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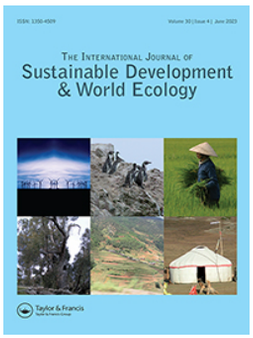

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The societal strength of transition: a critical review of the circular economy through the lens of inclusion

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ABSTRACT

Realizing a circular economy (CE) has been widely recognized by practitioners and researchers as the key to the transition toward sustainability. Thus far the academic emphasis has been predominantly on economic and environmental aspects. However, the development and implementation of CE initiatives actually rely on extensive collaboration at the societal level. Hence, an understanding of how a more inclusive society can strengthen the transition is warranted. By systematically and critically reviewing the related academic literature, the results of this paper show that sensitivity to inclusion aspects is crucial to alleviate the transitional burdens on society. Seven main aspects were discerned on inclusion: (1) informal waste pickers, (2) e-waste and health risks, (3) accessibility of services/materials/facilities, (4) consumer behavior, (5) corporate and institutional involvement, (6) technology application, and (7) governance measures. Following these insights, a strong sustainability perspective and agenda on the CE transition are proposed by identifying key actors and structuring their interrelationships as an inclusive system.

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KEYWORDS
Inclusion; circular economy; waste management; informal sector; strong sustainability

1. Introduction

Many countries have made the circular economy (CE) transition a core strategy for realizing the 2030 Sustainable Development Goals (SDGs) and meeting the national targets of the 2015 Paris Agreement (Dong et al. 2021). Typically, CE research and practices are known to focus on industrial symbiosis (Dong et al. 2017; Bian et al. 2020), closed-loop supply chains (Souza 2013; Ghisolfi et al. 2017), circular product design (Den Hollander et al. 2017; Mestre and Cooper 2017) and circular business models (Bocken et al. 2016; Lüdeke-freund et al. 2019). Each of these examples adheres to the basic principles proposed by the Ellen MacArthur Foundation (EMF) including: (i) design out waste and pollution, (ii) keep products and materials in use, and (iii) regenerate natural systems (EMF 2020). In essence, these CE topics and principles focus predominantly on transitioning the production and consumption patterns of economic systems.

Yet, as we have come to learn from a few recent academic contributions (Padilla-Rivera et al. 2020; Schröder et al. 2020; Mies and Gold 2021), this is at best a narrow view of an effective CE transition. Thus far, CE has gained its traction in changing consumption and production patterns mostly with its focus on resource-, technology-, and economy-related solutions (Korhonen et al. 2018). However, the implementation of CE needs more than just recycling technology and business models; it requires socio-technical transitions in long processes to accelerate the shift from a linear economy to a circular economy, rather than staying in a recycling economy (Haas et al. 2015; Den Hollander et al. 2017). On top of that, there is a dissonance between CE and more generic sustainability transitions. Certainly, as with its inception through the Brundtland Report, published in 1987, sustainability has carried a broader scope, including people in its tracks, by the creed that 'contemporary development should not compromise the ability of future generations to meet their own needs' (Cassen 1987). Here, the goal of the sustainability transition is positioned as the collective good of humanity within and across generations, with an emphasis on the sustainability of resource use (Holden et al. 2014). Since the United Nations 2030 Agenda for SDGs was agreed in 2015, a set of more specific goals and a broader framework of indicators has been proposed, including economic, social, and environmental aspects, and the creation of peaceful, just and inclusive societies was prioritized (U.N. 2015). The sustainability transition has

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therefore been combined with a clear set of more people-centered measures. These measures have not yet been internalized within the views surrounding the CE transition therefore making it incomplete and potentially ineffective for realizing sustainability (Schröder et al. 2019; Corvellec et al. 2022).

In this paper we aim to solve this dissonance between CE and sustainability transitions, by developing the argument that the inclusion of people is at the heart of any effective transition. First, we open up a disruptive and insightful view of sustainability transitions, called 'strong sustainability (SS)', as a perspective in which sustainability requires coherent and systemic changes in the economic, environmental, as well as social spheres. SS sees economic, environmental and social capital as complementary, yet not interchangeable (Neumayer 2013), which is a breakaway from more commonplace interpretations of sustainability, following the transactional views like the Triple Bottom Line. With this new interpretation in hand, we introduce the five dimensions of inclusion (Liang et al. 2022) and how it has been and should be applied in CE research and practice. Finally, a research design is proposed and reported, by means of a critical review, account and synthesis of academic efforts that have so far contributed to this lens of inclusion.

The remainder of the paper is organized as follows. Section 2 introduces the theoretical concepts on the intersection of SS, CE, and inclusion. Section 3 describes the methodology followed in order to execute our research. Section 4 presents the quantitative and synthesis results of the critical review. In section 5, a strong sustainability perspective and future research agenda of inclusive CE are developed and discussed. Finally, conclusions, contributions and limitations of this research are presented in Section 6.

2. Theoretical underpinnings for an inclusive CE

2.1. The theory of strong sustainability (SS)

A few key theoretical concepts can be used to develop a case for the CE transition to attain more effectiveness. In the academic literature on CE, a few studies can be recognized for their focus on social aspects. Most notably, these include incorporating the human development index into CE indicators (Schröder et al. 2020), applying the framework of social sustainability in CE studies (Mies and Gold 2021), and using stakeholder theory as a tool to measure social performance within the CE context (Padilla-Rivera et al. 2020). This has shown the academic sensitivity to the role of people in the CE transition. Yet, as CE is clearly connected to its economic and environmental sides, this social side has not yet been synthesized with them (Kirchherr et al. 2017; Mies and Gold 2021; Steuer 2021; Vanhuyse et al. 2021). This leaves us unaware of, first, how the social side can be harnessed to promote the CE transition; and second, how to make the outcomes of the CE transition equally beneficial to all the different groups in society.

A promising concept to help in generating this synthesis is SS. This concept departs from a Triple Bottom Line interpretation of social, economic and environmental aspects as dimensions that can partially overlap (e.g. an activity has social, economic and environmental implications) (Elkington 1997), to vast 'spheres' in which the aspects are nested within each other (e.g. economic activity feeds on sociological and natural systems) (Giddings et al. 2002) (Figure 1). An econosphere is defined as a system that includes the flows related to three types of economic activity: production, consumption and accumulation (Nations et al. 2003). A sociosphere can be defined as an area of activity where the actors are able to unite in sharing

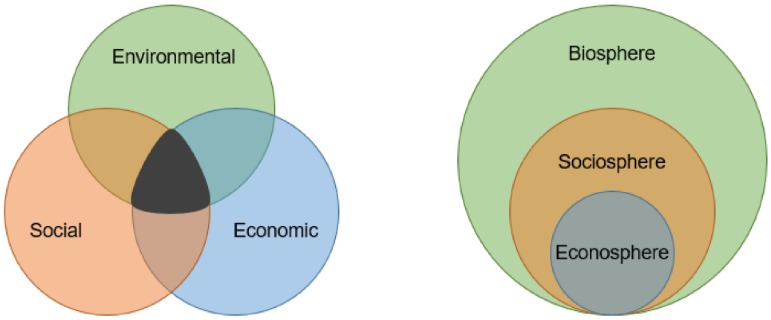

Figure 1. Triple Bottom Line vs. Strong sustainability. Triple Bottom Line (Elkington 1997). Strong sustainability (Giddings et al. 2002).

understandings, rules, and principles, regarding the activity (Galligan 2006). The biosphere is the global ecological system composed of all living beings and their relationship, as well as their interaction with abiotic elements (Folke et al. 2011). This sphere interpretation has fundamental implications for the role of the social side in sustainability transitions. In essence, it posits the social system as a communication barrel between the economic and environmental systems. The question remains how these systems communicate within an CE transition and how we can make it healthy.

Since CE both in research and practice is not only focused on impact prevention but also on system reconfiguration (moving away from the linear economy), the SS concept creates a better theoretical basis on which CE direct contribution to sustainability transitions can be grounded. Particularly, SS emphasizes that the economic sphere is a subset of the sociosphere, and that the sociosphere is embedded in the biosphere (Neumayer 2013). This nested structure means that any issue related to sustainability must be considered systemically. The current CE transition is mostly focused on technological, and market innovations in the economic sphere as well as energy and pollution in the environmental sphere, without considering how the sociosphere should be equipped to accommodate and support the CE transition (Schöggl et al. 2020). Without changing the framework conditions of the sociosphere (e.g. people's awareness, willingness, capabilities, and organization), the CE transition itself will not be sustainable, as vested interests that can benefit from the current economic model will strongly resist the transition process.

2.2. Inclusion: a multi-dimensional process

It can be settled that a stronger focus on the sociosphere makes the CE transition more truly sustainable. Some studies have discussed this area and the most frequently addressed social aspects are employment (Gutberlet 2008; Khan 2018), health risks (Zolnikov et al. 2018), social welfare (Wilson et al. 2006; Steuer et al. 2018), and consumer behavior (Wang et al. 2016; Ma et al. 2018). These studies focus on the impact of the CE transition on the different stakeholders in the sociosphere.

However, there are still many examples revealing that CE measures are not yet clear as to how the sociosphere can be equipped to systemically contribute to the sustainability transition. On a global scale, more than 22 million people are informally involved in the waste recycling process, who are crucial to the CE transition but often unrecognized and marginalized (Gutberlet 2021). Meanwhile, social and technical conditions are often not well equipped to support an efficient, safe and decent work environment, such as prejudice against scavengers and the lack of safe tools for waste sorting and transportation, especially in some developing countries where the recycling industry is more concentrated (Rutkowski and Rutkowski 2015; Den Hollander et al. 2017). To overcome these issues **the sociosphere should become less of a passive field full of victims but rather activated as a driving force. In essence, we argue that a more activating concept for the sociosphere can be the concept of inclusion within CE.**

Inclusion is a multidimensional process aimed at creating conditions which enable full and active participation of every member of the society in all aspects of life and benefit from it equally (UNDP 2007). This perspective not only emphasizes the social impacts of CE transition, but more importantly, it considers how people could actively recognize and participate in the CE transition. Researchers have defined social inclusion as a multidimensional, relational process that increases opportunities for social participation and enhances the abilities to fulfil normative social roles (Silver 2015; Liu et al. 2020); and at the collective level, enhances social justice, equality, integration, and solidarity (Ornstein 2017; Anttiroiko and De Jong 2020). (Liang et al. 2022) conducted a comprehensive literature review and defined five dimensions of inclusion in an urban

Table 1. Dimensions of inclusion and their description in the context of CE.

