Journal of Environmental Science and Engineering A 13 (2024) 136-150
doi:10.17265/2162-5298/2024.04.004

The Integration of Circular Economy and Impact Assessment: A Bibliometric Analysis

Marina Morhy Pereira and Marcelo Montaño
São Carlos School of Engineering, University of São Paulo, São Carlos-SP 13563-120, Brazil

Abstract: In spite of the proximity between "CE (Circular Economy)" and "sustainability", it is relevant to consider that a circular strategy is not inherently sustainable or free from significant environmental and social impacts. Therefore, assessing the impacts of CE initiatives and the promotion of circularity in development projects submitted to IA (Impact Assessment) processes are crucial, though the relationship between both fields has not been yet systematically addressed. Hence, the present paper is focused on the identification of the links between IA and CE, based on the application of bibliometric techniques and Content Analysis. The outcomes revealed three thematic clusters in which significant overlaps were found: the 1st revealed LCA (Life Cycle Assessments) as the most used IA technique to assess the impacts of CE strategies, the 2nd encompasses climate change and environmental issues, and the 3rd cluster revealed that the integration of sustainability is the most frequent objective linking IA and CE, though characterized by different approaches. The findings allow concluding that IA fosters the transition to CE by assessing the impacts of circular initiatives and CE strategies can improve IA practice by making it more effective.

Key words: IA, CE, sustainability, bibliometric analysis.

1. Introduction

Although the terms "CE (Circular Economy)" and "sustainability" are commonly used interchangeably, a circular strategy is not necessarily a sustainable one [1]. The CE can be defined as an umbrella concept that addresses how humankind produces and consumes products and services, with the primary goal of adjusting the production-consumption system to meet environmental sustainability needs [2]. IA (Impact Assessment) is a process, that, as an output, produces information regarding a development's potential effects to enable decision-makers to consider their options [3], including decisions regarding CE policy implementations [4]. In this sense, the Environment Action Programme of the EU (European Union) [5] supports a move towards a CE and to achieve this goal the actions should be subject to IA where relevant [6]. Such as the CE, IA is also an umbrella term [7, 8]. The confusion between the terms "CE" and "Sustainability" is common because one of the main goals of the CE and IA is to promote sustainability [7, 9]. However, to truly promote sustainability, CE activities must first have their impacts assessed [10].

The need to assess CE activities comes from Weak Circular practices, those that do not lead to increased sustainability [11-14] thanks to the rebound effect and the Jevon paradox. The first occurs when technological advancement leads to an increase in energy consumption [15], while the second occurs when this new technology leads to an increase in material production because increased resource efficiency leads to an increase in the use of this resource rather than a decrease in use [16]. These findings suggest that the contribution of circular strategies to global environmental sustainability should be measured [17].

Because of the EC's problems in measuring and analyzing all of the impacts of projects due to the variables listed above [18], the IA is a tool that can help

Corresponding author: Marina Morhy Pereira, M.Sc. in Environmental Sciences, research field: environmental policy instruments.

CE efforts be more effective. This is because the IA is a technical and political process that provides accurate information, ensures that environmental problems are considered as early as possible, and, finally, the IA is legitimized primarily through public participation [19]. Assessing the impacts of CE actions is critical for their implementation, particularly in the public sector [20], but CE Environmental Impact Assessments are primarily concerned with waste, greenhouse gas emissions, and the use of virgin raw materials, with little or no regard for biodiversity loss [21]. In this sense, CE strategies can improve IA practice by making it more effective [22]. IA aids the transition to a CE by assessing the effects of circular initiatives and ensuring that there is no overexploitation of natural resources or additional manipulation of ecosystems.

To the best of our knowledge, the relationship between the fields of CE and IA has not been comprehensively addressed in the literature, hence the goal of this paper is: to investigate the possible connections between CE and IA. Thus, the main research question addressed in this paper is: What are the links between CE and IA concepts in academic literature? The secondary research questions are: What are the main themes where IA and CE intersect? (RQ1) When it comes to the overlapping where the themes intersect, do the patterns found hold for the papers that discuss CE and IA at the same time? (RQ2) This research should be viewed as a theoretical contribution to the CE and IA literature. A comparative bibliometric study was performed, which was supplemented by a qualitative investigation of the conceptual relationships discovered. In general, IA and CE were found to have occasional overlaps in three thematic groups: Life Cycle Analysis, Environment, and Sustainability. Each of them will be developed throughout this paper. By using bibliometric techniques on a representative sample of research papers about this disciplinary area, followed by a Content Analysis, this research seeks to close a knowledge gap in IA and CE by enhancing and supplementing the findings of previous studies that have described it from a more qualitative viewpoint.

2. Methods

Bibliometric analysis and content analysis methods were combined in this paper. Bibliometric analysis has a purpose in itself, but it also informed and guided the content analysis. Despite its ability to identify the most important papers, analyze their connections, and recognize changes in the intellectual framework of research disciplines [23], bibliometric analysis does not replace in-depth reading and content analysis [24]. To examine the retrieved data, the bibliometric study employed scientific mapping approaches (keyword and citation analysis, as well as bibliometric clustering). The leading eigenvector technique was chosen to group terms for the bibliometric grouping and is used to identify themes in which IA and CE present a strong connection. The outcomes from bibliometric analysis were then interpreted to identify the main areas shared by CE and IA. Content analysis was based on the most recent and cited papers that are part of both fields at the same time. Fig. 1 illustrates the research steps.

Data were gathered considering the period determined by the date of the first CE document, thus securing the possibility of an integrated debate with IA. The search was conducted within Scopus and Web of Science databases. For bibliometric analysis, papers with the terms “circular economy”, “impact assessment”, or both, in title, abstract, or keywords were considered of interest, which resulted in 68,477 publications published between 2001 and 2023.

Given the scarcity of publications that dealt with both CE and IA, the occurrences of keywords in papers that contained both terms (direct links) and keywords that happened frequently in only one of the terms (indirect connections) were examined. This method is useful since keywords are reliable indicators of conceptual linkages connected to the investigated discipline developed by the writers themselves to summarize their papers [25].

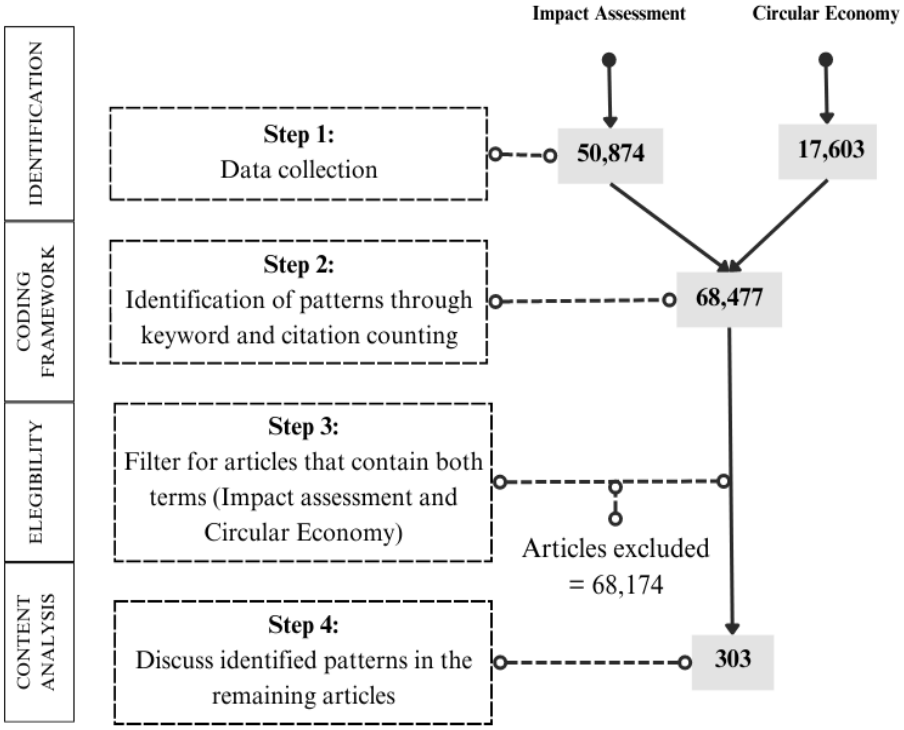

Fig. 1 Research steps.

