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Designing circular innovation ecosystems: insights from stakeholders, values, and investment policies

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Adopting the circular economy principles as a solution to overcome the challenges of the linear economy is increasing globally. In this regard, the related studies showed that circularity is a property of systems, not individual entities. Therefore, any ecosystem design process, including the implementation of circular innovation ecosystems (CIEs), needs in-depth and comprehensive insights into the design process, transformation of ecosystem components, and transition requirements toward circular ecosystems. This study utilized a two-step research methodology consisting of a systematic literature review on sustainable innovation ecosystems and CIEs alongside using grounded theory coding procedures to analyze 10 interviews based on an analytical ecosystem modeling tool to investigate the transformation of ecosystem components in circular ecosystems. Our findings illustrated that circular ecosystem design needs ecosystem actors' synchronic and incremental evolvement. The results also showed that implementing the CIEs requires broader networks of stakeholders, a new interactive economic model, an open platform for co-innovation and co-creation, transforming ecosystem value propositions, and defining new investment models and policies. The findings also inform policymakers and ecosystem researchers about the requirements of any transition toward CE ecosystems. Accordingly, proper policy-making structures and models for tackling transformation obstacles are provided.

KEYWORDS

innovation ecosystem, circular economy, circular innovation ecosystem, transition, circularity

1. Introduction

Considerable evidence, both from the theoretical and practical areas, shows that the current economic model is not sustainable and there are increasing intentions toward the implementation of sustainable values in the economy to transform the current linear economy into a circular economy (Bertassini et al., 2021; Sarja et al., 2020). To solve the current issue, according to MacArthur (2013), the circular economy (CE) is recognized as a viable option to replace the current linear model. The CE facilitates sustainable economic growth through the approaches such as decarbonizing and dematerializing business activities (Konietzko et al., 2020a). According to Geissdoerfer et al. (2018a), one of the main characteristics of CE is maximizing the value of material resources and minimizing the overall use, waste, emission, and pollution of entities within an ecosystem. In other words, many authors believe that circularity is a property of ecosystems, not individual entities (Lieder and Rashid, 2016; Kirchherr et al., 2017; Konietzko, 2020).

Thus, a systematic approach covering all the role players of a system is needed. This approach will be accompanied by the highest collaboration of actors inside an economic structure (Ghisellini et al., 2016; Hartley et al., 2020). The previous studies on CE highlighted that the better implementation of circular concepts requires broader relationships of all stakeholders, in-depth engagement of ecosystem components, and new business models and business interactions among all actors (Korhonen et al., 2018; Goyal et al., 2021). In other words, the transition toward a circular ecosystem requires the transformation of ecosystem components at various layers, including micro, meso, and macro levels (Kern et al., 2020; Sarja et al., 2020).

An innovation ecosystem refers to the interconnected network of organizations, institutions, and individuals that collaborate and interact to foster innovation and drive economic growth. It encompasses a wide range of stakeholders, including businesses, universities, research institutes, government agencies, and venture capitalists. The key elements of an innovation ecosystem include knowledge sharing, collaborative partnerships, access to funding, supportive policies, and a culture of entrepreneurship and risk-taking. By leveraging the collective expertise, resources, and creativity of its participants, an innovation ecosystem creates an environment that nurtures the development and diffusion of new ideas, technologies, and products (Ferasso et al., 2018).

Merging the CE concepts into the innovation ecosystem design processes has always been an interesting subject that remained ambiguous in previous studies. Those studies analyzed the Circular Innovation Ecosystems (CIEs) from various perspectives. Some authors applied the ecosystem approach lens to explore the internal and external behaviors of the CIEs (Konietzko, 2020). Some others tried to explore the CIE characteristics based on synthesizing the ecosystem entities and structures (Friant et al., 2021). There are also some studies on how circular notions have been merged into the ecosystem design processes to explore the incentives and obstacles (Hsieh et al., 2017). Around this research area, our reviews also enlightened us that the recent studies mostly focused on the constituents of innovation ecosystems through the circular economy perspectives, for example, circular business models, circular supply chains, and other innovation ecosystem components (Linder and Williander, 2017; Kazancoglu et al., 2018; Asgari and Asgari, 2021).

Given the lack of studies on CIEs, the research goal is to present a set of recommendations for the process of circular ecosystem design through synthesizing the transformation of innovation ecosystem components toward CIE focusing on stakeholders, values, and investment policies. The previous research mostly investigated the innovation ecosystem from the sustainability perspective, but the CIE was not sufficiently discussed (Hsieh et al., 2017; Takacs et al., 2020; Asgari and Asgari, 2021; Trevisan et al., 2021). Thus, research from both sustainable and circular perspectives can enlighten the architectural structure of circular ecosystems that have not been studied before. Our reviews also clarified that studies related to the CIE are rare (Konietzko, 2020; Konietzko et al., 2020a). Therefore, expanding the current literature, especially through an ecosystem approach aiming at ecosystem design, would be beneficial for all researchers, policymakers, and actors of the innovation ecosystem and circular economy practitioners.

This research explores the CIE based on the transformations of three core components of an ecosystem which have been identified as the core components during the transition toward CE based on the current systematic literature review. This approach was utilized for two reasons: first, the previous studies, especially the systematic literature reviews, highlighted these three components as the most affected entities in circular ecosystems (Zhijun and Nailing, 2007; Bonviu, 2014; Scott, 2017); second, according to the previous research studies, innovation ecosystem designing requires many components, but this process seeks three core elements more than anything else (Domenech and Bahn-Walkowiak, 2019; Marino and Pariso, 2020; Asgari and Asgari, 2021).

Accordingly, the research question is as follows: what are the key points recommended by the existing literature and experts on sustainability and CIEs to successfully implement a CIE? To address the research question, we first conducted a systematic review of both the current literature about sustainable innovation ecosystems and CIEs to explore the essentials, building blocks, and novel approaches to ecosystem design. Second, we used an analytical tool entitled "EPM"[1] to analyze the transformation of linear innovation ecosystems toward CIE based on the experts' perspectives.

The findings of the study carry significant implications for both researchers and practitioners interested in fostering sustainable and circular economies. By examining the perspectives of stakeholders, exploring their values, and assessing investment policies, this research sheds light on key factors that contribute to the successful design and implementation of CIEs. The study's findings provide valuable insights into the importance of collaboration among diverse stakeholders, the integration of sustainable values into decision-making processes, and the alignment of investment policies with circular economy principles. These implications can be applied in practice by policymakers and business leaders who seek to create supportive environments for circular innovation. By actively involving stakeholders from various sectors and ensuring their values are considered, policymakers can design comprehensive strategies that foster collaboration and address key barriers to circularity. Furthermore, business leaders can use the insights from this study to develop investment policies that prioritize circular innovation and allocate resources toward sustainable initiatives. Overall, the implications of this research highlight the significance of incorporating stakeholder perspectives, values, and investment policies into the design of CIEs, ultimately contributing to a more sustainable future by helping practitioners to know how to design and develop circular ecosystems through modeling.

This study is outlined as follows: The second section provides a literature review by explaining how the resource pool has been shaped by sustainable and circular ecosystems. In this section, both sustainable and circular ecosystems are reviewed. The third section illustrates the research design, including the model presentation, interview description, and analysis methods. The fourth section presents the findings, exploring general findings from an ecosystem perspective, and subsequently depicting specific answers to the research questions. The fifth section contains the conclusion.

1 Ecosystem Pie Modeling.

2. Literature review

This study seeks to investigate CIE by exploring the existing literature on innovation ecosystems, more specifically from a sustainable perspective, and the accessible knowledge of circular ecosystems. This separation was accomplished due to the precise consideration of the direct and indirect effects of the actors and phenomena in both contexts that may affect the shaping process of CIE in a holistic view. On the other hand, despite the similarities, some distinguished aspects exist in both contexts that have their own effects on CIE. In this regard, the sustainable perspectives, as well as the circular perspectives, have been studied separately. Thus, the research structure is based on exploring the components of sustainable (S)/CIE. To this end, first, the innovation ecosystems and, second, the CIEs have been studied deeply. This research aimed to provide some recommendations for the interaction of CIE components, describe how values should be implemented in a CIE, and suggest some key points regarding CIE investment policies in CIEs. Therefore, we investigated the innovation ecosystems intensely to extract the indexes we need to analyze any possible component transformation in internal and external boundaries. Then, we screened the resources regarding the circular economy concepts to synthesize how the circular economy can affect the innovation ecosystem's structural and behavioral design to implement a CIE.

2.1. Pool architecture

We conducted a systematic literature review for the first section of this research according to Moher et al. (2009). We made two resource pools, the first one includes the sustainable innovation ecosystem resources and the second one contains the circular economy's constituent elements in the circular ecosystems. To organize the thematic structure of this research, we extracted the frequent and shared categories in ecosystem shaping studies according to the ecosystem thinking approach (governance and policies, entities, and soft programs). This was accomplished by considering the multidimensional aspects of the ecosystems according to the ecosystem thinking approach.

Regarding the first pool, we tried to cover the resources encompassing innovation ecosystem design from the sustainability perspective. This section includes the principles of transition toward sustainable innovation ecosystems (Geisendorf and Pietrulla, 2018; Reike et al., 2018; Hartley et al., 2020; Dokter et al., 2021).