Dimensions of inclusion	Conceptual dimensions of the inclusive city (Liang et al. 2022)	Description in the context of CE*
Social inclusion	Both immigrates and local citizen can pursue better living conditions, using their legal entitlements and participating in social activities.	The maximization of product and service values on the premise of meeting consumer needs and the welfare of workers and neighboring inhabitants.
Environmental inclusion	Current patterns of production and consumption are carried out without sacrificing the needs and interests of future generations.	Production and consumption patterns with no or less use of natural resources and low environmental burden or even positive environmental contribution, as well as habitat-friendly waste-to-resource processes.
Economic inclusion	Eliminate material inequities and increasing access to employment opportunity.	Fair economic opportunities for everyone in the CE transition, including labor markets, finance, entrepreneurship, and trade.
Spatial inclusion	Everyone has equal access to public housing, transport, and other public infrastructure.	Equal access to tools, services, and facilities to participate in and benefit equitably from the CE transition.
Political inclusion	Citizens have equal political rights and obligations before the law, political participation, and a sense of belonging to that state.	Equal political rights and obligations of governments and citizens in formulating and promoting favorable policies for CE transition.

Note: *Developed by Author's based on the five-dimension framework of (Liang et al. 2022).

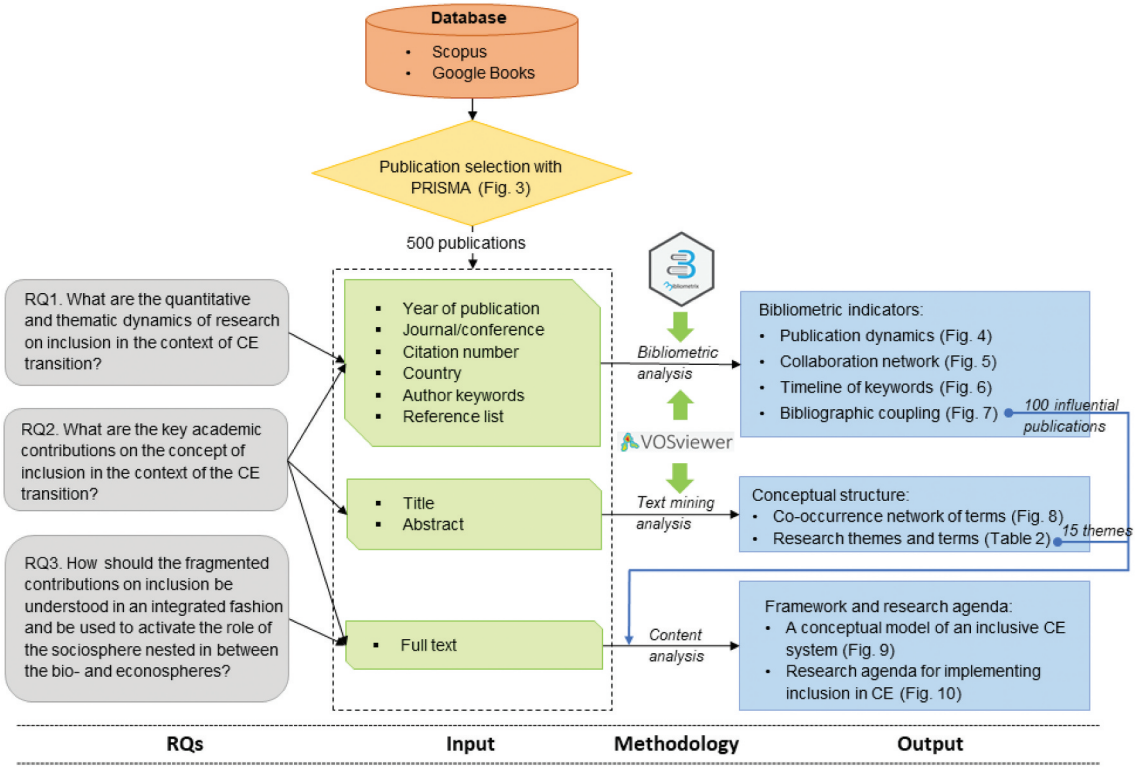

Figure 2. Research design.

context, including social, environmental, economic, spatial, and political inclusion. Within this framework, we apply the five dimensions to the context of CE and give a description of each dimension in Table 1.

Within this context, we take the lens of inclusion to examine the existing work to learn what aspects of inclusion have been considered and integrated within the CE transition and to synthesize how these aspects manifest themselves in an overarching system. Hence, the research questions addressed in this paper are:

RQ1. What are the quantitative and thematic dynamics of research on inclusion in the context of CE transition?

RQ2. What are the key academic contributions on the concept of inclusion in the context of the CE transition?

RQ3. What are the shortcomings of the existing academic contributions on inclusion in the context of the CE transition and how to overcome them to activate the role of the sociosphere in realizing sustainable CE?

To ensure that this review is comprehensive and critical, we conducted a mixed-method approach. In terms of data selection, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement is applied to ensure objectivity and integrity in screening the literature. In terms of literature analysis, we first use bibliometric analysis to quantify overall trends in relevant publications and to identify the most influential scholars and publications in the field. Second, through the text mining technique, we efficiently extracted the key terms in the relevant literature and summarized the most popular research themes. Third, through content analysis of the most influential publications, we segment and gain insight into the main academic contributions on the concept of inclusion in the field of CE transition. Based on this, we develop a conceptual model of inclusive CE that identifies the key actors and their interrelationships in structuring the sociosphere of CE transition. Finally, we propose a research agenda to urge active participation and collaboration among researchers to promote an inclusive CE transition.

3. Methodology

3.1. Research design

In this study, we focus on the role of human interactions in sociosphere in CE transition and how different groups are affected. As the place where the majority of the population congregates, the city is the typical unit of analysis for observing social interactions. Therefore, we applied Liang et al.'s conceptual framework of the inclusive city to define the concept of inclusion in this study, including 5 dimensions: social inclusion, environmental inclusion, economic inclusion, spatial inclusion, and

political inclusion (Liang et al. 2022). The research goal is to identify current and future opportunities for implementing the concept of inclusion properly in achieving a CE that puts people on an equal footing with economic benefit and environmental preservation.

This study adopted a mixed-methods approach that consists of a quantitative and a qualitative analysis to review the literature of inclusion in CE. The overall research design is illustrated in Figure 2.

3.2. Data selection

To ensure consistent and complete presentation of data selection steps, the PRISMA statement is applied to the data selection process (Higgins et al. 2019). The PRISMA Statement consists of a 27–item checklist and a four-phase (identification-screening-eligibility-included) flow diagram that can provide substantial transparency in the selection process of literature in a systematic review (Moher et al. 2009). As our research topic covers a multidisciplinary and multi-temporal literature, PRISMA's objective and transparent data selection criteria and procedures can minimize bias in the selection of literature data, which lays the foundation for a systematic and accurate knowledge framework around the research topic. We performed searches in Scopus and Google Books on 5 March 2021. The exact selection process is illustrated in Figure 3 and described as follows.

(1) Identification: The first step is to select databases for the literature collection. Scopus indexes more journals than Web of Science, including more international and open access journals (Aksnes and Sivertsen 2019). It is therefore able to provide literature on as many dimensions as possible for the study of inclusion in CE. Based on our research questions, we first conducted a preliminary searching in Scopus with the query:

$$\mathrm{TITLE}-\mathrm{ABS}-\mathrm{KEY}\left(\mathrm{inclusi}^{*}\ \mathrm{AND}\ \mathrm{circular}\right) \quad (1)$$

In the searching result, we found that 'inclusive recycling' and 'inclusive waste management' are two main topics in the inclusive CE research, and they are more directly related to the sociosphere that we are concerned with. Therefore, we expand the searching query to:

$$\mathrm{TITLE}-\mathrm{ABS}-\mathrm{KEY}\left(\mathrm{inclusi}^{*}\ \mathrm{AND}\ \mathrm{circular}\ \mathrm{OR}\ \mathrm{recycl}^{*}\ \mathrm{OR}\ \mathrm{waste}\right) \quad (2)$$

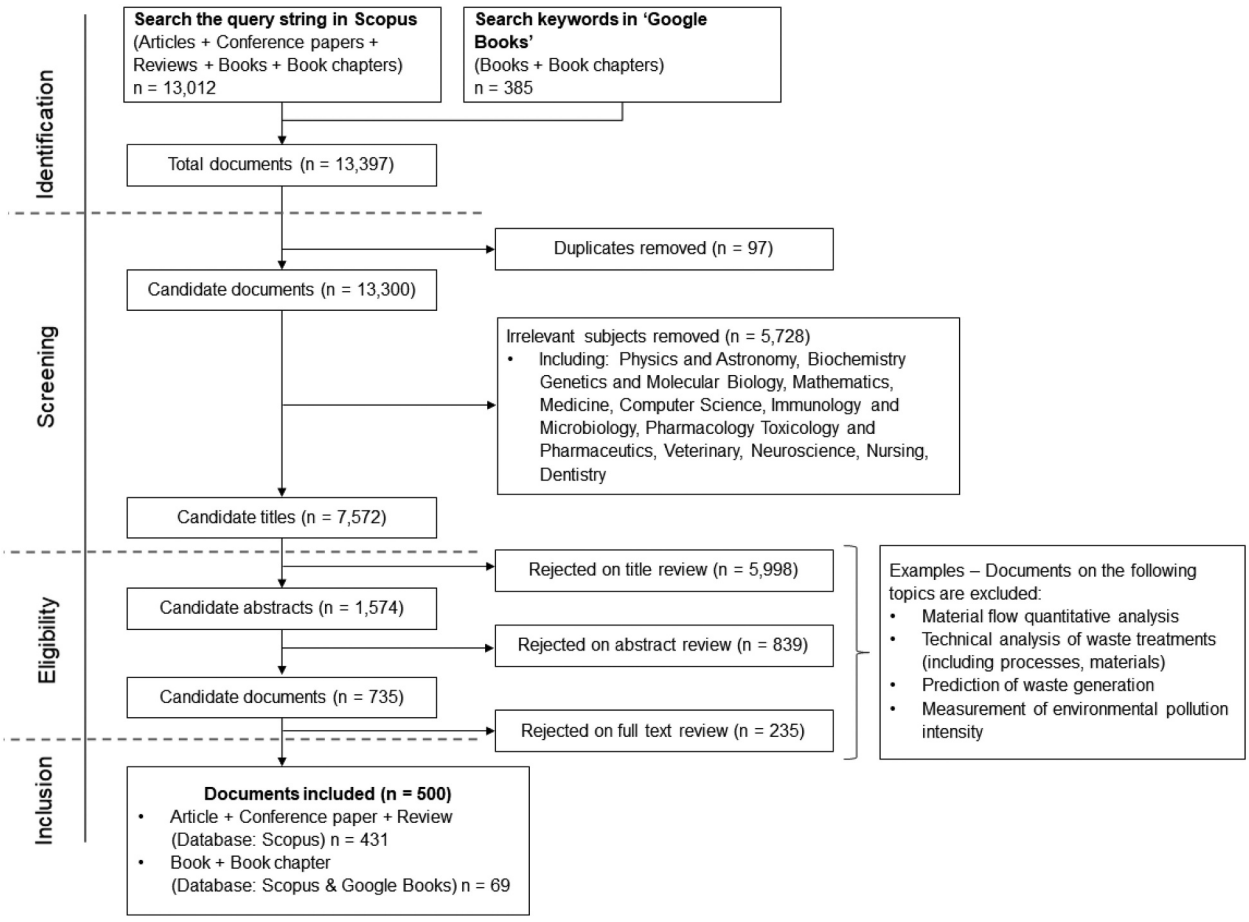

Figure 3. Publication selection using PRISMA.