Indirect links were taken into consideration if appeared in at least 15% of the documents. Furthermore, the frequency of scientific citations was tracked. Citations found most frequently within retrieved papers were counted to establish direct relationships between prominent publications in CE and IA literature. Citations that occurred in papers that exclusively discussed CE or IA were investigated to find patterns that would further guide a more focused content analysis. As with citation analysis, keywords found in papers solely about CE or IA were investigated to help guide the content analysis. Regarding the keyword analysis, the keywords that occurred in papers that exclusively discussed CE or IA were studied to guide the coding process and content analysis. Although bibliometric techniques are quantitative, they are employed to make assumptions about qualitative characteristics [26], allowing the identification of knowledge gaps, the generation of new research questions, and the positioning of the authors' intended contributions to the fields. Therefore, this paper also seeks to identify in the texts the thematic patterns identified through bibliometric analysis as well as the main areas that should be further explored in the literature.

3. Results

3.1 The Connection between IA and CE

IA literature (50,874 documents) was found almost three times the size of CE (17,603 documents). This is probably because IA is a mandatory instrument globally adopted [27], while CE principles are just at the beginning of their formal incorporation into public policies [28]. Less than 1% (303 studies) of the dataset represents the amount of the dataset that directly overlaps (IA and CE). The fact that there is only one percent of the studies that overlap the two fields shows the lack of studies specifically about the connection between CE and IA. The majority of these 303 documents were recently published, and 19 out of the 20 terms most frequently applied (see Table 1) appear in studies in both bodies of literature.

Table 1 Most common keywords in both CE and IA literature.

Rank	Keywords	Keyword count in the domain			
		IA+CE	CE	IA	IA and CE
1	circular economy	10,821	10,701 (98.89%)	120 (1.11%)	178 (1.64%)
2	life cycle assessment	3,902	869 (22.27%)	3,033 (77.73%)	107 (2.74%)
3	impact assessment	2,908	15 (0.52%)	2,893 (99.48%)	14 (0.48%)
4	environmental impact assessment	2,814	20 (0.71%)	2,794 (99.29%)	19 (0.68%)
5	sustainability	2,460	1,873 (76.14%)	587 (23.86%)	34 (1.38%)
6	recycling	1,292	1,189 (92.03%)	103 (7.97%)	19 (1.47%)
7	climate change	1,162	175 (15.06%)	987 (84.94%)	5 (0.43%)
8	environmental impact	1,040	159 (15.29%)	881 (84.71%)	15 (1.44%)
9	sustainable development	1,006	667 (66.3%)	339 (33.7%)	13 (1.29%)
10	health impact assessment	917	0 (0%)	917 (100%)	0 (0%)
11	waste management	773	680 (87.97%)	93 (12.03%)	17 (2.2%)
12	environment	450	147 (32.67%)	303 (67.33%)	4 (0.89%)
13	industrial ecology	386	279 (72.28%)	107 (27.72%)	12 (3.11%)
14	waste	369	329 (89.16%)	40 (10.84%)	3 (0.81%)
15	renewable energy	365	164 (44.93%)	201 (55.07%)	1 (0.27%)
16	social impact assessment	343	2 (0.58%)	341 (99.42%)	2 (0.58%)
17	air pollution	323	13 (4.02%)	310 (95.98%)	1 (0.31%)
18	reuse	315	296 (93.97%)	19 (6.03%)	6 (1.9%)
19	industry 4.0	302	289 (95.7%)	13 (4.3%)	3 (0.99%)
20	risk assessment	266	19 (7.14%)	247 (92.86%)	1 (0.38%)

Table 2 Top 10 author keywords with balanced (>15 %) appearances across CE and IA literature.

Rank	Keywords	Keyword count in the domain				
		IA+CE	CE	IA	IA and CE	Cluster
1	circular economy	10,821	837 (22.46%)	2,889 (77.54%)	104 (2.79%)	Sustainability
2	life cycle assessment	3,902	175 (15.06%)	987 (84.94%)	5 (0.43%)	LCA
3	sustainability	2,460	667 (66.3%)	339 (33.7%)	13 (1.29%)	Sustainability
4	climate change	1,162	117 (70.91%)	48 (29.09%)	1 (0.61%)	Environment
5	environmental impact	1,040	147 (32.67%)	303 (67.33%)	4 (0.89%)	LCA
6	sustainable development	1,006	279 (72.28%)	107 (27.72%)	12 (3.11%)	Sustainability
7	environment	450	164 (44.93%)	201 (55.07%)	1 (0.27%)	Environment
8	industrial ecology	386	99 (43.81%)	127 (56.19%)	3 (1.33%)	Sustainability
9	renewable energy	365	140 (46.2%)	163 (53.8%)	2 (0.66%)	LCA
10	agriculture	247	76 (30.77%)	171 (69.23%)	0 (0%)	LCA

The terms that are most frequently used in CE and IA literature fields with balanced appearances (>15%) are “Life Cycle Assessment”, “Sustainability”, and “Climate Change”. IA and the CE seem to have a strong connection to each other and this association may come from the fact that the LCA is the most widely used IA methodology for evaluating CE strategies. Regarding “Sustainability”, because it is the primary objective of both fields, it suggests a connection between the issues [7, 9]. IA and CE being connected by “climate change” (IA+CE), is also supported by theory in both areas separately. Climate change can influence the environmental effects predicted by IA predictive models for forecasting impacts [29] which has led to “climate change” being identified as an important research trend in IA for 2015, particularly for developed countries [30]. Because the CE concept is adaptable to a wide range of industries (including waste, energy, buildings, and transportation) and increased resource efficiency, it has the potential to effectively

deal with the issue of climate change [31].

Bibliographic coupling of author keywords was approached for thematic grouping (Fig. 2). Findings reveal the distinct emergence of three clusters: one centered on Sustainability, Sustainable Development, and Industrial Ecology; another on Climate Change and the Environment; and a third that encompasses primarily the terms "life cycle assessment', "environmental impact", "renewable energy" and "agriculture". The keywords "circular economy" and "impact assessment" were not taken into account for keyword analysis because they were search terms used to obtain the results being studied, which explains their appearance among the most cited words. The thematic areas where IA and CE are associated appear to be clearer when assessing keyword frequency, which is supported by thematic grouping and the examination of word frequency across literature fields.

The Directive 2008/98/EC of the European Parliament and of the Council of November 19, 2008, on waste and repealing certain Directives [32] is the only publication in the top ten most cited papers that is equally important (>5%) to both CE and IA fields (see Table 2). This may point to an existing connection between IA and CE that is about the potentialities existing within public policy, especially related to waste. Additionally, only half of the top-cited publications are also cited in papers that overlap the literature fields (IA and CE). It is noteworthy that just 12 of the 50 most cited documents have equal relevance to both fields. Only one of these 12 contained both the terms "impact assessment" and "circular economy" (IA and CE), whilst three of them were European Union Directives and one was ISO 14040 (the LCA standard procedure). The top 10 references (Table 3) as well as these 12 papers were taken into account for the content analysis because they could aid in understanding the previously discovered thematic pattern.

