting, accounting for 44% of total mentions. “Reduce” (R2) ranks second at 26%, followed by “Rethink” (R1) and “Repair” (R4), each at approximately 10%. The language covers emissions reduction, energy efficiency, and waste minimization, often tied to cost-saving initiatives or environmental compliance. “Repair” (R4), at 10%, is the only mid-strategy that focuses specifically on a product’s lifespan.

To illustrate broader circularity trends, Walmart stated in its 2020 sustainability report: “Reduce unnecessary packaging, use better packaging materials [...] Walmart is taking specific aim at plastics, with expanded waste reduction commitments for our U.S. private brands [...]” (Walmart Sustainability Report 2020, 28), suggesting a nascent shift in strategic framing around circular design principles.

4.2.3 | The Rs Convergence for Both Academia and Industry

Both academia and T-50 firms have seen a rise in the use of R-related terminology over the past decade, with a shared focus on upstream “refuse”, “rethink”, and “reduce” strategies. However, the data also reveal a divergence in hierarchy, with a stronger emphasis on reducing (R2) in academia than on refusing (R0) in corporations. Yet it is interesting to look beyond these three main concepts that seem to align both parties and to observe that the fourth most often mobilized concept is “repurpose” (R7) in academia and “repair” (R4) in the T-50.

We can illustrate this overall convergence in upstream strategy prioritization with a statement from Mercedes-Benz Group, which, in its 2021 sustainability report, stated: “[...] we want to reduce the amount of critical materials used by keeping second-use raw materials in the cycle for as long as possible. [...] This enables us to reduce the proportion of critical raw materials used as well [...]” (Mercedes-Benz Group Sustainability Report 2021, 19), illustrating how Rs alignment is leveraged to reinforce strategic positioning in sustainability.

4.3 | The SDGs and Rs Correlation

The intersection between the SDGs and circularity strategies is examined by analyzing their co-occurrence in academic literature and the T-50 sustainability reports. Tables 3 and 4 document the frequency with which paragraphs were assigned the same combination of SDG and R-strategy (e.g., SDG 13—Climate Change and R2—Reduce). The analysis reveals distinct patterns in how circular practices are framed in relation to global sustainability priorities.

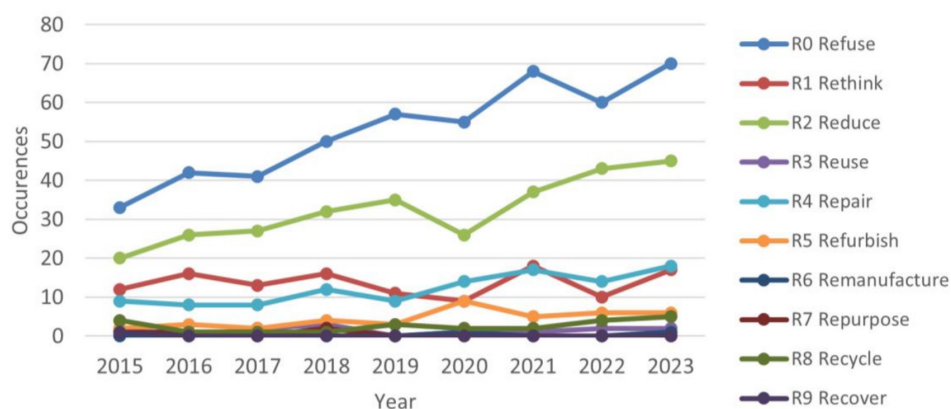


FIGURE 9 | Rs evolution across 2015–2023 in corporate reporting.

TABLE 3 | SDGs and Rs percentage correlation across 2015–2024 in academic sources.

Rs	SDGs									
	SDG 06	SDG 07	SDG 08	SDG 09	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 17
R0 Refuse	0.1					2.8				
R1 Rethink			3.6	0.5	0.1	15.6	10.1	0.1	0.3	0.1
R2 Reduce		11.9		0.7		24.5	0.2		0.2	
R3 Reuse					0.1	0.1			1.2	
R4 Repair										
R5 Refurbish					0.1					
R6 Remanufacture										
R7 Repurpose				5.8			16.7			
R8 Recycle	0.2					4.9				
R9 Recover		0.3				0.3				

TABLE 4 | SDGs and Rs percentage correlation across 2015–2023 in corporate reporting.