Further, in the searching result of query (2), we found 'informal circular', 'informal recycling', 'informal waste sector' and 'informal waste management' as high frequency keywords. Therefore, we put them into the query to enlarge the sample size of relevant publications. Hence, we searched publications that are published in English before 2021 with the following query string in Scopus:

$$\begin{aligned} &\mathrm{TITLE}-\mathrm{ABS}-\mathrm{KEY}\left(\mathrm{inclusi}*\ \mathrm{AND}\ \mathrm{circular}\ \mathrm{OR}\ \mathrm{recycl}*\right.\\ &\left.\mathrm{ORwaste}\right)\mathrm{ANDPUBYEAR}<2021\mathrm{ANDLANGUAGE}(\mathrm{English})\\ &\mathrm{ORLITLE}-\mathrm{ABS}-\mathrm{KEY}(\mathrm{informalAND\ circularORrecycl}*\\ &\mathit{ORwaste})\mathit{ANDPUBYEAR}<2021\mathit{ANDLANGUAGE}(\mathit{English}) \end{aligned} \tag{3}$$

In addition, Google Books, the world's largest e-book database, can complement Scopus with its keyword search technology that not only searches the title of the book/chapter but also the keywords present in the full text to provide the most relevant literature. Therefore, the most commonly used terms mentioned above were searched in Google Books, and relevant publications that are published in English before 2021 were identified.

The search terms were found in the title, abstract, and keywords of existing publications. These are often the places in an article, where authors are tasked to convey the essence of their academic study, and so this includes valuable hints on the relation between concepts in the conduct of their work (Schraven et al. 2015).

(2) The screening process: duplicate data from Scopus and Google Books are removed. We also removed documents on subjects irrelevant to the topic at hand, including Physics and Astronomy, Biochemistry Genetics and Molecular Biology, Mathematics, Medicine, Computer Science, Immunology and Microbiology, Pharmacology Toxicology and Pharmaceutics, Veterinary, Neuroscience, Nursing, Dentistry.

(3) The eligibility process: we conduct the exclusion method to determine the eligibility of a document. In theory, publications are excluded if they do not specifically focus on human interactions in or impacts on the sociosphere, including: a) material flow quantitative analysis; b) technical analysis of waste treatment (processes, materials); c) prediction of waste generation; and d) measurement of environmental pollution intensity. In practice, we first read the title of each publication: if it clearly falls into one of the five categories listed above, it is excluded from our dataset; otherwise we retain the publication for abstract reading. Thereafter, we read the abstracts: if the publication is clearly relevant to inclusion in CE, we keep it in the dataset; otherwise, there are relatively small numbers of publications for which we need to go through the full text to determine relevance.

(4) Inclusion: After the selection process, we were left with 500 directly relevant articles, conference papers, reviews, and books/chapters. The following information was compiled and used for the follow-up qualitative and quantitative analysis: 1) year of publication, 2) journal/conference of publication, 3) country of publication, 4) author keywords, 5) reference lists, 6) title of the publication, 7) abstract, and 8) full text.

3.3. Data analysis approach

3.3.1. Bibliometric analysis

Since the bibliometric literature review (BLR) enables rapid analysis of keyword, author and bibliographic information in large samples (Phulwani et al. 2020), we applied it in this study to quantitatively identify the development dynamics and leading trends of inclusion in CE. Specifically, author network analysis, keywords co-occurrence analysis, and bibliographic coupling analysis in BLR can give us insights on academic communication among the studies, the conceptual evolution of a research field and future research directions (Schraven et al. 2021). In this study, we selected Bibliometrix and VOSviewer (version 1.6.16) for bibliometric analysis. Bibliometrix is an open-source tool programmed in R (Aria and Cuccurullo 2017). With its advantage of facilitating the analysis of dynamic trends in the literature, we identified publications dynamics over time, core publications and evolution in topics. Meanwhile, VOSviewer (van Eck NJ and Waltman 2010), with its powerful network visualization, was used for countries collaboration analysis and bibliographic coupling analysis.

3.3.2. Text mining analysis

We use text mining analysis to identify key terms in the literature related to inclusion in CE, and to identify the main research themes through cluster analysis and visualization. Text mining is a technique that uses Natural Language Processing (NLP) to extract normalized, structured data from documents in text form (Jung and Lee 2020). As text mining can capture the most representative phrase patterns and semantic structures from large amounts of textual data, the technique has been broadly used by researchers to analyze research themes and trends in a specific subject (Ranjbari et al. 2021). In this study, VOSviewer is used to conduct a text mining analysis on the title and abstract of the publication based on the term co-occurrence algorithm (Van Eck and Waltman 2011).

3.3.3. Content analysis

To provide better insight into the quantitative results and enrich the thematic analysis of the literature, we perform a content analysis on the 100 most representative publications. These 100 publications are consist of the 20 most-linked publications in each of the five clusters obtained from the bibliographic coupling analysis. Content analysis is a qualitative research method

to identify the presence of certain words, themes, or concepts within some given qualitative data, which allows an in-depth understanding of the research concepts and their relationships (Stemler 2000). Meanwhile, the research themes identified through text mining provided us with guidance on the classification of the main academic contributions of these publications on inclusion in CE. Consequently, we identified and analyzed the main elements (actors, facilities and contextual factors) involved in an inclusive CE and their interactions.

4. Results and analysis

4.1. Bibliometric analysis

4.1.1. Publication dynamics

We counted the annual number of publications in our dataset. Figure 4 illustrates the trend in the number of publications of inclusion research in the field of CE from 1984 to 2020. The number of annual publications in this field was extremely low until 2000. Between 2000 and 2008, there was a slight increase in the number of publications. Since 2009, the number of publications has increased dramatically, to the point that publications published since 2009 make up over 90% of our dataset (i.e. 448 out of 500). The increased quantity of annual publications illustrates the expansion of this topic, but the overall number (500) remains low compared to the rich discussion of CE transition (more than 9600 CE publications listed in Scopus by the end of 2020).

4.1.2. Academic cooperation network

We use VOSviewer to identify all the countries that mentioned in the affiliations of authors that listed in a publication and visualize the international academic collaborative network in this field. Of the 78 countries that contributed to our sample, the top 10 contributing countries and their cooperation on the subject or

Figure 4. Dynamics of the number of publications on the subject of inclusion in CE.

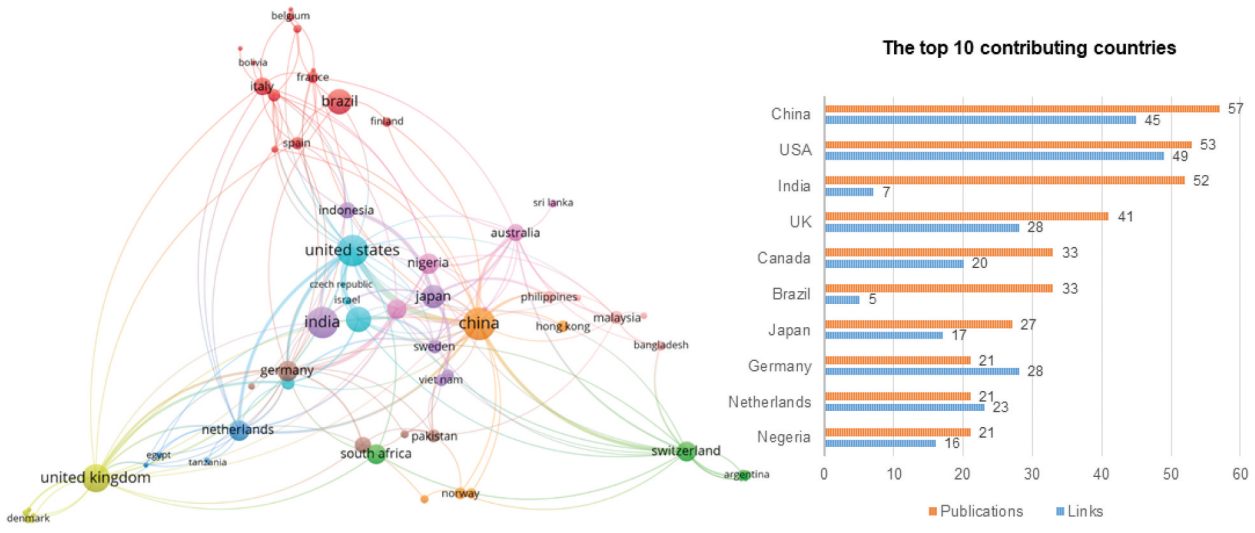

Figure 5. Collaboration network between countries.

with other countries are shown in Figure 5. On the left side of the figure, the larger each circle is, the more publications hail from the corresponding country, and the thicker the links between the circles, the more cooperation there is between them. The results indicate that China, the USA, India, the UK, Canada and Brazil are major contributors in inclusion-related research in CE, with 57, 53, 52, 41, 33 and 33 papers respectively. In terms of international collaboration, the USA, with 49 links, is the core country in the global network on this subject, followed by 45 of China and 33 each for the UK and Germany. Conversely, of the top 10 contributing countries, India, with 7 collaborations, and Brazil, with 5 collaborations, have relatively weak international collaboration networks.

