Original Paper

Bridging ESG and the Circular Economy.

Advancing corporate sustainability through the updated R-Hierarchy and Circularity Scoring Model

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Acronyms: C2C: Cradle to Cradle; **CE**: Circular Economy; **CSM**: Circularity Scoring Model; **ESG**: Environmental, Social and Governance; **NGO**: Non-Governmental Organization.

Keywords: Circular Economy (CE); closed-loop production; Environmental, Social and Governance (ESG) factors; Circularity Scoring Model (CSM).

Abstract. *This paper explores the relationship between Circular Economy (CE) and Environmental, Social, and Governance (ESG) frameworks – a connection that remains ambiguous in both academic literature and practical application. This lack of clarity hinders corporate accountability and progress toward sustainability goals. To address this, we examine how CE and ESG intersect by integrating relevant theories and practical approaches. We identify key strategic overlaps across diverse CE and ESG indicators and frameworks, demonstrating how each can inform and strengthen the other. We begin by outlining foundational theories and current practices in both CE and ESG, then explore how their integration can enhance organisational alignment and accountability, particularly in the environmental dimension of ESG. To support this synergy, we propose an updated 10-R framework for qualitative reporting, incorporating new dimensions such as Regeneration (e.g., Rewilding and Restoration) to reflect biodiversity considerations. Additionally, we introduce the Circularity Scoring Model (CSM) to assess organisational CE performance concerning ESG objectives quantitatively. Our findings suggest that embedding CE principles into accounting and investment practices can highlight opportunities for improvement, such as transitioning to renewable energy, sourcing alternative materials, extending product lifespans, enhancing repairability, minimising waste, and increasing use of recycled or regenerative resources.*

1. Introduction: Connecting circularity with the Environmental, Social and Governance

This article addresses a vital issue in contemporary environmental management and corporate strategy – the relationship between circular economy (CE) and Environmental, Social and Governance (ESG) criteria. We critically analyse the link between CE and the E of the ESG, exploring how they can support long-term business goals, social and environmental value, and the ethical and transparent governance factors and systems required. CE is based on the concept of a closed-loop production system and requires innovation in inputs, processes, consumer relationships, and governmental

regulations (e.g., Kopnina & Poldner, 2021; Kirchherr, 2022). ESG frameworks include sustainable finance, impact investment, positive screening, and sustainability disclosures that support long-term business, social, and environmental value, ethical and transparent governance factors, and systems required for this (e.g., Chouaibi & Affes, 2021). In capital markets, some investors use ESG criteria to evaluate companies and help determine their investment plans (Alkaraan et al., 2023a), a practice known as ESG investing (PWC, 2023; Stedman, 2023). At times, these investments are specifically linked to CE (Patil et al., 2021) and to the promise that "each principle of the circular economy can have a positive impact on biodiversity" (Ellen MacArthur Foundation, n.d.a).

Circular strategies are sometimes conceived as a 10-R scale hierarchy of sustainable production that ranges from absolute closing of the natural resource-production circle (refusal to make or buy new products, infinite reuse) to partial closing (recycling, downcycling) (Potting et al., 2010; Kirchherr, 2022). Notably, the R of Refuse in the model implies avoidance of production and consumption of non-circular or unsustainable production (which may not align with conventional business thinking), followed by the Rs of Rethink, Re-use, Repair, Reduce, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (Potting et al., 2017). The higher a circular strategy is on the ladder, the tighter the waste loop becomes. This indicates that the strategy requires fewer materials and is therefore more circular. The 10-Rs range from closing (refusing or reusing), extending (prolonging usability through repair and re-use), intensifying (gaining more use in a shorter period), narrowing (using fewer resources), and dematerialising (reduction of total material and energy throughput at every stage of the production and consumption chain) (Bocken et al., 2016; Geissdoerfer et al., 2018a).

As discussed in the emerging literature linking ESG and CE, both are supportive of value networks involving diverse and at times conflicting interests of stakeholders, such as shareholders, employees, customers, suppliers, logistical service providers, members of civil society, nongovernmental organisations, the environment, and governments (e.g., Patil et al., 2021; van Langen et al., 2023; Babkin et al., 2023; Wamane, 2023). Considering varying accountability regimes in pluralistic societies (Brown et al., 2015) such links promise to make environmental sustainability meaningful, as the academic community and practice increasingly call for a broadened and more critical understanding of organisations' accountability concerning the environment (Bebbington et al., 2007; Gray, 2010; Busco et al., 2018).

Building on this literature, we argue that CE standards and practices have the potential to make the 'E' of the ESG framework more actionable and accountable and that ESG frameworks can make CE approaches more rigorous. Critical analysis shows that there is also a shift from "greenwashing to ESG-washing" in the circular economy field (Todaro & Torelli, 2024), especially when it comes to the claims that CE can have

beneficial effects on ecosystems and biodiversity (Ellen MacArthur Foundation, 2022; n.d.a). With the increased attention in environmental management literature to the topics of regeneration and conservation of biodiversity (Cavalcante et al., 2022; Kopnina et al., 2024; Han et al., 2024), it is surprising to see them disconnected from the mainstream CE and ESG indicators. Ellen MacArthur Foundation (n.d.b) popularises CE and stresses its importance for ecosystem regeneration, "enabling biodiversity to thrive", yet the 10-R hierarchy does not include Regeneration (including Rewilding and Restoration).

The first objective of this article is to articulate how the system of ESG reporting, rating, prioritising investments, and business strategy decisions impacts CE and vice versa. The second aim is to propose means to further analyse, compare, and quantify the circularity performance of organisations as part of ESG criteria, resulting in enhanced CE scoring and organisational accountability for biodiversity loss through an added regeneration dimension. Thirdly, we will analyse how aligning CE and ESG can help inform organisations and managers about planning, risk management, measuring, forecasting, innovating, or weighing opportunities or threats relating to sustainability and circularity principles. Considering these objectives, the research questions are:

1. How does the ESG framework influence the adoption and success of circular economy practices?
2. What tools and metrics can effectively measure and integrate circularity into ESG criteria?
3. How can the aligned CE and ESG frameworks inform better decision-making and foster accountability for sustainable and more circular operations?

These objectives drive the need to explore the intersection of CE and ESG frameworks. While ESG has become a key factor for investment decisions, especially in capital markets, there are concerns about "ESG-washing" concerning circular economy strategies. The authors aim to critically examine how the impact of ESG reporting, rating, and business strategies on CE and vice versa can be maximised to counter ecosystem decline and biodiversity loss.

The study emphasises that circular strategies, supported by both technological and social innovation, can be more rigorously applied within the ESG framework. Through an update of the existing 10-R framework and our introduction of the newly developed Circularity Scoring Model (CSM), we aim to bridge the gap between CE and ESG, standardising reporting and ensuring organisations enhance sustainability accountability. Below, we highlight the most strategic areas of overlap to bridge the gap between the dispersed studies of various matrices and indicators within ESG and CE. Finally, we discuss broader implications of opportunities that lead to value maximisation and threats

to circular operations. We advocate standardisation of qualitative reporting on CE themes via the updated 10-R framework and further develop the proposed CSM quantitative substantiation of the circularity performance of organisations as part of ESG criteria, resulting in enhanced circular accountability of organisations.