Rs	SDGs							
	SDG 07	SDG 08	SDG 09	SDG 12	SDG 13	SDG 14	SDG 15	SDG 17
R0 Refuse	13.7		25.9	11.2				
R1 Rethink	0.7	0.8	2.2		0.3		0.3	0.3
R2 Reduce	34.7		1.0		1.8	0.5		
R3 Reuse				1.7				
R4 Repair								
R5 Refurbish								
R6 Remanufacture				0.3				
R7 Repurpose			0.5					
R8 Recycle				3.7				
R9 Recover	0.2							

4.3.1 | The SDGs and CE Rs Correlation in Academia

In academic literature, the co-occurrence of SDGs and R-strategies has expanded significantly, with the total number of SDG–R linkages rising from 276 occurrences until 2019 to 1500 in 2024 alone. SDG 12 (Responsible Consumption and Production) is most frequently associated with R-strategies, accounting for almost 50% of associations, as shown in Table 3. This illustrates how academic narratives have internalized the CE as a central operational pathway for achieving more sustainable production and consumption systems.

“Reduce” (R2) remains the most commonly linked R-strategy (accounting for 37%), particularly in connection with SDG 12. This correlation alone accounts for a quarter of all links. Interestingly, more downstream Rs, such as “Repair” (R4) and “Remanufacture” (R6), have not shown any correlation with the SDGs.

As a 2021 academic article notes, “An additional well-consolidated repurpose loop present in the aeronautics sector was found to be the so-called retrofit market” (Diaz et al. 2021, 7). This captures a practical shift in framing circularity through the repurpose loop (R7) and a clear climate orientation (SDG 13) as transformative rather than incremental.

4.3.2 | The SDGs and CE Rs Correlation in Industry

In the T-50 reporting, the co-occurrence of SDGs and R-strategies doubled between 2015 and 2023. Although the volume remains lower than in academia, the correlation patterns reveal meaningful trends. SDG 7 (Affordable and Clean Energy) is the dominant axis, with a correlation of almost 50% with the Rs strategies, as shown in Table 4. Its first significant intersection is with R2 (reduce) at 34%, followed by R0 (refuse) at 13%.

However, downstream Rs from reuse (R3) to recover (R9) account for less than 7%.

The following declaration from a T-50 firm in its 2023 sustainability report demonstrates a pragmatic link between radical and yet operational circularity (R0, refuse) and the industry, innovation, and infrastructure (SDG 9): “[...] we are also making investments to create efficiencies [...], including automating and mechanizing many of our facilities and leveraging hydrogen-powered forklift technology.” (Home Depot Sustainability Report 2023, 48).

4.3.3 | The SDGs and Rs Correlation in Both Academia and Industry

Across both corpuses, a clear convergence emerges around the strategic pairing of specific SDGs with CE strategies, suggesting a shared sustainability logic despite differences in vocabulary and framing. The most consistent intersection is between SDG 7 (Affordable and Clean Energy) and R2 (reduce), with 11.9% in Academia and 34.7% in T-50 sustainability reports.

The second and most common intersection is much smaller, between SDG 12 (Responsible Consumption and Production) and R8 (recycle), with 4.9% in academia and 3.7% in sustainability reports. While some points of convergence exist between academia and T-50, many differences remain in the focus of their activities or the lens used to study them.

We can illustrate the convergence of research on SDG 7 (affordable and clean energy) and R2 (reduce) with this quote from Hillerbrand (2018), “The lack of progress for SDG7 cannot, of course, be attributed solely to the formulation of the goal, its targets, or its indicators. [...] substantial changes in behavioral patterns on individual and societal level [...] cannot overcome all motivational hurdles.” (p. 5).

4.3.4 | Implications for Academia and Industry

The observed patterns of divergence and convergence between academic and corporate discourse suggest several implications for how CE strategies and SDGs can be leveraged more effectively in practice and research. Rather than viewing them as operating in parallel silos, the results point to complementary strengths that can be mobilized more strategically.

From an industry perspective, academic research adds value by systematically advancing upstream circular strategies and conceptual experimentation. The strong academic focus on Reduce (R2), Rethink (R1), and Refuse (R0), together with recurring intersections such as SDG 12—Rethink (R1) and SDG 13—Rethink (R1), highlights a body of work that explores design-stage interventions, alternative use models, and systemic reconfiguration. These insights can inform corporate strategy by supporting earlier decision-making, particularly in product design, portfolio steering, and scenario analysis, where firms often remain constrained by operational routines and reporting requirements. Academic emphasis on Repurpose (R7), which remains marginal in corporate discourse, further suggests

untapped opportunities for cross-sector innovation in secondary markets and functional redefinition.