4.1.3. Evolution in topics

An analysis of the temporal distribution and frequency of author keywords in the publications in our dataset depicts the evolution in research themes regarding inclusion in CE over the last decades. As shown in Figure 6, the most frequent keywords occurring between 2013 and 2019 were recycling, e-waste, informal sector, informal recycling and developing countries. This is also a period of exponential growth in the number of publications on inclusion in the field CE. This shows that exclusion issues arising from informal waste collection and e-waste recycling in developing countries have attracted a lot of academic attention during this period. Municipal solid waste and sustainable development are the two keywords with the largest time spans, reflecting the longstanding focus on municipal solid waste and its frequent integration with sustainable development research in this field. In the last five years, a number of keywords have emerged as new research hotspots, such as waste pickers, stakeholders, system dynamics and formalization, which indicated the recent focus of academic research on stakeholder-evolved, systematic research on the formalization of waste pickers.

4.1.4. Bibliographic coupling

The technique of data clustering is a typical bibliometric analysis tool in order to group articles with similar characteristics and determine the research directions (Du et al. 2021). Specifically, bibliographic coupling identifies the links between publications that indicate how many cited references they have in common (Van Eck and Waltman 2020). In our study, we conducted bibliographic coupling analysis with VOSviewer to examine data clustering and the common topics in each cluster. In our sample, 456 of the 500 publications were linked to each other and were used to construct the bibliographic coupling network. As a result, five main clusters of publications were generated and shown in different colors in Figure 7.

The five main clusters of publications are: governance, institutional involvement, public participant (cluster 1, red), e-waste management, pollution, and health risks (cluster 2, green), community and corporate involvement, employment and welfare (cluster 3, blue), technology, business model, consumer behavior (cluster 4, yellow) and regulation, performance evaluation, access to waste service (cluster 5, purple). To further reveal the academic contributions of the five clusters, we conduct a content analysis of the 100 most

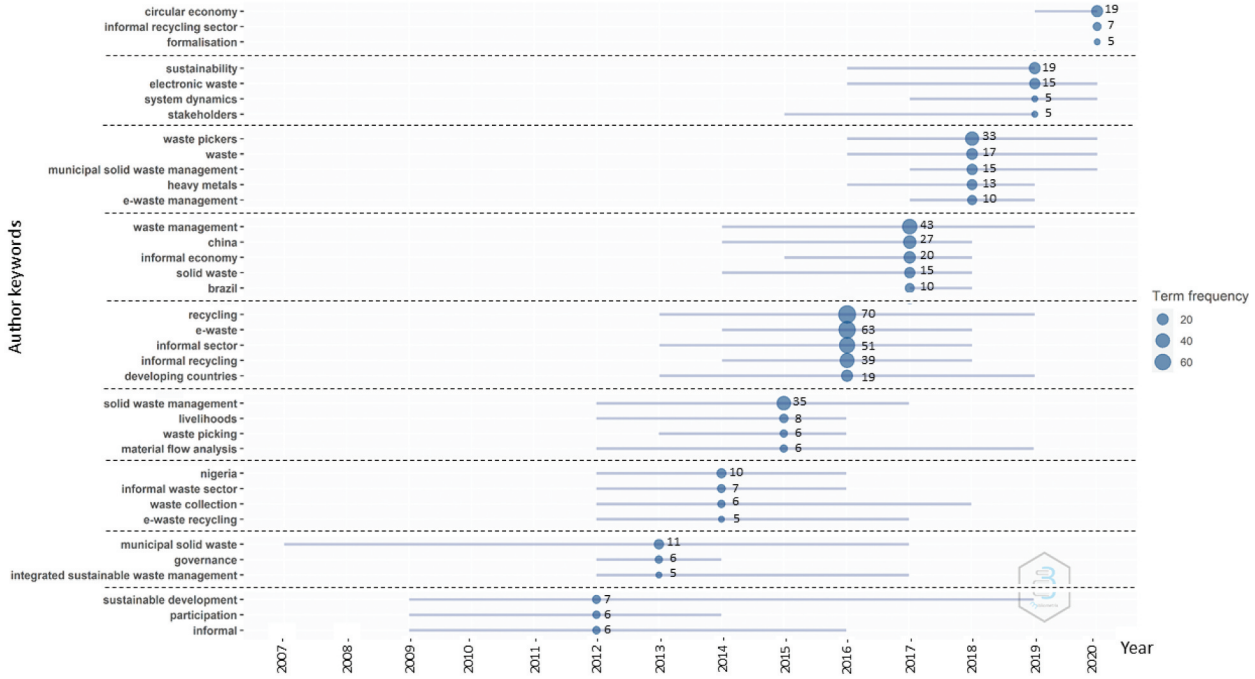

Figure 6. Timeline and frequency of author-used keywords.

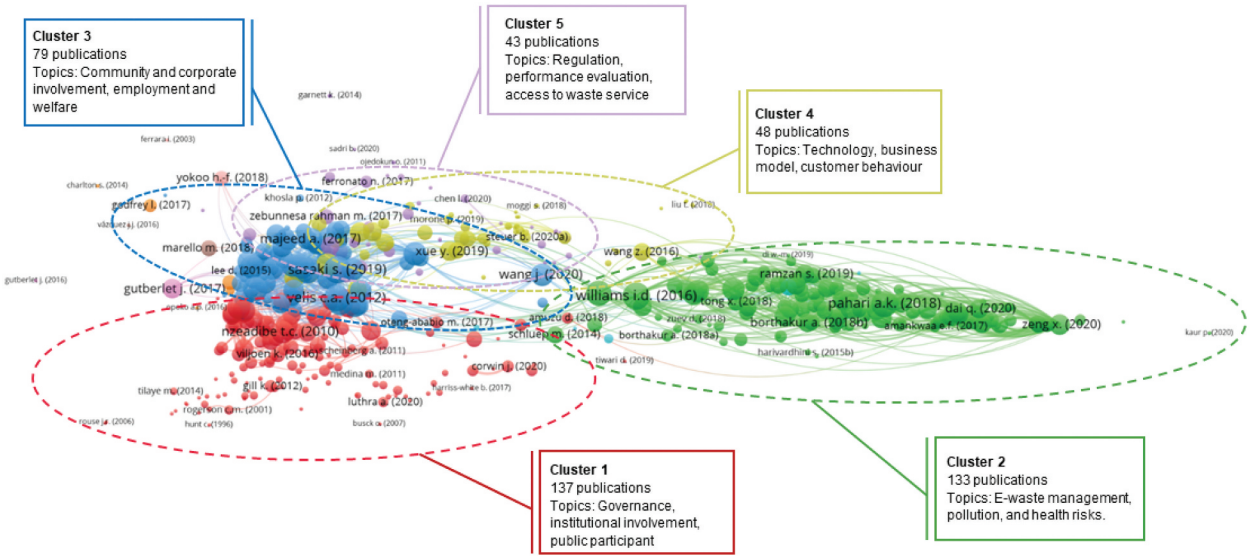

Figure 7. Bibliographic coupling network.

representative publications (the 20 most-linked publications in each cluster) in Section 4.3.

4.2. Text mining analysis

We conducted a text mining analysis with VOSviewer and identified 11,121 terms from the title and abstract of the publications in our dataset. We compared the result of grouping and visualization by varying the minimum number of occurrences of a term from 2 to 10. We found that when we set the minimum number of occurrences of a term to five, 496 terms were identified and formed a clear co-occurrence network (as shown in Figure 8), and the thematic relevance of terms in each cluster and the differentiation between clusters are high. In Figure 8, the larger the circle of a term, the more times the term appears in the literature; the thickness of the line between two terms indicates the frequency of their co-occurrence in the same publications. The results of the text mining analysis show that the existing research on inclusion in the CE field is concentrated in four clusters. Based on the main terms found in each cluster, we identified 15 subdivided research themes, as listed in Table 2. These research themes will provide a basis for classifying publications for the subsequent content analysis.

4.3. Content analysis

Among the 500 publications in our dataset, we selected the top 20 linked articles in each of the 5 main clusters revealed by the bibliographic coupling

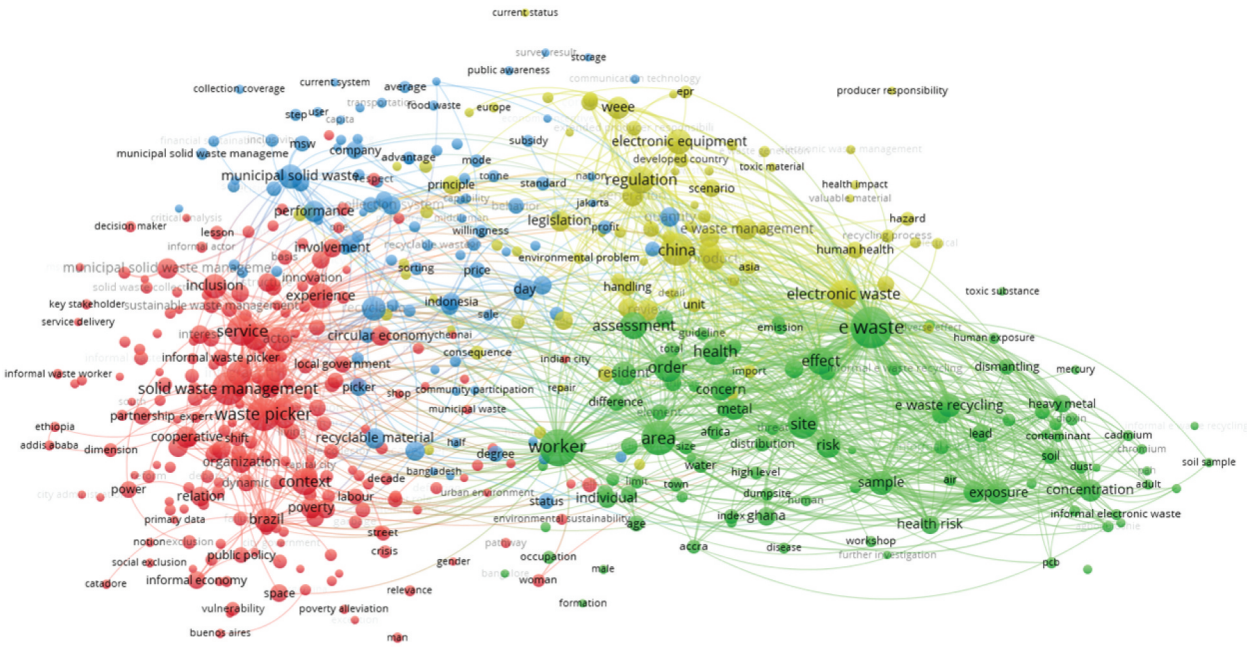

Figure 8. Co-occurrence network of terms in titles and abstracts.

Table 2. Research themes and main terms.