2. Methodology

This study adopts a desk-based research methodology to critically assess the fragmented relationship between Environmental, Social, and Governance (ESG) criteria and Circular Economy (CE) principles, to support more robust corporate sustainability practices. Recognising the current conceptual and practical disconnect between ESG frameworks and circularity metrics, we aimed to bridge this gap by proposing a novel evaluative approach: the Circularity Scoring Model (CSM). Our research process involved an extensive literature review conducted via major academic databases such as Web of Science, Scopus, and Google Scholar. We employed keyword combinations such as *"circular economy"*, *"closed-loop production"*, *"regeneration"*, *"ESG"*, *"Environmental, Social, and Governance"*, *"sustainability reporting"*, and *"corporate accountability"*. Boolean operators (AND, OR) were used to refine search outcomes and ensure comprehensive coverage.

Despite the value of scholarly databases, we identified a significant scarcity of integrated approaches directly linking ESG and CE, particularly concerning practical implementation and standardised metrics. To complement the academic insights, we expanded our scope to include industry white papers, professional blogs, and interdisciplinary sources accessed via standard web searches. This broader scope captured emerging frameworks, practitioner insights, and current discourse in the sustainability field.

To ensure quality and relevance, the literature was filtered using the following inclusion criteria**:**

- Published in 2016 or later, focusing on recent developments in CE and ESG.
- Addressed interdisciplinary themes, spanning business, environmental science, and sustainability accounting.
- Originated from peer-reviewed journals or credible grey literature produced by recognised institutions or experts.
- Written in English.

Insights gathered from this review directly informed the design of the Circularity Scoring Model (CSM). Instead of relying on existing models like the 9-R framework, we introduced a revised version of the R-Hierarchy, incorporating new dimensions such as

Regeneration, *Rewilding*, and *Restoration* - concepts that directly address biodiversity and ecological restoration within the environmental aspect of ESG. To demonstrate the model's application, we present an illustration (proof of concept) involving a Romanian agribusiness, selected through convenience sampling. One of the co-authors maintains a professional relationship with Circuworld[1], a technology provider specializing in circular economy solutions and organic waste valorisation, with complementary consultancy services. This affiliation provided first-hand access to internal data and operational insights necessary for applying the CSM in a real-world context. The case company was chosen for its ongoing circular initiatives. Using both qualitative and quantitative internal data, we applied the CSM to assess its current circularity performance and simulate the potential improvements achievable through targeted interventions. This example serves not as empirical validation, but as a practical demonstration of how ESG-CE integration can be operationalised and visualised within a corporate sustainability framework.

2.1 Data analysis

The selected literature was critically examined to identify overlaps, gaps, and synergies between ESG frameworks and CE practices. Particular attention was given to literature that addressed innovative CE practices and their potential to enhance ESG performance. Based on the findings, two key contributions were developed to bridge the gap between ESG and CE:

1. Updated 10-R Framework**:** Expanding on existing CE models, we introduced two additional principles—Regeneration (including Rewilding and Restoration), —to address biodiversity and ecosystem-focused criteria. This updated framework provides a more holistic approach to CE by integrating natural capital regeneration into sustainability strategies.

2. CSM**:** Building on the gaps identified in qualitative reporting practices, the CSM was developed as a proof of concept to quantify the CE performance of companies and organisations. The model was designed to offer both versatility across industries and integration with existing ESG reporting frameworks. To demonstrate the model's practical application and validate its internal logic, we applied it to the available data of a Romanian agribusiness, offering early insights into its potential for broader use.

While the methodology provides a foundation for linking CE and ESG, certain limitations must be acknowledged:

- Theoretical Scope**:** The study primarily draws on existing literature and may not fully capture the nuances of emerging CE and ESG practices in specific industries.

[1] www.circuworld.com

- Quantitative Validation**:** While the CSM provides a conceptual framework, further empirical research is needed to validate its application across diverse organisational contexts.
- Geographical Focus**:** The review primarily included sources with a global perspective, but regional variances in CE and ESG adoption were not deeply analysed.

3. Linking ESG and CE in theory and practice

The next sections will introduce ESG and CE theory and practice, before exploring how each can inform and reinforce the other. Its purpose is to provide clarity and insight into the link between ESG and CE by cross-fertilising between these streams of resonant theory and practice. We highlight the most strategic areas of overlap between the dispersed studies of various ESG and CE matrices and indicators. We propose a standard for qualitative reporting through an updated version of the 10-R framework. We introduce the CSM to help quantify the CE performance of organisations to link ESG targets. The reinvigorated theoretical synergy between ESG and CE results in recommendations for practice, improved alignment, and enhanced circular accountability for organisations with a focus on the environmental aspects of ESG.

3.1. Environmental, Social and Governance

ESG is a framework for businesses to consider the impact and dependencies on the environment and society, along with the quality of their corporate governance. It comprises all non-financial topics not typically covered by traditional financial reporting. It also provides a way to measure business risks and expose opportunities in those areas, for example, socially responsible investment (Weed, 2021). The E in ESG, environmental criteria, includes the energy, and the resources an organisation uses, the waste and emissions it produces in its production and operational process and the consequences for living beings as a result. E encompasses carbon emissions, climate change and environmental impact.

The S, the social criteria, addresses the relationships a company has and the reputation it fosters with people and institutions in the communities where it does business. S includes labour relations and diversity and inclusion. The G, governance, is the internal system of practices, controls, and procedures a company adopts to govern itself, make effective decisions, comply with the law, and meet moral and ethical demands of stakeholders.

There is a proliferation of studies on the effectiveness of ESG frameworks in Africa and Asia (e.g., Mgbame et al., 2020; Melinda & Wardhani, 2020), the Middle East (e.g., Al-

Hiyari and Kolsi, 2021), Europe (e.g., La Rosa & Bernini, 2022), and America (e.g., Lisin et al., 2022). ESG ratings are often linked to socially responsible, environmental and governance metrics (Widyawati, 2020), which are "umbrella term for investment practices that target firms with "positive" social and environmental profiles" (Linnenluecke, 2022:2). Mutual fund companies, investment research firms, financial consultancies on responsible investment or accountancy, non-governmental organisations focused on responsible/ethical investment, and platforms focused either on sustainability investment or accountancy proliferate. ESG investing has evolved to meet the demands of institutional and retail investors, as well as certain public sector authorities, that wish to incorporate the impact of ESG factors on long-term financial risks and opportunities in their investment decision-making processes to generate long-term value. Carbon accounting, for example, is used to quantify and measure carbon emissions but also to help make informed decisions regarding mitigation strategies (Yanai et al., 2020) and is also used in the CE (Wang et al., 2019).