Since 2008, IA and CE have both attracted more attention (see Figs. 3 and 4). Following the 2008 financial crisis, CE appears to have gained momentum [33] and emerged as a viable way to change the capitalist-dominated economic system that had caused the crisis. Additionally, since the adoption of the "Circular Economy Promotion Law of the People's Republic of China" in 2009, much attention has been paid to achieving a CE at the corporate, inter-firm, and social levels [34]. Most recently, while China was the first country to implement the CE concept, the Ellen Macarthur Foundation was the first to become known

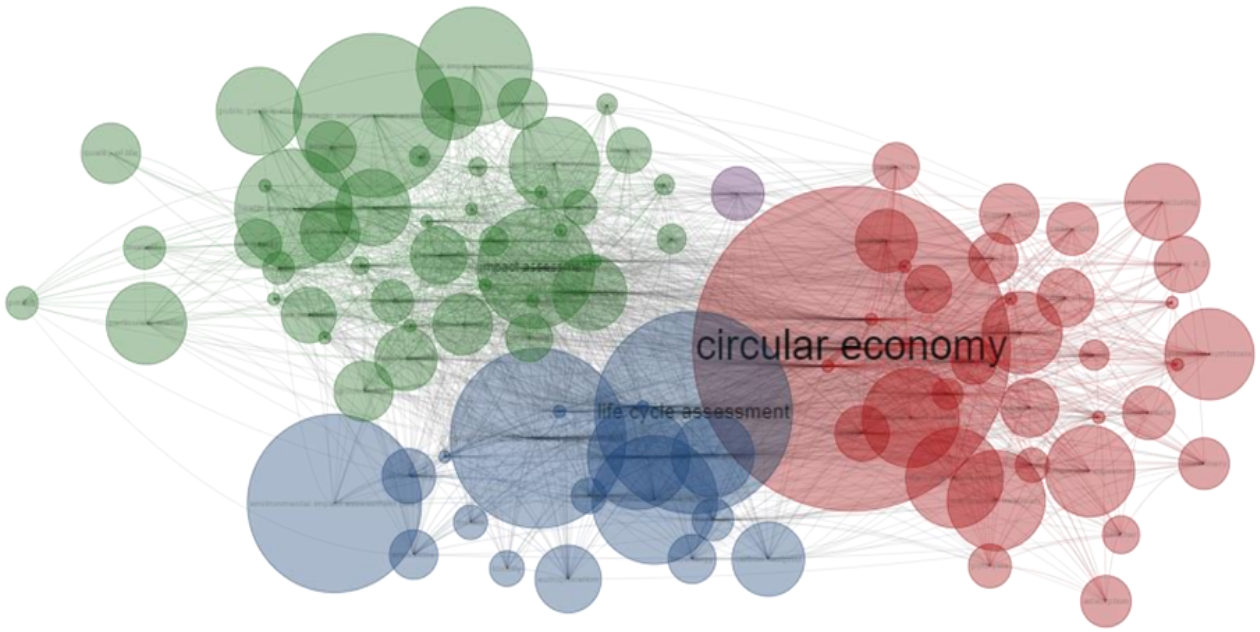

Fig. 2 Keyword network (Authors, 2023).

as a supporter of the idea in the UK in 2012, 2013, and 2014 [35]. The European EIA Directive revisions (2003 and 2009, and consolidation in 2011 [36]), as well as the Chinese Law on Environmental Impact Assessment of 2003 and Plan Environmental Impact Assessment Regulation of 2009 [37], appear to be important IA policies that coincide with the growth of IA production, particularly around 2012.

The ten most frequent terms in the CE literature include "sustainability", "sustainable development", "industry 4.0", and "industrial ecology", supporting CE's broader conceptual focus. Contrarily, the most frequent keywords found in the IA field are related to different types of IA (such as Life Cycle Assessment, Environmental Impact Assessment, Health Impact Assessment, and Social Impact Assessment), "climate

Table 3 Top 10 references, with balanced appearances in both CE and IA literature (with a minimum of one occurrence in the IA and CE domain) (Authors, 2023).

Reference	IA+CE	CE	IA	IA and CE
Kirchherr et al. (2017). Conceptualizing the circular economy: An analysis of 114 definitions	204	200 (98.04%)	4 (1.96%)	3 (1.47%)
Geissdoerfer et al. (2017). The circular economy—A new sustainability paradigm?	195	190 (97.44%)	5 (2.56%)	0 (0%)
Ghisellini et al. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	179	177 (98.88%)	2 (1.12%)	2 (1.12%)
Haas et al. (2015). How circular is the global economy?	227	224 (98.68%)	3 (1.32%)	0 (0%)
Korhonen et al. (2018). Circular economy: The concept and its limitations	104	103 (99.04%)	1 (0.96%)	1 (0.96%)
Murray et al. (2017). The circular economy: An interdisciplinary exploration of the concept and application in a global context	97	96 (98.97%)	1 (1.03%)	1 (1.03%)
Lieder & Rashid (2016). Towards circular economy implementation: A comprehensive review in the context of manufacturing industry	91	91 (100%)	0 (0%)	0 (0%)
Bocken et al. (2016). Product design and business model strategies for a circular economy	84	83 (98.81%)	1 (1.19%)	1 (1.19%)
Stahel (2016). The circular economy	78	78 (100%)	0 (0%)	0 (0%)
UE (2008). Directive 2008/98/EC of The European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives	77	72 (93.51%)	5 (6.49%)	0 (0%)

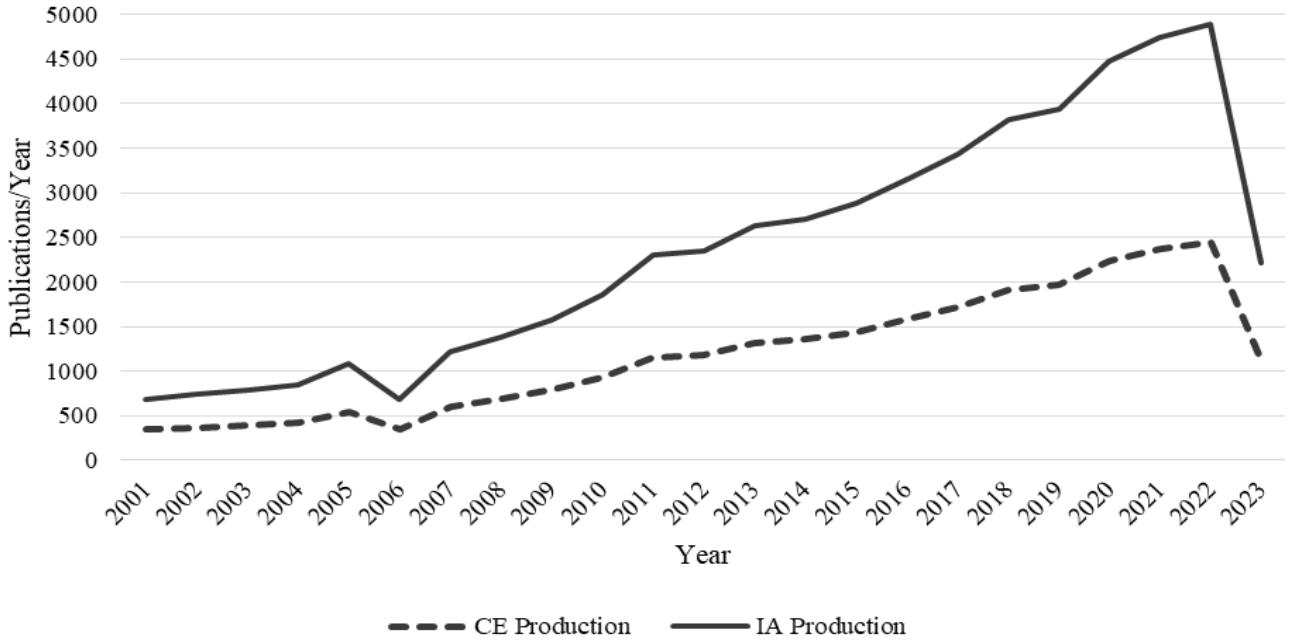

Fig. 3 Number of publications per year (Authors, 2023).

