

## RESEARCH ARTICLE OPEN ACCESS

# Conceptualizing Circular Ecosystems: An Analysis of 45 Definitions

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## ABSTRACT

The circular ecosystem concept is gaining prominence among academics and practitioners. However, critics claim the concept is used and understood differently by different actors. While conceptual plurality offers possibilities for broad interpretations and engagement, it can undermine the relevance of the concept as an analytical lens due to knowledge fragmentation. This paper aims to create transparency regarding the current understandings of the circular ecosystem concept. For this purpose, we have gathered, coded and analysed 45 circular ecosystem definitions. Our findings indicate that circular ecosystems are most frequently depicted as the interactions and resource flows between independent actors. However, it is often not highlighted that these actors are not stakeholders in the conventional sense, as they can fulfil different roles in different contexts. We further find that circular ecosystem definitions show few explicit linkages to the older and more prevalent circular business model and industrial ecology concepts despite strong conceptual interdependencies. A considerable body of literature subdivides the circular ecosystem into six sub-ecosystems: industrial, urban, entrepreneurial, knowledge, innovation and business. We critically discuss and synthesise the various circular ecosystem conceptualisations throughout this paper and propose a new unified definition, categorisation and framework. Overall, we hope to contribute towards the coherence of the circular ecosystem concept and streamline the growing research in this area around a common understanding of the underlying real-world phenomena.

## 1 | Introduction

The circular economy (CE) is restorative and regenerative by design. In a CE, biological and technical materials are recirculated into the economy with the ambition to close linear resource flows, minimise waste generation and pollution and use products and materials at their highest level of utility for as long as possible (Geissdoerfer et al. 2020). In essence, the CE aims to decouple economic growth from environmental degradation associated with the consumption of finite resources,

which dominates the linear take-make-waste economic model (Kanda et al. 2020). Thus, the CE concept has received widespread support from businesses, policymakers and academics as an approach to achieving sustainable development (Kirchherr et al. 2023).

The transition to a CE is systemic and disruptive (Kanda 2023; Blomsma et al. 2023), and fundamentally changes the nature of collaboration and competition among economic actors, their value networks, and societal institutions (Geels and

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Kemp 2007). The CE's systemic nature and the complexity of circular models suggest that individual actors often cannot implement circularity in isolation. Instead, collaboration among multiple and different types of actors is necessary, interacting in complex cross-sectoral settings (Kanda et al. 2020). While traditionally individual business models have been a key focus for implementing circularity and aligning incentives across different stakeholders (Rashid et al. 2013), some prominent circular business model researchers now argue that the traditional boundaries of the business model, with its focus on one focal organisation or business unit with a limited set of conventional value chain partners, such as suppliers, customers and shareholders, restrict a comprehensive analysis of real-world implementation of CE models. This is because these models are often characterised by the following: (1) additional, more diverse stakeholders, including non-conventional value chain partnerships, (2) more comprehensive coordination, including new governance and performance measurement systems, and (3) new capabilities, including new and unfamiliar roles. Therefore, circular ecosystems are proposed as a more fit-for-purpose analytical lens for many cases (Geissdoerfer et al. 2020; Kanda et al. 2020).

Circular ecosystems<sup>1</sup> encompass various types of multi-actor networks, different overarching goals and multiple levels of analysis, including different key actors and their ability to act (Aarikka-Stenroos et al. 2023). Besides prominent developments of the ecosystem concept in the business and management literature, there are various subcategories of circular ecosystems, such as circular innovation ecosystems, circular entrepreneurial ecosystems, circular industrial ecosystems and circular knowledge ecosystems (for reviews, see Table 1, Aarikka-Stenroos et al. 2021 and Kanda 2023 discuss the sub-systems systematically).

As the circular ecosystem concept grows in popularity, its interpretation and application by different authors can obscure and fragment its conceptualisation. While the concept of ecosystems is used loosely, it offers a common language for discourse and a broad basis for collaboration among various actors. However, it can also undermine the concept's usefulness as an analytical lens to inform the implementation of circular models and transform the linear economy. A concept with multiple fragmented and contested meanings is eventually bound for conceptual deadlock and collapse (Kirchherr et al. 2017; Korhonen et al. 2018). To address this issue, we examine the definitions of circular ecosystems in the CE literature to highlight the distinct sub-categories, main elements, the agency of actors and the exchanges between them to create value to address the research question: "What is the current understanding of the concept of circular ecosystems?" To do so, we analyse 45 academic articles defining circular ecosystems.

As illustrated in Table 1, there have been a range of literature reviews on circular ecosystems. However, none of these reviews has focused on the definitions of circular ecosystems, except for one attempt by Aryee (2024). However, the definition proposed by the author has a range of flaws that make it less useful. For example, the definition does not reflect the reviewed literature nor does it actually constitute a (descriptive)

**TABLE 1** | Previous reviews of the circular ecosystem concept.

#	Review	Focus
1	Aarikka-Stenroos et al. 2021	Categorisation of CE ecosystems
2	Asgari and Asgari 2021	Conceptualisation of drivers and incentives in circular ecosystems
4	Kapsalis et al. 2019	Investigation of interactions between the principles of ecosystem services and the circular economy through inter-organisational systems
5	Min et al. 2021	Identification of drivers and barriers for circular ecosystems for SMEs in China
6	Pietrulla 2022	Proposal of circular ecosystem classification and success factors
7	Trevisan et al. 2022	Proposal of CE ecosystem framework
8	Aryee 2024	Proposal of CE ecosystem definition
9	Aryee et al. 2025	Trace the historical development of the concept

definition in the conventional sense: it seems more of an aspirational manifesto than a description of the defined concept. It conflates normative goals (e.g., environmental quality, social equity), conceptual foundations (e.g., paradigm shifts, holism) and operational mechanisms (e.g., orchestration, governance) into a single, expansive sentence. By intermingling the 'why', 'what' and 'how' of a circular ecosystem without delineating their respective boundaries, it undermines rather than improves conceptual clarity. Consequently, the text does not convincingly establish the distinctive features and theoretical boundaries of a circular ecosystem, making it difficult to differentiate this model from other, unrelated frameworks in sustainability or economics.

We argue that there is both academic and practical relevance in comprehensively and systematically reviewing circular ecosystem definitions, determining how actors understand and, thus, operationalise the concept. It is essential to make explicit the different meanings and understandings associated with the ecosystem concept in the CE literature, and thus help ensure the conceptual coherence required for the further theoretical development and practical application of the circular ecosystem concept.

The remainder of the paper is organised as follows. After this introduction, Section 2 introduces the two core underlying

concepts of this research: CE and ecosystems. Section 3 describes the research method we used, before Section 4 presents and discusses the results. We conclude the paper in Section 5 and suggest future research trajectories.

## 2 | Background

This section provides a brief overview of the two key underlying theoretical concepts of the circular ecosystem notion: the CE (Section 2.1) and the ecosystem (Section 2.2) concepts.

### 2.1 | The Circular Economy

The CE describes “an economic system in which resource input and waste, emission, and energy leakages are minimised by cycling, extending, intensifying, and dematerialising material[water] and energy loops. This can be achieved through digitalisation, servitisation, sharing solutions, long-lasting product design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling” (Geissdoerfer et al. 2020, 3).

While a leakage-free cycling of resources and energy is not theoretically possible (see, e.g., Zotti and Bigano 2019 and Skene 2018), the optimisation of the current system can bring a broad range of environmental, economic and—potentially social—benefits (Webster 2015; Geissdoerfer et al. 2017), making it one of the key concepts for scholars, policymakers and industrial decision-makers to address a broad range of sustainability challenges from climate change, over waste and pollution to resource scarcity.

Claims for the potential real-world benefits of a CE include the reduction of international GHG emissions by 39% and virgin resource use by 28% (CGRI 2021), and a positive influence over a range of other environmental indicators, such as an 80% reduction in ocean plastics (UNEP 2021), but also considerable economic benefits, including a global USD 4.5T boost in GDP

by 2030 (Lacy and Rutqvist 2015) and the creation of 6 million jobs (ILO 2018).

The current understanding of the CE concept can be traced back to different preceding schools of thought, such as industrial ecology (Graedel and Allenby 1995), cradle-to-cradle (McDonough and Braungart 2002), looped and performance economy (Stahel 2010) and the blue economy (Pauli 2010). However, the concept only gained widespread uptake in its current form by academia, industry and policymakers after a series of influential publications by the Ellen MacArthur Foundation and McKinsey & Company (EMF 2012, 2014, 2015).

Since then, academic interest in the topic has been immense (see Figure 1), with 9609 articles containing ‘circular economy’ in their title on the Scopus database and single articles (Geissdoerfer et al. 2017) reaching up to 3844 citations (7613 on Google Scholar) as of 4 June 2024 (see Table 2).

At an organisational level, business model innovation is a key and growing focus of academic research, with 549 papers with ‘circular AND business model’ in the title on Scopus (as of 4 June 2024) and a considerable increase in publications since 2015, as illustrated in Figure 2.

This might be explained by its analytical strengths in aligning operational aspects with stakeholder incentives, which early scholars have hoped can overcome the gap in the uptake of sustainable technologies (Rashid et al. 2013), and the concept’s power in planning, analysing and communicating sustainable business ideas (Geissdoerfer et al. 2022).