Regarding the second pool, the specifications of CIEs have been extracted. For both resource pools, three existing ecosystems, namely the knowledge ecosystem, innovation ecosystem, and business ecosystem, were investigated, but the researchers' main focus was on the innovation ecosystems' constituents. This approach helped us select a group of research that applies the ecosystem thinking approach regarding the transition of ecosystems from the unsustainable/linear design to the sustainable/circular design by removing biased studies. Figure 1 indicates the resource pool architecture of this study.

The first pool (Sustainable Innovation Ecosystems) and the second pool (CIEs) were shaped by selecting 232 and 143 resources in Figures 2, 3, according to Moher et al. (2009).

For both research pools, we adopted similar strategies. The duplicates from databases have been removed at the second step in a four-step screening model. In the third and fourth steps, some acceptance and non-acceptance criteria including timelines, keywords according to sustainability and circularity concepts, and research lens have been defined. Moreover, ensuring reliability and validity in a scientific paper required meticulous attention to methodological rigor. To achieve reliability, we employed a systematic and transparent approach throughout the review. We clearly defined our research question, inclusion and exclusion criteria, and search strategy, which minimized potential biases and enhanced the reliability of the findings. Additionally, we conducted a comprehensive search across multiple databases. The selection of studies was performed independently by multiple reviewers at different times and the results were compared, and any discrepancies were resolved through discussion and consensus. To enhance validity, we critically appraised the quality and risk of bias of the included studies, employing standardized tools and assessment frameworks. The process is shown in Table 1.

2.2. Innovation ecosystem from sustainability perspectives

The term innovation ecosystem is derived from the fundamentals of ecology to explore the essential concepts of an ecosystem in a profound way (Ferasso et al., 2018). This concept was also studied through the evolution of agglomeration concepts. As an example, according to Adner (2006), the ecosystem term justifies its application as we discuss organizations' strategies and practices.

In this sense, the ecosystem term has been taken in a wide variety of contexts, referring to a network of affiliated organizations around an ecosystem builder or facilitator in a way that the whole system produces valuable goods and services (Oh et al., 2016; Adner and Feiler, 2018). Given the pre-mentioned definition, the innovation ecosystem is defined as a popular and emerging concept in academic and industrial circles, providing the possibility of collectively working to enable knowledge flow, support technological development, and generate innovation (Dias Sant' Ana et al., 2020). In this context, the innovation ecosystem offers a systematic approach by concentrating on how the interconnected actors create and sustain competitive advantages independently or in an integrated system dependently (Jacobides et al., 2014). Accordingly, the innovation ecosystem is composed of different stakeholders and role-players, including governmental bodies, industrial sections, and associations, who coevolve with each other to create new values and mechanisms through innovation (Ma et al., 2018; Choi, 2020). According to this definition, the innovation ecosystem describes the co-existence of many actors that jointly create values. The core concept in this definition is that the ecosystem's value creation is entirely greater than the sum of values created by single components.

On the other hand, sustainable innovation ecosystems are the newborn entities that inherit the structures and behaviors of innovation ecosystems and accept the values and complementary

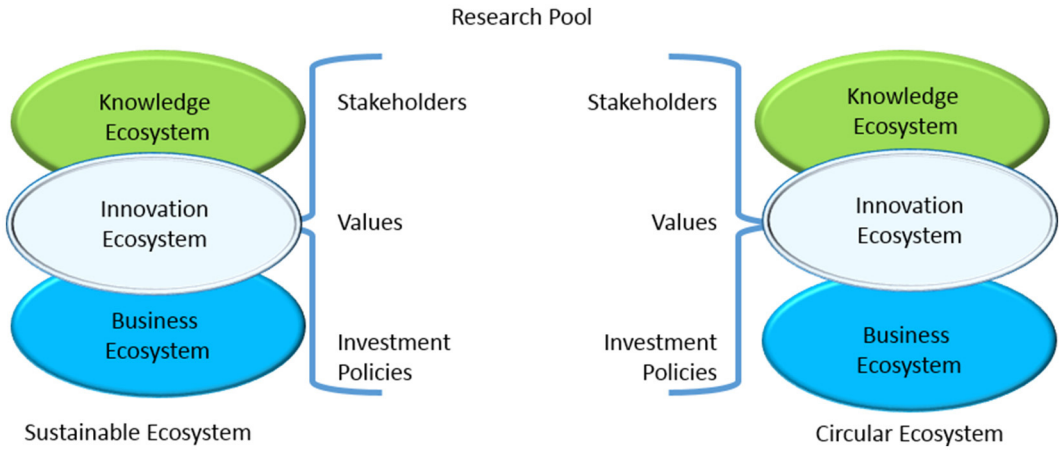

FIGURE 1
Resource pool architecture.

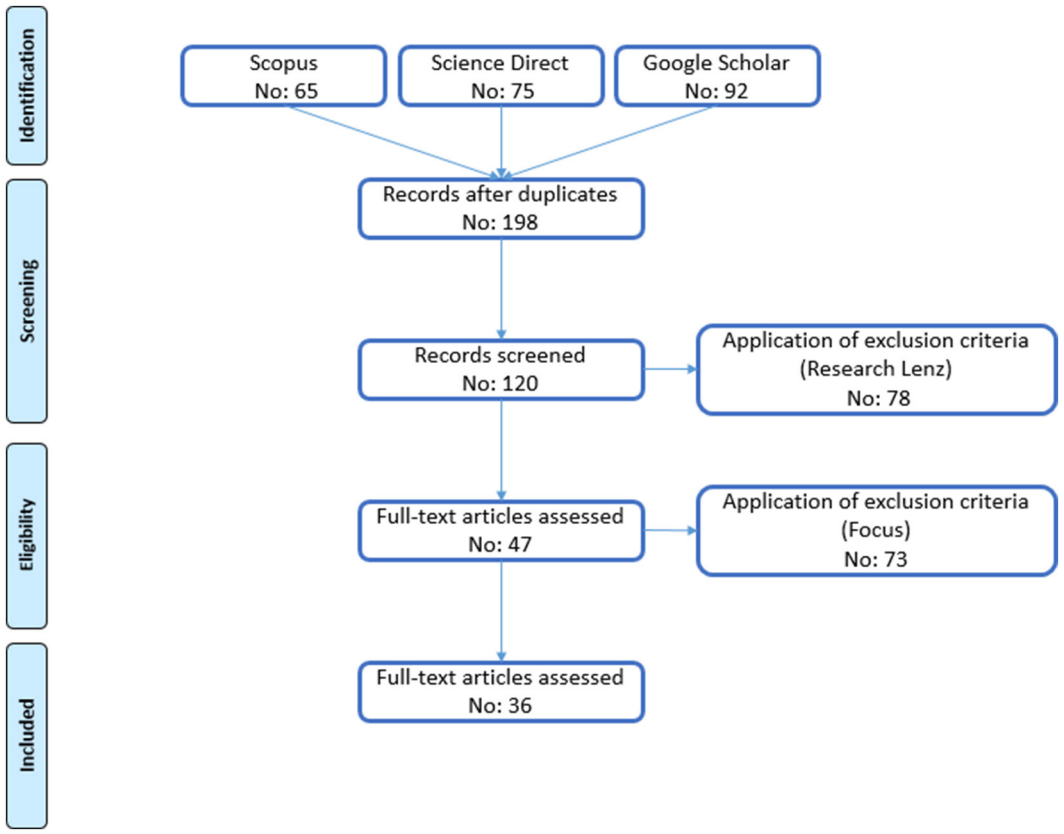

FIGURE 2
Resource pool sustainable ecosystem.

components of such ecosystems (Yin et al., 2020). The recent studies about innovation ecosystems from the sustainability perspective are mostly focused on the ecosystem components. In this regard, the sustainable business plan, sustainable supply chain, and sustainable value chain discussions are among the frequent topics. Table 2 shows the characteristics of the innovation ecosystem from the sustainability perspective.

2.3. Circular innovation ecosystem

According to many studies, the fundamentals of CE are the property of systems rather than the individual product or services (Adner and Feiler, 2018; Kazancoglu et al., 2018; Konietzko et al., 2020b). In this framework, the transition toward CE needs the transformation of ecosystem components under an

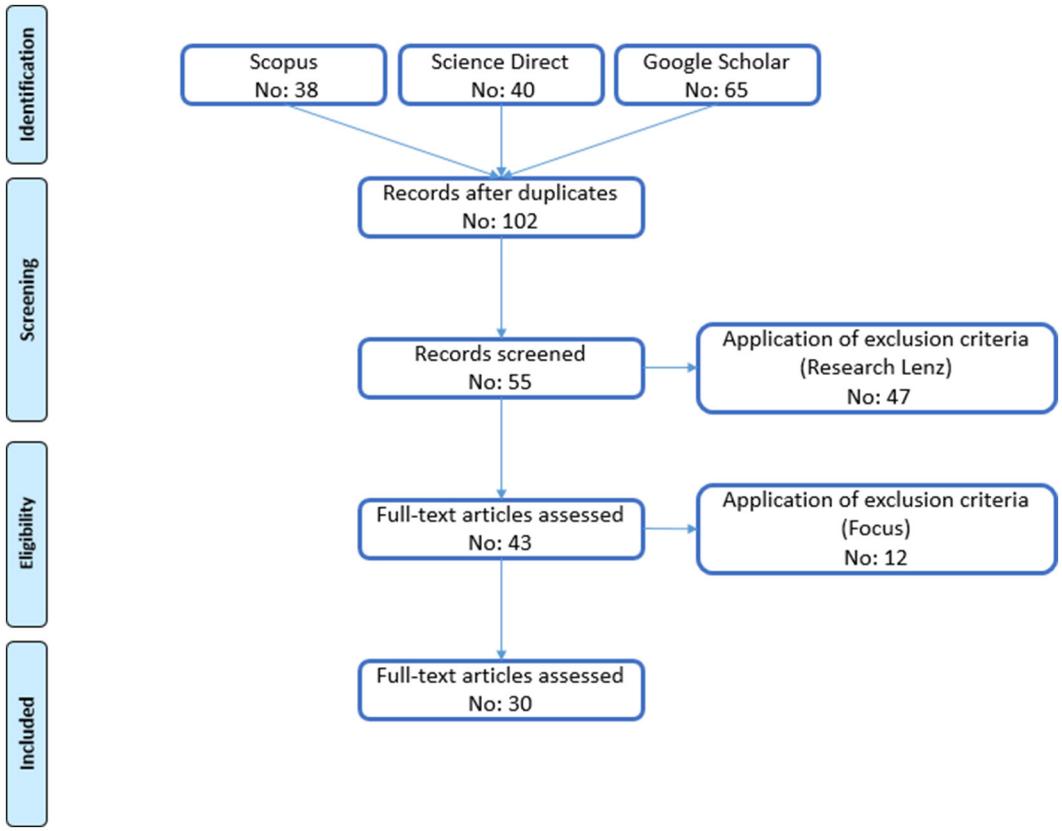

FIGURE 3
Resource pool circular economy.