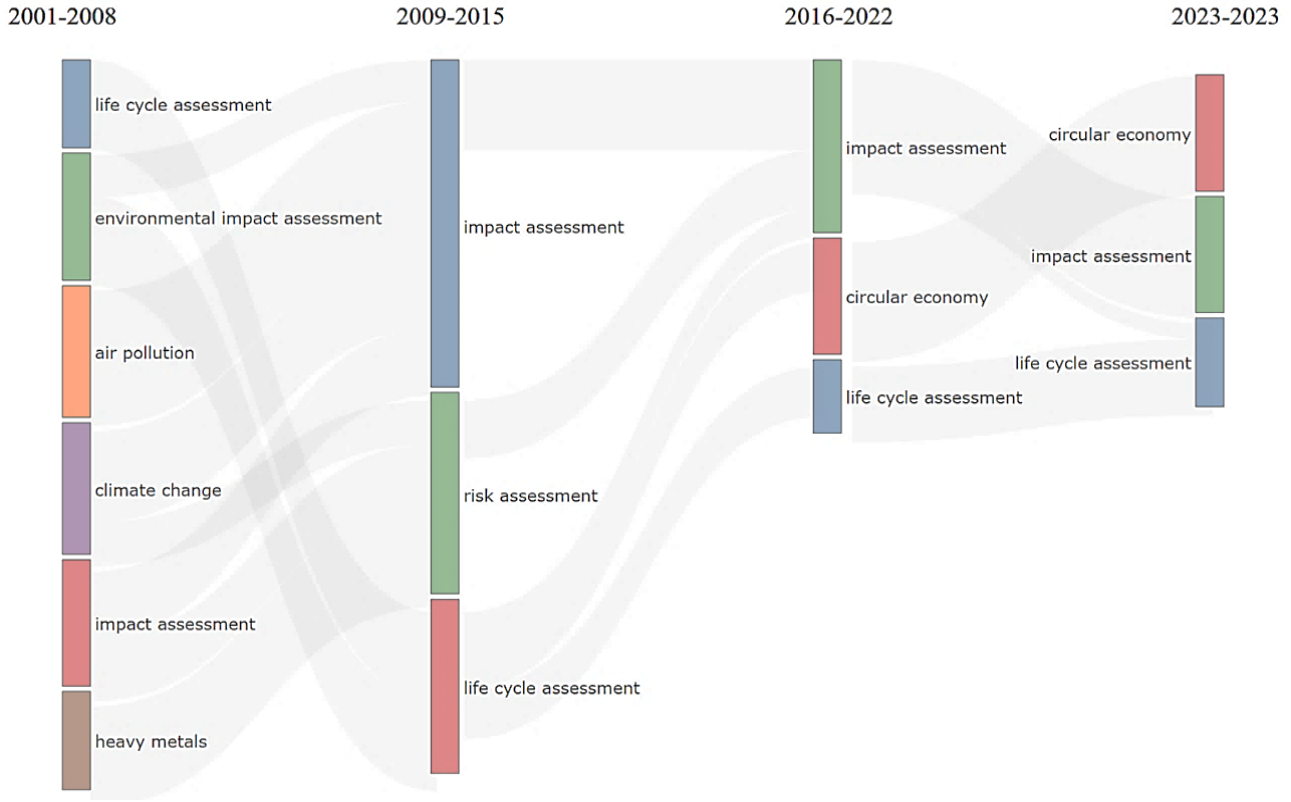

Fig. 4 Thematic evolution (Authors, 2023).

change", and "air pollution", in which, when compared to CE, IA seems more concerned with practice than theory. When IA and CE literature bodies are examined together, it is also significant to note that, starting in 2009, there are clearly the emergence of the three thematic areas where IA and CE connect (Fig. 4). The People's Republic of China's Circular Economy Promotion Law was established in 2008, and it was necessary to evaluate the potential hazards of putting circular measures into practice in 2009. Life Cycle Assessment was already used in the country to evaluate how products and services affected the environment, but it was noted that since 2009 its capacity to evaluate CE measures has been further investigated. Also, the three major theme areas of "circular economy", "impact assessment", and "life cycle assessment" were already clear as of 2015.

The strategic diagram produced by the leading eigenvalues technique is displayed in Figs. 5. The interaction between IA and CE in three theme areas—Sustainability, Environment, and Life Cycle Assessment—can be seen and confirmed here, much like in the co-occurrence network. Within the sustainability cluster, there is a deeper relationship between the themes of sustainability and CE as well as between CE and recycling. The strategic diagram demonstrates that LCA is both a critically important subject for examining the relationship between IA and CE (basic/transversal theme) and a highly developed theme (motor theme). LCA's placement in the "motor theme" quadrant also shows a connection to theories that are relevant to other, conceptually related topics. Impact Assessment, Environmental Impact Assessment, and climate change all seemed to be highly specialized and unimportant about the link under investigation. This is exclusively true for Environment Impact Assessment, according to our analysis of balanced keyword appearances across IA and CE. The rather even distribution of climate change across IA and CE (see Table 2) highlights the significance of this theme for understanding this connection.