However, as pointed out by Kanda et al. (2020) and Geissdoerfer et al. (2020), there are limitations to the usefulness of business model innovation in its original form. This is because, having its root in Porter’s (1985) value chain notion, the concept originally focused on the business unit and later the company level (see, e.g., Osterwalder and Pigneur 2010), with a limited number of traditional value chain partners, such as suppliers,

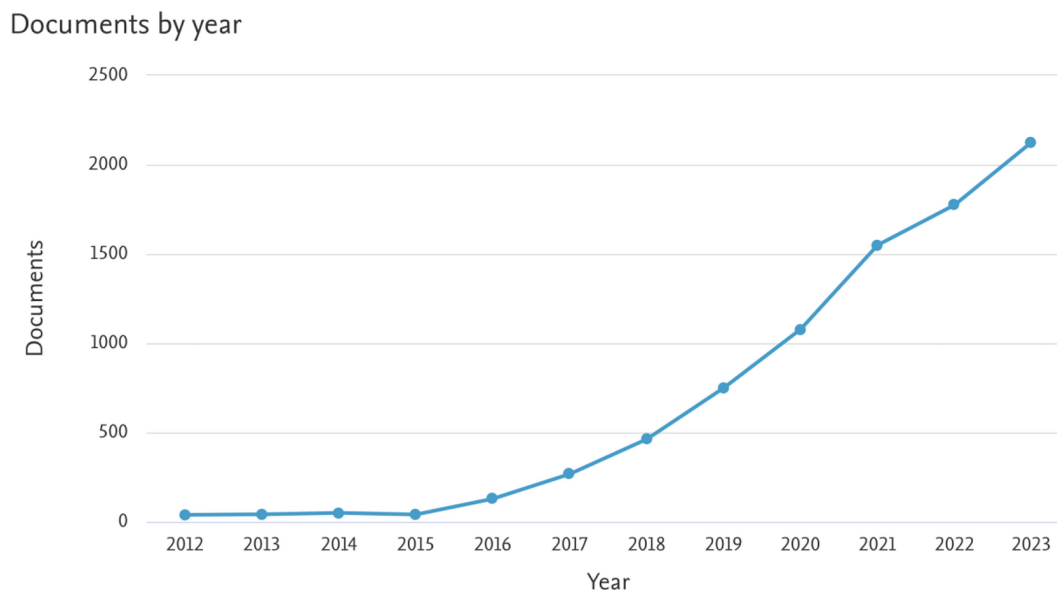
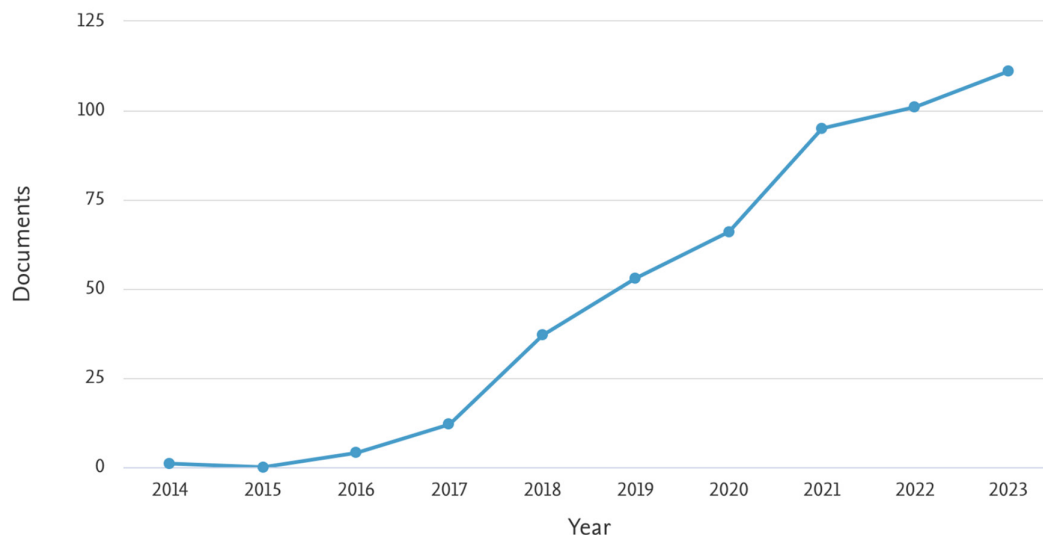


FIGURE 1 | Documents with ‘circular economy’ in the title from 2012 to 2023, Elsevier Scopus database (4 June 2024).

**TABLE 2** | Top 10 most cited circular economy articles (Elsevier Scopus database, 4 June 2024).

Rank	Authors	Title	Year	Cited by
1	Geissdoerfer M.; Savaget P.; Bocken N.M.P.; Hultink E.J.	The Circular Economy—A new sustainability paradigm?	2017	3844
2	Kirchherr J.; Reike D.; Hekkert M.	Conceptualizing the circular economy: An analysis of 114 definitions	2017	3693
3	Ghisellini P.; Cialani C.; Ulgiati S.	A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems	2016	3304
4	Korhonen J.; Honkasalo A.; Seppälä J.	Circular Economy: The Concept and its Limitations	2018	1997
5	Bocken N.M.P.; de Pauw I.; Bakker C.; van der Grinten B.	Product design and business model strategies for a circular economy	2016	1925
6	Murray A.; Skene K.; Haynes K.	The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context	2017	1679
7	Lieder M.; Rashid A.	Towards circular economy implementation: A comprehensive review in context of manufacturing industry	2016	1600
8	Stahel W.R.	The circular economy	2016	1381
9	Tukker A.	Product services for a resource-efficient and circular economy—A review	2015	1270
10	Su B.; Heshmati A.; Geng Y.; Yu X.	A review of the circular economy in China: Moving from rhetoric to implementation	2013	936

Documents by year



**FIGURE 2** | Documents with ‘circular’ and ‘business model’ in the title from 2012 to 2023, Elsevier Scopus database (4 June 2024).

customers and shareholders. However, this unit of analysis is less suitable for describing many circular operations that depend on an intricate and often extensive value network outside the organisational unit, making an ecosystem perspective more adequate for analysing, planning and communicating these circular models (Geissdoerfer et al. 2020; Kanda et al. 2020).

## 2.2 | Ecosystems

The ecosystem concept is often attributed to Sir Arthur Tansley (Kanda 2023; Aryee et al. 2025). Tansley (1935) introduced the concept in the field of ecology in 1935 and suggested that organisms are strongly interconnected with their environment and together form one physical system (p. 299).

Building on similar principles, in the business and management literature, the prefix *eco* in ecosystems, as introduced by, for example, Moore (1993), emphasises ecological aspects of businesses and their change processes. Moore (1993) draws inspiration from anthropology and biology on the co-evolution process in which interdependent species evolve in a continuous cycle and how natural ecosystems collapse when environmental conditions change too rapidly. Moore (1993) suggests extending this systematic approach to strategy, in that a company should not be viewed as a member of a single industry, but as part of a business ecosystem that spans multiple industries.

From these early contributions, several ecosystem sub-categories and definitions have been proposed in the business management and strategy literature. While Jacobides et al. (2018) identified three categories of ecosystems in the literature: *business ecosystems* (e.g., Teece 2018), *innovation ecosystems* (e.g., Baldwin et al. 2024) and *platform ecosystems* (e.g., Kretschmer et al. 2022), but there are additional ecosystem concepts in the literature, such as *entrepreneurial ecosystems* (e.g., Spiegel 2017), *service ecosystems* (e.g., Vargo et al. 2015) and *knowledge ecosystems* (e.g., Clarysse et al. 2014). Table 3 provides an overview of selected definitions.

Despite the different sub-categories of circular ecosystems and the confusion around the use of the concept (e.g., Kanda 2023; Aryee et al. 2025), most definitions seem to have four overarching characteristics that define circular ecosystems: synergistic value, organisational autonomy, complex actor interdependence and ecosystem roles. (1) *Synergistic value*: the sum of the whole is greater than the individual parts, i.e., ecosystems have a system-level outcome that generates more value than what the ecosystem actors can achieve by themselves (e.g., Autio and Thomas 2020; Bremner et al. 2017; Teece 2018); (2) *organisational autonomy*: ecosystems are composed of heterogeneous actors that are largely independent (e.g., Baldwin et al. 2024; Bremner et al. 2017; Kretschmer et al. 2022); (3) *complex actor interdependence*: these autonomous ecosystem actors are linked through complex interactions and interdependencies (e.g., Adner 2017; Kretschmer et al. 2022; Jacobides et al. (2018). *Ecosystem roles*: ecosystems have distinctive governance mechanisms that are dictated by the different roles of different actors in different contexts (Adner 2017; Kretschmer et al. 2022; Kanda et al. 2025). Altogether, these characteristics of ecosystems shape the agency of their stakeholders, i.e., ecosystem actors do not only act as individuals and organisations, but also by their role within the ecosystem, which essentially determines their material, knowledge or value contribution to the ecosystem.

Based on this analysis, we define ecosystems as: “An ecosystem is a heterogeneous community of largely independent actors linked by complex interactions and interdependencies, collectively creating synergistic value, with each actor adopting distinct ecosystem roles that shape their contributions and the governance structure of the system.” in the context of this paper.

There is a range of underlying schools of thought closely related to the ecosystem concept, including innovation networks (e.g., Granovetter 1973; Powell and Grodal 2005), socio-technical systems (e.g., Trist 1981; Mumford 2000; Geels 2004), innovation systems (e.g., Freeman 1987; Lundvall 1992), clusters and hubs (e.g., Saxenian 1994; Porter 1998; Cohen and

Fields 1999), innovation precincts (e.g., Clark et al. 2000; Katz and Wagner 2014) and place-based approaches (e.g., Barca et al. 2012; Busso et al. 2013). Despite their considerable conceptual overlap, these notions are usually not conceptually delineated or integrated, residing in different disciplines that investigate similar real-world phenomena but are not talking to each other (Kanda 2023). This represents a significant conceptual shortcoming, indicating a potential disconnect between theory and practice.

The transition to a CE encompasses multiple actors across several sectors, geographies and time (Geissdoerfer et al. 2020). To describe and analyse the complex changes required for the efficient and effective use of material, water and energy resources, the concept of ecosystems has been introduced to the CE discourse as an extension of the prevalent business model innovation lens. The ecosystem serves as both a metaphor and a concept in the CE literature, enabling the analysis of complex constellations of actors, technologies and institutions that are interconnected through various interdependencies and co-evolutionary patterns (Aarikka-Stenroos et al. 2021).