As with ESG, definitions of CE differ widely, with over a hundred definitions and uses reported (Kirchherr et al., 2023, 2017). This has implications as to how CE is viewed in ESG. CDP, for example, a charity that operates the international disclosure system for investors, municipalities, and commercial organisations, has multiple applications for scoring for the CE, with little consistency in applications[2]. In other words, there seems to be a lack of consistent understanding and use of the concept of CE for ESG investment or accountancy (Alkaraan et al., 2023a, b). A commonly accepted and understood language to create synergy between CE and ESG is still underdeveloped (Walker, et al., 2021).

3.2 Circular Economy

According to the European Parliament (2023), the circular economy is a model of production and consumption, sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products if possible. This final phrase – 'if possible' – is a pragmatic acceptance that, whilst much of the literature assumes a closed loop and zero waste economy as the ideal goal (e.g., Kalmykova et al., 2018; Nußholz, 2018), limitations to the achievements of a circular economy are almost inevitable, at least within the context of our increasingly raw-material hungry, energy-inefficient, non-CO_2-capturing mainstream economy. Nevertheless, ESG asset managers are interested in CE because the umbrella term "sustainable production" requires an understanding of certain principles that are clearly articulated in circular or cradle-to-cradle (C2C) systems (McDonough & Braungart, 2010). C2C, which may be said to be one of the inspirations

[2] https://www.cdp.net

or design principles underlying CE, identifies three key principles of alternative production systems: (a) waste equals food; (b) use current solar income, and (c) celebrate diversity.

Archetypes of circular business models emphasise non-economic value as a basis for competitive and collaborative advantage (Kopnina & Poldner, 2021). Value creation can expand from the "traditional areas" of different forms of "capital", namely financial, manufactured, intellectual, social, natural, and human, requiring both investment and accountancy systems (Hoang, 2018) that cause no harm to biodiversity, even if it is profitable to do so. This requires integrating biodiversity into financial decision-making (Nedopil, 2023), also in CE and ESG (Kopnina et al., 2024). CE promises to slow down the use of natural resources, reduce landscape and habitat disruption, help limit biodiversity loss and reduce greenhouse gas emissions (Alkaraan et al., 2023a, b). Designing out waste principles and closed-loop production systems, as well as C2C, offer ways to counter the dependency of production on the extraction of natural resources and wasteful production manufactured at poor quality or with a limited lifespan, in other words, with "built-in obsolescence" (Bulow, 1986). A CE aims to minimise or better eliminate the need for new natural resources by shifting from a "take-make-waste" production to a closed-loop industrial ecosystem (Kopnina & Bowden, 2023) or a system as close as possible to that. The design of modular products, which are more durable and at the end of their extended use can be re-utilised (Kopnina & Bowden, 2023) is one action perspective. It is through modularity that circular production can be geared toward reducing risks to biodiversity (Ruokamo et al., 2023), increasingly attracting the attention of ESG investors (Molin et al., 2022). However, this attention to biodiversity is often expressed indirectly, as in the current 10-R model.

A typical strategy in a CE involves value chain operators, small and medium-sized enterprises, multinationals, industry representatives, and governmental and non-governmental organisations (Lieder & Rashid, 2016; de Jesus & Mendonça, 2018; Geissdorfer et al., 2020). CE developed in various contexts with different motivations, some driven by the presence or absence of environmental regulation, others by the need for resource management in industrialised settings (Kopnina & Bowden, 2023).

In 2009, the CE Law Promotion mandated action at all levels of government and industry across China (Matthews & Tan, 2011; Su et al., 2013; McDowell et al., 2017). Place-based planning interventions (McDowell et al., 2017; Zhu et al., 2018) promoted co-industrial parks, incentivizing firms to reorient their process of production while fostering economic growth (Mathews & Tan, 2011; McDowell et al., 2017; Homrich et al., 2018; Yu et al., 2022).

In a parallel attempt, the European Commission (2015) has developed a policy titled "*Closing the Loop: An EU Action Plan for the CE*." This policy also concentrates on minimising the use of virgin natural resources and waste minimisation in each step of the value chain, whilst also supporting sustainable economic growth (Ghisellini et al., 2016; Domenech & Bahn-Walkowiak, 2019). The European policy is a hybrid approach, combining both top-down and bottom-up elements, in a sense of reliance on regulation and finance, including ESG, as incentives to nudge organisations towards 10-R activities (McDowell et al., 2017), and to change consumers into renters or users (Lazarevic & Valve, 2017). The European approach focuses on both strategic and operational levels, including the design of products, monitoring of processes, and safeguarding value (economic and other) beyond traditional corporate strategic management (Kopnina & Bowden, 2023). Sharing or collaborative economy, manufacturing relationships, location of operations, and customer-use payment models are offered as alternatives (Tukker, 2015; Kopnina & Poldner, 2021). However, the concept of CE is often linked to relative decoupling (Parrique et al., 2019). This suggests insufficient decoupling of economic growth from environmental pressures. Without meaningful decoupling, the claims of CE regarding ecosystem protection and biodiversity preservation become tenuous.

3.3 The updated 10-R Framework

The 10-R Framework categorises circularity strategies within the production chain along a spectrum from fully circular and, in principle, zero environmental impact, to fully linear and most environmentally destructive (Potting et al., 2017). This framework is a combination of the R-lists drawn up by Rli (2015) and Vermeulen et al. (2014). It is not by any means the only or most widely accepted or 'best' CE framework; it is, however, a highly cited way of conceptualising circularity and one that we have found useful in our work trying to bring CE and ESG together. This article offers an updated version of the 10-R framework that introduces Regenerate (which can include Rewilding and Restoration, e.g., creation of strictly protected conservation areas) being the most circular strategy.

To ensure the maintenance of planetary conditions that sustain life as we know it today, companies must change their operations by giving more than they take, rather than just reducing harm through reduction strategies such as efficiency increases. By shifting from a linear economic model to a circular one, companies and investors can change the focus from extraction to the regeneration of nature. Instead of degrading nature, regeneration strategies aim to build natural capital, allowing ecosystems to rebuild, increase biodiversity, and return biological materials to the earth's natural cycles (Ellen MacArthur Foundation, 2022). Before the industrial age, natural systems were capable of self-regeneration. Transitioning to a regenerative CE model enables relevant stakeholders to

aid the restoration and support of natural systems, maintaining positive reinforcing cycles of well-being between humans and wider nature (Buckton et al., 2023).

For these reasons, we introduce Regenerate as the prime circularity strategy, giving companies agency to set tangible goals. In our update, we also lowered the position of Reduce in the 10r-framework (from R3 to R5) compared to the version by Potting et.al. (2017). Reducing is an important strategy to slow down demand for the earth's finite resources. However, it is a 'less bad' solution to the traditional take, make and waste approaches, thus maintaining the status quo of unsustainable practices (Braungart, McDonough, 2010).