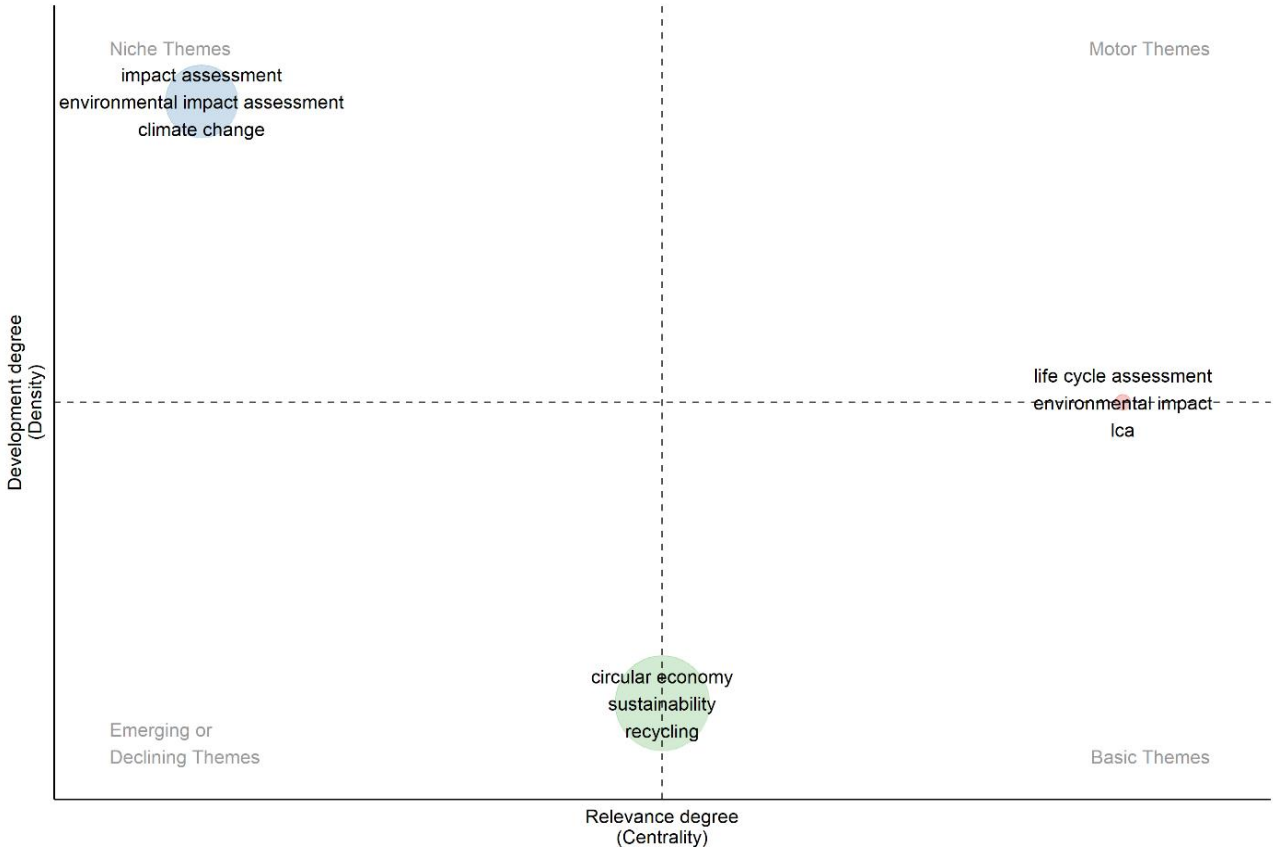

Fig. 5 Strategic diagram generated by leading eigenvalues algorithm (Authors, 2023).

3.2 Overlapping Area between IA and CE

The content analysis only applies to papers in the IA and CE intersection. This was done to qualitatively evaluate the contributions of this intersection to the wider field of study. The most cited and most recent publications from the IA and CE literature were thoroughly examined for the content analysis. "Sustainability" and themes connected are the first thematic patterns to emerge from the keyword and citation analysis. In contrast to CE field scholars, IA researchers use the term "sustainability" disproportionately more often (see Table 1), whereas CE researchers use the term "sustainable development" more frequently. While some authors hold that the CE can support sustainable development, this idea is contested by those who see sustainable development as a collection of ideas that were implemented using linear thinking, with CE only being feasible if sustainability was viewed from a wider perspective [38]. One of the key issues is that while the CE becomes a more viable business concept, firms continue doing "business as usual". This concern can be explained by the fact that, despite efforts by some businesses to embrace the sustainability initiative and redefine the vocabulary to create the appearance that it is not difficult to manage and deliver, others have questioned the concept's applicability [35]. This demonstrates that, although this topic is discussed in the theory of CE literature, most authors see sustainable development and the CE as interconnected fields [39], and CE policy measures are still focused on weak sustainability practices [40].

The notion that the practice of CE is directed towards a weak practice and that, as a result, such practices need to be reviewed is clearly expressed in the most cited papers. In this regard, the majority of the cited authors stress the significance of evaluating CE policy measures, but there are not any clear definitions or

criteria for doing so [41]. As a result, it is still challenging to evaluate the true environmental impacts of biofuels, biomaterials, and other eco-efficiency projects because they are frequently assessed using LCA, which is not always the best method for such scenarios [17]. IA is also cited as being necessary as a solution for any unsustainable impacts that can result from recycling procedures and the creation of new materials [42].

In contrast, the IA changes depending on how one views the problems that sustainability aims to address [17]. The practice of IA recognizes that to be effective, it must achieve strong sustainability [43]. The imbalance between the occurrences of the keywords "Sustainability" (which appears more in papers relating to IA) and "Sustainable Development" (which appears more in papers related to EC) shows evidence for the argument that was identified through bibliometric analysis. Thus, by evaluating the impacts of circular activities and ensuring that they achieve strong sustainability, IAs might promote the practice of the CE. Additionally, assessing the impacts of CE policy implementations aids to meet one of the six European Union policy environmental goals which is achieving the CE to move towards environmental sustainability [44, 45].

The first academic and sustainable economics movement to integrate prior theories and examine the potential circulation of resources was known as "industrial ecology" [33, 35]. This concept has a strong connection to the "recycling" of goods within the economy. Because it slows down usage cycles and delays resource output, resource cycling is essential for a CE [35]. However, the CE practice has largely focused on "waste management", which has limited the CE perspective [42]. In this regard, the most investigated issues in the body of CE literature are "recycling", "waste management", and "sustainability", which may point to weak circular practices. Recycling and reuse are essential when switching from fossil to renewable energy sources, as is converting efficiency improvements into a decrease in overall resource extraction [41]. Circularity does not nor should not limit itself to recycling activities, which is contrary to the way that most organizations see it [46]. On the other hand, a survey showed that the major part of IA professionals (involved in the research) are aware that CE extends beyond conventional waste management and recycling notions to encompass broader sustainability aspirations and of the need to approach matters at a system level [47]. Therefore, even though sustainability is the goal of both IA and the CE, the literature suggests that IA practice is more focused on strong sustainability than existing CE policy measures.

Within the sustainability thematic group, it is worth drawing attention to the term "industry 4.0". Given that 96% of the term's occurrences are concentrated in the literature of CE, at first glance it does not seem that Industry 4.0 reflects a theme of integration between both concepts of IA and CE. However, due to the enormous risks connected to the insufficient environmental and social management of the future growth in the exploitation of these developing technologies, IA is vital in this context as we face the 4th Industrial Revolution [44]. It will be necessary for the IA to address issues such as rising inequality, resource depletion, greenhouse gas emissions, and the degradation of the environment. Thus, given that currently, IA is still unable to handle all the effects of the 4th Industrial Revolution, IA can gain from a deeper integration with CE initiatives to tackle this challenge of the 21st century.

The majority of the overlapping papers (IA and CE) employ LCA as an IA method to examine how CE initiatives would affect the environment. Some evaluated technical alternatives [48, 49], but the majority of them are connected to LCA applied to the agricultural sector, such as Refs. [50-52], who evaluated alternative options for organic waste valorization and used LCA to assess its environmental impacts comparing them to other treatment options. Given the current state of resource scarcity, climate

change, environmental degradation, and rising food demand, the CE is presented in this context as a viable option for fostering sustainable, restorative, and regenerative agriculture [53]. Through procedures that could produce sustainable bio-products including fertilizers, energy, minerals, and polymers, agricultural waste can be turned into resources [54]. Additionally, the retrieved documents [55, 56] demonstrate how LCA may be used to assess the environmental impacts of recovering nutrients and water from wastewater treatment.

The second thematic group has the most prominent direct and indirect connections. Some, like Kim and Wolf [57], view the "Life Cycle Assessment" or "Life Cycle Impact Assessment" as a particular type of IA, while others, like Manuilova et al. [58] and Tukker [59], view the LCA as a tool to be used in the IA process. One way to understand the relationship between IA and CE through the LCA approach is to consider it as one of the primary IA techniques employed in assessing the sustainability of CE actions [13]. It is crucial to note that many LCA studies inadequately account for environmental effects related to land use and resource degradation [1], and integrated IA techniques with a focus on sustainability (such as those that incorporate techniques and socioeconomic assessments) can result in more trustworthy and accurate results. To improve results for CE measures and outcomes that are more focused on sustainability, it is suggested that the LCA be included together with other IA methodologies within the process of evaluation. This idea is supported by Fischer [60] who states that IA process cannot deal with CE if the approach to IA is strictly procedural, being applied as a one-time exercise to a particular CE strategy, policy, or plan, being a necessary system or framework approach. Even though Life Cycle Assessment is the most frequent method for assessing how CE initiatives will affect the environment, a more comprehensive approach is required.