On the other hand, corporate practice provides academia with insight into which circular strategies scale under real-world constraints. Industry’s strong focus on Refuse (R0), Reduce (R2), and Repair (R4), along with its concentration on SDGs 7, 9, and 13, reflects strategies that firms can currently operationalize, measure, and justify within regulatory and market contexts. These patterns highlight the importance of feasibility, infrastructure compatibility, and energy-related performance, offering empirical grounding for academic models that often assume greater organizational flexibility. In particular, the prominence of Repair (R4) in corporate discourse signals a growing commitment to product-life extension that warrants deeper scholarly investigation.

Finally, areas of overlap are pointing to promising zones for joint advancement. The shared emphasis on upstream strategies and recurring intersections, such as SDG 7—Reduce (R2) and SDG 12—Refuse (R0), indicates common ground where science-based insights and large-scale implementation can reinforce one another. These convergence points provide a basis for collaborative experimentation, shared metrics, and translational research designs that align academic rigor with corporate impact. Strengthening these interfaces could help transform CE and SDG frameworks from parallel reference systems into mutually reinforcing drivers of sustainability transitions.

5 | Discussion

5.1 | The SDGs as a Common Ground

The integration of SDGs into CE literature and corporate reports has often been described as fragmented or inconsistent (Di Vaio et al. 2024). Our results offer a more optimistic perspective, revealing clear alignment on SDG 12 (Responsible Consumption and Production) as the primary entry point into circularity discourse for both academia and the T-50. This shared emphasis supports earlier theoretical claims that SDG 12 serves as a boundary object, a flexible yet stabilizing reference point for circularity-related strategy (Desing et al. 2020).

By empirically mapping the co-occurrence of SDGs with specific R-strategies, this study moves beyond conceptual assertions and offers a data-driven account of how SDG 12 functions as both a strategic anchor and a narrative bridge between theory and implementation.

Sharma et al. (2024) argue that SDG 12 is the primary target for integrating circularity through digital innovation pathways. Although our study does not examine digitalization per se, it confirms the centrality of SDG 12 across both corpuses. Moreover, by tracing its systematic association with R-strategies such as “Reduce” (R2) and “Recycle” (R8), we extend their argument by showing how SDG 12 serves as both a strategic anchor and a narrative bridge between theory and implementation. However, a closer look at the data suggests that academia continues to engage more comprehensively with the SDG framework. In contrast to corporate actors, who focus overwhelmingly on SDG 12

and, to a lesser extent, SDGs 13 and 9, academic literature shows broader uptake across the full SDG spectrum. This pattern aligns with observations by Bocken and Antikainen (2018) that academic circularity narratives are often embedded in system-level sustainability thinking, whereas companies tend to pursue narrower operational goals.

Yet the convergence we observe, especially post-2020, suggests a gradual narrowing of this gap. Companies increasingly align circular strategies with climate action (SDG 13) and industrial innovation (SDG 9), echoing scholarly calls to integrate CE into decarbonization and industrial transition agendas (Manninen et al. 2018). This trend indicates that the SDGs are not merely symbolic in corporate discourse but are becoming functional anchors for communicating and organizing circular action. Still, the marginal role of social goals (e.g., SDG 1—no poverty, SDG 5—gender equality, SDG 10—reduced inequalities) in both datasets reinforces prior concerns (Ghisellini et al. 2024) that CE thinking remains overly focused on material and environmental dimensions, with limited engagement with equity, inclusion, or justice-oriented outcomes. Here, the academia-industry gap appears less a divergence than a shared conceptual blind spot, underscoring a missed opportunity to embed circularity within more inclusive and justice-oriented sustainability frameworks.

5.2 | Circular Hierarchies in Motion

By adopting a longitudinal, text-mining perspective, this study offers a dynamic reinterpretation of the widely discussed hierarchy gap between the theoretical desirability and practical implementation of circular strategies.