Since its introduction into the CE literature, the ecosystem discourse has grown rapidly and has been applied to different analytical foci, including innovation, entrepreneurial, knowledge and industrial ecosystems. Each of these comes with different perspectives on the agency of actors, key mechanisms, analytical levels, key concepts and what is exchanged between actors (Kanda 2023). These different sub-categories of ecosystems are sometimes used interchangeably, which can undermine the relevance of the ecosystem concept as an analytical lens to foster the adoption of CE models.

### 3 | Method

Previous literature suggests at least two research methods to analyse the definition and meaning of concepts (Dahlsrud 2008). One approach is to interview experts or stakeholders. This approach can sometimes be unreliable as interview respondents may struggle to provide precise and comprehensive responses. A second approach is to analyse and synthesise written definitions of the concept and compare them with the real-world phenomena that are to be defined. Written definitions in academic literature are often more deliberate, precisely worded and iterated in a peer-review process. The second approach was adopted in this article, building on established approaches in previous research (Kirchherr et al. 2017, 2023).

Analysing written definitions of the concept of circular ecosystems in academic literature presents challenges. Some journals have very restrictive word counts, which can limit how much authors explicate a definition; other authors might omit aspects of a definition they consider non-essential, while some scholars might not explicitly label certain sentences in their text as definitions of circular ecosystems even though they intend to define the concept (Kirchherr et al. 2017). Furthermore, some scholars may not pay sufficient attention to providing a clear definition of a concept, as this may not be the primary focus of their paper, which is then also not picked up by peer reviewers who focus on more central aspects of the manuscript.

**TABLE 3** | Exemplary definitions of ecosystems from the management and strategy literature (adapted from Jacobides et al. 2024).

Source	Category	Definition	Focus
Adner (2017)	Ecosystems	“The alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (p. 40)	<ul style="list-style-type: none"> <li>• Collaborative value proposition</li> <li>• Actor alignment based on common incentives and motivations</li> </ul>
Baldwin et al. 2024	Innovation ecosystems	“A network of autonomous economic actors interacting to create value, including a complementary surplus, which is distributed across actors” (p. 1)	<ul style="list-style-type: none"> <li>• Modularity</li> <li>• Interfaces enabling connections and innovation</li> </ul>
Bremner et al. 2017	Business ecosystems	“Many industries are characterized by networks of interdependent firms. Often termed ecosystems, these networks consist of firms that offer discrete products or services that collectively form a valuable solution” (p. 215)	<ul style="list-style-type: none"> <li>• Network of interdependent firms</li> <li>• Collective solution based on individual offerings</li> </ul>
Clarysse et al. 2014	Knowledge ecosystems	“The flow of tacit knowledge between companies and the mobility of personnel [through] geographic co-location [constitute] knowledge ecosystems where local universities and public research organizations play a central role in advancing technological innovation within the system” (p. 1164)	<ul style="list-style-type: none"> <li>• Flow of knowledge and personnel through geographic co-location</li> <li>• Technological innovation</li> </ul>
Jacobides et al. (2018)	Ecosystems	“A set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled” (p. 2264)	<ul style="list-style-type: none"> <li>• Non-generic complementarities</li> <li>• Need for multilateral coordination at the overall ecosystem level</li> </ul>
Kretschmer et al. 2022	Platform ecosystems	“A defining feature of platform ecosystems is the interdependence between a stable core or “platform” that interfaces with a dynamic and heterogeneous set of complementary components to generate a stream of derivative products” (p. 407)	<ul style="list-style-type: none"> <li>• Core platform interfaces with complementary actors</li> <li>• Generation of derivative products</li> </ul>
Pidun et al. 2019	Business ecosystems	“a business ecosystem is a dynamic group of largely independent economic players that create products or services that together constitute a coherent solution.” (p. 2)	<ul style="list-style-type: none"> <li>• Provision of coherent solution based on individual products and services</li> <li>• Dynamic group of independent organisations</li> </ul>
Teece 2018	Business ecosystems	“A business ecosystem is a group of interdependent organizations collectively providing goods and services to their customers. Shared standards and interfaces are inherent features of platform-based ecosystems. They permit the members of the ecosystem to innovate independently while competing collectively against other firms and/or ecosystems in the relevant market.” (p. 151)	<ul style="list-style-type: none"> <li>• Collective provision of products and services</li> <li>• Shared standards and interfaces</li> <li>• Joint competition in the market</li> </ul>
Vargo et al. 2015	Service ecosystems	“An S-D logic, service-ecosystems view centres on the collaborative creation of value (i.e., value co-creation), the integration of dynamic resources, and the institutions that influence, and are influenced by, interactions among multiple actors” (p. 63)	<ul style="list-style-type: none"> <li>• Collaborative value creation</li> <li>• Integration of dynamic resources</li> <li>• Institutional arrangements</li> </ul>

In recognition of these challenges, we have considered entire articles to identify both explicitly labelled definitions and also implied definitions of the concept of circular ecosystems, including those expressed in figures and frameworks. This approach provides a broad basis for critically analysing the definitions and

meanings associated with the concept of circular ecosystems in the scientific literature.

The remainder of this method section describes the sample development and our coding framework.

### 3.1 | Sample Development

To develop the sample for our literature review on the definitions of circular ecosystems, we conducted a search using the Elsevier Scopus database. Scopus is a comprehensive and reliable database for academic publications, and it has been used in several highly cited literature reviews in the CE field (see, e.g., Brax et al. 2021; Seuring et al. 2020; Geissdoerfer et al. 2020). This search, first performed on 21 December 2023, utilised the search term ‘circular \* ecosystem\*’ to capture a broad range of relevant literature. We focused exclusively on journal articles and reviews to ensure the inclusion of peer-reviewed, high-quality articles, particularly appropriate when analysing definitions of a concept.

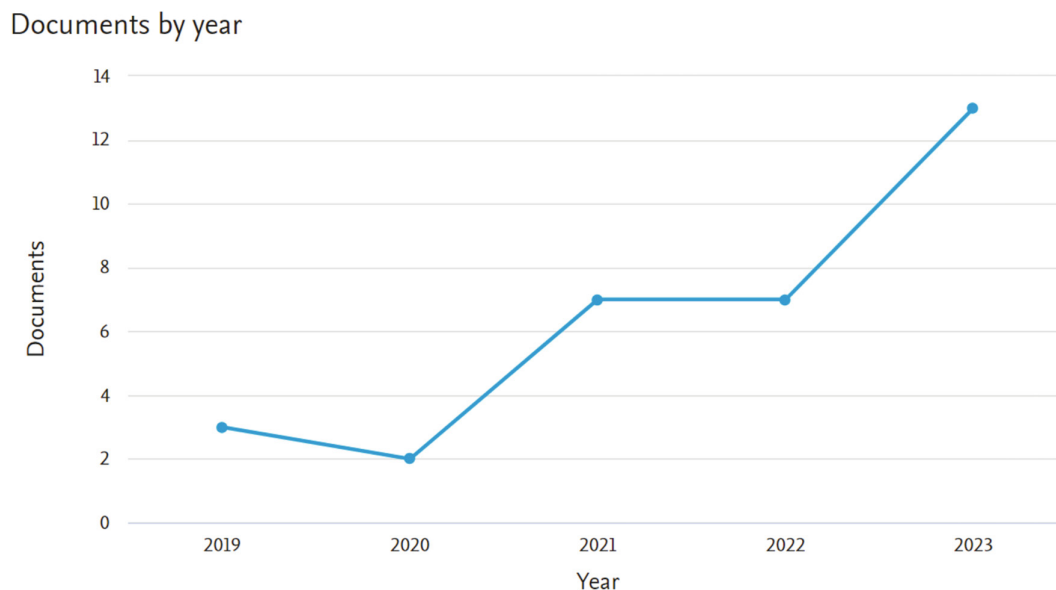
To capture a multidisciplinary perspective, which is characteristic of the CE literature, we included articles from the following subject areas: Environmental Science, Business, Management and Accounting, Engineering, Social Sciences, Energy, and Economics, Econometrics and Finance. By incorporating these diverse fields, we aimed to comprehensively cover the various approaches to circular ecosystems. We proceeded to exclude articles from subject areas deemed less pertinent to our research focus, including Computer Science, Decision Sciences, Materials Science, Medicine, Mathematics, Biochemistry, Genetics and Molecular Biology, and Agricultural and Biological Sciences. This exclusion helped us maintain a clear focus on the core areas relevant to our study.

Our search period included publications from 2019 to 2024, ensuring that our review reflects the most recent advancements and definitions on circular ecosystems. Moreover, our search period also represents a period of prominence in the use of the circular ecosystem concept. However, we also made an exception to include one agriculture-focused article from 2012 due to its significant relevance to the definition of circular ecosystems as often described in a snowballing approach. The initial search yielded a total of 31 documents. Upon closer inspection,

we found one document not relevant and were unable to access another. To expand our sample, we employed a further cross-reference snowballing technique, which identified an additional 15 relevant documents. However, one of these was also inaccessible. Consequently, our final sample comprised 43 documents. These 43 documents form the foundation of our literature review, providing a comprehensive overview of the current state of definitions on circular ecosystems within the specified subject areas. Figure 3 below illustrates the distribution of identified articles over the years, highlighting the relatively recent surge in publications on circular ecosystems.

### 3.2 | Coding Framework

An analysis of the definitions of circular ecosystems requires a coding framework that is systemic and transparent, showing how both explicit and implicit definitions of the concept are converted into numeric data for the purposes of analysis (Bourque 2004). The coding process was thus developed through an iterative approach, with the initial coding dimensions established based on our expert understanding of the concept of ecosystems. For example, all the authors have previously published papers on the concept of the CE and, more recently, on ecosystems and have thus read extensively on circular ecosystems as a basis for developing our initial coding framework. Therefore, this first step was largely deductive. Next, two of the authors dedicated time to read, identify definitions, and discuss iteratively. As a result, additional coding dimensions were added throughout the coding process and can be described as largely inductive, a method also referred to as emergent coding (Dahlsrud 2008; Haney 1998). Our final coding dimensions, summarised in Table 4, relate to the basic definition of ecosystems, sub-categories of ecosystems, analytical focus, system boundaries, research field and ecosystem elements. What these dimensions entail is explained in the table, which also depicts which dimensions were deductive [D] and which ones were emergent codes [I] as we read the literature.