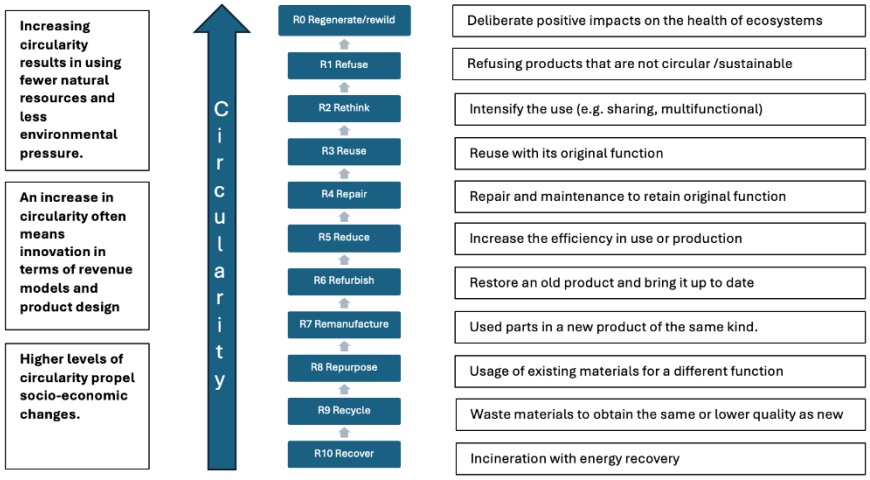


Figure 1. Updated circularity strategies within the production chain, adopted from Potting, et al. (2017).

We propose using the updated R-hierarchy model as a standard reporting unit for circular business models or funds within the ESG framework. The updated 10-R model as a reporting tool can help create a common language and understanding of what regeneration within CE entails in the context of ESG practices. The model could be expanded with a measurement and accounting for assessing its impact on ESG performance. However, it is vital to be explicit about the scope of what is being scored and avoid selective reporting. Recommended are separate analyses and scores ranging from large to smaller organisational units, depending on the line of business the organisation is active in, a company, or a branch, division, or department, and at the level of a process or a product. Another use is to benchmark the current situation in the market

and compare this with the aspirations of the organisation. In this way, the model can help to identify potential areas for improvement on multiple levels, thus improving the ESG performance. Using the updated R model can give investors a clear indication of their portfolio regarding CE performance to create more transparency (Lee, 2021).

3.4 The Circularity Scoring Model to Quantify Circularity Performance

Building on the work of Haas et al. (2015, 2020) and Mayer et al. (2019), the CSM has been developed as a proof of concept to quantify circularity through material and energy flow analysis used to determine the relative percentage of circular practices by companies or organisations as compared to their overall practice. The CSM integrates:

- Material flow analysis concepts,
- ESG-aligned sustainability metrics,
- Circularity principles across the updated R-hierarchy,
- And a focus on Scope 3 emissions and indirect impacts, recognising their often underreported yet substantial role in corporate footprints.

To provide a tangible link between the CE and the ESG framework, we recognise a need for more accurate and transparent reporting on sustainability performance for companies and organisations. Typically, scoring recommendations such as those formulated by the Taskforce on Nature-related Financial Disclosures (TNFD) and the Task Force on Climate-related Financial Disclosures (TCFD) are centred around a risk management approach to nature and climate. As has been illustrated by Sassanelli et al. (2019) in their comparative research on CE performance assessment methods, the measurement and assessment of circularity are not yet uniform in methodology, nor common practice in companies. Their work identifies a need for a holistic methodology which provides a set of Key Performance Indicators (KPI) "able to systematically and practically measure and assess the circularity degree of a given system and to take into account all the heterogeneous resources involved in its lifecycle" (Sassanelli et al., 2019, p. 449). As such, with the CSM, we propose a uniform model for scoring the level of circularity for companies and organisations irrespective of sector, industry, or geographical location, based on four key dimensions which influence the level of circularity for companies and organisations.

The CSM measures circularity based on the four key dimensions influencing CE and circularity of companies and organisations: 'Energy Consumption', 'Resource Extraction', 'Waste Prevention' and 'Regenerative Impact' as introduced below:

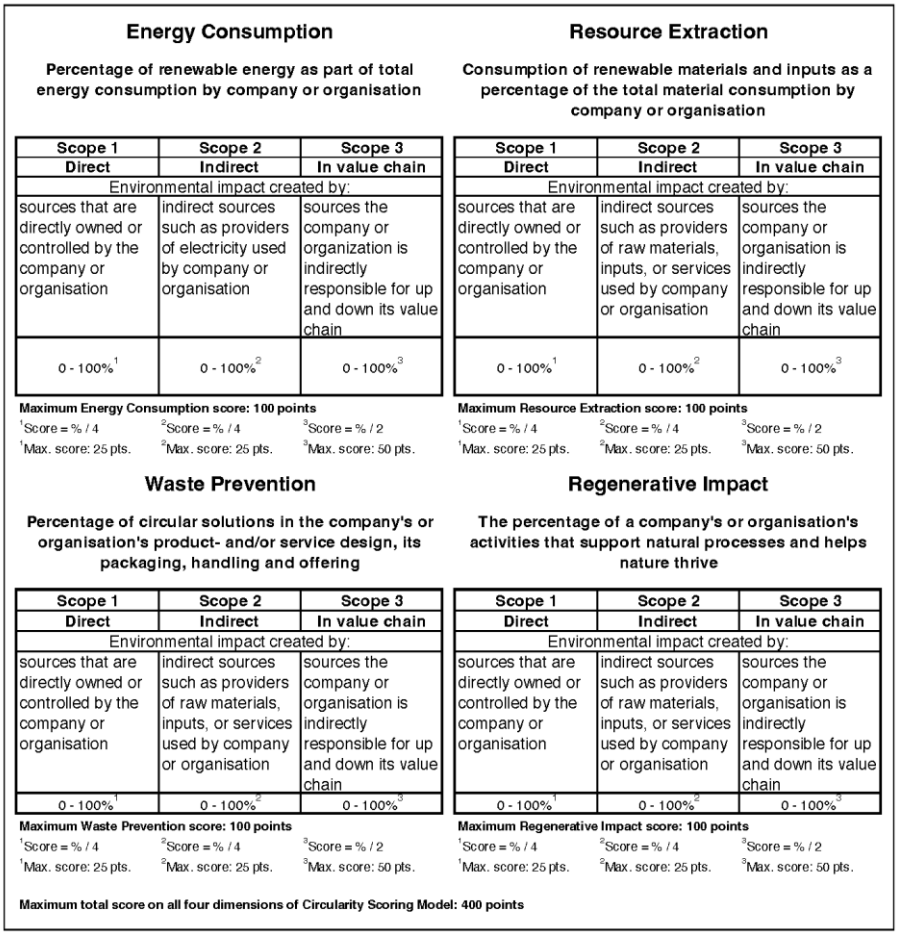
- Energy Consumption. The production and consumption of non-renewable energy result directly in air pollution, climate change, water pollution, thermal pollution, and solid waste disposal. Regarding energy, circularity is measured as the percentage of renewable energy as part of total energy consumption by a company or organisation.
- Resource Extraction. Extraction of materials such as mining and deforestation results in destabilised soils, increased erosion, and reduced nutrient levels in terrestrial ecosystems and overall environmental degradation. Resource extraction is measured by the consumption of renewable materials and inputs as a percentage of the total material consumption by a company or organisation.
- Waste Prevention. Waste negatively impacts our environment due to contamination and pollution of air, soil and freshwater bodies, the squandering of finite resources, and the extinction of species. Regarding waste prevention, circularity is measured as the percentage of circular solutions in the company's product- and/or service design, packaging, handling and offering.
- Regenerative Impact. When shifting our economic activities from linear to circular, our focus shifts from resource extraction to ecosystem regeneration. An organisation's regenerative impact is measured as the percentage of the organisation's activities that support natural processes and help nature thrive.