Existing literature frequently highlights the disconnect between the most theoretically desirable strategies (e.g., Refuse, Rethink) and those most commonly implemented, such as Recycle (Reike et al. 2018). Yet longitudinal data offer a dynamic view of this gap: while “Recycle” (R8) is considered the most commonly implemented, it does not dominate either the academic or the corporate corpus. A much more diverse set of Rs is addressed in both, with a predominance of upstream “Refuse”, “Rethink”, and “Reduce”.

This rebalancing is more pronounced in academic discourse, where higher-order strategies such as “Rethink” and “Refuse” are gaining traction. Their rising frequency—particularly after 2020—confirms theoretical claims that the future of circularity lies in upstream, design-oriented innovation (Brown et al. 2021). These strategies are often linked to business model transformation, service-based logic, and systemic reconfiguration (Bocken et al. 2025).

The work by Nazir et al. (2024) confirms that while corporate disclosures emphasize mid-stream Rs such as “Reduce” and “Recycle”, academic literature increasingly engages with upstream strategies like “Refuse” and “Rethink”. Our findings empirically support this divergence and add a longitudinal dimension. Unlike their bibliometric focus, our text-mining approach reveals narrative shifts over time, offering a more dynamic view of how these strategies evolve across theory and practice.

In corporate reports, the shift is more incremental. Companies remain anchored in mid-tier Rs, which align better with existing infrastructure and reporting mechanisms. However, the steady growth of “Repair” and “Refurbish” suggests that corporate actors are beginning to integrate longer product-life and after-market strategies into their sustainability logic. From a strategic perspective, this pattern suggests that mid-stream life-extension strategies may function as “bridging practices”, enabling firms to experiment with circularity while progressively building the skills required for upstream transformation. This aligns with Pla-Julián and Guevara’s (2019) observation that firms are beginning to embed life cycle thinking into their sustainability agendas, although implementation often remains partial and shaped by industry-specific strategic priorities.

Importantly, this transition does not imply that companies are merely lagging behind academic thought. Rather, it suggests a pragmatic convergence: as technical feasibility and market readiness evolve, companies are adopting a broader R repertoire that mirrors conceptual hierarchies, albeit with different pacing and emphasis (Reike et al. 2018). This convergence also aligns with insights from Pla-Julián and Guevara (2019), who emphasize companies’ role in integrating life cycle thinking into upstream strategies.

5.3 | Connecting Goals to Circular Strategies

One of the most striking contributions of this study is the empirical mapping of SDG–R pairings across two institutional domains. Our results fill this gap by showing that both academic and corporate actors increasingly articulate circular strategies aligned with specific SDGs, thereby reinforcing the conceptual work of Murray et al. (2017).

These correlations are not random but patterned. For example, SDG 12 (Responsible Consumption and Production) is overwhelmingly paired with the four Rs: “Refuse”, “Rethink”, “Reduce”, and “Recycle”. This suggests that the CE is operationalized primarily through material and waste-related interventions, whether upstream or downstream. This empirical alignment confirms earlier conceptual propositions by Lewandowski (2016), who argued that CE practices tend to crystallize around production and consumption flows. These pairings suggest a shared strategic logic taking shape, with circular practices increasingly embedded in organizational sustainability planning. The gap between academia and industry, once a clear divide between concept and application, appears to be narrowing in SDG–R integration. This co-evolution reflects what Geissdoerfer et al. (2017) described as the mutual shaping of sustainability and circularity frameworks.

However, differences remain. Academic texts more often explore abstract combinations, such as linking “Refuse” or “Recycle” to SDG 6 (Clean Water and Sanitation), whereas corporate reports did not draw any such link to SDG 6. This reflects a divergence in social roles: academia pushes conceptual boundaries, whereas firms operate within implementation constraints. As Moreau et al. (2017) note, these differences stem from distinct social and institutional conditions that shape how circularity is framed.

5.4 | Reframing the Academia vs. Industry Gap

Taken together, our findings align with the evolving view proposed by Bocken and Geradts (2020), which reframes the academy-industry divide as a dynamic interaction in which academic research sets ambitious directions and companies progressively adapt through experimentation and business model iteration. While academic research sets directional aspirations through higher-order strategies and systemic thinking, companies respond by gradually absorbing these narratives, implementing mid-tier strategies, and grounding them in metrics, compliance, and stakeholder reporting.