**FIGURE 3** | Distribution of articles over the years.

**TABLE 4** | Coding framework (result of iterative coding process).

<b>Coding dimension</b>	<b>Explanation</b>	<b>Elements</b>	<b>Deductive/ Inductive</b>
Basic definitions	Description of the fundamental and distinctive characteristics of a concept or term		D
Types	Subcategories of circular ecosystems that focus on a specific kind of flow (e.g., knowledge ecosystem), purpose (e.g., CE innovation ecosystem) or context (e.g., CE urban ecosystem)	CE industrial ecosystems	D
		CE service ecosystems	D
		CE entrepreneurial/start-up ecosystems	D
		CE knowledge ecosystems	D
		CE innovation ecosystems	D
		CE business ecosystems	D
		CE construction/multi-project ecosystems	I
		CE digital/platform ecosystems	I
		CE urban ecosystem	I
		CE food ecosystem	I
Focus	Analytic lens that highlights certain characteristics of circular ecosystems and excludes others	Knowledge and information flows	D
		Resource/material and energy flows	D
		Economic value flows	D
		Stakeholder and interactions	D
		Drivers and barriers	D
		Incentive structures	D
		Governance	I
		Risk sharing	I
		Circular ecosystem management	I
		Scale or system boundary	Unit of analysis on which ecosystems are investigated, ranging from the intra-organizations (Micro) over the multi-organizational, industry and regional level (Meso) to the country, multi-country and global level (Macro)
Meso	D		
Macro	D		
Key actors in focus	Analytic lens that focuses on key actors in circular ecosystems and excludes others	(Incumbent) producers	D
		(Incumbent) suppliers and service providers	D
		Orchestrators	D
		Research institutes and universities	D
		Customers/end users	D
		Government and regulators	D
		Retailers	I
		Start-ups	I
		Consultants	I
		Investors	I
(Other) societal stakeholders	I		

(Continues)

TABLE 4 | (Continued)

Coding dimension	Explanation	Elements	Deductive/ Inductive
Research field	Disciplinary field in which the research was undertaken, or which paradigms are applied in the analysis	Management and strategy	D
		Entrepreneurship	D
		Innovation and technology management	D
		Industrial ecology	D
		Engineering	D
		Business model innovation	D
		Policy	I

Note: If the question posed per coding dimension is answered with ‘Yes’, the dimension is coded as ‘1’; otherwise, it is coded as ‘0’; [D]= deductively; the coding dimension was chosen already prior to starting the first round of coding, [I]= inductively; the coding dimension was added during the coding process.

### 3.3 | Coding Procedure

The identified articles were manually coded. Automatic coding via computer software or generative AI could be inflexible, miss nuances and lead to misleading results. Manual coding also utilises the expert insights of scholars on the topic, thereby helping us to avoid misinterpretation of definitions and to identify both implicit and explicit definitions. All manual coding was undertaken in Excel. Nonetheless, manually coding can also raise challenges regarding the reliability of coding between different persons (Olswang et al. 2006); thus, the two authors who coded the documents had regular dialogue throughout the coding process to synchronise their coding and to ensure their results were comparable based on an initial set of coding rules—a recommended good practise in manual coding (Hruschka et al. 2004). Furthermore, any attempt to convert qualitative definitions into numeric data somehow introduces some distortion, but such quantification also provides a useful approach to compare different definitions and highlight key trends for further conceptual development and practical application.

## 4 | Results

### 4.1 | Sample Overview

This section is divided into five sub-sections. First, different types of circular ecosystem definitions identified in the literature are presented. Second, various sub-categories of the circular ecosystem are elaborated. This is then followed by a presentation of the analytical focus on different circular ecosystem categories, the key actors within these categories, and the key frameworks associated with each category.

### 4.2 | Definitions of Circular Economy Ecosystems

We found three types of circular ecosystem definitions in the literature: (1) *direct definitions*: 19 articles in the sample defined the concept explicitly; we provide an overview of these definitions in Table 5; (2) *separate definitions of CE and ecosystem*: six authors referred to circular ecosystems by defining both

underlying concepts without defining the combined concept explicitly; (3) *implicit definitions*: 20 authors did not explicitly define the circular ecosystem concept but described different aspects in their articles—these definitions we extracted through coding; see Section 3.

Besides a CE focus, the direct definitions in Table 5 have some commonalities, including:

- *A focus on stakeholders and their interactions*: Most definitions mention stakeholders or ‘actors’ as a key element of the circular ecosystem notion (e.g., Aminoff et al. 2017; Aarikka-Stenroos et al. 2021), with a handful of authors also including a list of actors that they consider relevant, such as “policy-makers, investors, academics and educators, designers, consumers and users, brands or companies, manufacturers, and material experts.” (Min et al. 2021, 4). Together with the stakeholder, the role of their actions and interactions is often mentioned (e.g., Kanda et al. 2021; Pietrulla 2022) with a few authors pointing out the importance of collaboration (e.g., Ferrari et al. 2023) and coordination (e.g., Pietrulla 2022)
- *Consideration of resource, information, and value flows*, besides stakeholders, roles, and interactions, flows are the second most frequently mentioned element of circular ecosystems (e.g., Tate et al. 2019; Sandberg 2023; Boldrini and Antheaume 2021). These flows include material or resource flows (mentioned 31 times), such as raw materials, components and waste streams (e.g., Aminoff et al. 2017), information and knowledge flows (mentioned 26 times), such as communication and data exchange (e.g., Konietzko et al. 2020a), and value and economic flows (mentioned 21 times), such as the exchange of money and services (e.g., Asgari and Asgari 2023).

Including articles with separate definitions of CE and ecosystem and implicit definitions of circular ecosystems, there is a range of additional themes central to how circular ecosystems are defined:

- *Classification into different types of circular ecosystems*: Most authors mention specific types or subtypes of circular

**TABLE 5** | Overview of explicit definitions.

Source	Definition	Focus
Trevisan et al. 2022, 292	“A system of interdependent and heterogeneous actors that go beyond industrial boundaries and direct the collective efforts towards a circular value proposition, providing opportunities for economic and environmental sustainability.”	Interdependent and heterogeneous actors; circular value proposition; economic and environmental sustainability
Ferrari et al. 2023, 2	“Systems comprising actors that work together to create and improve products, solutions and services based on CE principles.”	Collaborative actors; circular value proposition
Gomes, de Faria, et al. 2023, 2	“A circular ecosystem consists of a group of interdependent, autonomous actors that collectively generate a circular value proposition”	Interdependent but autonomous actors, joint value proposition; circular value proposition
Gomes, Castillo-Ospina, et al. 2023, 2	“By circular ecosystem innovation, we refer to innovating in the ecosystem structure and its components (value proposition, roles, activities, and links) with the aim of materializing a circular value proposition”	Circular value proposition
Asgari and Asgari 2021, 567	“Building a circular ecosystem needs not only CBMs but also expects Circular Supply Chains (CSCs), circular customer behaviours, circular value chains, and circular ecosystem infrastructures in terms of relationships and communities”	Circular infrastructures; relationships and communities
Yu et al. 2023, 3	“Has its originality in Industrial Symbiosis, a subfield of industrial ecology that promotes the co-creation of mutual benefits among industrial units based on symbiotic exchanges of materials, energy, and services”	Co-creation of mutual benefits; exchange of material, energy and services
Geissdoerfer et al. 2020, 13	The [circular] value network and business model portfolio perspective can be combined to an ecosystem view. Besides combining multi-business model and multistakeholder views into a network perspective, ecosystem analyses can also expand not only to several business units but entire organisations (i.e., a multi-corporation view).	Business model portfolio; multi-stakeholder view; multi-corporation
Kanda et al. 2021, 5	Describes relationships, interdependencies and co-evolutionary interactions between entities exchanging (i) material and energy resources, (ii) economic value, or (iii) knowledge in a particular context.	Interdependencies; co-evolution; material, energy and service exchanges
Aminoff et al. 2017, 530	“Co-evolving, dynamic and potentially self-organizing configurations, in which actors integrate resources and co-create circular value flows in interaction with each other.”	Co-evolution; self-organizing interactions; circular recourse flows
Wurster et al. 2020, 2	“We define a circular economy (CE) innovation ecosystem as the evolving set(s) of actors, activities, and artefacts, and the institutions and relations that are important for the innovative performance within a circular economy.”	Institutions and relations; co-evolution
Parida et al. 2019, 717	“[We] view a business ecosystem as a loosely related business community. Accordingly, due to the inherent system approach taken in business ecosystem studies, we propose that adopting the ecosystem perspective may help explain the implementation of the circular economy on a system level.”	Loosely related business community
Aarikka-Stenroos et al. 2021, 261	“Communities of hierarchically independent, yet interdependent heterogeneous set of actors who collectively generate a sustainable ecosystem outcome.”	Hierarchically independent actors; interdependent actors; joint value creation

(Continues)

TABLE 5 | (Continued)