The model follows the scope and differentiation that first appeared in the Greenhouse Gas Protocol (CHG, 2004). There, scope 1, 2 and 3 emissions are introduced, identifying three categories of emissions, highlighting the extended emissions impact of organisational activity. Scope 1 relates to emissions created by sources that are directly owned or controlled by a company or organisation. Scope 2 emissions are all indirect emissions, created through the generation of energy as consumed by that company or organisation. Scope 3 emissions are those that the company or organisation is indirectly responsible for, up and down its value chain. Scope 3 emissions typically form the largest part of the organisational emission footprint. For example, there are significant carbon emissions from the extraction, manufacture, and processing of raw materials. Instead of limiting the company's impact to the carbon footprint alone, the CSM expands the premise of scopes 1, 2 and 3 to the environmental impact, including, but not limited to, carbon emissions. As such, we generalise the scopes 1, 2 and 3 frameworks beyond carbon and energy accounting, to cover the broader environmental impacts of companies and organisations.

Specifically, this means that scope 1, 2, and 3 differentiation is applied not only to Energy Consumption but also to Resource Extraction, Waste Prevention, and Regenerative Impact. For Resource Extraction, scope 1 covers the consumption of renewable materials and inputs as a percentage of the total material consumption by company or organisation, while in scope 2 this consumption is expanded to indirect sources such as

providers of raw materials, inputs or services. Scope 3 addresses the level of resource extraction as part of the sources the company or organization is indirectly responsible for up and down its value chain. For Waste Prevention, scope 1 includes the circular solutions in a company or organization's product- and/or service design, its packaging, handling and offering to prevent direct waste generation on-site, where Scope 2 reflects waste prevention activities through purchased raw materials, inputs and services, and Scope 3 encompasses circular solutions for waste prevention in the related up- and down value chain. For Regenerative Impact, scope 1 relates to on-site regenerative practices such as soil restoration or habitat creation as a percentage of a company or organization's activities. Scope 2 accounts for regenerative effects of purchased materials, inputs or services, and Scope 3 includes regenerative initiatives adopted by supply chain partners or ecosystem restoration activities linked to supply chain choices. By applying this extended scope logic, the CSM ensures consistency across all dimensions of circular performance, creating a comprehensive view of both direct and indirect environmental impacts associated with organisational activities.

Regarding the scoring metrics as introduced above, for each of these four dimensions, we follow the findings of Ducoulombier (2021), Hertwich and Wood (2018), and Huang et al. (2009), all highlighting that value chain emissions and environmental impact (scope 3) make up the largest share of emissions for most organisations. Because of this, for each dimension, the CSM attributes 50 per cent of the possible circularity scoring points to the scope 3 activities of the company, as environmentally conscious strategies and decisions of a company in the value chain will yield the biggest impact. Through this, we hope to stimulate companies to become more actively involved in their respective value chains. For scope 1 and 2 activities, a maximum of 25 per cent of the total points for each of the respective four dimensions can be achived. Accountability within the CE practice is an unknown terrain, even though the concept of circularity is well-known (Kwarteng et al., 2023). Tools and frameworks to quantify circularity are therefore needed. Using scoring based on the above-listed four key dimensions, it becomes possible to quantify the level of circularity practices of an organisation or company, track circularity over time, and formulate goals based on its circularity scoring. The proposed CSM could also be used for inter-company comparison between the circularity scores of the respective four dimensions of the model. We hope that through the CSM accountability and visibility of circular practices and values will improve. Finally, we hope that the suggested quantification metrics for circular accountability and circularity scoring can become drivers for finance allocation through ESG and thereby a more CE.



Energy Consumption

Percentage of renewable energy as part of total energy consumption by company or organisation

Scope 1	Scope 2	Scope 3
Direct	**Indirect**	**In value chain**
Environmental impact created by:		
sources that are directly owned or controlled by the company or organisation	indirect sources such as providers of electricity used by company or organisation	sources the company or organization is indirectly responsible for up and down its value chain
0 - 100%[1]	0 - 100%[2]	0 - 100%[3]

Maximum Energy Consumption score: 100 points

[1]Score = % / 4 [2]Score = % / 4 [3]Score = % / 2

[1]Max. score: 25 pts. [2]Max. score: 25 pts. [3]Max. score: 50 pts.

Resource Extraction

Consumption of renewable materials and inputs as a percentage of the total material consumption by company or organisation

Scope 1	Scope 2	Scope 3
Direct	**Indirect**	**In value chain**
Environmental impact created by:		
sources that are directly owned or controlled by the company or organisation	indirect sources such as providers of raw materials, inputs, or services used by company or organisation	sources the company or organisation is indirectly responsible for up and down its value chain
0 - 100%[1]	0 - 100%[2]	0 - 100%[3]

Maximum Resource Extraction score: 100 points

[1]Score = % / 4 [2]Score = % / 4 [3]Score = % / 2

[1]Max. score: 25 pts. [2]Max. score: 25 pts. [3]Max. score: 50 pts.

Waste Prevention

Percentage of circular solutions in the company's or organisation's product- and/or service design, its packaging, handling and offering

Scope 1	Scope 2	Scope 3
Direct	**Indirect**	**In value chain**
Environmental impact created by:		
sources that are directly owned or controlled by the company or organisation	indirect sources such as providers of raw materials, inputs, or services used by company or organisation	sources the company or organisation is indirectly responsible for up and down its value chain
0 - 100%[1]	0 - 100%[2]	0 - 100%[3]

Maximum Waste Prevention score: 100 points

[1]Score = % / 4 [2]Score = % / 4 [3]Score = % / 2

[1]Max. score: 25 pts. [2]Max. score: 25 pts. [3]Max. score: 50 pts.

Regenerative Impact

The percentage of a company's or organisation's activities that support natural processes and helps nature thrive

Scope 1	Scope 2	Scope 3
Direct	**Indirect**	**In value chain**
Environmental impact created by:		
sources that are directly owned or controlled by the company or organisation	indirect sources such as providers of raw materials, inputs, or services used by company or organisation	sources the company or organisation is indirectly responsible for up and down its value chain
0 - 100%[1]	0 - 100%[2]	0 - 100%[3]

Maximum Regenerative Impact score: 100 points

[1]Score = % / 4 [2]Score = % / 4 [3]Score = % / 2

[1]Max. score: 25 pts. [2]Max. score: 25 pts. [3]Max. score: 50 pts.