No. and color of the cluster	Themes	Main terms
1. Red	IWPs	Informal actor, Informal waste collection, Informal waste collector, Informal system, Informal waste sector, Informal waste, Informal waste management, Waste collector, Waste picker, Formalization
	Governance	City administration, Decision maker, Governance, Local authority, Municipal government, Policy maker, Public policy, Waste management policy
	Corporate and Institutional involvement	Institution, Non-governmental organization (NGO), Organization, Private sector, Participation, Partnership, Private company, Stakeholder, Social enterprise
	Employment and poverty	Employment, Income generation, Poverty alleviation, Poverty reduction, Unemployment
	Social stigma and inequity	Discrimination, Gender, Respect, Woman, Social exclusion
2. Green	Health risk and welfare	Age, Blood, Child, Disease, E-waste worker, Exposure, Human exposure, Health, Health risk, Threat, Wage
	E-waste pollution	Air, Cadmium, Contamination, Copper, Dioxin, Dust, E-waste recycling, Emission, Hazardous substance, Heavy metal, Informal e-waste, Mercury, Pollution, Polychlorinated biphenyl, Soil, Surface soil, Toxic substance, Water
	Technology application	Assessment, Communication technology, Technique, big data, modeling
	Access to waste service	Area, Distribution, Dumpsite, Location, Resident, Site
3. Blue	Waste management performance evaluation	Average, Capability, Collection coverage, Effectiveness, Paper analysis, Performance, Quantity, Recyclable material, Respondent, Recycling rate, Ton
	Community involvement	Community participation, Middleman, Practitioner
	Consumer behavior	Household waste, Inhabitant, Interface, Public, Public awareness, Residential area, Satisfaction, Willingness
	Economy	Economic benefit, Economic growth, Economic incentive, Economic value, Financial sustainability, Price, Profit, Socioeconomic condition, Subsidy
4. Yellow	Regulation	Asia, Europe, Consumer, Extended Producer Responsibility (EPR), Legislation, Manufacturer, Principle, Producer, Regulation
	E-waste impacts	China, Electronic waste, Electronic equipment, Hazard, Health impact, Human health, Import, Management practice, Precious metal, Toxic material, Waste Electrical and Electronic Equipment (WEEE) management

analysis (Figure 7) for the qualitative content analysis. Guided by the 15 research themes obtained from the text mining analysis (Table 2), we conduct an in-depth content analysis of these 100 publications. As a result, we synthesize the inclusion studies in the field of CE into seven areas of academic contribution and 22 research topics within five dimensions of inclusion. This section will introduce the specific content of each aspect and topic in detail.

4.3.1. Informal waste pickers (IWPs)

Among the inclusion studies in the field of CE, IWPs, especially in developing countries, have received a lot of attention due to their significant contribution to the global waste value chain and the unequal treatment they receive. Related research has focused on the economic and social dimensions of inclusion, including securing livelihoods, work security, social stigma and children, elderly and women rights.

4.3.1.1. Securing livelihoods.

A group of studies focused on the large number of self-employment opportunities that waste-picking activities provide for developing countries (Gutberlet 2008; Khan 2018). In Brazil, 500,000 IWPs make a living by recycling aluminum (Schröder et al. 2019); in Cairo, 70000 Zabaleen families sustain their livelihoods by recycling waste in the city (Fahmi and Sutton 2010); in China, 6 million IWPs are active in 'urban mines' collecting waste in exchange for basic necessities (Fei et al. 2016). People from marginalized groups who are poor, less educated or physically disabled find shelter in waste collection centers and work on waste disposal (Papaoikonomou et al. 2009).

4.3.1.2. Work security.

Most of the IWPs lack legal employment security, resulting in monthly incomes far below the social average, working hours and intensities that exceed health loads, and poor working conditions (Wilson et al. 2006). Many IWPs have experienced a variety of occupational health hazards, including respiratory diseases, skin diseases, kidney and liver problems, cuts, burns and fractures, and mental illness (Zolnikov et al. 2018). With the reform of waste management policies and the updating of relevant high technologies, the scaled-up waste management industry has progressively excluded IWPs (Suthar et al. 2016), which puts them at risk of losing their income (Rouse 2004; Rankokwane and Gwebu 2006).

4.3.1.3. Social stigma.

The contribution of IWPs to solid waste management is not recognized by the public due to a lack of publicity (Nzeadibe and Ajaero 2011). (Binder and Mosler 2007) examined the impact of the official discourse on the marginalization of IWPs and the resulting social injustice. Structured interviews revealed that IWPs are often stigmatized due to their profession being associated with environmental pollution (Yousafzai et al. 2020) and crime (Radulovic 2018). This further contributes to the difficulty for IWPs to gain social acceptance and recognition and therefore to connect to social networks that can support their personal development (Chikarmane 2012; Omokaro 2016).

4.3.1.4. Children, elderly and women rights.

In developing countries, scavenging is the main means by which many children and older people obtain the basic necessities of life (Ferraz and Gomes 2012). However, their access to the most valuable recyclables is limited due to poor mobility and bargaining power (Adamo 2014). Being overlooked by the municipal solid waste management (MSWM) also increased their vulnerability (Hunt 1996). In terms of gender equity, research shows that the socio-political space of the waste economy tends to be dominated by men (Nzeadibe and Adama 2015) and traditional socio-cultural and physical differences result in women being disadvantaged in waste disposal activities (McAllister et al. 2014).

4.3.2. E-waste and health risks

The rapid development and iterations of Information and Communication Technologies (ICTs) have enabled more and more people to have access to electronics and to replace them frequently, resulting in e-waste becoming the fastest growing waste stream in the world (Umair et al. 2016). Relevant literature focuses on the social and environmental dimensions of inclusion, including direct heavy metal exposure, air/water/soil emission, and energy consumption.

4.3.2.1. Direct heavy metal exposure.

During the recycling and dismantling of e-waste, workers are directly exposed to various hazardous substances, especially heavy metals (Puangprasert and Prueksasit 2019; Awere et al. 2020). E-waste handlers are more likely to develop cancer than the general population due to arsenic exposure (Yang et al. 2020) and dioxin-like compound (DLC) exposure (Dai et al. 2020). Residents living near e-waste disposal facilities, especially children, have higher concentrations of heavy metals in their hair than children living in non-exposed areas (Soetrisno and Delgado-Saborit 2020), and their exposure to lead, cadmium and mercury is likely to have an impact on their cognitive abilities (Kim et al. 2020).

4.3.2.2. Air/Water/Soil emission.

Hazardous chemicals can escape into the environment as a result of informal and non-standard e-waste recycling activities (Zeng et al. 2016). (Zeng et al. 2020) demonstrated that in areas where long-term e-waste disposal takes place, the concentration of heavy metals in soil and water is higher than the safety limit. (Zheng et al. 2016) found that in areas where the waste dismantling communities are located, the PM2.5 value and average metal concentration in the air are higher than normal. Due to the pyrolysis process of electronic component recycling, the entire industrial area where the e-waste recycling plant is located is covered with deposits of toxic metals (Chakraborty et al. 2016).

4.3.2.3. Energy consumption.

Compared to primary mining, e-waste recycling expands the efficient reuse of minerals and metals, including gold, copper, platinum and various rare earth elements (Gollakota et al. 2020). However, the dismantling, transportation and smelting of e-waste is currently an energy-intensive industry (Patil and Ramakrishna 2020). Waste electronics are mechanically shredded and transported to smelters, where metals are extracted at high temperatures, generating large amounts of carbon dioxide gas and toxic exhaust gases (Gall et al. 2020). Therefore, how to improve the accuracy and efficiency of e-waste recycling to reduce energy consumption is also a hot topic of current research (Raghupathy and Chaturvedi 2013).

4.3.3. Accessibility of services/materials/facilities

Waste collection service is to collect solid waste from the point of disposal and transfer it to the point of treatment or landfill (Wang et al. 2008). People have different access to relevant services/materials/facilities due to the resources they possess, which affects the efficiency and inclusiveness of waste management systems. Related research has focused on the spatial and social dimensions of inclusion, including the accessibility of waste collection points, waste transfer tools and recycling facilities for impaired people.

4.3.3.1. Waste collection points.

The insufficient number of formal collection points leads to negative attitudes towards waste management among residents (Wekisa and Majale 2020) and contributes to the formation of informal collection points that affect environmental sanitation and the health of residents (Ackah 2017). Empirical quantitative research in South Africa has shown that regular street-side collection has the potential to overcome temporal and spatial barriers to residents' access to waste services (Strydom 2018). A case study of Brazil proves that the siting and maintenance of formal waste collection points is important to increase the spatial inclusion of MSWM (Zolnikov et al. 2018).

4.3.3.2. Waste transfer tools.

Several case studies from developing countries have focused on the spatial exclusion of IWPs and residents due to the lack of effective waste transferring tools. Some recyclers are forced to use 'free ride' to transfer recyclable waste and are therefore inefficient and lack independence (Kasinja and Tilley 2018). IWPs and low-income residents have to use trolleys to transport their waste, with high time cost and physical effort (Chikowore and Kerr 2020). In this context, studies have worked on developing simple tools to assist recyclers in transporting waste to improve accessibility, such as motorized waste collection tricycles that can navigate narrow roads (Stern et al. 1997).

4.3.3.3. Recycling facilities for impaired people.

People with disabilities face additional difficulties in participating in the CE activities. Related inclusion research discusses the barriers to recycling facilities for people with disabilities and inclusive design to improve these facilities. For example, the lack of assistive design has resulted in people with impaired vision being unable to use recycling bins in public areas (Siu 2013). Some recycling facilities have entrance controls and steps that turn away people with mobility impairments (Karagiannidis et al. 2008). (Clarkson et al. 2013) suggests directions for the design of public recycling bins and related facilities to accommodate diversity while maintaining equity for all.

4.3.4. Consumer behavior

Consumers directly participate in the three main stages of the product lifecycle: purchase, use, and waste disposal. Thus consumer behavior has a direct impact on the success of CE initiatives and their economic and social inclusion (Parajuly et al. 2020). Relevant research has focused on the following topics: CE awareness and education, household recycling behavior, and willingness to pay for waste treatment.

4.3.4.1. CE awareness and education. A key element in developing inclusive CE initiatives is to consider differences in residents' CE awareness in different regional and cultural contexts (Ferronato et al. 2017). Several studies have examined consumers' willingness to purchase products made by recycled materials (Biswas and Roy 2016), households' attitudes towards waste reduce and classification (Zondi and Telukdarie 2017), and consumers' awareness of CE regulations and schemes (Ramzan et al. 2019). (Afullo 2015) found that public education is essential for direct household involvement in community waste treatment. (Jalil et al. 2014) proved that CE education could promote public participation in and benefits from CE transition, thereby increasing the social inclusion of CE transition.