TABLE 1 Acceptance and non-acceptance criteria.

Area of research	Innovation ecosystem		Circular economy	
Types of criterion	Acceptance criteria	Non-acceptance criteria	Acceptance criteria	Non-acceptance criteria
Timeline	From 2000 to 2021	Before 2000	From 2000 to 2021	Before 2000
Research Lenz	Ecosystem thinking approach on the sustainable innovation ecosystem	Non-sustainable ecosystems or independent research areas	Ecosystem thinking approach on the circular innovation ecosystem	Independent or special research areas
Focus	Stakeholders, values, and relationships	Other components	Stakeholders, values, and relationships	Other components
Typology	Journals, guidelines, rules, regulations, and books	Non-research-based statements or non-valid expressions	Journals, guidelines, rules, regulations, and books	Non-research-based statements or non-valid expressions

ecosystem thinking approach. Therefore, implementing a circular ecosystem requires an in-depth analysis of ecosystem components to discover how those entities are transformed during a transition toward CE. Reviewing the recent studies revealed that the new perspectives on CIE define the necessity of simultaneous and balanced configuration of economic, environmental, industrial, technological, and societal aspects of a given economic system or sector (Moraga et al., 2019; Oliveira et al., 2021).

In this framework, discussing the circularity under the ecosystem thinking approach requires the widespread transformation of innovation ecosystem structures (Konietzko et al., 2020b). In some cases, the transformation in this context proposes voluntary actions, and in others, it is defined as a set of activities to provide circularity rules and systems (Dokter et al., 2021; Vinante et al., 2021).

This study utilizes an ecosystem approach to discover CIE structures. As mentioned earlier, ecosystems are composed of a set of components, procedures, service providers, customers, rules, and many other tangible and intangible assets that work together to achieve some common goals (Thomas and Autio, 2012). The previous researchers, mostly those who discussed the circularity at the system levels, stated that circularity is

TABLE 2 A systematic review of the innovation ecosystem focusing on sustainability.

Main streams	Topic	Related and interconnected contents	Ref.
Governance and policy level	Discussing the strategies for the design, implementation, and management of sustainable ecosystems	Developing the implementation of sustainable values in the design, implementation, and management of innovation ecosystems. Proving the models, frameworks, and strategies respecting the principles of sustainability in upward governmental documents	Ciasullo et al. (2020), Raharjo et al. (2021)
	Analyzing the Implementation of the ecosystem thinking approach in defining the actors, assets, investors, and role-players	Creating the ecosystem architecture based on the core values of sustainability. Providing practical solutions and approaches for the operational procedures of ecosystem components	Fukuda and Watanabe (2012), Oliveira-Duarte et al. (2021)
	Developing service-based businesses	Moving from manufacturing to serviticizing Creating adaptable business approaches to environmental values	Geissdoerfer et al. (2018b), Liu and Stephens (2019)
	Proving the exchange and open platforms for sharing knowledge and experiences	Designing the knowledge flows across the ecosystem components and knowledge institutions in the area Creating the gateways, platforms, tools, and contexts that facilitate the circulation of knowledge and information in the area	Gamidullaeva (2018), Tuffnell et al. (2019)
	Providing sustainable structures for the various actors in the ecosystem	Enhancing the direct investment in the infrastructures and facilities within the ecosystems Shaping the ecosystem structures respecting sustainable values	Suominen et al. (2019), Fukuda (2020)
Entity level	Innovating business model to include sustainable recommendations	Redesigning, restructuring, and transforming business model components regarding mission, stakeholders, and relationships at all components	Lüdeke-Freund et al. (2018), Gil-Gomez et al. (2020)
	Discussing the necessity of sustainable values in product development	Providing the strategies, models, approaches, and operational tasks regarding product design and product management procedures under a sustainable product design framework	Miranda et al. (2019), Singh and Sarkar (2020)
	Adopting the technologies for the sustainable supply chain and value creation	Developing the soft and hard technologies regarding the supply chain section procedures Redesigning the value chain focusing on the enhancement of sustainability principles	Tuffnell et al. (2019), Junge and Straube (2020)
	Providing long-term relationships with actors	Analyzing the approaches by which the strongest relationships and sustained interactions can be established among actors	Fukuda and Watanabe (2012), Raharjo et al. (2021)
	Implementing supporter and facilitator organizations	Running new institutions that facilitate the crafting and transition of entities from traditional to sustainable entities within the ecosystem	Ciasullo et al. (2020), Yin et al. (2020)
	Developing social entrepreneurship, enterprises, and social innovators	Encouraging the social actors to provide solutions for issues via social enterprises, social innovations, and social entrepreneurship. Enhancing the sense of empathy among ecosystem citizens	Oliveira (2008), Surie (2017)
	Including broader stakeholders	Redesigning the ecosystem structures to cover the broader role-players and actors in the ecosystem	Cillo et al. (2019), Tuffnell et al. (2019)
Soft level:	Adopting technologies for waste management	Inventing the technologies and innovational activities for the reuse, recycle, and redesign of used materials in various steps at different ecosystem components	Yin et al. (2020), Oliveira-Duarte et al. (2021)
	Facilitating the knowledge and innovation transfer from scientific centers to the ecosystem actors	Developing the knowledge and technology transfer tools to discriminate the knowledge and building the knowledge-based communities within the ecosystem	De Vasconcelos Gomes et al. (2018), Dias Sant' Ana et al. (2020), Asgari et al. (2021a)
	Providing programs for increasing sustainability awareness	Increasing community awareness about the necessity, infrastructures, and programs of sustainability-related notions	Cao et al. (2020), Oliveira-Duarte et al. (2021)
	Developing the NGOs and non-profit institutions	Supporting and developing NGOs and non-profit organizations focusing on social responsibilities in building a sustainable society	Oh et al. (2016), Beliaeva et al. (2019)
	Enhancing community engagement	Increasing community engagement with the governmental and public sectors at various levels of the governance model	Esmaeilpoorarabi et al. (2020), Asgari et al. (2021b)
	Discussing the interconnected relationships	Building relationships among customers and business entities	Tuffnell et al. (2019), Yin et al. (2020)
	Developing the norms and standards	Creating standards for sustainable activities of ecosystem entities	Surie (2017), Liu and Stephens (2019)
	Programs and planning.	Developing the programs, strategies, and plans for the implementation of sustainable values in minds and practices	Ciasullo et al. (2020), Oliveira-Duarte et al. (2021)

the consequence of collaborative activities and is not accessible through independent actions (Hsieh et al., 2017; Konietzko et al., 2020a). Therefore, the ecosystem thinking approach in circular ecosystems will illustrate new designs for circular ecosystem architectures.

Applying the circular values in innovation ecosystems will certainly be accompanied by some indispensable risks and opportunities. An ecosystem perspective can distribute the challenges to the ecosystem components. This act provides the necessary time and tools for the components of the ecosystem to tolerate the risks and simultaneously use the recently created opportunities of the ecosystem (Bocken et al., 2016b; Dantas et al., 2021).

The CIE discusses the following main streams based on the ecosystem thinking approach: the results are shown in Table 3.

2.4. Insights from literature review

Incorporating circular concepts and configurations in an innovation ecosystem is complex and requires a holistic view of many interconnected ecosystem components' mechanisms and work procedures.

This study combines the achievements of both concepts to discover how innovation ecosystems are shaped; in this study, due to the interconnectedness of circularity and sustainability, both domains have been reviewed, but the focus in the ecosystem design process has been put on the circular ecosystem design process.

Reviewing the previous studies on both circularity and sustainability, studies show that, although the incorporation of the CE concept in the innovation ecosystem at the ecosystem level affects a lot of components, this intervention transforms three components, namely, stakeholders, values, and investment policies, more than others. In other words, the CE transformation by focusing on stakeholders, values, and investment policies creates a new ecosystem design aiming at implementing CIEs. Thus, to be considered circular, an innovation ecosystem must at least contain the circularity values in three core entities of the innovation ecosystem. Under such circumstances, the ecosystems, especially the innovation ecosystems, rely on stakeholders, values, and investment policies as the essential components that need to be transformed to implement a CIE (De Vasconcelos Gomes et al., 2018; Liu and Stephens, 2019; Konietzko, 2020). Therefore, any transition toward CIE will be accompanied by the transformation of basic innovation ecosystem components, specifically the stakeholders, values, and investment policies.