Source	Definition	Focus
Berghuis et al. 2023, 374	“A circular economy (CE) ecosystem is a multi-actor entity in which interdependent actors play complementary roles. Actors include for profit companies, public services, governmental bodies such as ministries, municipalities and cities, universities, non-profit organisations, and citizen—consumers. A CE ecosystem emerges or is created around a common, system-level goal related to resource circularity, and may involve the creation of CE knowledge, CE businesses, and economic value.”	Multi-actor, interdependence; complementarity; system-level goal(s); resource circularity
Zucchella and Previtali 2019, 276	“The relationship between industrial ecosystems and circular business models requires a deeper understanding: whereas the ecosystem provides a “stakeholders’ architecture,” a system of actors and their relationships, the circular business model (which has mostly been conceived at the single firm level), can encompass this system of actors and provide the “operational and economic architecture” to make the ecosystem viable and sustainable also from the financial point of view.”	Multi-actor; relationships; system-level goal
Boldrini and Antheaume 2021, 6	“[Circular] Ecosystems that bring together heterogeneous actors may offer opportunities for creating value by reframing what resources mean, or by valuing “ordinary” and “junk resources” that were previously unconsidered. Networks, consisting of independent organizations involved in long-term relationships, need orchestration to achieve collective goals.”	Heterogeneous actors; interdependency, collective goals, orchestration
Moggi and Dameri 2021, 2830	“A circular ecosystem results from the contributions of various stakeholders; however, the claims and value propositions of these stakeholders can differ, hampering long-term sustainability of the ecosystem. [...] sharing people, infrastructure and knowledge, together with mutual trust among stakeholders, are the preconditions of a circular ecosystem. Long-term continuity depends on additional tools that enhance financial self-sufficiency, namely, participative governance, a co-designed circular business model, accountability, frequent engagement, local actions and the development of advocacy power.”	Diverse stakeholders; Pre-conditions for interdependence; governance
Pietrulla 2022, 3	“Ecosystem as affiliation in the CE context means that all relevant stakeholders along the material flow chain (or loop) must be considered to make circularity a reality. Ecosystem as structure focuses on the activities needed per stakeholder and, hence, the interdependent coordination of activities like the collection of materials at the end of a product’s lifecycle and their reintroduction into the circular flow.”	Interdependence; material, energy and services flows
Min et al. 2021, 4	“The CE ecosystem can be regarded as the conceptual framework for exploring the influencing actors in the CE process. [...] Mainly the actors in CE are identified as policy-makers, investors, academics and educators, designers, consumers and users, brands or companies, manufacturers, and material experts.”	Multi-actors

(Continues)

TABLE 5 | (Continued)

Source	Definition	Focus
Uusikartano et al. 2020, 3	<p>“A location-specific community of hierarchically independent, yet interdependent actors (such as companies, municipalities, associations, citizens) aiming for environmentally sustainable energy and material flows through optimizing and innovating with material flows and stocks (see [4]) in symbiotic collaboration and by utilizing/contributing/reacting to the wider urban operating environment within which they are located. [They] are furthermore place- and time-dependent physical set-ups providing place-specific needs and assets. All [...] actors and materials do not need to be collocated, nor can they as some resources (e.g., rare minerals) and producers are not locally available. This means that the boundaries of an industrial CE ecosystem can vary between different resources. Nevertheless, the ecosystem is characterized by issues specific to a certain area (such as available local side streams or the transport costs of rarer raw materials to that specific area).”</p>	<p>Location-specific community; hierarchically independent; interdependency; energy and material flows;</p>

ecosystems, including business (mentioned 25 times), industrial (mentioned 17 times), innovation (mentioned 15 times), digital (mentioned seven times), entrepreneurship (mentioned six times), knowledge (mentioned six times) and service ecosystems (mentioned four times).

- *Link to circular business model concept:* A subset of authors explicitly refers to the close relationship of the circular ecosystem and circular business model concepts (e.g., Zucchella and Previtali 2019; Moggi and Dameri 2021) with two authors laying out explicitly the shift in unit of analysis from the business unit and company focus of conventional business model innovation theory to the ecosystem perspective (Geissdoerfer et al. 2020; Kanda et al. 2021).
- *Focus on incentive structures, governance and risk sharing:* Similar to the circular business model literature (see e.g., Rashid et al. 2013; Geissdoerfer et al. 2020), many authors mention the special role of investigating incentive structures, i.e., how to align interests among ecosystem participants (e.g., Barquete et al. 2022; Gomes, de Faria, et al. 2023), governance, i.e., how to coordinate actions and relationships between the actors (e.g., Gomes, Castillo-Ospina, et al. 2023; Parida et al. 2019; Kanda et al. 2025) drivers and barriers, i.e., what factors foster or hinder the performance and success of an ecosystem, and risk sharing, i.e., in how far the setup and integration into an ecosystem mitigate the economic risks for its participants (e.g., Press et al. 2020; Parida et al. 2019).
- *Focus on three different analytical scales:* The authors focused on one or a combination of three analytical scales, similar to what Kirchherr et al. (2017) found for the CE concept: micro, starting their analysis at the business and organisational level (mentioned 16 times), meso, aiming at the value network and industry level (mentioned 34 times) and macro level, aiming at national and multinational economies (mentioned 15 times).

### 4.3 | Categorisation of CE Ecosystems

From our literature review, we identified at least 10 sub-categories of ecosystems in our literature review. These sub-categories of ecosystems overlap and include the following: (i) *circular industrial ecosystems*, (ii) *circular service ecosystems*, (iii) *circular entrepreneurial ecosystems*, (iv) *circular knowledge ecosystems*, (v) *circular innovation ecosystems*, (vi) *circular business ecosystems*, (vii) *circular construction ecosystems*, (viii) *circular digital platform ecosystems*, (ix) *circular urban ecosystems* and (x) *circular food ecosystems*.

To present these sub-categories concisely, Aarikka-Stenroos et al. 2021 suggested the ecosystem can be grouped into three categories based on ecosystem interactions, flows and outcomes. Accordingly, these three categories of circular ecosystems are the following: (i) *material flow-based ecosystems* (e.g., industrial and urban ecosystems); (ii) *knowledge flow-based ecosystems* (e.g., entrepreneurial and knowledge ecosystems) *economic value flow-based ecosystems* and (iii) (e.g., innovation ecosystems and business ecosystems).

We tried to use Aarikka-Stenroos et al.'s (2021) framework to categorise the 10 sub-categories. However, we were not able to match the categories. Analysing the reasons for this mismatch, we found that in practice, ecosystems are not neatly categorised and material, information and economic values flows are integrated and overlap with each other. This means that most ecosystems will have several of the different value streams present, contradicting the logic of Aarikka-Stenroos et al. (2021). As a conceptual framework that does not represent the real-world phenomena it aims to describe, it is not helpful for our purposes. Therefore, we refuted that classification and grouped the sub-categories logically based on the empirical instances of ecosystems known to us. This led us to three categories: (1) *multi-actor ecosystems*, focused on different ecosystem actors and their interrelations; (2) *platform and knowledge ecosystems*,

focused on the tools and platforms used to coordinate between stakeholder actors; (3) *sector-specific ecosystems*, focused on specific sectors. We tested the new framework with all empirical cases we found in the literature reviewed in this paper and found it to be consistent. This indicates that we defined a useful framework that we suggest for further use.

#### 4.3.1 | Multi-Actor Ecosystems

*Circular business ecosystems* focus on coordination among diverse actors, including producers, suppliers, service providers, end users, regulators and civil society organisations to create value for customers (Kanda et al. 2021).

These different economic actors create value together based on their different expertise and resources. This collective action can be based on formal or informal collaboration between actors, but also be characterised by competition, for example, for resources, legitimacy and power, and based on conventional market mechanisms. While leadership is important in circular ecosystems to give signals to ecosystem actors to invest towards an overarching vision, it can also develop organically, based on the conventional supplier–customer relationships. For the analysis and eventual design of ecosystems, there is a need to capture these actors, relationships and interactions for a broader perspective beyond the focal firm and limited stakeholder set included in most conventional business model and strategy perspectives, to be able to analyse, plan and communicate the different economic, environmental and social benefits generated collectively by such ecosystems.

From the field of industrial ecology, the concept of *industrial ecosystems* draws inspiration from natural ecosystems, aiming to optimise the use of materials and energy while minimising waste in industrial processes (Parida et al. 2019). By channeling waste as inputs into other processes, these ecosystems foster closed-loop production that promotes resource efficiency and effectiveness. Circular resource flows and the valorisation of waste are central to industrial ecosystem approaches. The optimisation of material and energy resource flows can occur within one factory, an industrial park with different industries, or within a geographic area.

*Circular innovation ecosystems* focus on diverse actors, such as firms, universities, research institutions and government agencies, working together to facilitate the development, diffusion and use of innovations to maximise resource efficiency and reduce environmental impact. Key elements include the development of circular offerings, resource infrastructure and effective coordination among stakeholders based on collaboration, experimentation and facilitating platforms. By fostering collaboration and value co-creation, circular innovation ecosystems facilitate the exchange of economic value, innovative ideas and technologies through the innovation chain, creating conditions for a transition towards a CE. Compared to business ecosystems generally characterised by collaboration and competition among independent economic actors, collaboration is essential for developing innovations such as circular business models due to the need to depend on specific actors to source raw materials, reverse logistics and deliver value.

#### 4.3.2 | Platform and Knowledge Ecosystems

*Digital and platform ecosystems* have recently emerged as technological and online platforms developed by organisations to enable many other organisations to build complementary products and services, increasing value and attracting users. Collaboration and innovation within the digital landscape are central to these ecosystems, shaping the way digital technologies contribute to the CE. These platforms are particularly common among new ventures developing circular business models since they have a relatively low entry barrier compared to developing a product or service from scratch. Such platforms often essentially serve as a meeting space for suppliers and users to exchange products and services around an economic value.

*Knowledge ecosystems* include users and producers of knowledge organised around a collective search for knowledge. Knowledge ecosystems often focus on the early stages of new knowledge production in pre-market settings often led by universities, research and competence centres. The system-level outcomes of knowledge ecosystems are the collaborative exploration of new knowledge to facilitate the effective and efficient use of material and energy resources, which individual firms and organisations cannot achieve in isolation. Such ecosystems are driven by regular interactions to search for and combine new knowledge between academic, industry and government to address circularity challenges and thus benefit from proximity, trust and continuous interaction (da Silva et al. 2022). The exchange of such knowledge can be facilitated by digital platforms, physical meetings, reports and documentation that conveys key insights for circularity (Espina-Romero et al. 2022). Knowledge ecosystems can be connected to specific industrial sectors such as biogas, textiles and plastics under a broad CE umbrella.