This dynamic invites us to reconsider the literature's persistent narrative of disconnect. Instead of a gap, what we observe may be a sequencing of logics: theory leads with ambitious abstraction, and practice follows with pragmatic operationalization. Recognizing this sequencing has practical implications: it suggests that misalignment between academic prescriptions and corporate practices should not be interpreted as failure but as an expected phase in translating CE principles into implementable strategies. This echoes the co-evolutionary perspective proposed by Franco (2017), which views academic and business domains as mutually shaping one another over time through iterative cycles of knowledge creation and implementation. In this sense, the value of comparative analysis lies not in determining which domain is more advanced or legitimate, but in tracing how ideas migrate across institutional boundaries. This perspective aligns with Kalmykova et al. (2018), who emphasize that CE concepts evolve through iterative exchanges among academic, policy, and business contexts. This underscores the importance of future research that not only measures discursive alignment but also examines the conditions under which it leads to real-world change (Murray et al. 2017).

This reframing constitutes a conceptual contribution to CE scholarship and has practical implications for how translational research and corporate experimentation are understood and evaluated over time.

6 | Conclusion

This is one of the first studies to empirically compare how academia and industry jointly articulate CE strategies and SDGs over time, using a multi-layer NLP-based analytical framework. By doing so, the paper moves beyond descriptive trend analysis and offers a structured mapping of CE–SDG alignments that can inform both sustainability research and corporate strategy. By jointly analyzing academic and corporate discourse over a decade, this study empirically captures how CE strategies and SDGs co-evolve across institutional domains, rather than treating them as static or isolated frameworks. By examining the following research question: “Where do academia and industry diverge and converge in driving the agenda of CE strategies and SDGs?” we pursued three objectives: (1) to compare CE “R-strategy” hierarchies and SDG salience across academic literature and corporate sustainability reporting, (2) to map where SDGs and circular strategies co-occur within each domain, and (3) to identify areas of convergence and divergence that can support cross-sector learning and cooperation between academia and industry.

Drawing on a large-scale computational textual analysis of 919 academic articles and 404 sustainability reports from the top 50 Fortune Global 500 companies over the period 2015–2024, the study addressed the first objective by systematically comparing the relative prominence of SDGs and circular strategies across the two corpuses. This comparison revealed clear differences in emphasis: academic discourse engages more broadly with the SDG framework and increasingly prioritizes higher-order circular strategies such as “Refuse” (R0), “Rethink” (R1), and “Reduce” (R1), whereas corporate reporting concentrates on a narrower subset of goals—most notably SDG 13, SDG 12, and SDG 9—and mobilizes a more limited range of circular strategies.

The second objective was addressed by analyzing the co-occurrence patterns between SDGs and CE strategies at the paragraph level. This mapping shows that SDG 12 serves as a central anchor in both domains, consistently paired with multiple R-strategies, particularly “Reduce” (R2) and “Recycle” (R8), where companies should foster cooperation. These patterns demonstrate that CE principles are not referenced in isolation but are increasingly articulated through specific sustainability goals, albeit with different strategic logics across academia and industry.

Finally, the third objective was met by identifying areas of convergence and divergence between the two corpuses. Despite differences in scope and pace, both academic and corporate discourse show growing alignment on upstream circular strategies and climate and production-related SDGs. These shared focal points indicate that the relationship between academia and industry cannot be reduced to a static “gap” but is better understood as a dynamic interplay in which academic abstraction and business implementation evolve together and could generate more knowledge.

Building on these findings, the paper offers three distinct contributions to the CE and sustainability literature. First, it provides one of the few comparative analyses of how SDGs and R-strategies are referenced across institutional settings, addressing calls for greater empirical grounding of CE frameworks (Geissdoerfer et al. 2017; Kirchherr et al. 2017). Second, it challenges the notion of a “gap”, offering instead a co-evolutionary view of academic and corporate discourse (Franco 2017; Moreau et al. 2017). Third, by empirically identifying recurring CE–SDG hybrid pairings across academia and industry, the study reveals how circular strategies are selectively adapted to different institutional logics—an aspect that has remained largely conceptual in prior research.

For practitioners, the results indicate that aligning specific R-strategies with clearly prioritized SDGs—particularly SDG 12 and SDG 13—can serve as a decision heuristic to prioritize circular initiatives, align sustainability teams with operational units, and structure coherent transition roadmaps. Explicitly linking R-strategies to these goals can strengthen sustainability narratives, investor confidence, and regulatory preparedness. The growing focus on product life-extension strategies such as “Repair” (R4) and “Refurbish” (R5) also signals opportunities for innovation in service models, aftermarket offerings, and resource efficiency. Organizations may also use this analysis to benchmark against industry peers and academia, improve sustainability reporting, and identify opportunities for cooperation.