4.3.4.2. Household recycling behavior. In recent years, the focus of research has shifted from means of raising CE awareness to methods that can bring about behavioral change. Household recycling behavior is influenced by population density, distance from residence to waste collection points, car ownership, weight of waste and economic incentives (Manomaivibool and Vassanadumrongdee 2012). (Wang Z et al. Wang et al. 2016; Ma et al. 2018) analyzed the factors that stimulate residents to engage in waste recycling, including: environmental education, the financial and time cost of recycling activities, and regulation. Related research in the UK (Timlett and Williams 2008) suggests that door-to-door services, incentives and personalized feedback are highly effective in increasing household participation in waste recycling and reducing.

4.3.4.3. Willingness to pay for waste treatment. Households paying for waste disposal services can increase the financial sustainability of the service providers, thus increasing the economic inclusion (Abdulredha et al. 2020). (Islam et al. 2016) investigated residents' willingness to pay for waste disposal services in different regions, and the results showed that the percentage of people willing to pay is 10% in Bangladesh, 10% in China (Liu et al. 2006) and 39% in Nairobi (Afullo 2015). (Song et al. 2019) revealed that the higher the respondent's income, the stronger the willingness to pay, while the effect of education level is not significant.

4.3.5. Corporate and institutional involvement

Manufacturers, cooperatives, community-based organizations (CBOs) and NGOs contribute to the economic, social and environmental inclusion of CE by investing technology and knowledge in the clean production of products and the sound treatment of waste. Relevant research has focused on the following topics: Corporate Social Responsibility (CSR), formation of cooperatives, micro-enterprises, NGOs and CBOs.

4.3.5.1. Manufactures and CSR. Several studies have analyzed how the source of products – manufacturers – incorporate the concepts of CE and CSR in their business operations, including technological innovation (Daú et al. 2019), public engagement (Foroudi and Palazzo 2021), brand reputation (Donato et al. 2019) and self-evaluation of environmental impact (Jurišová 2019). The majority of CSR activities in studies focused on product packaging (Stewart and Niero 2018) and end-of-life management of products (Faccio et al. 2014), followed by circular product design (Mestre and Cooper 2017), business models (J-C et al. 2020) and employment conditions (Di Tullio et al. 2018).

4.3.5.2. Formation of cooperatives. A number of cases in developing countries have examined the role of waste disposal cooperatives in improving economic and social inclusion. On the one hand, these cooperatives formed by IWPs can offer IWPs better work security and reducing occupational discrimination and health hazards (Uddin and Gutberlet 2018). On the other hand, cooperatives have greater bargaining power in the market and are able to undertake larger-scale recycling activities (Tremblay et al. 2010; Moggi et al. 2018). Importantly, the formation of cooperatives enables dialogue between IWPs and the local administrations, facilitating the development of knowledge-sharing networks between formal and informal waste management systems (Terazono et al. 2012).

4.3.5.3. Private waste traders, CBOs and NGOs. The complementary waste services provided by micro-enterprises and non-profit organizations have attracted the attention of many scholars. With CBOs' networking and NGOs' knowledge support (Snel 2001; Tukahirwa et al. 2011), small private waste traders can provide low-cost collection services for household waste, increasing the coverage and efficiency of community waste services (Gutberlet et al. 2016) and providing employment opportunities for the local poor (Toole and van der Ree 2004). What cannot be ignored is that private waste traders, CBOs and NGOs may be excluded by existing local recycling business (Rogerson 2001) and challenged by policy changes (Tilaye and Van Dijk 2014) due to conflicting interests or philosophies.

4.3.6. Technology application

Emerging Internet and information technologies have significant advantages in data collection and analysis. By analyzing and optimizing production, consumption, recycling activities on the supply chain, the economic and social inclusion of the CE transition process could be improved. Relevant research has focused on the following topics: data access and analysis, waste trading platform, and knowledge sharing networks.

4.3.6.1. Data access and analysis. The application of ICTs, Big Data, Internet of Things (IoT) and Geographic Information System (GIS) in the field of supply chain management has contributed to the formation of the smart recycling systems (Xue et al. 2019). Researchers in China conducted studies on start-ups engaged in smart recycling and found that they have advantages in data collection of trade and logistics (Silva de Souza Lima and Mancini 2017). Advanced Internet technologies are used to analyze the flow of funds, information and products of informal activities to provide data support for their formalization (Kawai et al. 2012).

4.3.6.2. Waste trading platform. Several studies have worked on the application of web-based cloud technologies to make the waste trade more efficient and fair (Tao and Xiang 2010; Zhu et al. 2020). (Taslim et al. 2018) show that online auction platforms for recyclables with transparent prices, ease of use and security can help stimulate more users to participate in waste recycling. By establishing a trading platform to dynamically compare data on the supply and demand of construction waste in different regions, (Lu et al. 2020) provides an optimized solution for the transportation and trading of construction waste.

4.3.6.3. Knowledge-sharing networks. Documenting and sharing the skills and experiences gained by different stakeholders in the supply chain is essential to improving the efficiency and inclusiveness of supply chain management (Gutberlet 2008). Research has shown that the use of instant messaging, portable video devices and web-based communication platforms facilitates the creation of knowledge-sharing networks between the informal and formal sectors, improving urban managers' knowledge of the composition of municipal waste (Wilson et al. 2012), the pricing of informal trade channels (Sim et al. 2013) and optimized collection routes (Ramos et al. 2013).

4.3.7. Governance measures

Governments guide and regulate the activities of citizens through different institutional relationships in order to maximize the public interest, influencing political and economic inclusion in the practice of CE (Gutberlet 2015). Relevant research has focused on the following topics: laws and regulations, performance monitoring, and pluralist decision-making.

4.3.7.1. Laws and regulations. Laws and regulations restrict the actions of actors in the supply chain. Studies have pointed out the centrality of EPR in most CE-related policies and legislation (Akenji et al. 2011). EPR motivates manufacturers to use cost-optimized methods that are consistent with environmental standards and human health (Salhofer et al. 2016). Related studies have also explored the impact of green taxes and financial subsidies on consumers and recycling companies. Examples include carbon taxes, noise taxes, fuel efficiency taxes (Ferrara 2003) and financial subsidies to help recycling companies purchase modern equipment (Streicher-Porte and Yang 2007) and upgrade recycling technologies (Adanu et al. 2020).

4.3.7.2. Performance monitoring. (Bringhenti et al. 2011) has demonstrated that performance monitoring plays an important role in achieving circular and inclusive goals. Research in this topic focuses on three areas: first, the selection of processes in the supply chain to be monitored, such as produce, use, recycle and disposal (Wilson et al. 2015); second, the selection of evaluation indicators, including cost, scale, operations, environmental impact and social impact (Santiago and Dias 2012); and third, the improvement of techniques and methods for performance evaluation, such as the social life cycle assessment and material flow analysis (Aparcana and Salhofer 2013).

4.3.7.3. Pluralist decision-making. Decision-making on CE-related policies and projects is a process that involves and affects all stakeholders (Borthakur 2015). Pluralistic decision-making is critical in improving the political inclusion by analyzing all stakeholders and their ways to participate (Joseph 2006), identifying factors influencing decision-making on MSWM

(Garnett and Cooper 2014), developing the frameworks for decision-making (Garnett et al. 2017), and encouraging community participation in decision-making (Louise Bjerkli 2013). (Dos Muchangos et al. 2017) found that complex stakeholder networks and political contexts in developing countries posed obstacles to the implementation of pluralistic decision-making.

4.4. A synthesis of inclusive CE aspects inside the sociosphere

Based on the survey of the literature, we identified the key actors and facilities in the formal and informal sectors, and the interactions between them, as well as how they are influenced by contextual factors (see Appendix). We found that while existing research has provided a broad understanding of actors, but more on an individual level, the debate on how to motivate them as a system to achieve CE is absent. Moreover, much of the literature describes the sociosphere as a passive field affected by the CE transition, but lacks reflection on the way in which the sociosphere can become an enabler to prevent trade-offs with social interests.

To see how different actors play a role in practicing different CE strategies, we have looked at (Kirchherr et al. 2017) and drew lessons from the way they categorize and define aims and enablers of CE, such as 'the CE concept largely neglects (the aim of) social equity' (p. 227) and 'the consumer is the most central enabler of circular business models' (p. 228). These points are confirmed in our literature review and fit our arguments equipped with SS. Therefore we applied the concept of SS and CE strategies to develop a model of inclusive CE to show how the sociosphere acts as a communicating barrel between the natural environment and the economic pursuits of actors (see Figure 9). This model can serve as an analytical framework to understand the mechanism of how sociosphere practice CE principles in an inclusive manner, which will be further explained as follows.

In the conceptual model, the econosphere is a subset of the sociosphere, and that the sociosphere is embedded in the biosphere. This nested structure enables a systemic view of CE transition. It illustrates how the informal and formal sectors in sociosphere can be equipped to accommodate the CE strategies.

The econosphere is a social domain that emphasizes the economic activities including production,