#### 4.3.3 | Sector-Specific Ecosystems

The *urban ecosystems* concept focuses on material and energy flows in cities and urban areas. In this approach, cities and urban areas are analysed as complex milieus that provide habitats for citizens and institutions while offering valuable ecosystem services. Urban ecosystems are hosts to multiple actors, groups, sectors, industries and governance structures, with diverse and sometimes conflicting interests who share a common locality. By sharing a common territory, these diverse actors often strive for collaboration and alignments of interests for common interests. The concept of urban ecosystems recognises the materials and energy metabolism within cities and urban areas, emphasising sustainable urban development, resource management, and the well-being of both human and natural ecosystems.

An *entrepreneurial ecosystem* consists of a set of interdependent actors and factors that enable productive entrepreneurship within a particular territory. Entrepreneurial ecosystems foster the establishment of new ventures by interdependent actors. Entrepreneurial ecosystems consider contextual elements including actors, networks, institutions, culture and infrastructure, and their dynamic interactions, supporting successful entrepreneurship often within specific regions.

Thus, entrepreneurial ecosystems are not just about the focal entrepreneurs that create new ventures but also about knowledge institutions, local governments, funding agencies, and incumbent firms that seek to enable productive entrepreneurship often in a territory (Berghuis et al. 2023). *Circular entrepreneurial ecosystems* encompass an interdependent set of actors (and factors) in a territory that seek to explore entrepreneurial opportunities using CE principles. These actors include accelerators, incubators, maker spaces, universities and intermediaries facilitating circular business model experimentation and venturing. Such ecosystems are defined by alignment and coordination structures and also the complementary of roles (Pietrulla 2022).

*Service ecosystems* focus on the integration of resources and the co-creation of value among interconnected actors. The concept focuses on the multi-actor and dynamic nature of service exchange and value creation. Through shared institutional logics, various value proposing actors collaborate to deliver value and meet customer needs. Service ecosystems highlight the interdependence and collective efforts of actors in providing value within CE. Such ecosystems also highlight how services impact the environment but also how services can be used to improve the environmental performance of products in product-service bundling. Service ecosystems, similar to other ecosystems, are dynamic and change according to what customers find valuable, shaped by both formal and informal institutions such as norms, standards, beliefs, meanings on the personal, firm and societal level.

Finally, *food ecosystems* in the identified literature often focused on the valorisation of food waste to produce biogas (for heating, electricity, upgraded into biomethane for transport), biofertiliser and carbon dioxide. In such ecosystems, the role of orchestrators is identified as important to develop a vision regarding the proper management of food waste, encouraging trust and commitment among ecosystem actors to invest in the vision and continuously reconfiguring the ecosystem to meet the dynamics of the local context (Zucchella and Previtali, 2019). You find an overview of the different categories and types in Table 6.

#### 4.4 | Analytical Focus Circular Economy Ecosystems

As summarised in Section 4.1, there are different definitions and approaches to the concept of circular ecosystems. Similarly, the analytical focus of circular ecosystems can vary depending on context and analytical scope. As listed in Table 7, the most common elements include stakeholders and interactions (mentioned by 29 sources), followed by flows (25 sources mentioned resource/material and energy flows, 23 sources mentioned knowledge and information flows and 19 mentioned economic value flows), incentive structures (mentioned by 16 sources), governance (15 sources), risk sharing (14 sources) and drivers and barriers for ecosystem success (11 sources).

As outlined in Table 8, while the most common system scale for ecosystems in the reviewed literature is the meso level

(mentioned by 24 sources), which takes a group of several organisations (and sometimes individuals) and the interactions and interrelations between these for a certain geographic area or industry as its focus, some authors also include micro (mentioned by 13 sources) and macro system (12 sources) level perspectives. This is remarkable as it indicates a conceptual flexibility that is well suited to analyse the real-world complexity of organisational arrangements, where, e.g., different business units of the same corporation and diverse individual and intra-organisational actors might be involved. This means that depending on the type of analysis, the lens of the ecosystem concept can shift considerably, from the intra-organisational ecosystem (e.g., analysing the collaboration between different organisational units) to national and multinational ones (e.g., analysing global industrial value chains). It is further remarkable to notice that four sources remained unclear about the focus of their analysis, indicating that besides a desirable conceptual flexibility, there might also be a potentially less helpful conceptual fuzziness in some of the circular ecosystem research.

#### 4.5 | Key Actors Covered in Circular Ecosystem

The investigated literature has a significant focus on stakeholders or ‘actors’ as a key element of circular ecosystems (e.g., Aminoff et al. 2017; Aarikka-Stenroos et al. 2021). Authors either refer to a specific list of actors that they consider relevant, such as “policy-makers, investors, academics and educators, designers, consumers and users, brands or companies, manufacturers, and material experts.” (Min et al. 2021, 4) or just mention some of the actors that might be relevant without claiming comprehensiveness (e.g., Konietzko et al. 2020).

Table 9 synthesises the stakeholders mentioned in the investigated literature, with producers, customers and suppliers being the most mentioned actors, while investors and consultants were considered only by few authors.

There is some correlation between the type of ecosystem and the stakeholders mentioned. For example, authors using entrepreneurial ecosystems often refer to start-ups (e.g., Berghuis et al. 2023), but the most commonly cited stakeholders, such as producers, customers and suppliers, are found across all types in the literature.

While the terms ‘actors’, ‘stakeholders’ and ‘roles’ are used interchangeably in the literature, there is a material difference of ‘orchestrators’ from the other stakeholders mentioned. This term appears to refer more to an actor’s roles related to governance rather than the type of stakeholders (producers, suppliers, etc.). This indicates conceptual value in differentiating between stakeholders (who is involved) and roles (what do they do) when describing ecosystems, analogous to first approaches in transition theory (see e.g., Kanda et al. 2020). This finding is consistent both with stakeholder theory (Freemann 1984) and the concepts of ecosystem catalysts (Savaget et al. 2025), transition brokers Cramer (2020), intermediaries (Kanda et al. 2025), and, in fact, ‘orchestrators’ (Dhanaraj and Parkhe 2006). In related work on circular start-ups, Henry et al. (2024) propose four roles that these start-ups adopt: conveners, reinforcers, pioneers and

TABLE 6 | Categorisation of circular economy ecosystem types.

Category	Sub-category/type	Example definition	Occurrence	Rank
Multi-actor ecosystems	CE business ecosystem	“A set of actors—producers, suppliers, service providers, end users, regulators, civil society organizations that contribute to a collective outcome” (Konietzko et al. 2020a, 3)	25	1
	CE industrial ecosystems	“Physically located industrial systems within which circular resource flows occur and have sustainable industrial production through resource recycling and reuse as their ecosystem-level outcome.” (Aarikka-Stenroos et al. 2021, 265)	17	2
	CE innovation ecosystems	“Describe how legally independent actors can jointly create value. The focus of this perspective is on a technology or new value proposition that requires the joint efforts of multiple actors to be successfully implemented” (Konietzko et al. 2020a, 3)	15	3
Platform and knowledge ecosystems	CE digital/platform ecosystems	“Describe how actors organize themselves around common technological and market-oriented platforms. Platforms organize data streams, economic interactions and social exchanges across users (Konietzko et al. 2020a, 3)	7	4
	CE knowledge ecosystems	“A regional community of hierarchically independent, yet interdependent heterogeneous set of actors who advance the translation of advances in CE research knowledge into sustainable products and services.” (Aarikka-Stenroos et al. 2021, 269)	6	7
Sector-specific ecosystems	CE urban ecosystems	“Type of ecosystem that focuses on material and energy flows are urban ecosystems, which refer to the built environments that include administrative actors and the physical infrastructure.” (Aarikka-Stenroos et al. 2021, 265)	7	5
	CE entrepreneurial/start-up ecosystems	“A regional community of hierarchically independent, yet interdependent heterogeneous set of actors who facilitate the start-up and scale-up of entrepreneurial new ventures focused on sustainable business opportunities.” (Aarikka-Stenroos et al. 2021, 269)	6	6
	CE service ecosystems	“A set of actors that interact with and depend on each other to co-create value” (Konietzko et al. 2020a, 3)	4	8
	CE multi-project ecosystems	“A multi-project ecosystem entails a circular construction ecosystem where the resources used for a new project can be traced back to the waste streams from many other projects.” (Yu et al. 2023, 1)	2	9
	CE food ecosystems	Not defined.	2	10

**TABLE 7** | Overview of circular economy focus dimensions.

Focus	Occurrence
Stakeholder and interactions	29
Flows	
Resource/material and energy flows	25
Knowledge and information flows	23
Economic value flows	19
Incentive structures	16
Governance	15
Risk sharing	14
Drivers and barriers for ecosystem success	11

**TABLE 8** | Three different system scales for circular ecosystems.

Type	Description	Occurrence
Micro	Intra-organisation unit of analysis (e.g., business unit)	13
Meso	Multi-organisational, industry and regional level	24
Macro	Country, multi-country and global level	12

**TABLE 9** | Overview of key actors in circular ecosystems, ranked by occurrence.

Rank	Type	Description	Occurrence
1	Producers	Manufacturers of the products that leave the ecosystem towards external B2B and B2C customers	36
2	Customers/end users	B2B and B2C buyers and users of the ecosystem's output products	31
3	Suppliers & service provider	Raw material, component and service providers for the producers	30
5	Government and regulators	National, regional and local public sector authorities	26
4	Other societal stakeholders	Non-government actors, such as NGOs	21
6	Start-ups	Newly founded business ventures	14
7	Retailers	Businesses that sell on products or services	13
8	Orchestrators	Actor who coordinates and integrates the activities of various ecosystem participants	11
9	Research institutes and universities	Public and private higher education and research organisations	11
10	Investors	Funding bodies providing financial resources and sometimes advice and non-monetary resources (e.g., access to network)	7
11	Consultants	Service providers specialised in advising organisation on specific topics, such as operations, strategy and digitalisation	4

champions. Table 10 provides an overview of example stakeholders and roles.