According to many studies, implementing a CIE, besides the overall transformation of infrastructures, needs some disruptive innovations that change linear ecosystems' cultural and normative design (Bertassini et al., 2021; Dantas et al., 2021). These disruptions at ecosystem levels create novelties in stakeholders, values, and investment policies. Therefore, the stakeholders are essential because this component shapes the main role-players of ecosystems (Bertassini et al., 2021). The values are important because the circularity concepts affect the system values more than other components (De Vasconcelos Gomes et al., 2018). Finally, investment policies are indispensable because they are crucial in shaping innovation ecosystems in the initial formation steps (Luo, 2018; Yin et al., 2020).

Given the pre-mentioned concepts, the literature lacks knowledge on how transformations are realized during the transition and how the ecosystem shaping process occurs, focusing on these three core components.

Additionally, in this research, the literature review insights have been used to create a basis for discussing the fundamentals of CIEs during interviews. In other words, analyzing the CIE components has been accomplished, followed by discussing the probable transformation of ecosystem components in a CIE based on the review of the literature.

3. Research design

3.1. Research approach

To achieve the research goals, we adopted a two-step research approach consisting of a systematic review to extract the principles of (sustainable/circular) innovation ecosystem and an in-depth interview following a familiarization meeting with some experts based on the literature review insights to build a framework that explains the characteristics of stakeholders, values, and investment policies in a circular ecosystem. To this end, we first held a meeting with some experts in the innovation ecosystem who were also familiar with the fundamental notions of the circular economy.

In this meeting, in the beginning, we explained the research goals, procedures, and steps and then requested them to participate. The discussion contents in this meeting were organized around the insights extracted from the literature review. Therefore, in the first meeting, by introducing the reviewed studies to interviewees, the questions such as how sustainable and circular ecosystems are shaped and what kind of transformations are considered for making a CIE were shared. During the meeting, we also introduced an ecosystem canvas modeling entitled "Ecosystem Pie Model" (EPM). The EPM was developed by Talmar et al. (2020) as a strategy tool to map, analyze, and design (i.e., model) innovation ecosystems. From the scholarly literature, this canvas distilled the constructs and relationships that capture how actors in an ecosystem interact in creating and capturing value. The EPM was designed to illustrate and simulate the requirements of a CIE. This tool indicates the possible transformation of ecosystem components. The blank version of EPM is shown in Figure 4.

The authors considered some reasons that justified the utilization of this canvas for shaping the CIE. In this context, the ecosystem value proposition in the center of the canvas, besides the layers such as the resources, activities, value addition, value captures, and other EPM components, provides a systematic approach and a multidimensional analysis of the ecosystem. On the other hand, the interconnected and mapped relations show the interaction of ecosystem actors. Using EPM requires the design of ecosystem components and their relationships to others; therefore, the ecosystem values, as well as the necessary relationships, indispensable structures, and crucial linked components can be implemented in design steps. Moreover, EPM is a progressive tool; thus, in each step, all procedures can be evaluated and even restructured. In the next step, the authors organized interview

TABLE 3 A systematic review on CIE.

Main streams	Topic	Related and interconnected contents	Ref.
Governance and policy level	Analyzing the upstream international and national documents to provide solutions for the creation and management of circular ecosystems	Providing models, frameworks, and approaches to develop the strategies at various levels and among ecosystem components, such as how different firms and organizations deal together to reach sustainable goals. How the government could facilitate the implementation of ecosystems under CE values and how to manage the interaction of different role-players	Parida et al. (2019), Konietzko (2020), Konietzko et al. (2020b), Friant et al. (2021), Patwa et al. (2021)
	Discussing the areas such as eco-industrial parks, eco-industrial networks, industrial symbiosis, and smart structures and infrastructures	Viewing circular economy based on the regional setting by analyzing the circular economy systems through the regional innovation perspective The application of CE in smart cities and living ecosystems	Hsieh et al. (2017), Liu and Stephens (2019), Konietzko (2020)
	Discussing the transition toward CE	Synthesizing the transition process from linear ecosystems to circular ecosystems by analyzing the component transformations	Asgari and Asgari (2021), Sarja et al. (2020)
	Discussing the rules, regulations, key performance indicators KPIs), and standards of CE	Providing a set of rules and developing the regulations and indicators for the governing, canalization, and tuning of entities within a living ecosystem	Kern et al. (2020), Konietzko et al. (2020b)
Entity level	Creating CE familiar entities from scratch	Applying the CE fundamentals, rules, and regulations as the standard and appendix for running new entities in the ecosystem	Wieringa et al. (2019), Kern et al. (2020)
	Mapping stakeholders and partners	Designing and defining the stakeholder networks, the expectations, and the ways to interact with others under sustainable rules	Whicher et al. (2018), Liu and Stephens (2019)
	Discussing the supply chain, value chain, closed loops, and capturing values systems	Highlighting the characteristics of a supply chain in the circular systems besides the transformation of value chains and describing how value could be captured in the CE ecosystems	Govindan et al. (2015), Kazancoglu et al. (2018)
	Discussing the material flows and supplier networks in production units	Building the adaptive materials under the principles of CE to fulfill the expectations of the 3Rs	De Jesus and Mendonça (2018), Konietzko (2020), Wu et al. (2021)
	Discussing the facilitator, digital platforms, and intermediary organizations	Strengthening the intermediary rules of dealers to empower the networks.	Asgari and Asgari (2021), Suchek et al. (2021), Liu et al. (2022)
	Discussing the scientific- and knowledge-based institutions	Creating the social, financial, and scientific institutions to develop sustainable solutions for the hard and soft issues of the ecosystem entities	Giampietro and Funtowicz (2020), Konietzko (2020), Zhang et al. (2021)
	Analyzing the interconnected entities and the micro-ecosystems	Shaping the micro-ecosystems and evaluating the maturity level of all sub-ecosystem entities	Brown et al. (2020), Asgari and Asgari (2021)
	Building and designing customer communities	Building the customer and communities regarding the CE product and services respecting the CE values	Konietzko (2020), Takacs et al. (2020)
Soft level:	Discussing the innovation and technological issues	Creating knowledge, products, services, and technologies in ecosystem entities to implement the CE	De Jesus and Mendonça (2018), Nham (2022)
	Fostering social innovation and social businesses	Creating and developing social innovation values, business models, communities, and organizations within the ecosystem	Surie (2017), Takacs et al. (2020), Padilla-Rivera (2021)
	Discussing the disruptive phenomenon and technologies	Analyzing, observing, and verifying the ecosystem value, structure, and behavioral change while implementing CE into the ecosystem	Liu and Stephens (2019), Konietzko (2020)
	Discussing the organizational change	Providing the organizational change models and approaches regarding the transition toward CE	Konietzko (2020), Yin et al. (2020)
	Discussing customer behavior	Analyzing customer behavior to increase the acceptance rate of circular products and services in terms of values and prices	Parida et al. (2019), Mostaghel and Chirumalla (2021)
	Discussing the effects of change in integrated ecosystems	Planning the implementation programs and procedures to prepare the ecosystems to apply the CE values	MacArthur (2013), Korsunova et al. (2021)
	Discussing the programs and plans for the implementation of CE in ecosystems	Synthesizing the internal procedures of sub-ecosystems to find the possible transformation of components. For example, business model and supply chain	Rajput and Singh (2019), Konietzko (2020)
	Analyzing the transformation of entities after applying the transition	Verifying the changes that occur after the transition toward CE	Ghisellini et al. (2016), Asgari and Asgari (2021)
	Discussing new cost structures	Providing the models, frameworks, and approaches for the cost structures at the ecosystem and sub-ecosystem level	Kortmann and Piller (2016), Mishra et al. (2018)
	Enhancing the engagement process in CE ecosystems	Providing the approaches that increase the engagement of sub-ecosystem components	Marino and Pariso (2020), Diaz et al. (2021)