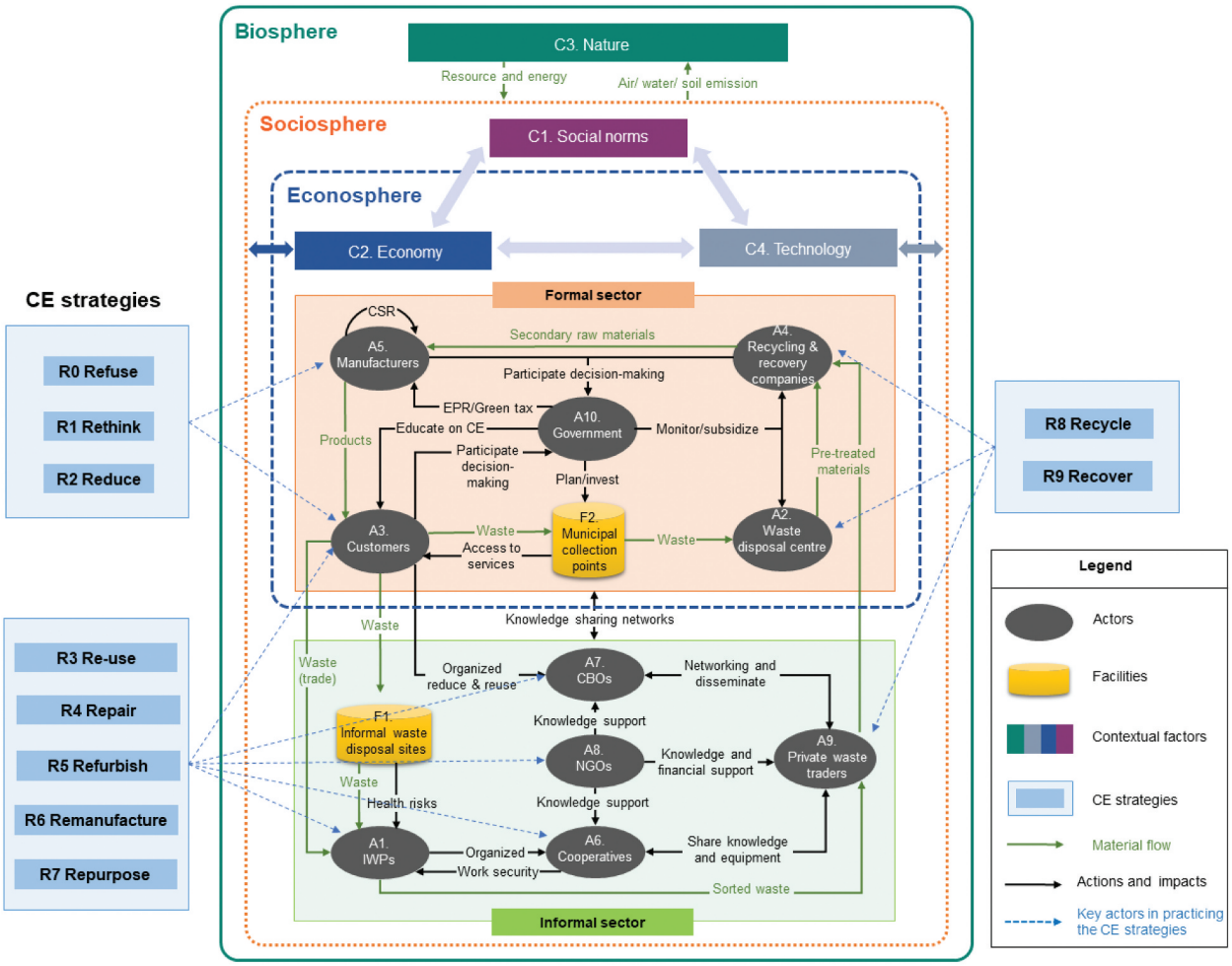

Figure 9. A conceptual model to sketch an inclusive CE system.

consumption, and accumulation (Nations et al. 2003). There are five main actors that form the formal sector in the econosphere: (i) Manufacturers are at the front end of the supply chain, producing products from natural or secondary raw materials. They are often influenced by policies (e.g. EPR) and market rules to change their business strategies (e.g. CSR) to accommodate CE initiatives. (ii) Consumers are involved in CE by purchasing products and disposing of waste, and their behavior is mainly influenced by their income, CE awareness, and the accessibility of CE-related products and services. (iii) Waste disposal centers are responsible for collecting, sorting and pre-treating waste from municipal waste collection points. They are usually planned, built and supervised by municipalities to provide waste management services and create jobs in the city. (iv) Recycling and recovery companies use recyclable materials from waste to produce by-products and safely dispose of the waste. They are decomposers in the waste system, important for closing the supply chain loop, and are often supported by policies and subsidies. (v) State and local governments are responsible for developing laws and regulations that facilitate the CE transition, planning and investing in infrastructure, and monitoring, subsidizing, and evaluating CE programs. Stakeholders are involved in governance in the form of participating in decision-making process of CE-related policies.

The sociosphere is an area where the actors can share understandings, rules, and principles (Galligan 2006), regarding the CE activities. Except the institutionalized formal sector, there are five main actors are active in informal sector: (i) IWPs are often exposed to social exclusion such as livelihood risks, health risks and social stigma. (ii) Cooperatives are formed by IWPs with the help of NGOs and other organizations to develop larger and safer waste trading activities. The formation of cooperatives can provide job security for IWPs and facilitate the development of knowledge-sharing networks between the formal and informal sectors. (iii) Private waste traders are micro-enterprises or individuals who collect and pre-process waste from IWPs and consumers. They provide third-party recycling services outside of MSWM and receive technical or financial support from CBOs, NGOs, and cooperatives. (iv) CBOs represent the rights and needs of consumers, participate in policy development and evaluation of CE programs, and promote community-based CE projects by conducting networking and dissemination activities. (v) NGOs share knowledge of CE with other actors in both formal and informal sectors, and provide policy advice and business strategies to governments and companies that are consistent with CE principles to promote efficient, scaled-up CE initiatives.

The CE activities in sociosphere involve social norms, technology, economy, and nature as main contextual factors. (i) Social norms constitute a common belief of all actors, like CE and inclusion, which can stimulate actors to participate and cooperate towards unified goals. Trust and understanding are critical to establishing and maintaining information communication and knowledge sharing between formal and informal sectors. Consensus on social norms can be promoted through education and dissemination. (ii) Innovative technologies unlock more possibilities for closing the loop and increasing inclusiveness by offering significant advantages in terms of increased data accessibility and information transparency. Based on emerging technologies, cost-efficient web-based waste trading platforms and CE knowledge dissemination networks enable more people to understand and participate in and benefit equitably from the CE transition. (iii) The economic environment, such as the regional and global economy, has an impact on consumer behavior and manufacturers' motivation to implement the CE framework. Market preferences for environmentally friendly products contribute to the development of CE-related industries, creating jobs and economic benefits. (iv) Nature refers to all non-human-made environments in the biosphere. The sociosphere interacts with biosphere through material exchange, i.e. resource and energy extraction and air/water/soil emissions. The deterioration of natural conditions prompts actors in sociosphere to take measures, such as governments adjusting environmental laws, manufactures applying low-emission technologies, and cooperation between actors in undertaking natural regeneration initiatives (e.g. local composting).

5. Discussion

In the previous chapter, the conceptual model of an inclusive CE system (Figure 9) has been visualized and explained. In connection to the literature found and the SS viewpoint, it synthesizes key contributions that we have noted still missing in the scholarly debate. Specifically, the existing research on inclusive CE focuses more on an individual level, without considering how to organize different actors as a whole to drive CE transition, rather than being passively affected by CE transition. In this section we discuss the way to elevate the debate through the subversive view of SS and propose a research agenda for implementing inclusion in CE.

First, we note that the SS viewpoint exerts that society is actually not a tradable component in a broader sustainability transition, but it acts as a communicating barrel between the natural environment and the economic pursuit of actors. This is an important point to reassert into the sustainability transition, because both the Brundtland report (Cassen 1987) and the SDGs from the UN (U.N. 2015), already mentioned the importance of

a people-cantered transition. Specifically, they emphasize that achieving sustainability outcomes requires the active participation of all the different groups in society pursuing this goal. The criticism that we arrive at, is the fact that CE seems to have ignored the role of people (Padilla-Rivera et al. 2020; Schröder et al. 2020; Mies and Gold 2021), something which these landmark documents actually emphasized. With its clear scoping of the sociosphere at the centre and its interrelations to the biosphere and the econosphere, the framework clearly zooms in at the core function of the sociosphere to be a communication barrel in line with the SS viewpoint (Neumayer 2013). This basically means that the sociosphere is an area of activity where actors unite and share understandings, rules and principles (Galligan 2006). The conceptual model thereby positions these activities to help in overcoming the shortfall of CE as noted by recent scholars (Schröder et al. 2019; Corvellec et al. 2022).

Second, looking closely at the inner workings of the sociosphere, its role as a communication barrel become clearer. In effect, it appears to be shaped by actors with their interactions during the transition. With the description of the sociosphere of (Galligan 2006) in mind, the study revealed that this composition can be viewed as a set of organs of the system that can and should be positioned to effectively carry economic measures with a positive environmental impact. In so doing, it become clear that the configuration of actors in the sociosphere is actually a tool to make the transition more effective. The framework proposes that in order for the society to be strengthened, a few elements need to change. First, a mindful integration between the formal and informal sector are warranted. Second, for these sectors to integrate, some conditions need to be recognized (e.g. people's awareness, willingness, capabilities and organization) and met by all actors. The conceptual model elaborates on how components of the system need to interact to be well

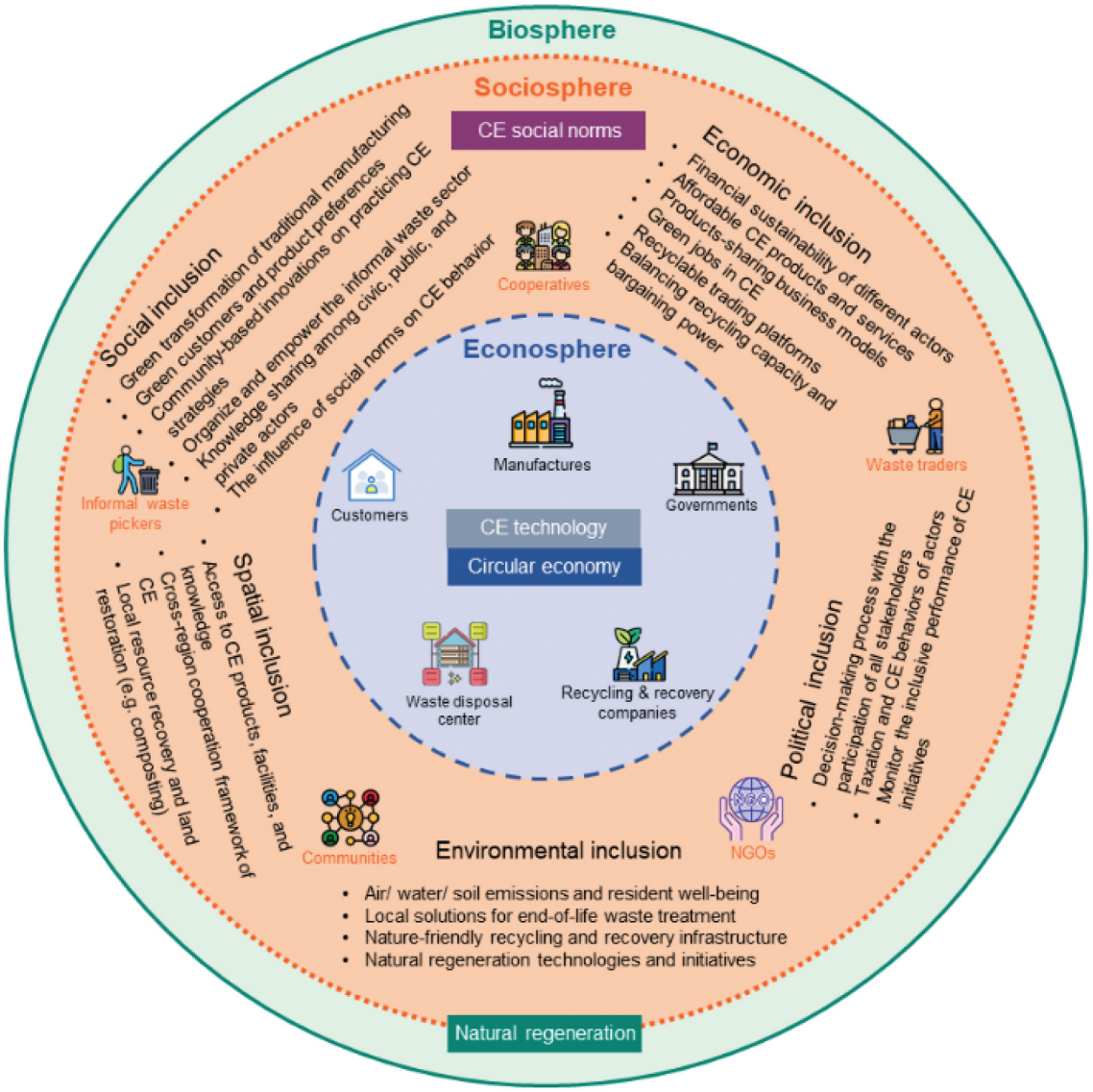

Figure 10. Research agenda for implementing inclusion in CE.

prepared for a CE transition. A further quantification of these components can then give direction to the changes needed.