Limitations remain. The analysis captures frequency and co-occurrence but not the depth or credibility of implementation. Mentions in reports may not reflect actual operational change. Moreover, the T-50 sample may not represent SMEs or firms in the Global South, calling for broader replication. Finally, our co-occurrence-based method may miss subtler semantic or conceptual links—future research could apply NLP techniques and emerging technologies to explore these nuances.

Beyond its direct contributions, the findings also open avenues for further research. The sharp rise in references to SDG 13 (Climate Action), for example, invites closer examination of how CE and SDG discourse align with major global policy milestones, such as the Paris Agreement (COP21). In addition, the growing emphasis on lifecycle-oriented circular strategies suggests potential implications for sustainability-related skills and employment, prompting research into how academia and industry shape emerging competencies for the CE transition (Straub et al. 2023).

Despite these caveats, this study provides a robust foundation for understanding how circularity and sustainability are co-constructed across academia and industry—and how a more integrated discourse could accelerate meaningful climate and development action and cooperation in the years ahead. By shifting the focus from whether academia or industry is “ahead” to how circularity and sustainability narratives co-evolve over time, this study reframes a long-standing debate and opens new empirical avenues for strategy and policy-oriented research.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix A

R-Level	Strategy	Description
R0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
R1	Rethink	Make product use more intensive (e.g., through sharing products, or by putting multi-functional products on the market)
R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
R3	Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
R4	Repair	Repair and maintenance of defective product so it can be used with its original function
R5	Refurbish	Restore an old product and bring it up to date
R6	Remanufacture	Use parts of discarded product in a new product with the same function
R7	Repurpose	Use discarded product or its parts in a new product with a different function
R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
R9	Recover	Incineration of materials with energy recovery

Appendix B

SDG	Title of the SDG	# 9	Industry, innovation, and infrastructure
# 1	No Poverty	# 10	Reduced Inequalities
# 2	Zero Hunger	# 11	Sustainable Cities and Communities
# 3	Good Health and Well-being	# 12	Responsible Consumption & Production
# 4	Quality Education	# 13	Climate Action
# 5	Gender Equality	# 14	Life Below Water
# 6	Clean Water and Sanitation	# 15	Life on Land
# 7	Affordable and Clean Energy	# 16	Peace, Justice and Strong Institutions
# 8	Decent Work and Economic Growth	# 17	Partnerships for the Goals

Appendix C

Rank	Journal title	Occurrences
1	Sustainability	178
2	Journal Of Cleaner Production	90
3	Science Of The Total Environment	40
4	Journal Of Environmental Management	34
5	Sustainable Production And Consumption	24
6	Sustainable Development Goals Series	23
7	Circular Economy And Sustainability	23
8	Business Strategy And The Environment	22
9	Environment Development And Sustainability	21
10	Energies	21