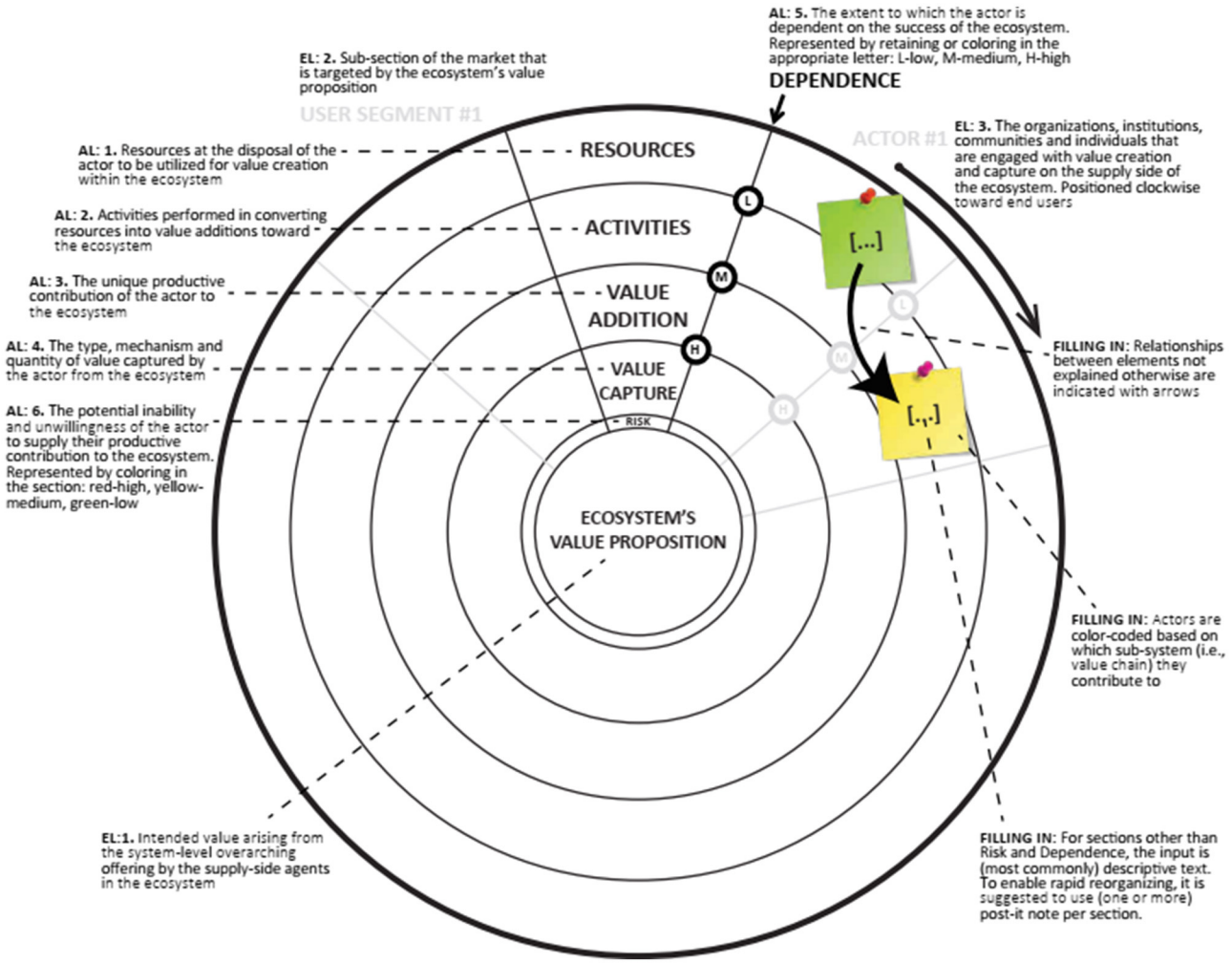

FIGURE 4
The EPM canvas as a tool to model the CIE (Copyright https://ecosystempie.com/).

sessions to discuss the possible transformation of ecosystem components during the transition in an expert panel using EPM based on insights from the literature review.

3.2. Participant selection and interview procedures

There were multiple criteria for selecting the members of the expert panel. The members were all among the people who have practical and theoretical dominance in innovation and technology areas. They were selected based on the following criteria: (a) at least 5 years of experience in managerial positions in innovation ecosystems; (b) being a member of the strategic planning committee of the areas; (c) mastering the ecosystem design; and (d) familiar with the fundamentals of the circular economy.

During this research, we utilized semi-structured collective interviews in different rounds. This was accomplished by dividing the subjects into various sections for the following reasons: (a) focusing on the core elements in an in-depth interview; (b) assigning sufficient time for each interview; and (c) giving time to the interviewers to think and review the last statements. The output of interviews was subsequently transcribed into texts for the coding step. Table 4 shows the characteristics of the interview process.

3.3. Reliability and validity

Regarding the interviews conducted in the study, a purposive sampling method was employed. Participants were selected based on their expertise, knowledge, or experience relevant to the research topic. This method allowed for the targeted recruitment of individuals who could provide valuable insights and in-depth information. To ensure reliability and validity in the interview process, several measures were taken. First, a detailed interview guide was developed, consisting of open-ended questions that were designed to elicit comprehensive and meaningful responses. This helped ensure consistency in the data collected across different interviews. Additionally, all interviews were conducted by the

TABLE 4 Interview process.

No.	Position	Interview rounds	Ecosystem main focus	Final interview
1	The president of the innovation distric		University/multidisciplinary	35
2	Development Officer at a tech park		University/multidisciplinary	38
3	The strategist in innovation development		Health	42
4	CEO at an incubator center	Round 1 (EPM structure) 63 min	Health	28
5	CEO at an accelerator center		Fin-tech	36
6	Professor at a University + CEO at an Accelerator	Round 2 (EPM filling issues) 62 min	Social innovation	24
7	The vice president of the science secretariat		University/multidisciplinary	45
8	Ecosystem and innovation development strategist	Round 3 (Discussing stakeholders, values, and relationships) 43 min	Fin-Tech	32
9	Ecosystem and innovation development strategist		University/multidisciplinary	36
10	Development Officer at a tech park		University/multidisciplinary	31

same trained interviewer to minimize potential variations in data collection.

To enhance the reliability of the findings, the interviews were audio-recorded and transcribed verbatim. This allowed for accurate representation and interpretation of participants' responses during the analysis phase. Furthermore, a coding framework was developed to systematically analyze the interview data, ensuring transparency and rigor in the data analysis process.

Ethical issues were duly accounted for in the study. Informed consent was obtained from all participants before the interviews, and they were assured of the confidentiality and anonymity of their responses. The study protocol and interview procedures were reviewed and approved by the relevant ethics committee to ensure compliance with ethical guidelines and safeguard the rights and wellbeing of the participants.

3.4. Coding procedures

This study utilized a coding procedure based on (but not using completely) the general structure of the Grounded Theory approach (GT) as mentioned by Strauss and Corbin (1997). To this end, three steps of coding, namely, open coding, axial coding, and selective coding, were applied to the transcribed interviews. In the first step, by using open coding, through sensitizing questions and comparing data and codes, the ideas regarding the possible transformation of actors and ecosystem value proposition (EVP) in circular ecosystems with a focus on three main ecosystem components have been extracted. Additionally, during this step, the core ideas of interviewers concerning the new design of ecosystems after implementing the circular values have been analyzed intensively to find similarities and shared insights.

In axial coding, the relationships between the applied values of the circular economy in ecosystems focusing on three main ecosystem elements have been investigated (values, stakeholders, and investment policies). The similarities and distinctions in this step have been labeled respecting the comparison of ecosystem components before and after the transition based on EPM. This step focused on various structural and organizational behavior of ecosystem actors. This study ensures that diverse transformation and multidimensional shapes of ecosystems during the transition toward circularity have not been neglected (because the interviewers were selected from different ecosystems). In fact, in this step, the interrelationships of transformed actors and the requirements of circular ecosystems have been highlighted in coding procedures.

In selective coding, by analyzing the extracted transformations of the three mentioned ecosystem components based on the pre-defined categories, new actors and the infrastructures for the role-playing of circular ecosystem components have been shaped. This step revealed the necessary actors and transformations required by any transition toward CIEs.

4. Results

4.1. General findings

Analyzing the interviews, besides the insights from the literature review, highlighted that implementing a correct shape

for the CIE requires new mindsets, redesigning traditional structures, and deploying new infrastructures. The findings revealed that the CIE's overall mechanisms are quite different from sustainable innovation ecosystems, despite the similarities in some basic elements and functionalities. According to the findings, implementing the CIE requires new modified entities (supply chain, business ecosystem, and communities) alongside the transformation of traditional components in the ecosystem.

The findings also highlight the role of soft programs as a crucial part of shaping the CEIs. The interviewees believed that, besides the hard infrastructures, there should be actors equipped with soft skills and programs to handle CE-related tasks at the ecosystem level. Soft skills and programs are defined as activities aiming to develop new governmental and regional policies, increase CE awareness, invent new business models, extend interconnected relationships, build multidimensional capacities, find new opportunities, and introduce new leadership approaches. In this context, the responders, during the interview sessions, highlighted several times that the maturity level of ecosystem components regarding the acceptance of CE-related concepts should be monitored and evaluated. These programs also transform the old strategies by including new missions, visions, and tools for a new economic model within a CIE.

4.2. Stakeholders in the CIE

Using EPM as a progressive tool to shape CIE highlighted the synchronic incorporation of soft skills and hard infrastructures. The literature review also indicates the overall transformation of stakeholders, values, and investment policies as the main transition pillars at the ecosystem level. These perceptions state that by creating CIE's components, the pre-design and post-design relationships must be reviewed to ensure the optimum implementation of ecosystem actors. This idea means that the CIE makes new connections, establishes new links among stakeholders, and, in some cases, even creates new stakeholders during the transition steps. Moreover, as a recommendation, due to the level of change in previous experiences of responders, the findings emphasize the creation of a new stakeholders map instead of using the traditional design of ecosystem stakeholders.

Given the collective ideas of interviewees, there are three essential notions for stakeholders in a CIE: (a) a broader network of stakeholders, (b) a new economic model that encourages the transformation of relationships and interaction among ecosystem actors alongside providing new circularity-based interactions, and (c) an open platform for co-innovation and co-creation within the ecosystem. Table 5 shows the general recommendations for stakeholder map design in a CIE.

4.3. A broader network of stakeholders

The responders believed that despite the linear innovation ecosystems in which only the nodes with added value or benefits in line with the ecosystem goals are preferred to join the networks, in CIE, there should be the possibility for the other actors to introduce their circular capacities as the values providing the chance for profiting the circular ecosystem opportunities. This approach is considered a promising approach for the actors that are not following circular rules but can be transformed to benefit the present opportunities of a circular ecosystem.