Third, as noted previously the conceptual model provides clear outline of conditions by which the system needs to change. Thereby it opens up the possibility to give a clear direction for this change. This is where quantification of inclusiveness and circularity need to be defined. Previous work proposed some stand-alone indicators to describe parts of the sociosphere (Padilla-Rivera et al. 2020; Schröder et al. 2020; Mies and Gold 2021). However, following the SS perspective, the conceptual model suggests that these indicators should actually be synthesized to direct a systematic change, rather than changes informed by a single indicator. The systematic change, if applied with help of quantified indicators, is proposed to then better prepare society for a CE transition. The indicators can then map the required conditions for this in the shape of actors that need to act in resource flows and need to share knowledge to one another purposefully. This provides a basis for developing a quantification and direction for a well-equipped society in a CE transition.

Therefore, we can use the conceptual model to identify the knowledge gaps still existing in the use of inclusion in CE. Based on the above perspectives, we here again apply the five-dimensional framework of inclusion in CE (Table 1), culminating in a list of 22 inclusive CE research themes that urgently need attention in CE practices (Figure 10).

6. Conclusions

In the context of finite planetary resources and climate change, many policy makers and researchers have identified the CE transition as a central strategy for realizing SDGs. Based on the SS model, we believe that only by mobilizing as many actors as possible within the sociosphere to adapt and promote an inclusive CE transition can we truly contribute to people-centered sustainable development. This study conducted a critical literature review with both quantitative and qualitative approaches on a total of 500 journal articles and books to create a comprehensive view of CE transition through the lens of inclusion.

The contribution of this study is threefold. First, as the first study to investigate how to manifest the sociosphere in the CE transition through the lens of inclusion, we described the evolution of the literature in the field over time and identified the main publications and academic collaboration networks. It shows that inclusion research in the context of CE first received academic attention in 1984 and developed rapidly after 2010. China, the United States, India, Japan and European countries have established a good international cooperation network in this research field.

Second, by identifying key actors involved in CE transition and structuring their interrelationships as an inclusive system, it enables a comprehensive understanding of the role and mechanism of human interaction in promoting the transition. The experiences of developing countries particularly highlight the actors that have been overlooked in the policy decision-making process, like the IWPs, cooperatives, private waste traders, CBOs and NGOs in the informal sector. They make up for the neglected links in government- and business-led CE initiatives, especially small-scale community-based waste utilization, waste separation, and waste recycling, through spontaneous, bottom-up CE initiatives. Knowledge sharing and collaboration between the informal and formal sectors in different regions, is critical to addressing the challenges in the CE transition. With these insights provided in the conceptual model of the inclusive CE system, this study has enabled future research to systematically analyze aspects of inclusion during CE transitions.

Third, as an extension of the research gaps revealed by the preceding analysis, we organize and propose a research agenda with the aim of sorting out the most pressing and critical research topics in the field to encourage researchers and all the stakeholders to actively engage in and jointly promote the inclusive CE transition. For researchers, we need to develop frameworks and indicators to assess inclusiveness and circularity, as well as model and simulate stakeholder behavior and the impact of contextual factors on the socioeconomic system in the CE transition. Meanwhile, it is also important to address potential exclusion in practice and to propose solutions from a technical and institutional innovation perspective, in collaboration with traditional manufacturing and recycling industry practitioners. Additionally, we need to provide policy recommendations on formulating inclusive regulations and performance evaluation metrics to guarantee the equitable distribution of resources and benefits among stakeholders during the development of new industries in CE. At the global scale, we also emphasize the importance of international cooperation in improving regional inequalities in the CE transition.

This study has certain limitations. First, we only considered English-language literature in academic databases. In future study, news reports and government reports in different languages could be collected to enrich the sample of literature. It will also enable the detailed analysis of the differences and commonalities in the research aspects that each country focuses on in this field. Second, we selected searching keywords based on our observations of current research on inclusion in CE, which emphasizes the main research components of the field, namely 'circular', 'recycle' and 'waste'. With the development of this field, future research could further examine in detail how the concept of inclusion is reflected in each aspect of the '10 R

principles' of CE. Finally, we developed a conceptual model that sketches an inclusive CE system in cities, but it only qualitatively described the actions and impacts between two pairs of actors. Subsequent studies can simulate the interactions and cumulative impacts between multiple actors through System Dynamic modeling or Agent-Based Modeling. Combined with quantitative indicators of inclusiveness and circularity, it can quantify the systemic impact of different CE activities and contextual factors on the circularity and inclusiveness of the CE transition.

List of abbreviations

BLR	Bibliometric literature review
CBO	Community-based organization
CE	Circular economy
CSR	Business model and corporate social responsibility
DLC	Dioxin-Like Compounds
EPR	Extended Producer Responsibility
GIS	Geographic Information System
ICT	Information and Communication Technology
IoT	Internet of things
IWP	Informal waste picker
MSWM	Municipal Solid Waste Management
NGO	Non-governmental organization
NLP	Natural Language Processing
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SDGs	Sustainable Development Goals
SS	Strong Sustainability
WEEE	Waste Electrical and Electronic Equipment

Disclosure statement

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Appendix

Ten types of actors are marked as A1 to A10, two types of facilities are marked as F1 and F2, and four contextual factors are marked as C1 to C4. The order of the numeric labels depends on the order in which the element is recognized in the table below.

Areas of academic contribution	Dimensions of inclusion	Research topics	Identified actors, facilities, and contextual factors*	Actions and impacts	Representative sources
IWPs	Economic and social	Securing livelihoods	A1. IWPs C1. Social norms C2. Economy	A1→C2, Job creation	(Gutberlet et al. 2009; Fahmi and Sutton 2010; Fei et al. 2016; Schröder et al. 2019)
		Work security		A6→A1, Work security	(Moggi et al. 2018; Uddin and Gutberlet 2018)
		Social stigma		C1→A1, Social stigma	(Nzeadibe et al. 2010; Radulovic 2018; Yousafzai et al. 2020)
		Children, elderly and women rights			
E-waste and health risks	Social and environmental	Direct heavy metal exposure	C3. Nature F1. Informal waste disposal sites	F1→A1, Health risks	(Awere et al. 2020; Dai et al. 2020; Yang et al. 2020)
		Air/water/soil emission		F1&F2→C3, Air/water/soil emission	(Chakraborty et al. 2016; Zheng et al. 2016; Zeng et al. 2020)
		Energy consumption		C3→A4&A5, Resource and energy	(Raghupathy and Chaturvedi 2013; Gall et al. 2020; Patil and Ramakrishna 2020)
Accessibility of services/ materials/ facilities	Spatial and social	Waste collection points	F2. Municipal collection points A2. Waste disposal center	A10→F2, Plan/invest	(Ackah 2017; Wekisa and Majale 2020)
		Waste transfer tools		F2→A3, Access to services	(Karagiannidis et al. 2008; Strydom 2018; Zolnikov et al. 2018)
		Recycling facilities for impaired people			
Consumer behavior	Economic, social and spatial	CE awareness and education	A3. Customers A4. Recycling and recovery companies	A10→A3, Educate on CE A5→A3, Customers rethink and refuse certain products	(Jalil et al. 2014; Afullo 2015)
		Household recycling behaviour		C1→A3, CE awareness	(Biswas and Roy 2016; Zondi and Telukdarie 2017; Ramzan et al. 2019)
		Willingness to pay for waste treatment			
Corporate and institutional involvement	Economic, social, environmental	Manufactures and CSR	A5. Manufactures A6. Cooperatives A7. CBOs A8. NGOs A9. Private waste traders	A5→A5, CSR	(Stewart and Niero 2018; Yuan et al. 2014; Jurišová 2019)
		Formation of cooperatives		A1→A6, Organized	(Nzeadibe et al. 2010; Terazono et al. 2012)
		Private waste traders, CBOs and NGOs		A3→A7, Customers are organized by communities for reducing and reuse	(Toole and van der Ree 2004)
				A7→A9, Networking and disseminate	(Snel 2001; Gutberlet et al. 2016)
				A8→ A6&A7&A9, Knowledge or financial support	(Snel 2001; Tukahirwa et al. 2010)
				A6→A9, Share knowledge and equipment	(Terazono et al. 2012)
Technology application	Economic and social	Data access and analysis	C4. Technology	C4→all actors, Data access and analysis	(Kawai et al. 2012; De Souza Melaré et al. 2017; Xue et al. 2019)
		Waste trading platform		C4→all actors, Improve efficiency and fairness	(Tao and Xiang 2010; Taslim et al. 2018; Zhu et al. 2020)
		Knowledge-sharing networks		Among all actors, Knowledge-sharing networks	(Gutberlet 2008; Wilson et al. 2012; Sim et al. 2013)
Governance measures	Political and economic	Laws and regulations	A10. Government	A10→A5, EPR/Green tax	(Ferrara 2003; Akenji et al. 2011; Salhofer et al. 2016)
		Performance monitoring		A10→A2&A4, Monitor and subsidize	(Streicher-Porte and Yang 2007; Santiago and Dias 2012; Wilson et al. 2015)
		Pluralist decision-making		A3&A4&A5→A10, Participate decision-making	(Joseph 2006; Garnett and Cooper 2014; Garnett et al. 2017)

Note: *Actors are marked as An; facilities are marked as Fn; contextual factors are marked as Cn (n=1,2,3 . . .).