These different roles have considerable conceptual overlap, but can be translated into a mutually exclusive and collectively exhaustive set of five generic ecosystem roles. For these roles, we propose the following terms: (1) orchestrators, (2) brokers, (3) value creators, (4) innovators and (5) sponsors. Table 11 gives an overview of the five proposed ecosystem roles and their definitions.

#### 4.6 | Circular Ecosystem Frameworks

The investigated literature contained a variety of different elements, with several including explicit, illustrated frameworks; see Table 12.

Some frameworks feature not or not well described elements—e.g., the concentric lines in Tate et al.'s (2019) framework that could both refer to 'decentral information storage' or the 'principles' formulated by the authors. Of these principles, not all make logical sense, however, such as "Principle 4: in order to transition to a circular value system, secondary material flows need to continuously cross industry boundaries" (p. 124).

Other frameworks add additional elements, such as 'physical and intangible resources' (e.g., 'knowledge', 'use of the digestate') and 'trust'; 'coordination forms' (e.g., 'communication') and 'governance mechanisms' (e.g., 'culture socialisation' and again, 'trust') (Zucchella and Previtali 2019, 280).

**TABLE 10** | Overview of example stakeholders vs. roles in the literature.

Stakeholders		Roles	
Describes nature of actors in the circular ecosystem (who they are)		Describes the contribution of the actor for the circular ecosystem (what they do)	
Stakeholder type	Description (from Table 9)	Role	Description
Producers	Manufacturers of the products that leave the ecosystem towards external B2B and B2C customers	Transition brokers	Transition brokers help to establish and support collaboration between different actors and foster the appropriate conditions for ecosystem development (Cramer 2020)
Investors	Funding bodies providing financial resources and sometimes advice and non-monetary resources (e.g., access to network)	Ecosystem catalysts	An actor enacting change in an ecosystem without becoming a permanent part of it by developing an ecosystem, make it self-sustaining, and withdraw from it (Savaget et al. 2025)
Government and regulators	National, regional and local public sector authorities	Intermediaries	Actors who go in-between two or more parties and enable them to reach an outcome (Kanda et al. 2020)
Research Institutes and universities	Public and private higher education and research organisations	Orchestrators	Actor who coordinates and integrates the activities of various ecosystem participants (Dhanaraj and Parkhe 2006)

**TABLE 11** | Five ecosystem roles.

Role (what they do)	Definition	Typical stakeholder group (who they are)—can vary significantly across contexts
Orchestrators	Steer, govern and align ecosystem partners, set direction and manage interdependencies.	Producers/suppliers
Brokers	Connect actors, translate across domains and mediate between stakeholders.	Regulators/policy-makers
Value creators	Carry out or directly support production, delivery and practical implementation of circular solutions.	Service providers
Innovators	Develop, trial and push novel technologies, practices or business models.	Knowledge Institutions
Sponsors	Advocate for systemic uptake and provide enabling conditions such as finance, infrastructure or policy.	Civil society

Most frameworks have two types of elements in common: actors or stakeholders, such as ‘suppliers’ (Barquete et al. 2022, 8), ‘producers’ (Tate et al. 2019, 125) and ‘universities’ (Zucchella and Previtali 2019, 280) and flows or exchanges, such as ‘financial flows’ (Barquete et al. 2022, 8), ‘information flows’ (Tate

et al. 2019, 125) or ‘delivery of waste’ (Zucchella and Previtali 2019, 280).

This compares well with our analysis of definitions from Section 4.2, with its emphasis on different stakeholders and

TABLE 12 | Selected circular economy frameworks.

Framework	Illustration	Elements	Source
Ecosystem perspective	<p>The diagram illustrates an ecosystem perspective. It features a large dashed-line circle labeled 'Ecosystem' containing several smaller dashed-line circles, each labeled 'Actor'. In the center of the ecosystem are two overlapping circles: 'Business model' and 'Product Service'. A small grey oval is positioned at the bottom left of the ecosystem boundary.</p>	Actors Business Models Products and services	Konietzko et al. 2020a, 2
Material and information flows among actors	<p>The flowchart depicts material and information flows among actors. It starts with 'Suppliers' providing 'Plastic, paper and aluminium' to a 'Carton packaging manufacturer'. This manufacturer produces 'Carton package' for 'National customers' and 'Multinational customers' within the 'Food industry'. 'National customers' provide 'Pre-consumer package' to 'Ecological tile manufacturers' and 'Recyclers'. 'Multinational customers' provide 'Pre-consumer package' to 'Waste management company' and 'Recyclers'. 'Waste management company' provides 'Financial incentive' to 'Recyclers' and 'Information' to 'Shavings market'. 'Ecological tile manufacturers' produce 'Ecological tiles' for 'Dealers, distributors and end consumers'. 'Recyclers' provide 'Pressed material' to 'Shavings market' and 'Cooperatives'. 'Shavings market' provides 'Pressed material' to 'Cooperatives'. 'Cooperatives' provide 'Post-consumer package' to 'Collectors, NGOs and private companies'. 'End consumers' provide 'Post-consumer package' to 'Collectors, NGOs and private companies'.</p>	Actors Material flows Information flows	Barquete et al. 2022, 8

(Continues)

TABLE 12 | (Continued)

Framework	Illustration	Elements	Source
Schematic business ecosystem view	<p> <b>Principle 1</b>              ▲ decomposers and scavengers              ■ producers              ● consumers         </p> <p> <b>Principle 2</b> → Material flow  <b>Principle 3</b> → Information flow  <b>Principle 4</b> → Financial flow  <b>Principle 5</b> → Material flow  <b>Principle 6</b> → Information flow         </p> <p>             Industry 1, Industry 2, Industry 3, Industry 4, Industry 5, Industry 6              Decentralized information storage, Storage         </p>	Decomposers Producers Consumers Material flows Informational flows Financial flows	Tate et al. 2019, 125

(Continues)



TABLE 12 | (Continued)

Framework	Illustration	Elements	Source
Stakeholder involvement in ecosystem	<p>The diagram illustrates the RiCibo ecosystem. It shows a flow of surplus food (168 tons) from food donors to a participative governance board consisting of several NPOs. This board then distributes food to beneficiaries. External NPOs also interact with the system. Waste management entities are involved in handling waste, with a discount on waste taxes provided. Social services are also part of the ecosystem.</p>	Actors Groupings of actors Material and economic flows	Moggi and Dameri 2021
Circular eco-system conceptual framework	<p>The conceptual framework is divided into three main sections:</p> <ul style="list-style-type: none"> <li><b>Actors:</b> Includes Heterogeneous and Interdependent, Aligned interests, Defined roles, Reliability, Appropriate Balance, and Orchestration.</li> <li><b>Data, Materials, and flows:</b> Includes Reframe, Integrate, Share, and Manage. It features three interconnected boxes: <ul style="list-style-type: none"> <li><b>Value:</b> Circular value proposition, Multiple cycles of value, Value Co-creation, and Collective capture of value.</li> <li><b>Circular activities and strategies:</b> Collective purposes, Multiple CE activities, and Environmental and financial return.</li> </ul> </li> <li><b>Governance:</b> Non-hierarchical, Collaborative.</li> </ul>	Value Actors Data, Materials and flows Circular activities and strategies Governance	Trevisan et al. 2022

three types of flows: resource, information and economic flows. This is not surprising as most frameworks aim to be conceptual representations of the circular ecosystem concept.

While the investigated literature discusses several different types of ecosystems (see Section 4.3), this seems not to be reflected in the ecosystem illustrations, indicating that this is less a material difference between ecosystems than a point of view preference of the authors, e.g., based on their own disciplinary background.

Based on the commonalities in the frameworks and our analysis of the concept in Sections 4.2 to 4.5, we synthesised a ‘generic’ depiction of circular ecosystems to illustrate the concept in Figure 4.

Figure 4 depicts different stakeholder groups as dark blue circles, which are part of the ecosystem, whose system boundary is illustrated by a light blue, dotted line. The stakeholder types (e.g., producers/suppliers, service providers) within the system can have different ecosystem roles (e.g., brokers, sponsors) in different contexts and over time, indicated by the light blue rings around the circles showing the dynamic and strategic nature of ecosystem actors. The materials, energy, finance and data & knowledge inputs enter the ecosystem and are then transformed—through value creation between different ecosystem participants—into products, services and/or software outputs. This value creation creates innovation, resilience and sustainability (e.g., resource efficiency, improved environmental performance and stakeholder benefits) as ecosystem outcomes. The ecosystem is based on a range of enablers, symbolised by the bottom grey box: governance, technology platforms, spatial context and cultural norms (including trust,

personal networks, etc.). These describe framework conditions that can both enable but also hinder ecosystem development and processes.

## 5 | Concluding Discussion

In this paper, we analysed the definitions of circular ecosystems and mapped their analytical focus, distinct sub-categories, main elements, agency of actors and the exchanges between actors to create value. Specifically, the paper provides answers to the research question, “What is the current understanding of the concept of circular ecosystems?” In addressing this research question, we proposed a more comprehensive definition of the concept of circular ecosystems. The definition is based on the explicit and implied definitions provided by scholars writing on ‘circular ecosystems’. We connected our contribution to prior discussions on the concepts of ecosystems and CE, which already had a considerable track record before the recent surge in interest for their conceptual synthesis in the form of the circular ecosystems concept.

Based on the review of the ‘circular ecosystem’ literature, we propose this definition: “Circular economy ecosystems describe systems of stakeholders (producers, suppliers, etc.), their different roles (orchestrators, brokers, etc.), and the interactions and interrelations (knowledge and information, material and energy, and economic flows) between them, focused at extending, cycling, intensifying, and dematerialising resource loops.”