The circular ecosystem design process in this framework creates attractive and valuable advantages for the ecosystem actors. This approach provides motivations for proactive actors and encourages passive actors by regulations toward transition. With this, the proactive actors, mostly early-stage companies as the pioneers of change, join the network to find opportunities. On the other hand, the passive actors, mostly mature companies and institutions, join the network by the force of regional rules and regulations.

The findings revealed that the internal motivation of ecosystem actors regarding the acceptance of circular rules and methodologies are different; for example, joining the circular ecosystem for some entities costs, and for some others, have opportunities (Ghisellini et al., 2016; Carraresi and Bröring, 2021). To resolve this challenge, the interviewees believed that diversification of strategies to cover a broader network of stakeholders in a CIE is a suitable solution. Analysis of interviews also highlighted clustering as a solution for the network-making process among various stakeholders. In this regard, many responders believed that gathering similar ecosystem entities in a shared geographical area (ST parks, Innovation districts, etc.) can increase the peer-to-peer connection of partners, decrease the supplying costs, and result in better stakeholder cooperation in a CIE.

According to the findings, despite the linear innovation ecosystem, which is based on market demands or technology push (Dias Sant' Ana et al., 2020), the CIE requires a distributive structure to spread the opportunities in the ecosystem. In this regard, the responders refer to converting the ecosystem structure from market-oriented to opportunity-oriented as an accessible solution. According to them, this transition requires transparency and mutual understanding of ecosystem actors. In this regard, since the CIE is considered a complex ecosystem (Yin et al., 2020), any activity to expand the ecosystem borderlines could potentially increase the ecosystem's level of complexity. Therefore, providing broader transparent networks where the outputs, processes, and inputs are clear will remove the ambiguities and encourage ecosystem actors to interact more actively in circular ecosystems.

4.4. A new interactive economic model

In addition to the literature analysis, the responders' point of view revealed that the transition toward a CIE requires a new economic model that encourages the transformation of relationships among ecosystem actors alongside providing new circularity-based interactions. The normal deals among ecosystem actors should justify the needs and motivations for further circular-based interactions to shape such a new model.

TABLE 5 Stakeholders in the CIE.

Stakeholders in the CIE	
Activity	Required Transformations for CIE (Recommendations)
Intermediary role players	Creating waste managers (waste management service providers) as the intermediary entities between ecosystem actors
Linking actors	Linking waste producers to waste managers through bilateral profit models
Sharing sustainable project	Creating participatory and sharing models among ecosystem actors to decrease waste production in the ecosystem
Decentralizing	Decentralizing the suppliers and production units to a wide area
Distributing roles	Creating participatory projects aiming at increasing sustainability at the ecosystem level or actor level in the ecosystem. For example: assigning the monitoring role to a group of ecosystem actors
Open data platforms	Creating open data platforms for data gathering, monitoring, analyzing, and processing the resources and making appropriate decisions
Co-creation	Facilitating the co-creating among ecosystem actors by providing a closer mutual understanding of the concept of competitiveness in circular ecosystems
Interactive platforms	Creating platforms to increase the interaction of ecosystem actors, supporting platform-based businesses
Developing innovation clusters	Supporting the implementation of innovation clusters within the ecosystems. The clusters are the best architectures for capturing values and minimizing energy consumption in ecosystems
Crowdsourcing	Using the crowd-source platforms to gather the expectance of ecosystem actors to build ecosystem value proposition (EVP)
Business model innovation (CRM, CH)	Informing, training, and promoting the cheapest and greenest approaches for customer relationship management and distribution channels
Discussing issues	Implementing the forums and discussion panels among customers. This act provides a better understanding of barriers and incentives
Location Bases Platforms (LTP)	Creating location-based exchange platforms for suppliers and companies
Interchangeable material	Increasing the number of interconnected companies for using interchangeable tools and materials. For example, Company A creates product X that can use the spare parts of company C
Customer awareness	Creating information providers and content management services to inform the public and private sectors about the overall advantages of circular ecosystems for all ecosystem components
Social networks	Utilizing the potential of social networks to cover broader stakeholders into circular ecosystems. The goal is to educate and inform them about better engagement with circular ecosystem actors
Diversifying energy resources	Using replaceable energy resources for different products
Expanding repair services	Creating repair services for a wide range of products using common tools and materials

Traditionally, the ecosystem actors interacted with each other based on mutual benefits; the point is that during those interactions, the circular values have not been considered as the factors affecting the decision-making process of different sides. According to the findings, the CIE supports the consideration of circular values in the governance and policy-making process of ecosystem actors. Therefore, in CIEs, any deals, plans, or programs should be accompanied by the recommended remarks of the CE.

According to responders, two points encourage the ecosystem actors to interact widely and efficiently in a CIE. The first is the actors' understanding of the necessity of circular considerations in deals and interactions. This understanding modifies the traditional thinking model that only includes financial benefits as the main reason for any financial transaction. This concept also limits financial deals' harmful and unilateral effects during production and consumption.

The interviewers also stated that the pricing model is another bottleneck regarding the interaction of ecosystem actors in a CIE. According to them, the current pricing model considers circular or green products as special types (Shen et al., 2019). This strategy puts extra costs on the market and forces buyers to pay more for some special products. This is while in a CIE, the costs should not make a distinction between green products and other types. In this context, the CE models need to distribute the overall pressure to various ecosystem components, preventing the accumulation of costs and resources in a specific ecosystem section. On the other hand, the new economic model aims to balance the market through a system responsible for distributing the resources and interactions among ecosystem actors. This balancing system overly reduces costs, provides better relationships, and reconfigures the economic values within the ecosystem.

4.5. An open platform for co-innovation and co-creation

As the third point, the responders highlighted the necessity of stakeholders' interconnected networks as the ecosystem vessels defined under the sharing economy paradigm. In this regard, the co-creation and co-innovation in an integrated platform to share and distribute knowledge and resources within the ecosystem networks have been mentioned as indispensable entities. The previous studies have mostly focused on technological innovation as liable and required infrastructures of a CIE (Bressanelli et al., 2018; De Marchi and Di Maria, 2020; Uçar et al., 2020). According to the literature, the technologies such as AI, digital devices, big data analytics, and many others are considered fruitful achievements for a transition toward a circular ecosystem (Berg and Wilts, 2018; Rocca et al., 2020; Uçar et al., 2020).

However, this research highlighted that informing and awareness could be equally effective as complementary materials in a CIE. According to the responders, the efficient use of resources in a network could be realized, while all ecosystem actors can

define their roles based on acquiring sufficient consciousness from their positions and the status of other actors in the network. To shape this structure, at the first level, this CIE requires the creation, and at the second level, the arrangements of ecosystem actors simultaneously in a way that all positions would be predictable for all ecosystem actors. This CIE structure also needs awareness regarding any change in the network. Thus, there must be some tools and approaches to inform the ecosystem actors about the new status of actors as well as the entire ecosystem.

According to interviewers, such an open platform can bring people and information together. Thus, providing this crowd-sourced platform plays a role in aggregating the resources, bringing smartness in allocating resources to each ecosystem actor, better mapping of institutions within the ecosystem, and finally analyzing the status of the ecosystem by gathering related information.

Some other interviewers also stated that in a CIE, updating the status of ecosystem actors is more crucial than in traditional innovation ecosystems. The circular ecosystem actors are more sensitive to the market and demand changes. Therefore, the CIE needs a platform reflecting the changes and being able to predict the probable scenarios of the ecosystem status in some domains. Making this open platform can also help predict the issues regarding the adaptability of actors. This platform could also be useful in some cases, such as finding new opportunities and removing the bottlenecks within the CIE.

Discussing the redesigned ecosystems among interviewees highlighted that removing the obstacles, such as in supply chains and values chains of a CIE, requires the partnership of other actors, even competing entities. Under such circumstances, to make a partnership among ecosystem actors, the effectiveness of CE in the innovation ecosystem must be justified by showing the consequences of CIE implementation in the entire ecosystem using the data gathered through an open data platform.

4.6. Values in the CIE

In addition to the interpretation of coded interviews, literature analysis indicated that values are the core concepts during a transition toward CIE (Bocken et al., 2016a; Konietzko, 2020). According to responders, the definition, application, and dimensions of CIE values are distinguishable compared to traditional innovation ecosystems. Table 6 shows the recommendation for value design in the CIE.

After applying the CE values in traditional ecosystems, the ecosystems designers stated that, despite the necessity of the competitiveness concept as a value for growth. Still, in CIEs, this concept must be redefined according to the basic principles of the CE. The interviewers believed that there is a paradox between profit maximization and respecting CE values. They stated that, although this paradox can be resolved somehow in some cases, for example, by using recyclable energy resources, its consequences may appear differently in other ecosystem constituents, for example, in battery usage rate. In other words, based on their common insights, the restructuring and redesigning of ecosystem components during the transition toward CE will certainly be accompanied by some conflicts and paradoxes among ecosystem values. Under such circumstances, any short-term solution in complex systems may jeopardize the entire ecosystem in the long run.

On the other hand, given the upward paradox, CIE shaping needs reforming service and product design processes. Accordingly, capturing values using the same tools and materials in some contexts may be costly and consume the ecosystem's

TABLE 6 Values in the CIE.