Appendix D

R0 REFUSE	R1 RETHINK	R2 REDUCE	R3 REUSE	R4 REPAIR	R5 REFURBISH	R6 REMANUFACTURE	R7 REPURPOSE	R8 RECYCLE	R9 RECOVER
Minimalism	Sharing economy	Efficiency	Second-hand	Maintenance	Renovation	Reengineering	Alternative uses	Reprocessing	Energy recovery
Zero-waste	Product as service	Resource reduction	Product longevity	Fixing	Restoration	Reassembly	Creative reuse	Material recovery	Waste-to-energy
Avoidance	Multi-functional design	Eco-efficiency	Reuse platforms	DIY	Upgrade	Factory reset	Upcycling	Waste sorting	Heat recovery
Packaging-free	Resource efficiency	Less material	Resale	Toolkits	Renewal	Component remanufacture	Functional shift	Recycling systems	Incineration
Doing differently	Eco-innovation	Optimized design	Robust design	Repair manuals	Restoring products	Reconstruction	New life	Secondary materials	Waste treatment
Conscious consumption	Circular design	Minimal waste	Durable goods	Service centers	Retrofit	Part replacement	Redesigned purpose	Closed-loop recycling	Energy loops
Design optimization	Shared assets	Energy saving	Circular systems	Skill-building	Value addition	Sustainable remanufacture	Cross-purpose design	Resource recovery	Energy systems
Material exclusion	Collaborative consumption	Water saving	Reuse strategy	Defect correction	Green refurbishment	Eco-remanufacture	Sustainable repurpose	Sustainable recovery	Material combustion
Eco-awareness	Industrial symbiosis	Low-impact materials	Lifetime extension	Parts replacement	Component upgrading	Component adaptation	Eco-repurpose	Material reuse	Heat loops
Selective purchasing	Performance-based sharing	Eco-optimization	Re-commerce	Technical support	Refurbished goods	Factory shift	Design repurposing	Recycling innovation	Waste heat
Plastic-free	Design thinking	Compact design	Product sharing	Repair cafes	Circular refurbishing	Green remanufacturing	Second function	Recycling technology	Thermal recovery
Non-toxic materials	Redesign	Sustainable sourcing	Pre-owned	Sustainable repair	Resource renewal	Remade parts	Innovative repurposing	Waste conversion	Energy strategies
Sustainable choices	Optimized usage	Local sourcing	Reuse economy	Green workshops	Sustainable refurbishing	Product reassembly	Green innovations	Recycling economy	Thermal systems
Biodegradable	Eco-engineering	Lightweight materials	Circular lifecycle	Repair tools	Eco-renovation	Refitting	Impact-driven repurpose	Sustainable loops	Waste heat recovery
Waste prevention	Usage intensity	Durability	Pre-used	Durability enhancement	Lifecycle refurbish	Lifecycle remanufacture	New applications	Resourceful recycling	Energy cycle
Resource minimization	Lifecycle ecosystem	Green logistics	Product care	Component repair	Eco-enhancement	Restoration	Eco-design	Eco-materials	Renewable heat
Ethical sourcing	Lean design	Energy efficiency	Recommerce	Equipment repair	Component renewal	Remanufacture integration	Redefining products	Recycling processes	Waste utilization
Consumer awareness	Cross-sector collaboration	Material efficiency	Reuse support	Green maintenance	Product renewal	Value renewal	Sustainable transformation	Recycling initiatives	Thermal conversion

R0 REFUSE	R1 RETHINK	R2 REDUCE	R3 REUSE	R4 REPAIR	R5 REFURBISH	R6 REMANUFACTURE	R7 REPURPOSE	R8 RECYCLE	R9 RECOVER
Rejection	Sustainable ecosystem	Streamlined processes	Donation	Repairability	Upgrade strategies	Circular remanufacture	Green repurpose	Circular recycling	
Conscious design	Resource optimization	Waste reduction	Used goods	Resourceful repair	Refurbish solutions	Eco-remanufacture	Renewable applications	Material transformation	
Zero impact	Functionality	Design simplicity	Reused materials	Product repair	Eco-upgrading	Resource efficiency	Functional repurpose	Recycling streams	
Mindful consumption	Systemic change	Carbon footprint	Closed-loop	Sustainable fixing	Sustainable refurbishment	Manufacturing update	Sustainable functionality	Sustainable loops	
Upstream prevention	Innovative models	Supply chain efficiency	Sustainable reuse	Technical repair	Durability boost	Component integration	Creative design	Waste recovery	
Renewable choices	Sustainable business model	Smart materials	Material flow	Fault fixing	Sustainable renovation	Redesigned systems	Eco-transformation	Recycling networks	
Stepping back	Resource-conscious design	Efficient transport	Reuse innovation	Lifetime repair	Eco-renewal	Eco-remake	Design shift	Waste loops	
Regeneration	Eco-products	Renewable energy	Resource reuse	Repair economy	Green value	Product remanufacture	Eco-functional	Green transformation	
Impact cancellation	Smart systems	Eco-packaging	Eco-systems	Eco-repair	Refurbishment processes	Component integration	Product innovation	Recycling goals	
Smart choices	Shared solutions	Eco-efficient design	Product cycle	Repair insurance	Enhanced lifecycle	Resourceful remanufacturing	Renewed purpose	Material efficiency	
Zero waste	Business model innovation	Sustainable manufacturing	Second life	Workshop support	Eco-upgrades	Circular components	Purpose redefinition	Recycled inputs	
Resource creation	Sustainability strategies	Minimalist design	Waste reuse	Skill repair	Circular renewal	Recycled components	Resourceful thinking	Green reprocessing	
Sustainable alternatives	Systems thinking	Green supply chain	Repairable products	Circular repair	Lifecycle updates	Sustainable components	Adaptive purpose	Circular processes	
Design for the environment	Asset sharing	Optimized manufacturing	Reusable items	Product maintenance	Durability enhancement	Conscious manufacturing	Lifecycle innovation	Sustainable loops	
Prevention	Green cooperation	Longer lifespan	Eco-reuse	Fix strategies	Eco-restoration	Remanufacturing design	Sustainable alternatives	Recycling lifecycle	
Packaging innovation	Environmental performance	Reduced emissions	Sustainable flow	Support services	Revised durability	Material remanufacture	Purpose innovation	Sustainable transformation	
Waste loop	Cultural shift	Eco-minimalism	Product exchange	Repair technologies	Enhanced value	Eco-friendly remanufacture	Redesign adaptation	Eco-strategies	
Eco-consciousness	Consumer behavior	Waste minimization	Reutilization	Repair readiness	Sustainable renewal	Eco-construction	Lifecycle-driven purpose	Resource loops	