This definition aligns with specific characteristics of circular ecosystems that are fundamental for a descriptive

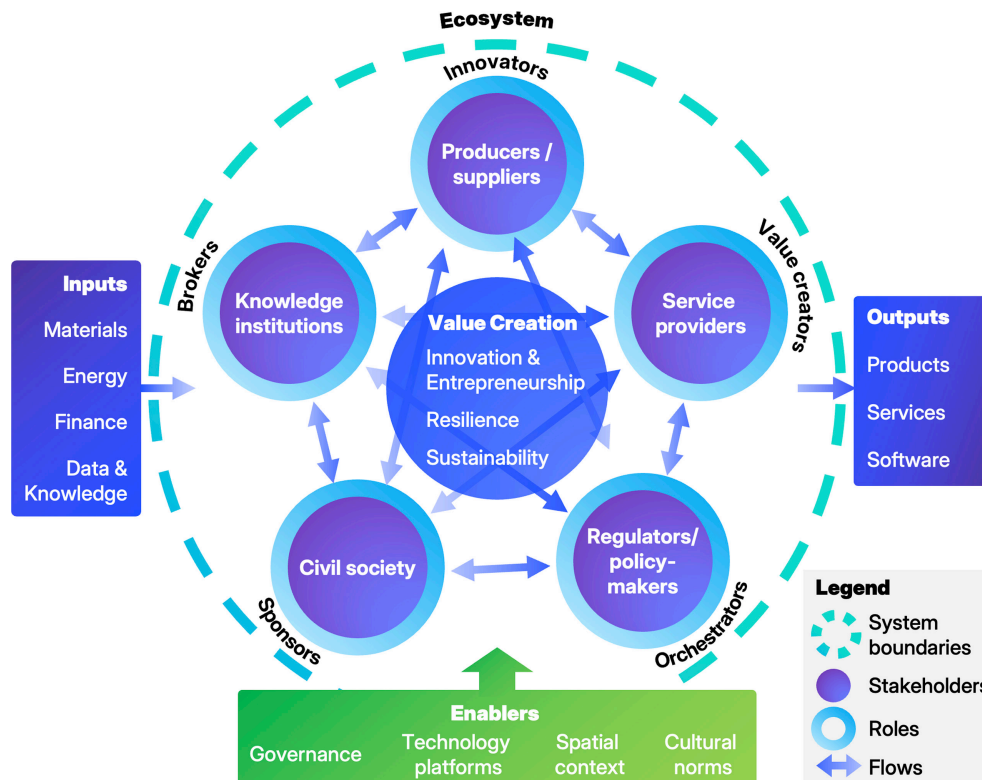


FIGURE 4 | Illustration of the circular ecosystem concept.

understanding of the concept, but which are fragmented across previous definitions. The proposed definition aims to be more precise and operationalisable and has implications for both theory and practice.

The definitions of circular ecosystems provided in the CE literature bring at least three extensions to ecosystem theory in general: (1) circular ecosystems are strongly tied to the exchange of material and energy resources, which must be effectively re-circulated into the economy; (2) these material and energy resource exchanges can be undertaken in transactional and non-transactional set-ups based on, for example, driven by proximity, trust and social trust; and (3) this non-transactional exchange of energy and material resources also highlights the importance of place and social attributes such as networks in circular ecosystems.

Place can include specific industries, territorial dynamics needed to realise the value proposition of the ecosystems and economically recirculate resources. Thus, our definition extends the understanding of ecosystems by highlighting aspects that can be particularly relevant in the CE context: (i) the materiality of exchanges, (ii) the non-transactional nature of some exchanges and (iii) location-specific characteristics of exchanges. The specificities mentioned above add to well-known aspects of ecosystems, such as their modularity, complementarity, non-hierarchical interactions, interdependencies and the deliberate attempt by ecosystem actors to develop system-level goals (cf. Jacobides et al. 2018).

However, it is important to note that the reviewed literature seemed to overemphasise non-transactional set-ups and ‘joint purpose’ instances, while it is equally, and—from a scale and impact perspective (see e.g., Porter and Kramer 2011)—potentially more important to understand different roles, interrelations and interactions in a conventional, market-based environment.

The concept of ecosystems has evolved significantly across various domains of study, transitioning to an increasingly diverse set of concepts, such as business, innovation and platform ecosystems. Earlier approaches typically emphasised firm-specific interactions, innovations and platform-based collaborations (Aryee et al. 2025). However, the CE literature introduces a more expansive view, integrating a wide range of actors, networks, technologies and institutions. This broader perspective reflects the often complex and interconnected nature of ecosystems in the CE context, which seeks to close material and energy loops through diverse mechanisms. This makes CE an ideal context to theoretically advance the ecosystem concept.

Nevertheless, challenges remain in applying the ecosystem concept to the CE literature. Early ecosystem literature was closely tied to prominent firms in the investigated ecosystems, often neglecting aspects such as identifying partners that can fulfil the often-diverse roles required by circular models. This limitation suggests that a critical examination of the ecosystem concept’s application to the CE is necessary. Specifically, it is vital to avoid oversimplifications to benefit from the unique contributions that ecosystem thinking can offer to CE research and the other way round (Klofsten et al. 2024).

The CE context necessitates a nuanced understanding of how various types of exchanges—such as material, energy, information, knowledge and value—occur within ecosystems. Unlike business, innovation or platform ecosystems, which primarily focus on commercial value exchanges, the CE emphasises material and energy flows, which can be non-commercial. This focus highlights the geographical specificities and requirements for economies of scale for material and energy exchanges, which can often constrain the economic performance of circular models. Conversely, knowledge exchanges have become increasingly geographically unbound due to digitalisation.

The CE context itself introduces several distinctive characteristics. It operates with an overarching goal of closing resource loops and is implemented at multiple levels—micro, meso and macro. This expanded scope includes focal firms, innovations, platforms and material and energy exchanges, and can incorporate a diverse range of actors, including customers and governments, who play crucial roles in facilitating circular practices. Moreover, the CE inherently involves collaboration across organisational boundaries, which can lead to coordination challenges and incentive gaps between actors required for an ecosystem approach.

Addressing these challenges involves an in-depth understanding of the different roles that different stakeholder groups can take in different contexts and over time. This understanding is critical for effectively managing the complexities of CE initiatives and developing effective approaches to purposefully design them from a strategic perspective or support their development from a policy perspective.

For business and policy practitioners, the proposed revised understanding of circular ecosystems has three main advantages: (1) the precise descriptive approach allows better grounding in industrial practice, better suited to explain the real-world phenomena that constitute circular ecosystems, which, in turn, allows better analysis, communication and planning of these systems. This provides a basis on which deliberate circular ecosystem design approaches can be developed; (2) the understanding that ecosystem actors’ roles can shift between contexts, and might need to be reassigned to other stakeholder groups, allows more targeted policy and value chain management approaches. It enables the replication of successful ecosystem models in new contexts, where certain stakeholder groups might be missing or are unable to fulfil the required role (e.g., fostering European models in Australia and Asia where government and private investor landscapes differ considerably); and (3) a focus on interactions and interrelations allows a deliberate mapping of, e.g., governance, drivers, barriers and risk sharing mechanisms, which helps to identify and close gaps in emerging ecosystems; and the deliberate design of the knowledge, resource and economic flows between stakeholders. This enables the modelling of ecosystem business cases and performance management and improvement of existing ecosystems.

Our research has several *limitations*. The employed search-string-based Scopus database search does not include non-academic contributions or journals not listed in the database in the initial sample. We mitigated this through cross-reference snowballing. While this increases the inclusiveness and

representativeness of the sample, the approach can still be affected by previous selection bias in the reviewed literature.

Our review indicates a range of *future research* avenues. One key recurring theme was circular ecosystem stakeholders and roles. The literature suggests considerable uncertainty about who the stakeholders are in various contexts and how they change roles across different geographies, industries and time periods. Besides comparative research to explore this, we suggest investigating how ecosystems reconfigure themselves in response to external shocks—e.g., if key ecosystem actors exit or cease to fulfil their role. Similarly, we think that the evolution of ecosystems over time and the role of external interventions and circular disruption merit investigation. We also recommend a more systematic integration of value, resource and information flows into future studies. Within these flows, we see an inconsistent consideration of especially water, energy and non-marketable streams. More research is needed to develop a comparable descriptive framework that unlocks more meaningful insights from an empirical comparative analysis of different circular ecosystems. Further research is also needed to define the boundaries of ecosystems, i.e., which stakeholders, roles and flows are considered inside versus outside the system, where one ecosystem ends and the next begins, etc. Connected to this, we also need to better understand the relationships between and portfolio implications of multiple ecosystems, from both a corporate strategy and an innovation policy perspective. Future research should explore a range of lenses for this, including portfolios, networks, and ecosystems of ecosystems.

While the critical role and benefit of circular ecosystems for the transformation to a CE is broadly accepted, the literature does not provide meaningful guidance on how to design ecosystems. While the closely related business model innovation and broader strategic management literature indicates a range of approaches to implement circularity-focused strategies, there is still an ecosystem-sized hole in the literature. Similarly, the literature does not discuss policy options to foster ecosystems or ecosystem portfolio approaches across jurisdictions. More research and guidance are needed on both the role of public policy in ecosystem emergence and the importance of ecosystem formation compared to other forms of innovation across desirable policy outcomes.

There are tendencies to see the CE as a framework for self-reliance and protectionism in the face of the increasing return of strategic competition, especially with China (see e.g., Barrie and Schroeder 2021; Mazarr et al. 2022). However, to achieve the ambitious environmental and economic goals associated with a CE, the concept needs to be implemented at a whole-of-the-economy level or at least considerably scaled up. The interaction between the circular ecosystem concept and international supply chains and trade policies will be critical but remains under-researched. We therefore recommend research in this area, especially around cross-border ecosystems and ecosystem integration into global value chains.

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## Endnotes

<sup>1</sup>In this research, we use the terms ‘circular ecosystem’ and ‘circular economy ecosystem’ interchangeably as used in the literature.

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