Values in the CIE	
Innovation ecosystem entity	Required transformations for CIE (Recommendations)
New circular technologies	Incorporating recycle-oriented technologies into the production units to cover the circular values in production lines
Concept redefining	Redefining the concept of partnership, competitiveness, co-innovation, and co-creation within the ecosystem
Facilitator centers	Implementing the facilitator centers to solve potential conflicts
Assessing metrics	Measuring the circular-based metric in various parts of the ecosystem
Diversifying design methods	Diversifying the product/service design methods to cover more sustainability values
Financing circular values	Introducing circular values as supported financial values within the ecosystem
Decentralizing governance	Decentralizing the governance and policy-making models at the ecosystem level
Modeling LCA	Modeling the life cycles of various products and services, this activity provides a clearer outline of the resource and energy conversion at the ecosystem level
Balancing	Creating balancing models between sustainable values and competitiveness values
Customer behavioral shaping	Creating cultural values for business model innovations using circular values. For example: serviticizing the businesses or using sharing economy models
Market shaping	Market shaping by increasing customer awareness regarding the positive effects of a circular lifestyle
Condemning consumerism	Promoting sustainability values and educating people to quit consumerism
Awarding	Appreciating sustainable businesses and promoting the circular values inside them
Standardization	Inventing global standards for the product design and consumption behaviors of ecosystem actors, including the customers
Regulating	Providing regulative activities to limit the overload of resource consumption at the ecosystem level
Developing local services	Educating people to use the local suppliers, local delivery services, and regional industries
Virtual services	Promoting the use of virtual services, online shops, and remote working
Life-styles	Promoting the lifestyles that use repaired tools (Minimal lifestyles)
Facilitating transition	Providing the required information for the transition of products and services to adopt the fundamentals of the circular economy

stored energy. Therefore, regarding the value design in CIEs, a single approach in most cases cannot provide the ecosystem's transition; thus, implementing the CIE needs the hybrid approaches of components transformation and building new entities from scratch.

This approach increases ecosystem actors' resource efficiency by distributing the resource load to all ecosystem components. Such a decentralized approach also defines each ecosystem actor's activity scope through a smart resource allocation system. This system assigns roles, facilitates the scalability of enterprises within the ecosystems, and helps them grow by allocating the smart resources they need. The smartness of such a resource allocation system helps the actors receive entries as much as they need. Therefore, the actors' consumption rate does not exceed the overall and pre-defined ecosystem consumption rate.

To solve the pre-mentioned CE paradox, the responders suggested that defining the CIE values needs a comprehensive approach that includes the different states of the ecosystem before and after applying the overall CE values. This approach is strictly linked to the benefits of a sustained and long-term development model against the current model of sacrificing anything for short-term organizational goals. In this approach, synthesizing the different parts of the Pie Model before and after the transition revealed that the ecosystem value proposition (EVP) for a CIE cannot be indifferent to competitiveness or digest and compromise competitiveness as an internal element. According to the ecosystem designers, however, innovating new business models and optimizing the supply and value chains can solve this problem to some extent, but the optimized solution can be found just when the financial factors justify the CE strategies within an innovation ecosystem. To this end, besides analyzing similar research, the coded interview enlightened that customer behavior in line with some regulative actions has the most influence on defining EVP.

Regarding customer behavior, the results showed that a CIE's redesigning process highly depends on market-shaping. According to the interviewers, customer behaviors (culture, ethics, and consumption model) are the factors that could affect the implementation of CE values in business models.

On the other hand, regarding the ecosystem regulations, the research findings stated that customer behaviors could not alone navigate the transformation of ecosystem components. In this context, a regulative institution is required to develop the ecosystem growth rules. Those rules and regulations facilitate the co-innovation and co-creation of entities inside the CIE. Such a framework does not allow ecosystem actors to act beyond the definitive borders and exceed the safe benefit zones of the ecosystem by sacrificing the resource or utilizing not authorized procedures.

Furthermore, the research findings based on ecosystem redesign processes using the Pie Model revealed that creating new behaviors besides regulative procedures are recursive and repetitive actions that may be realized more than once during the transition. According to interviewers, implementing new EVPs for CIEs requires new settings and configurations to be reached and reviewed several times by the market. This action provides a bilateral understanding between ecosystem actors and customers, resulting in reforming the ecosystem value chain, developing regulative programs, and redesigning EVPs and business model value propositions.

4.7. Investment policies in the CIE

The literature review refers to investment policies as the third core element in shaping CIEs. Investment policies have always been discussed as one of the major pillars of ecosystem generation among researchers and practitioners (Thomas and Autio, 2012; De Vasconcelos Gomes et al., 2018; Ferasso et al., 2018). This research highlights that moving forward to a CIE with the same linear structures and investment policies cannot be considered an optimized solution. Therefore, some modifications are required to support the transition and gather the building blocks of a CIE focusing on investment policies.

According to the interviewees, modeling the CIE transition based on the traditional innovation ecosystems by the Pie Model showed that eco-friendly investment policies should be considered as a set of key indicators for financial support in any developmental plan. These indicators can also limit the previous unsustainable approaches or investment policies in some cases. In others, these metrics can invent new investment programs in innovation ecosystems. Some experienced responders with financial backgrounds stated that investment is a key factor in the ecosystem generation process, but the unfair investment models may create obstacles during the transition toward CE.

Moreover, some interviewers worried that risk management and mitigation models would be the potential barriers during the transition. The responders believed that there are no liable tools or models to assess investment opportunities' various risks. Additionally, the current ROI structures designed for linear business models are not consistent with the fundamentals of the CIE. In this regard, the interviewees have also cited the exit models as the other ambiguous procedures in CIEs.

According to interviewees, under such unstable circumstances, discussing funding as one of the main strategies to support the transition will face difficulties such as the lack of monitoring and evaluation tools among the policy options. The interviewers mentioned the need for a framework based on which the impact assessment of investment policies and corresponding consequences can be assessed and evaluated before defining any strategies. Table 7 shows the basic investment policies that emerged from the coded interviews.

Furthermore, according to the interviewers, the investment policies are not limited to the strategies. The results indicate that transformed Pie Models also illustrate some other soft topics in investment strategies. The results are shown in Table 8.

5. Discussion

This study investigated the previous research and concluded that three core components must be redesigned regarding the CIE design process. In the next step, through the interviews with experts using an analytical tool for ecosystem design, the transition procedures have been studied, and related recommendations for researchers and practitioners have been provided.

The findings revealed that the CIE is a complex system based on the ecosystem thinking approach. Accordingly, it requires complex system approaches to analyze the behavioral and structural components. In other words, the CIE, in addition to

TABLE 7 The investment policies emerged from the coded interview.

Investment policy	Description
Co-investment by the public and private sectors	Encourage private sectors to invest more in CE by providing co-investment models and distributing the benefits among CE ecosystem actors
Diversifying the investment and financing tools	Providing the various models of financial support and investment tools to let business actors choose the models according to their own programs
Creating investment insurance models to facilitate the investment of private sectors and risk mitigation	Supporting the investors by creating investment insurance models, business support programs, such as preordering/prepaying, and programs to reduce the investment risk through business side/market side supports
Non-profit investment on circular business actors	Empowering the roles of charities and NGOs or public funds to promote circularity in markets, business entities, and production units within the ecosystem
Investment for reducing the hazardous effects of non-circular entities in the ecosystem	Inventing the business models or using the business model innovation approaches to create the value propositions based on the benefits of process, product, and service optimization on the linear entities
Develop investment platforms	Develop the platforms to predict the investment outcomes and modification of investment strategies in CIE using analytical approaches and big data analysis

TABLE 8 Investment soft topics.

Investment soft topics	Description
Training of business unites to tackle the challenges of the CIE	Empowering and capacity-building ecosystem components with a focus on business actors to be informed about the issues, obstacles, and bottlenecks of CE implementation, the approaches and tools to solve them, and institutional cooperation among ecosystem actors
Expanding the connection infrastructures	Creating the networks and connection gateways to share tangible and intangible assets among ecosystem actors. Providing the deal and interaction frameworks for ecosystem actors to facilitate the interrelationships
Developing the innovation facilitator centers and RandD units	Creating innovation centers, incubators, accelerators, and venture capital centers to boost the knowledge economy and provide cooperation among knowledge and business institutions to support the research and development activities regarding the CE product, services, and technologies
Focusing on Market shaping processes to consume the CE product and services	Rising awareness of consumers about the advantages of sustainable development ecosystems, informing them about the economic and environmental benefits, and creating advertisement and marketing strategies for circular products and services
Funding talent acquisition programs on sustainable jobs creation opportunities	Developing the talent findings and headhunting programs to attract high skilled and circular lover workers besides creating job opportunities focusing on sustainable positions within the area
Developing knowledge-sharing infrastructures	Establishing knowledge-based institutions besides the knowledge disseminators and scientific tribunes to inform the local communities about the recent achievements, sharing experiences and solutions, and discussing the faced issues and the approaches to solve them
Expanding smart supply chain models	Using new smart technologies and methods to minimize supply chain costs, increase quality, enhance monitoring, and assess procedures
Creating sustainable housing	One of the main assets of innovation ecosystems is the logistics and housing facilities. Therefore paying attention to sharing economy and investment in smart housing to provide sustainable facilities is playing a major role in CIEs
Investing based on impact assessment	Providing financial support, remunerations, investment tools, and non-financial supports, such as tax and public sharing costs, based on the outcomes and the impact assessment of the ecosystem actors

inheriting the basic components and features of linear innovation ecosystems, defines not linear but circular dimensions that create new behavioral and structural elements. The findings specifically highlighted that implementing the CIE needs an orchestration model of leadership among ecosystem actors. This model coordinates sub-ecosystem elements and provides the required infrastructures and tools for the interaction of ecosystem actors under a balanced framework at the ecosystem level. This orchestration model of leadership in innovation ecosystems creates visions and missions for an ecosystem actor while it joins the circular ecosystem. This model also revises the current positioning of actors by comparing the actor's core components, such as its values, stakeholders, and growth plans (Investment policies, M&A, cooperation, etc.) with the ecosystem value proposition (EVP in the Pie Model). Therefore, the finding recommends that in order to avoid the unbalanced status of ecosystems, any development plan for widening the ecosystems and inclusion of new entities must verify the adaptability of actors' core components with EVP.