The third category in which the two fields interacted was "Environment". The preservation of the environment is one of the core benefits of IA and is seen as one of the practice's primary goals [3]. Because both the positive and negative effects of the evaluated actions would be felt by the communities and the biophysical environment, the environment is at the center of decision-making supported by the IA [61]. As a new economic model that challenges the conventional linear model of production and consumption and places the environment on its basis, the CE presents an argument for preventing negative environmental effects. However, given that some CE practices may reduce environmental impacts during some stages of a product's life cycle but increase them during others [38], it is important to carefully assess these practices. As a result, the majority of CE practices are currently more directed towards weak sustainability.

"Climate change" is the current environmental problem that IA and CE are having the most difficulty addressing. Even at strategic levels of IA, it is difficult to evaluate recent worldwide concerns like resource consumption, biodiversity loss, and climate change since they must be taken into account at a global scale [17]. The CE can address environmental issues and the results of climate change [62]. This is because effective CE strategies can reduce climate change by delaying, closing, and narrowing material and energy loops, increasing resource efficiency [63]. The primary issue with institutional climate change negotiations is that rather than being focused on environmental sustainability, the dominant logic is one of economic growth, particularly the economic growth fueled by the fossil fuel industry [64]. The existing climate change policies are also ineffective since they emphasize market mechanisms like carbon trading as the primary means of emission reduction, with some of them emphasizing voluntary rather than required action [65]. The carbon "cap and trade" system's assumption that any reductions made anywhere are equivalent globally is theoretically sound, but the implications of climate change are most dangerous for the world's poorest populations [64, 65].

Because of the numerous competing interests engaged in climate change politics and the pressing environmental issues it raises, effective regulation must be put in place now rather than waiting for climate change voluntary organization agreements [66]. IA needs to advance beyond being a set of procedural requirements and recommendations, and start being legally binding to be able to assess circular activities, promote a shift to a CE, and be effective in leading to better global environmental protection [67]. Therefore, both fields struggle to deal with climate change environmental impacts.

"Health impact assessment" and "air pollution" were the two key themes connected to the "environment" thematic area that seemed to be only relevant to one of the research areas. The lack of a connection between the CE and one of the main IA types, the Health Impact Assessment (HIA) [61], may indicate a gap that needs to be filled by research and practice in both the IA and CE fields. In other words, IA can aid in assessing the social implications of the CE as CE measures are expected to have a positive impact on human health [68, 69]. Finally, sustainability is the most significant relationship discovered through this content analysis since Environmental Impact Assessment is a type of IA, and Life Cycle Assessment is a tool for IA (see Tables 1 and 2).

4. Conclusions

This research aimed to gain further insight, by determining the main areas of interactions between IA and CE, about the relationship existing between these two fields. The results point to IA and CE giving different emphases to sustainability, since strong sustainability appears to be a goal for IA while for CE practice the actions appear to lean more toward weak sustainability. Additionally, the results showed a need for a more thorough assessment of the environmental impacts of CE activities, instead of the utilization of LCA methodologies without the inclusion of other IA techniques within the evaluation process, finally, as a result, the difficulties that IA and the CE both face in dealing with the effects of climate change.

These findings contribute to expanding the comprehension of the relationship between IA and CE. This is important because of the mutual benefits and contributions the fields can give each other. In this sense, IA helps the transition to a CE by assessing the impacts of circular initiatives and attempting to ensure there is no overexploitation of natural resources and no further degradation of ecosystems. At the same time CE strategies can improve IA practice by making it more effective. The potentialities of this integration include reducing climate change and advancing low-carbon infrastructure [70], and the application of circular strategies has recently made it possible to evaluate the cumulative effects on a global scale [71].

Regarding the research gaps found through this research like the lack of CE addressing Health Impact Assessment, further research is needed to direct the CE to guarantee a positive impact on human health. Additionally, future works could focus on how to create and put into practice a framework for assessing the impacts of CE activities. Through inserting CE principles in the IA process, IA would be required to consider the entirety of the lifecycle of projects, from resource extraction to end-of-life, therefore making the process more efficient even when it is not assessing the impacts of a CE strategy implementation.

IA is both a process and a planning tool to achieve sustainability, and frequently challenges the status quo by inserting the environmental variable into the higher levels of decision-making processes. On the other hand, broader conceptualization of CE presents it as an alternative to the current economic model as a solution to the unsustainable linear way of production, consumption, and lifestyle. With further integration with the CE, it is expected that IA can be more effective regarding the change in the socioeconomic paradigms in which society is inserted.

Nevertheless, weak circular practices can lead to unsustainable outcomes given the lack of challenging

the capitalist system we are inserted in, and because IA is a political tool it has to deal with the unsustainable set of practices intrinsic to the current mode of production and consumption. Therefore, to achieve true sustainability, there is a need for systemic transformation, which involves emancipation and democratization, not just in socio-technical systems but also in the processes of capitalism and marketization.

Acknowledgments

This paper was supported by the National Council for Scientific and Technological Development (CNPq), grant number 131441/2021-3 and 315609/2021-4 and also by the Sao Paulo State Research Foundation (Fapesp), grant number 2021/14412-5.

References

[1] Navare, K., Muys, B., Vrancken, K. C., and Van Acker, K. 2021. "Circular Economy Monitoring—How to Make It Apt for Biological Cycles?" *Resources, Conservation and Recycling* 170: 105563. https://doi.org/10.1016/j.resconrec.2021.105563.

[2] Suárez-Eiroa, B., Fernández, E., and Méndez, G. 2021. "Integration of the Circular Economy Paradigm under the Just and Safe Operating Space Narrative: Twelve Operational Principles Based on Circularity, Sustainability and Resilience." *Journal of Cleaner Production* 322: 129071. https://doi.org/10.1016/j.jclepro.2021.129071.

[3] Morrison-Saunders, A., Pope, J., Gunn, J. A. E., Bond, A., and Retief, F. 2014. "Strengthening Impact Assessment: A Call for Integration and Focus." *Impact Assessment and Project Appraisal* 32 (1): 2-8. https://doi.org/10.1080/14615517.2013.872841.

[4] EC (European Commission). 2015. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe.* Geneva: European Commission, pp. 1-23.

[5] EC (European Commission). 2020. *Eighth Environment Action Programme*. Geneva: European Commission, pp. 1-34.

[6] Meuleman, L. 2015. "Owl Meets Beehive: How Impact Assessment and Governance Relate." *Impact Assessment and Project Appraisal* 33 (1): 4-15. https://doi.org/10.1080/14615517.2014.956436.

[7] Bond, A., and Dusík, J. 2020. "Impact Assessment for the Twenty-First Century—Rising to the Challenge." *Impact Assessment and Project Appraisal* 38 (2): 94-9. https://doi.org/10.1080/14615517.2019.1677083.

[8] Morgan, R. K. 2012. "Environmental Impact Assessment: The State of the Art." *Impact Assessment and Project Appraisal* 30 (1): 5-14. https://doi.org/10.1080/14615517.2012.661557.

[9] Liu, Z., Schraven, D., de Jong, M., and Hertogh, M. 2023. "The Societal Strength of Transition: A Critical Review of the Circular Economy through the Lens of Inclusion." *International Journal of Sustainable Development & World Ecology* 30 (7): 826-49. https://doi.org/10.1080/13504509.2023.2208547.

[10] Haupt, M., and Hellweg, S. 2019. "Measuring the Environmental Sustainability of a Circular Economy." *Environmental and Sustainability Indicators* 1-2: 100005. https://doi.org/10.1016/j.indic.2019.100005.