R0 REFUSE	R1 RETHINK	R2 REDUCE	R3 REUSE	R4 REPAIR	R5 REFURBISH	R6 REMANUFACTURE	R7 REPURPOSE	R8 RECYCLE	R9 RECOVER
Greener alternatives	Idea-generation innovation	Resource-conscious	Reuse initiatives	Repair communities	Revised product	Product revival	Resourceful design	Material reprocessing	
Relocate	Integrated systems	Lean manufacturing	Eco-consciousness	Lifetime enhancement	Lifecycle improvement	Eco-efficiency	Innovative transformation	Recycled materials	
Reduction strategies	Sustainable by design	Green energy	Component reuse	Spare part	Durable upgrading	Reconstructed goods	Resource transition	Closed-loop recovery	
Low-waste lifestyle	Dynamic design	Eco-production	Green marketplaces	Repair efficiency	Green refurbishment	Lifecycle rebuilding	Sustainable creation	Circularity focus	
Circular for life	Pay-per-use	Energy optimization	Sharing economy	Fault resolution		Green remanufacture		Green conversion	
Balanced ecosystem	Product ownership	Material reuse	Reuse planning	Repair networks		Circular integration		Recycling initiatives	
Resource awareness	Eco-economy	Zero-waste design	Robust lifecycle	Prolonged use		Eco-remanufacture		Green loops	
Environmental unity	Reconfiguring	Eco-innovation	Resource flow	Repairability score					
Waste elimination	Low-impact design	Sustainable logistics	Reuse economics	Resilient products					
	Service models	Conservation	Lifecycle extension						
	Resilience thinking	Low-energy processes	Green reuse						
	Eco-system integration	Environmental efficiency	Eco-strategies						
	Usage models	Sustainable inputs							

Appendix E

1. NLP Framework Initialization

The pipeline employs multiple NLP components:

- SpaCy's English language model (en_core_web_sm) for text processing
- Sentence-BERT (all-MiniLM-L6-v2) for semantic embeddings
- BERTopic for topic modeling
- Custom stopwords lists for text filtering

Core Processing Modules

2.1 Text Extraction and Cleaning

- PDF documents are processed using PyPDF2, extracting raw text while preserving document structure
- Text normalization includes:
 1. URL and email pattern removal
 2. Special character filtering
 3. Lemmatization with part-of-speech retention
 4. Stopword elimination

2.2 Semantic Chunking

Documents are segmented into coherent paragraphs using SpaCy's sentence boundary detection, with a minimum length threshold (60 characters) to ensure meaningful analysis units.

2.3 Topic Modeling

A hybrid BERTopic approach combines:

- Sentence-BERT document embeddings
- Customized CountVectorizer with n-gram ranges (1–3)
- Automated topic extraction and representation

2.4 Concept Matching

A dual-dictionary system compares extracted topics against:

- UN Sustainable Development Goals (SDG) lexicon
- Circular Economy 9R framework lexicon using cosine similarity thresholding (0.7) on semantic embeddings.

3. Analytical Workflow

The main analysis procedure:

- Loads and encodes reference dictionaries
- Processes PDF documents sequentially

For each document:

- Extracts and cleans text
- Identifies key topics
- Matches topics against reference frameworks

4. Quality Control

The system includes robust error handling:

- Minimum paragraph requirements
- Topic modeling validation
- Comprehensive error logging for problematic files