This research also stated that only the external ecosystem shaping interventions independently could not shape CIEs. This study revealed that in line with the external shaping procedures, such as defining the strategies and regulations as well as utilizing new technological tools, methods, and investment policies, shaping the internal mindsets and providing soft skills and circular supported innovation flows among ecosystem entities are playing major roles in the transition toward CIEs. On the other hand, reviewing the redesigned ecosystem models using the EPM enlightened the necessity of soft programs as well as relationships, awareness, capacity building, and market-shaping as the suggested interventions before any operational activity.

Despite the linear innovation ecosystems, the stakeholders in CIEs make many differences by providing new entities that affect the entire ecosystem. According to this research, redesigning the linear ecosystems aiming at shaping CIEs will create interconnected nodes, which help the ecosystem actors be informed about the temporal status, opportunities, and many other accessible advantages of the ecosystems. Thus, establishing those hubs in ecosystems is highly recommended for implementing the CIEs. The finding also stressed the opportunity-oriented approach as

an effective approach encouraging actors to interact widely based on opportunities linked to CE values. In this context, creating a mechanism to spread CE-related business opportunities over the ecosystem to engage more actors with CE values is also recommended for practitioners.

Furthermore, according to the requisites of CE, the new design of stakeholder networks needs a new economic model to verify the implementation of CE values among ecosystem actors' financial interactions. According to this new economic model, respecting the CE values in any deals among ecosystem actors is negligible. This model also forces actors to broaden their borderlines to consider not only their footprints in the interacted actors but also to assess the effects of their interaction at the ecosystem level. Given the findings, the CE approaches could be economically profitable at the ecosystem level if properly implemented. Accordingly, the new CE economic model emerges from the redesigning of ecosystem actors, reforms the cost structure, distributes the overall pressure of transformation among ecosystem actors, and balances the resource efficiency of ecosystem components within the area by engaging all actors in the consequences of their interactions.

Consequently, analyzing the reconfigured ecosystem components enlightened the need for a co-innovation and co-creation platform to provide managerial wisdom for the ecosystem design and management processes. In this regard, transparency, free flow of knowledge, and analytical tools are recommended as the key drivers for predicting issues and finding opportunities. This platform should be able to indicate how changing the strategies and manipulating the ecosystem factors can modify the ecosystem's performance.

The ecosystem design process using the Pie Model also restructured the value creation of CE ecosystems. In this regard, solving the triple paradox of competitiveness, profit, and CE values has been discussed as one of the major issues of CIE implementation procedures. In this context, reforming the traditional unsustainable ecosystems through the combined approach of component transformation and the creation of basic infrastructures is suggested as a practical solution. The advantage of this approach is defined based on introducing a new smart allocation system that assigns the resources according to predefined indexes (capabilities, tasks, roles, etc.). Such a system considers the statuesque and future status of sub-ecosystems before applying any modification in ecosystem shaping factors. Finally, regarding values, this study recommends customer behavior shaping and regulative actions as two essential notions of value design in CIEs. This study also recommends that, as a practical solution to create a CIE, the financial factors should justify incorporating CE values within the transactions. Thus, to be circular, the circularity should create financial benefits for ecosystem actors.

Finally, regarding the investment policy, the results revealed that the current perspectives on investment policies to implement a CIE or to facilitate the transition of linear ecosystems toward CIE are not operationalized. Given the findings, eco-friendly investment policies should be considered as a set of key indicators for financial support in any developmental plan. The findings showed that the appropriate investment policies must consider the CE's long-term visions regarding any investment activities within the ecosystem. This study suggests that effective investment policies must cover multiple criteria, such as the CE ecosystem maturity levels and CE sub-ecosystem growth procedures. Accordingly, the proposed investment policies conclude that regarding any deal between investors and business entities, the mutual understanding of ecosystem actors must define a long-term vision for the investment return models in which their footprints and the CE principles are seen and considered. These strategies also highlight that investing in the optimization processes of businesses can be potentially considered an effective approach for the transition toward CIEs. In the end, and beyond the previous notions regarding stakeholders, values, and investment policies, the current research reveals the Table 9 as the policy-making notions for shaping a CIE. The current findings are in line with previous studies that have explored circularity from ecosystem perspectives (Konietzko et al., 2020b). Furthermore, the current findings support the idea of shaping circularity based on system theories, which have recently been scrutinized by researchers (De Vasconcelos Gomes et al., 2018; Liu and Stephens, 2019; Konietzko, 2020).

6. Conclusion

The ecosystem thinking approach, despite the criticisms, has positive achievements, while the study environment includes a lot of actors with various attributes. In this study, we tried to consider the affecting factors from sustainability and circularity perspectives. However, we did not claim that all factors and dimensions have been considered in this study. But, to some extent, this study can uncover the circular ecosystem design process for researchers and practitioners.

This research has made two contributions. First, it has developed the existing literature on innovation ecosystems from the sustainability and circularity perspectives by reviewing the latest research and expanding the related notions. The previous studies mostly investigated the innovation ecosystem from a sustainability perspective, but the CIEs were not sufficiently discussed (Hsieh et al., 2017; Takacs et al., 2020; Asgari and Asgari, 2021; Trevisan et al., 2021). By reviewing the previous studies, it is revealed that the ecosystem approach can bring us collective wisdom covering all ecosystem actors and role-players. This approach clarified that the transition toward a circular ecosystem must be realized based on a synchronic and incremental process. In this context, the transformation of every single component in the ecosystem occurs by considering the evolvement of other components. Accordingly, based on the findings, defining the CE strategies depends on the big picture of the ecosystem actors involving the goals, missions, and visions of all stakeholders in the ecosystem. This research thereby suggests that regarding any transformation in ecosystem components, an in-depth investigation within ecosystem entities and among stakeholders as well as exploring the adaptability of values and investment policies are required to implement a CIE and verify the potential issues caused by interconnected deals and interactions. In this context, this study stated that three core components, namely, stakeholders, values, and investment policies, must be redesigned during the transition toward CE to shape a CIE. Accordingly, the transition process in these three components has been studied in this study.

TABLE 9 CIEs policy recommendations.

Intervention level	Policy recommendation
Ecosystem shaping level	Proper distribution of opportunities and roles created by the circular economy
	Considering definitive circular roles for ecosystem actors
	Developing the co-creation, co-evolvement, and co-innovation within the area
	Innovative financing of circular products and services
	Raising awareness regarding the consequences of CE in the ecosystem
	Establishing a legislative and regulatory institution for managing circularity in the ecosystem
	Integrated and centralized monitoring systems for assessing the circularity of institutions, products, and services
Ecosystem program level	Providing an accurate, complete, comprehensive, and collective definition of the circular ecosystem value proposition
	Changing perspectives toward ecological resources in financial deals. According to this idea, resources are considered common assets for the whole ecosystem, and using them creates responsibilities and consequences for the owner. This approach considers resources as borrowed assets only for a short time; therefore, the owners must control the waste as a part of their responsibilities
	Measurement, modeling, and simulation of circular strategies for assessing the final impacts
	Creating modular structures in product design, ecosystem design, and organizational design
	Using the opportunities of an open data world and the era of interconnected networks
	Establishment of specialized institutions that facilitate the creation or transition toward CIE
	Developing an intra-ecological balance system aiming at balancing competitiveness and sustainability within the ecosystem
	Developing resource-oriented strategy-making models. The economic model considers resources as crucial factors for developmental plans

As the second contribution, this study specifically targeted the CIE, focusing on stakeholders, values, and investment policies by analyzing the various components before and after the transformation using the EPM tool. The EPM as an analytical model provided in-depth insights into each ecosystem component's transformation and clarified the new dimensions of the CIEs after the redesign procedures. As findings, this research provided recommendations based on the previous studies and the collective wisdom of experts in this domain. These recommendations presented through an in-depth analysis of CIE design can help researchers and practitioners comprehensively view circular ecosystem design procedures. This research could be beneficial for researchers and practitioners who are trying to discover the various effects of applying CE notions in the ecosystem. The findings also inform the policymakers and ecosystem governors about the requirements of any transition toward CIEs. Moreover, this study suggests the policy-making structures and models for tackling the transformation obstacles. This study also revealed that further investigations, such as the essentials of market-shaping, analytical tools of ecosystem monitoring, and some new investment methods, are required to implement the CIEs.

6.1. Research limitations

While researching circular innovation ecosystems, certain limitations should be acknowledged. First, the scope of the study may have been constrained by time and resource limitations, potentially leading to limited sample size or some related field coverage. Second, the data collection process heavily relied on interviews and document analysis, which might introduce bias or incomplete information. Additionally, the study's focus on stakeholders, values, and investment policies might have excluded other relevant factors that could influence CIEs. It is important to recognize these limitations and interpret the findings within their respective constraints, ensuring a comprehensive understanding of the research's implications.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

Review, writing, modeling, and design: AA. Analyzing and data gathering and structuring: RA. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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