[11] Boldoczki, S., Thorenz, A., and Tuma, A. 2021. "Does Increased Circularity Lead to Environmental Sustainability? The Case of Washing Machine Reuse in Germany." *Journal of Industrial Ecology* 25 (4): 864-76. https://doi.org/10.1111/jiec.13104.

[12] Millar, N., McLaughlin, E., and Börger, T. 2019. "The Circular Economy: Swings and Roundabouts?" *Ecological Economics* 158: 11-9. https://doi.org/10.1016/j.ecolecon.2018.12.012.

[13] Schaubroeck, T. 2020. "Circular Economy Practices May Not Always Lead to Lower Criticality or More Sustainability; Analysis and Guidance Is Needed Per Case." *Resources, Conservation and Recycling* 162: 104977. https://doi.org/10.1016/j.resconrec.2020.104977.

[14] Velenturf, A. P. M., and Purnell, P. 2021. "Principles for a Sustainable Circular Economy." *Sustainable Production and Consumption* 27: 1437-57. https://doi.org/10.1016/j.spc.2021.02.018.

[15] Zerbino, P. 2022. "How to Manage the Circular Economy Rebound Effect: A Proposal for Contingency-Based Guidelines." *Journal of Cleaner Production* 378: 134584. https://doi.org/10.1016/j.jclepro.2022.134584.

[16] Mayumi, K., Giampietro, M., and Gowdy, J. M. 1998. "Georgescu-Roegen/Daly versus Solow/Stiglitz Revisited." *Ecological Economics* 27 (2): 115-7. https://doi.org/10.1016/S0921-8009(98)00003-2.

[17] Korhonen, J., Honkasalo, A., and Seppälä, J. 2018. "Circular Economy: The Concept and its Limitations." *Ecological Economics* 143: 37-46. https://doi.org/10.1016/j.ecolecon.2017.06.041.

[18] Calisto Friant, M., Vermeulen, W. J. V., and Salomone, R. 2020. "A Typology of Circular Economy Discourses: Navigating the Diverse Visions of a Contested Paradigm." *Resources, Conservation and Recycling* 161: 104917. https://doi.org/10.1016/j.resconrec.2020.104917.

[19] Bond, A., Pope, J., Morrison-Saunders, A., Retief, F., and Gunn, J. A. E. 2014. "Impact Assessment: Eroding Benefits through Streamlining?" *Environmental Impact Assessment Review* 45: 46-53. https://doi.org/10.1016/j.eiar.2013.12.002.

[20] Klein, N., Ramos, T. B., and Deutz, P. 2020. "Circular Economy Practices and Strategies in Public Sector Organizations: An Integrative Review." *Sustainability* 12 (10): 1-23. https://doi.org/10.3390/su12104181.

[21] Ruokamo, E., Savolainen, H., Seppälä, J., Sironen, S., Räsänen, M., and Auvinen, A.-P. 2023. "Exploring the Potential of Circular Economy to Mitigate Pressures on Biodiversity." *Global Environmental Change* 78: 102625. https://doi.org/10.1016/j.gloenvcha.2022.102625.

[22] Jiang, Y. J., Ying, H., and Sun, X. H. 2011. "Applying Circular Economy Theory in Environmental Impact Assessment." In Proceedings of the *2010 International Conference on Biology, Environment and Chemistry*. Singapore: IACSIT Press, pp. 463-6.

[23] Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., and Lim, W. M. 2021. "How to Conduct a Bibliometric Analysis: An Overview and Guidelines." *Journal of Business Research* 133: 285-96. https://doi.org/10.1016/j.jbusres.2021.04.070.

[24] Ramos-Rodríguez, A.-R., and Ruíz-Navarro, J. 2004. "Changes in the Intellectual Structure of Strategic Management Research: A Bibliometric Study of the *Strategic Management Journal*, 1980-2000." *Strategic Management Journal* 25 (10): 981-1004. https://doi.org/10.1002/smj.397.

[25] de Jong, M., Joss, S., Schraven, D., Zhan, C., and Weijnen, M. 2015. "Sustainable-Smart-Resilient-Low Carbon-Eco-Knowledge Cities; Making Sense of a Multitude of Concepts Promoting Sustainable Urbanization." *Journal of Cleaner Production* 109: 25-38. https://doi.org/10.1016/j.jclepro.2015.02.004.

[26] Wallin, J. A. 2005. "Bibliometric Methods: Pitfalls and Possibilities." *Basic & Clinical Pharmacology & Toxicology* 97 (5): 261-75. https://doi.org/10.1111/j.1742-7843.2005.pto_139.x.

[27] Glasson, J., and Therivel, R. 2019. "Introduction to Environmental Impact Assessment." In *Introduction to Environmental Impact Assessment*. London: Routledge. https://doi.org/10.4324/9780429470738.

[28] Droege, H., Kirchherr, J., Raggi, A., and Ramos, T. B. 2023. "Towards a Circular Disruption: On the Pivotal Role of Circular Economy Policy Entrepreneurs." *Business Strategy and the Environment* 32 (3): 1142-58. https://doi.org/10.1002/bse.3098.

[29] Ohsawa, T., and Duinker, P. 2014. "Climate-Change Mitigation in Canadian Environmental Impact Assessments." *Impact Assessment and Project Appraisal* 32 (3): 222-33. https://doi.org/10.1080/14615517.2014.913761.

[30] Li, W., and Zhao, Y. 2015. "Bibliometric Analysis of Global Environmental Assessment Research in a 20-Year Period." *Environmental Impact Assessment Review* 50: 158-66. https://doi.org/10.1016/j.eiar.2014.09.012.

[31] Yang, M., Chen, L., Wang, J., Msigwa, G., Osman, A. I., Fawzy, S., Rooney, D. W., and Yap, P.-S. 2023. "Circular Economy Strategies for Combating Climate Change and Other Environmental Issues." *Environmental Chemistry Letters* 21 (1): 55-80. https://doi.org/10.1007/s10311-022-01499-6.

[32] European Union. 2008. *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives.* Geneva: European Union, pp. 3-30.

[33] Henry, M., Schraven, D., Bocken, N., Frenken, K., Hekkert, M., and Kirchherr, J. 2021. "The Battle of the Buzzwords: A Comparative Review of the Circular Economy and the Sharing Economy Concepts." *Environmental Innovation and Societal Transitions* 38: 1-21. https://doi.org/10.1016/j.eist.2020.10.008.

[34] Lieder, M., and Rashid, A. 2016. "Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry." *Journal of Cleaner Production* 115: 36-51. https://doi.org/10.1016/j.jclepro.2015.12.042.

[35] Murray, A., Skene, K., and Haynes, K. 2017. "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context." *Journal of Business Ethics* 140 (3): 369-80. https://doi.org/10.1007/s10551-015-2693-2.

[36] Jha-Thakur, U., and Fischer, T. B. 2016. "25years of the UK EIA System: Strengths, Weaknesses, Opportunities and Threats." *Environmental Impact Assessment Review* 61: 19-26. https://doi.org/10.1016/j.eiar.2016.06.005.

[37] Jia, H., Sun, S., Cunkuan, B., Fan, C., and Dahe, J. 2011. "Expert's Perspective on the Performance of Chinese Technical Guidelines for Plan Environmental Impact Assessment." *Environmental Impact Assessment Review* 31 (6): 587-92. https://doi.org/10.1016/j.eiar.2011.01.005.

[38] Sauvé, S., Bernard, S., and Sloan, P. 2016. "Environmental Sciences, Sustainable Development and Circular Economy: Alternative Concepts for Trans-disciplinary Research." *Environmental Development* 17: 48-56. https://doi.org/10.1016/j.envdev.2015.09.002.