Maximum total score on all four dimensions of Circularity Scoring Model: 400 points

Figure 2. Circularity Scoring Model using qualitative and quantitative data from company sources.

Case Illustration: Application of Circularity Scoring Model

To demonstrate the practical application of the CSM as a proof of concept, we used available data from the agribusiness sector. While not exhaustive, it highlights key quantifiable changes in circularity metrics resulting from targeted sustainability interventions. For this, the internal data of a Romanian company producing corn, barley, and wheat is used to provide a simplified illustration of the application of the CSM as the company undergoes operational and strategic changes.

The before and after of these changes illustrate the working of the CSM, illustrated by the scoring for all the four dimensions of the model: Energy Consumption, Resource Extraction, Waste Prevention, and Regenerative Impact.

Initial Operational Context

Initially, this company used diesel-powered tractors on its land, LNG for drying its produce after harvesting, solar panels for the lighting of buildings, and chemical fertilisers as production inputs. Rejected batches of produce were disposed of. In this situation, from the total **Energy Consumption** (electricity, diesel, and LNG), 40% of the energy production (solar panels) is renewable, resulting in a scope 1 score of 10 points (40/4). Sourced electricity (80% of total energy sourced) is qualified as green, but the LNG consumed (20% of total energy sourced) does not, resulting in a scope 2 score of 20 points (80/4). Information on energy consumption in its value chain is unknown, apart from one seed supplier, which uses renewable energy in its operations. Seeds sourced from this company amount to 4% of the Romanian company's costs, hence resulting in a score of 2 points (4/2) for scope 3. The total score for Energy Consumption for this Romanian company would hence be 32 from the possible 100 points (10+20+2). Regarding its **Resource Extraction**, the company has a scope 1 score of 0 points, as no direct material extraction or production activities are performed by the company itself; it relies entirely on external suppliers for its agricultural inputs. For scope 2, the indirect material impact from purchased inputs, specifically chemical fertilizers, is significant: 100% of the inputs are chemical fertilisers, also resulting in a score of 0 points. Regarding scope 3, no regenerative or recycled materials were present in the supply chain, thereby also scoring 0 points. The total initial score for Resource Extraction is thus 0 points (0+0+0) initially. The **Waste Prevention** scope 1 score is 0 points (0/4) as rejected produce is disposed of with no internal recycling or reuse. There is no external supplier-related waste reduction with the supplied chemical fertilisers, with upstream packaging and associated waste. No circular packaging or services, resulting in a scope 2 score of 0 points (0/4). Lastly, supplier packaging and post-consumer waste are not addressed at all, leaving the scope 3 score also 0 points (0/2). The total initial score for Waste Prevention is thus 0 points (0+0+0). The **Regenerative Impact** scope 1 score is 0 points (0/4), as the company initially does not implement any internal regenerative practices such as soil restoration, biodiversity enhancement, or ecosystem regeneration. There is no external purchase of regenerative materials or services, with chemical fertilisers and conventional energy still in use, resulting in a scope 2 score of 0 points (0/4). Lastly, the company's suppliers do not engage in regenerative practices or ecosystem restoration activities, leaving the scope 3 score also at 0 points (0/2). The total initial score for Regenerative Impact is thus 0 points (0+0+0). In this initial operational context, the total score according to the CSM amounts to 32 out of 400 points (32+0+0+0).

New Strategy and Impact

The Romanian company decided to invest in a composting facility with heat recovery. It now produces organic fertiliser based on locally sourced chicken manure and its earlier disposed rejected production batches, replacing 75% of previously used chemical fertilisers. The recovered heat is used for the drying of corn, barley, and wheat, completely offsetting the earlier LNG consumption. As such, the new **Energy Consumption** scope 1 score increases to a score of 15 points (60/4), as now the 20% LNG consumption has been offset with sustainably recovered process heat. Scope 2 score remains 20 points (80/4), and the scope 3 score remains 2 (4/2). The total new score for the Energy Consumption dimension then becomes 37 points out of 100 (15+20+2), signalling an increased percentage of renewable energy as part of total energy consumption. The new circularity score for **Resource Extraction** improves significantly because of the internal production of organic fertiliser. Scope 1, previously 0 points, now reflects direct input production from recycled biological material, achieving a score of 25 points (100/4) due to full allocation for internal regenerative material use. Scope 2 benefits as the reliance on externally sourced chemical fertilisers is reduced by 75%, resulting in a scope 2 score of 18.75 points (75/4). Scope 3 remains 0, as the upstream supply chain remains largely unchanged in terms of material circularity. The total improved Resource Extraction score is therefore 44.75 points (25+18.75+0). The new **Waste Prevention** score improves notably due to the internal recycling of previously discarded produce. Scope 1 score rises to 25 points (100/4), as 100% of previously disposed batches are now diverted from waste streams and used as input for composting. Scope 2 also improves to 18.75 points (75/4), reflecting reduced packaging and operational waste associated with decreased purchases (75%) of external chemical fertilisers. Scope 3 remains at 0 points, as supplier packaging waste and downstream waste have not yet been addressed. The total improved Waste Prevention score is therefore 43.75 points (25+18.75+0). Finally, the new **Regenerative Impact** score experiences meaningful improvements. Scope 1 score increases to 18.75 points (75/4), as the use of organic fertiliser (replacing 75% of chemical fertilizers) supports improved soil health and local biodiversity on the company's own farmland. As there are no new purchased services or materials that actively contribute to regenerative outcomes, the scope 2 score remains at 0 points. Scope 3 scoring also remains at 0 points, as upstream supplier practices have not shifted to regenerative models. The total improved Regenerative Impact score is therefore 18.75 points (18.75+0+0), bringing the total score to 144.25 out of 400 points.

4. Towards a common language

Ideally, a CE approach places overcoming environmental problems centrally in economic planning and organisational strategy (Kopnina & Bowden, 2023). The business model innovation in CE is typically dependent on an initial design that enables reuse, recycling, and disassembly (Urbinati et al., 2017; Centobelli et al., 2020). In essence, CE promises to retain, reuse and/or recover materials, preserve biomass and energy, find nature-based solutions that do not threaten biodiversity and work to reduce the overall demand on natural resources while bettering our ecosystem and welfare (Kopnina et al., 2018; Kopnina & Poldner, 2021). As problems such as climate change, biodiversity loss and pollution are caused by increased consumption of non-renewable energy, land conversion, and rampant resource extraction and waste generation – all inconvenient truths for business operations (Panwar et al., 2023) – the overall impact of circularity should be absolute decoupling of economy from the use of (new) resources, which is very challenging in real life. Some of these frameworks and initiatives focus on CE but are without specifications and consensus as to how circularity is understood or measured. ESG-specific media groups like Environmental Finance[3] have also been touching upon the subject of circularity (e.g., Cox, 2022), the use of the term varies in application and in organisations that account and invest in these companies based on assumed circularity without unambiguous metrics for circularity scoring and accountability.

4.1 Circularity and ESG Connections

As in the case of a collaborative economy, cooperation of various stakeholders within ESG systems is needed. On one side of the ethical and moral spectrum, there are investors' demands (commercial interests). On the other side, some investments seek only social (intertwined with environmental) returns (philanthropy).

ESG and CE requirements as part of public tenders are an example of this. Such capabilities can be split into evolutionary or radical business model innovation (Geissdoerfer et al., 2018b), with the former including holding stakeholder dialogues to support sustainability-related associations, inclusive of critical and disruptive stakeholders and technologies (Inigo et al., 2017). The activities constituting dynamic capabilities may develop over time as new circular prototype products and new circular business models may evolve, followed by business model execution, then changing industry expectations, and finally business model evolution and building credibility (Wade et al., 2022). These developments typically require an initial ESG investment, which in turn requires an understanding of the main circularity principles or hierarchies of needed action.

[3] https://www.environmental-finance.com/

	Philanthropy		**Social Impact Investment**		**Sustainable and Responsible Investment**	**Conventional Financial Investment**
	Traditional	Venture	Social investment	Impact investment	ESG investing	Fully commercial investment
	|	|	|	|	|	|
Focus	Addresses societal challenges through the provision of grants	Addresses societal challenges with venture investment approaches	Investment with a focus on social and/or environmental outcome and some expected financial return.	Investment with an intent to have a measurable environmental and/or social return.	Enhance long-term value by using ESG factors to mitigate risks and identify growth opportunities	Limited or no regard to ESG
	|	|	Use of ESG metrics and methodologies			|
Return expectation	Social return only	Social return focussed	Social return and sub-market financial return	Social return and adequate financial market rate	Financial market return focussed on long-term value	Financial market return only

Table 1. The spectrum of social and financial investing is adapted from OECD (2019), based on earlier versions from various organisations.

However, it is not always clear as to what circularity gains are achieved due to the limited comparability of ESG studies across countries, at times the biased (against E of Environment) scoring metrics, the asset managers intentionally exaggerate or misrepresent sustainability characteristics in their products (Kolostyak, 2023). Sustainability gains might also be overshadowed by greenwashing, as well as "the aggregated nature of diverse environmental factors, different methodologies implemented by rating providers, and the lack of robust datasets have resulted in limited usefulness of environmental scoring as a tool for greening the financial sector" (Senadheera et al, 2021:2). Complicating the matters is the fact that while "virtue signalling" is becoming a widespread strategy of misleading investors (Kolostyak, 2023), large ESG fund managers, such as Stewart Investors, Liontrust Royal London, Schroder Asian Income, ticking a few boxes (Gard, 2021). The above make a case for scoring metrics such as the CSM introduced earlier. Also, there is emerging literature linking the

ESG framework to circular production systems (Patil et al., 2021; Blinova et al., 2022; Montalbetti, 2022; Iliev et al., 2023). Ellen MacArthur Foundation pays lip service to ESGs' potential to work together with the CE, without specifying concrete connections:

> "There is a growing recognition that ESG can not only identify risks but also deliver long-term growth and generate new sources of value by investing in players who are providing solutions and responses to the major challenges facing society… At the same time, governments, regulators, and central banks are reorienting public spending and policies towards the transition to an inclusive, low-carbon CE…" (Ellen MacArthur n.d.b).

The connection to nature-positive, biodiversity and ecosystem benefits of CE remains vague as well (Ellen MacArthur Foundation, n.d.b). Because Cradle to Cradle (C2C) challenges the take-make-waste production (McDonough & Braungart, 2010), the transformative potential of entire manufacturing is apparent, albeit poorly understood. Addressing this gap, this article surveys the general framework of circularity, based on C2C principles (McDonough & Braungart, 2010), and discusses the opportunities and limitations of applying the ESG framework to the CE.

4.2 Analysing circular systems in the context of ESG

Ideally, a circular system aims not just to increase the level of material and energy recovery but to eliminate the continuous need for the extraction of new and often scarce or finite resources, often an impossibility due to the laws of thermodynamics (De Man & Friege, 2016; Kopnina, 2021; Weed, 2022). As Josh Lepawsky (2022) noted, it is not possible to recycle energy continually (the second law of thermodynamics) without a loss in its quality or density, as no recycling plant can be run solely off the excess heat of another such recycling plant. Limited circularity can happen through dematerialisation, which requires the reorganisation of business through the transition from selling to leasing schemes (Savini, 2021; Stevens et al., 2021).

4.3 Greenwashing

Due to the fuzzy nature of defining the E in ESG and too easily branding products and processes circularly, greenwashing seems endemic in both systems (Kirchherr, 2022; Kopnina & Benkert, 2022). Circular frameworks can be subverted into the business-as-usual model (Corvellec et al., 2022). Greenwashing involves using misleading information to gloss over bad behaviour or the misrepresentation of facts under the pretence of environmentally friendly practices and sustainability. Greenwashing refers to unsubstantiated claims aimed to deceive consumers into believing that a company's products are environmentally friendly. In addition, there are dilemmas for investors too.

CE is not a domain of academic debate, but often a domain of practising (applied) academics or 'pracademics', receiving at least partial funding from corporate partners (Kirchherr, 2022). It is assumed that circularity is central to sustainable development, promising to marry a growth-centred economy (and corporate profit) with sustainability, which is questioned by critical authors (Kirchherr, 2022; Kopnina et al., 2024). A distinction between ideal, realistic, and subverted circular practice is helpful (Kirchherr et al., 2023, 2017). The companies that get certified as Cradle to Cradle or grace the Hall of Fame of the Ellen MacArthur Foundation rarely demonstrate products with infinite reuse (Bauwens, 2021; Kirchherr, 2022). Another concern is dubbed the "CE rebound" (Zink & Geyer, 2017), which underline the limitations of the very concept of circularity (Carus & Dammer, 2018; de Man & Friege, 2016; Holmes et al, 2021; Johansson & Henriksson, 2020; Kirchherr, 2022; Kopnina, 2021; Kopnina & Padfield, 2021). For example, in the food industry "waste is food" principle in the case of toilet waste is not the same in value as consumed products (Kopnina et al., 2023).

4.4 Strategic action linking ESG and CE

The implementation of CE is particularly challenging (e.g., Kalmykova et al., 2018), also due to the disconnect between business model innovation required for CE and drivers for finance allocation through ESG. Particularly dynamic capabilities, such as sensing, seizing, and reconfiguring (e.g., Marrucci et al., 2021), require different type of financial allocation to each activity. While there is a lot of research on "sustainable innovation" (e.g., Boons & Lüdeke-Freund 2013; Sehnem et al., 2022), few studies have attempted to analyse these capabilities concerning ESG.

ESG and CE initiatives can also come from private investments. Ideally, companies should become obliged or incentivised to disclose the proportion of waste and by-products that are redirected back into the production cycle or used for relevant purposes, for example, through scoring based on the proposed Circularity Scoring Model or the revised R framework. Also, this can:

1. Evoke confidence in ESG investments. Sustainability in both cases is seen as an engine for long-term business profitability: Customers, regulators and investor sentiment are changing in favour of more sustainable companies.
2. Stimulate sustainable businesses, as they will enjoy a lower cost of capital: Investors recognise that sustainable businesses offer lower risk and/or better long-term shareholder value. Businesses with poor ESG metrics or a lower score on the proposed Circularity Scoring Model will have higher costs of capital.
3. Result in safer working practices.

4. Result in reduced environmental harm and more environmentally sustainable practices.
5. Reduce inequality through increased justice and fairness as building blocks of our society.
6. Simulate collaboration to compete: Winning businesses will recognise they cannot improve their ESG footprint alone and will partner and collaborate across their value chain. The ability to manage partnerships and alliances will become more important to all organisations.

4.5 Reflection of what remains unaccounted for

Bauwens (2021) postulates that one aspect missing from ESG and CE is the discussion of the limitations of economic growth and profit-oriented enterprises. For example, in food or clothes, dematerialization is almost impossible due to the laws of thermodynamics (material products, such as food, change in quality when consumed, e.g., become excrement). Some products, such as components of consumer electronics and cars, can be reused (for example, metals), despite the inevitable material loss due to wear and tear. Some products can be easily repaired or refurbished, but the process can be costly. ESG investment and CE strategies are still both geared toward the optimistic win-win scenarios in which value creation, particularly economic one, can be combined with other benefits without realising such limitations.

By implementing closed-loop production systems and regenerative design practices, companies can move beyond merely minimising their impact to actively contributing to ecological restoration. To ensure a comprehensive evaluation of their products' biodiversity and extinction impacts from the design and manufacturing phase to the end-of-life phase, companies should systematically evaluate and disclose product-life biodiversity impact due to e.g., their energy consumption, or the company's resource extraction practices, both directly, and in its value chain, as part of the ESG disclosure (Hassan et al., 2021; Anthony & Morrison-Saunders, 2023).

The proposed Circular Scoring Model aims to provide a means for measuring this and a company's ability to achieve waste prevention and have a regenerative impact. By evaluating and scoring their circular performance, companies can identify potential areas for improvement, such as renewable input materials for production, extending product lifespan, enhancing repairability, and using recycled and eco-friendly materials. Moreover, ESG disclosures could also include how companies prioritise sourcing materials locally and establish circular supply chains to address concerns about negative environmental consequences associated with transportation (Niu et al., 2020). This approach encourages conscious consumption, reduces the biodiversity footprint, supports local economies and

social welfare, and aims to resolve "wicked problems" (Guthrie & Dumay, 2021). Finally, an enhanced ESG framework can assist companies in evaluating their progress towards a degrowth economic model by prioritising ecological sustainability over excessive growth, as was argued in the case of CE (Hofmann, 2022). A few conditions must be met. First, the more restricted definitions and applications of CE need to be considered to avoid greenwashing. Thus, circularity in the sense of absolute decoupling of resource consumption from production, or the R of Refuse, or degrowth, and dematerialisation, needs to be prioritised as best practices in circularity. Following this, the E of ESG might need to be considered along the criteria of this stricter definition of CE, radically reducing production and consumption by switching to alternative business models. This radical reorientation would highlight that the E of Environment needs to be linked to accounting and investment opportunities in types of businesses and practices that would radically address severe problems such as biodiversity loss, ecosystem decline, as well as climate change.

5. Conclusion and Recommendations

This article has addressed the relationship between ESG criteria and CE and explored some systems of ESG reporting, rating, prioritising investments, and the impact of business strategy decisions on CE and vice versa. We believe that the outcomes of our work underscore the need for further empirical studies to test the application of the proposed frameworks. Additionally, the integration of biodiversity-focused principles within CE calls for a deeper exploration of how organizations can operationalize regeneration and rewilding in their sustainability strategies. This methodology establishes a strong foundation for advancing theoretical and practical understanding of the relationship between CE and ESG, emphasizing their potential to enhance corporate accountability and sustainability outcomes.

In response to the first research question regarding the ESG framework and its influence on the adoption and success of circular economy practices, we have made explicit how the CE framework can invigorate the practice of ESG and proposed means for qualitative scoring circular practices and quantitative substantiation of CE efforts. We have established that linking CE principles through both accounting and investment practices can help to identify potential areas for improvement, such as a shift to renewable sources of energy, alternative input materials for production, extending product lifespan, enhancing repairability, reducing waste, using recycled and eco-friendly materials, and increased regenerative impact.

Concerning the second research question about the tools and metrics to measure and integrate circularity into ESG criteria, we propose a qualitative scoring for assessing CE

impact on current and future ESG performance based on the updated 10-R model combined with quantitative substantiation of CE efforts via the Circular Scoring Model, contributing to existing systems of ESG reporting, rating, and prioritising investments' impact upon CE and vice versa.

These models aim to inform organisations and managers about planning, measuring, forecasting, innovating, or weighing opportunities or threats relating to sustainability. We have also identified some potential pitfalls or bottlenecks, especially concerning greenwashing in both ESG and CE. As with ESG, definitions of CE differ widely, with the apparent danger of greenwashing and selective reporting on corporate success stories that may give investors and society false positive impressions. Linking stricter definitions (absolute decoupling of resource consumption from economic activity, restricting production and consumption, or the R of Refuse) of CE and a more restricted part of E of ESG (focusing on biodiversity loss mitigation measures), can help to address these issues.

In response to the third research question about the alignment of CE and ESG frameworks to inform better decision-making and foster accountability, we have argued that CE standards and practices have the potential to make the ESG framework more actionable and accountable and that ESG frameworks can make CE approaches more rigorous. We suggest connecting CE principles through both accounting and investment practices can help to identify potential areas for improvement, such as a shift to renewable energy, alternative input materials for production, extending product lifespan, enhancing repairability, reducing waste, using recycled and eco-friendly materials, and increasing regenerative impact. The qualitative reporting on CE themes via the updated 10-R (with 11-Rs including Regeneration) framework can provide companies with a clear, relevant, and biodiversity action-orientated conceptualisation of CE. Subsequent highlighting of E for ecosystems of ESG promises to make the connection between ESGs and CE practice more explicit and accountable. Doing so can help companies and investors to create a common language and give companies an easy-to-understand and implement means to improve non-financial reporting, find business opportunities, and increase the level of circularity. The proposed Circularity Scoring Model can serve to both demystify and quantify the circular performance of companies and organisations. In addition to optimising the use of existing ESG reporting tools, ratings, and metrics, using the CSM as an accountability and reporting tool provides a clear and tangible link between the CE and the ESG framework that could enhance non-financial reporting and help companies make informed, long-term sustainable business decisions.

We invite academics, practitioners, and (audit) companies to expand on the updated version of the 10-R framework and the proposed Circularity Scoring Model. The development of rankings based on circularity scores, and enabling benchmarking metrics

using a company's circularity performance as quantified through the CSM can contribute to the establishment of circular standards and measurement systems.

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