[39] Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., and Soto-Oñate, D. 2019. "Operational Principles of Circular Economy for Sustainable Development: Linking Theory and Practice." *Journal of Cleaner Production* 214: 952-61. https://doi.org/10.1016/j.jclepro.2018.12.271.

[40] Johansson, N., and Corvellec, H. 2018. "Waste Policies

Gone Soft: An Analysis of European and Swedish Waste Prevention Plans." *Waste Management* 77: 322-32. https://doi.org/10.1016/j.wasman.2018.04.015.

[41] Haas, W., Krausmann, F., Wiedenhofer, D., and Heinz, M. 2015. "How Circular Is the Global Economy? An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005." *Journal of Industrial Ecology* 19 (5): 765-77. https://doi.org/10.1111/jiec.12244.

[42] Ghisellini, P., Cialani, C., and Ulgiati, S. 2016. "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems." *Journal of Cleaner Production* 114: 11-32. https://doi.org/10.1016/j.jclepro.2015.09.007.

[43] Loomis, J. J., Bond, A., and Dziedzic, M. 2022. "Transformative Effectiveness: How EIA Can Transform Stakeholders' Frames of Reference." *Environmental Science & Policy* 136: 207-15. https://doi.org/10.1016/j.envsci.2022.06.007.

[44] Dusík, J., and Bond, A. 2022. "Environmental Assessments and Sustainable Finance Frameworks: Will the EU Taxonomy Change the Mindset over the Contribution of EIA to Sustainable Development?" *Impact Assessment and Project Appraisal* 40 (2): 90-8. https://doi.org/10.1080/14615517.2022.2027609.

[45] EC (European Commission). 2023. *Sustainable Finance: Commission Takes Further Steps to Boost Investment for a Sustainable Future*. Brussels: European Commission, pp. 1-3.

[46] Kirchherr, J., Reike, D., and Hekkert, M. 2017. "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." *Resources, Conservation and Recycling* 127: 221-32. https://doi.org/10.1016/j.resconrec.2017.09.005.

[47] Fothergill, J., and Murphy, J. 2020. "The Circular Economy and Impact Assessment: A Primer." In *Proceedings of the 40th Annual Conference of the International Association for Impact Assessment*, 26-29 May 2020, pp 1-52.

[48] Muñoz, P., Letelier, V., Muñoz, L., Gencel, O., Sutcu, M., and Vasic, M. 2023. "Assessing Technological Properties and Environmental Impact of Fired Bricks Made by Partially Adding Bottom Ash from an Industrial Approach." *Construction and Building Materials* 396: 132338. https://doi.org/10.1016/j.conbuildmat.2023.132338.

[49] Santos, G. Z. B. dos, Caldas, L. R., Melo Filho, J. de A., Monteiro, N. B. R., Rafael, S. I. M., and Marques da Silva, N. 2022. "Circular Alternatives in the Construction Industry: An Environmental Performance Assessment of Sisal Fiber-Reinforced Composites." *Journal of Building Engineering* 54: 104603. https://doi.org/10.1016/j.jobe.2022.104603.

[50] Ferronato, N., Paoli, R., Romagnoli, F., Tettamanti, G., Bruno, D., and Torretta, V. 2023. "Environmental Impact Scenarios of Organic Fraction Municipal Solid Waste Treatment with Black Soldier Fly Larvae Based on a Life Cycle Assessment." *Sustainable Waste Management & Circular Economy* 31: 17651-69. https://doi.org/10.1007/s11356-023-27140-9.

[51] Silalertruksa, T., Wirodcharuskul, C., and Gheewala, S. H. 2022. "Environmental Sustainability of Waste Circulation Models for Sugarcane Biorefinery System in Thailand." *Energies* 15 (24): 9515. https://doi.org/10.3390/en15249515.

[52] da Costa, J. S., Maranduba, H. L., de Sousa Castro, S., de Almeida Neto, J. A., and Rodrigues, L. B. 2022. "Environmental Performance of Orange Citrus Waste as Raw Material for Pectin and Essential Oil Production." *Food and Bioproducts Processing* 135: 165-77. https://doi.org/10.1016/j.fbp.2022.07.008.

[53] Velasco-Muñoz, J. F., Mendoza, J. M. F., Aznar-Sánchez, J. A., and Gallego-Schmid, A. 2021. "Circular Economy Implementation in the Agricultural Sector: Definition, Strategies and Indicators." *Resources, Conservation and Recycling* 170 (42): 105618. https://doi.org/10.1016/j.resconrec.2021.105618.

[54] Gontard, N., Sonesson, U., Birkved, M., Majone, M., Bolzonella, D., Celli, A., Angellier-Coussy, H., Jang, G. W., Verniquet, A., Broeze, J., Schaer, B., Batista, A. P., and Sebok, A. 2018. "A Research Challenge Vision regarding Management of Agricultural Waste in a Circular Bio-Based Economy." *Critical Reviews in Environmental Science and Technology* 48 (6): 614-54. https://doi.org/10.1080/10643389.2018.1471957.

[55] Lima, P. de M., Lopes, T. A. de S., Queiroz, L. M., and McConville, J. R. 2022. "Resource-Oriented Sanitation: Identifying Appropriate Technologies and Environmental Gains by Coupling Santiago Software and Life Cycle Assessment in a Brazilian Case Study." *Science of the Total Environment* 837: 155777. https://doi.org/10.1016/j.scitotenv.2022.155777.

[56] Magalhães, I. B., Ferreira, J., Castro, J. de S., Assis, L. R. de, and Calijuri, M. L. 2022. "Agro-Industrial Wastewater-Grown Microalgae: A Techno-Environmental Assessment of Open and Closed Systems." *Science of the Total Environment* 834: 155282. https://doi.org/10.1016/j.scitotenv.2022.155282.

[57] Kim, M., and Wolf, C. 2014. "The Impact Assessment We Want." *Impact Assessment and Project Appraisal* 32 (1): 19-20. https://doi.org/10.1080/14615517.2013.872847.

[58] Manuilova, A., Suebsiri, J., and Wilson, M. 2009. "Should Life Cycle Assessment Be Part of the Environmental Impact Assessment? Case Study: EIA of CO_2 Capture and Storage in Canada." *Energy Procedia* 1 (1): 4511-8.

https://doi.org/10.1016/j.egypro.2009.02.269.

[59] Tukker, A. 2000. “Life Cycle Assessment as a Tool in Environmental Impact Assessment.” *Environmental Impact Assessment Review* 20 (4): 435-56. https://doi.org/10.1016/S0195-9255(99)00045-1.

[60] Fischer, T. B. 2019. “Editorial.” *Impact Assessment and Project Appraisal* 37 (1): 1. https://doi.org/10.1080/14615517.2019.1550599.

[61] João, E., Vanclay, F., and den Broeder, L. 2011. “Emphasising Enhancement in All Forms of Impact Assessment: Introduction to a Special Issue.” *Impact Assessment and Project Appraisal* 29 (3): 170-80. https://doi.org/10.3152/146155111X12959673796326.

[62] Bonciu, F. 2020. “Is Circular Economy Compatible With Capitalism?” *Romanian Economic Business Review* 15 (1): 16-30. https://ideas.repec.org/a/rau/journl/v15y2020i1p16-30.html%0Ahttps://ideas.repec.org//a/rau/journl/v15y2020i1p16-30.html.

[63] Gallego-Schmid, A., Chen, H.-M., Sharmina, M., and Mendoza, J. M. F. 2020. “Links between Circular Economy and Climate Change Mitigation in the Built Environment.” *Journal of Cleaner Production* 260: 121115. https://doi.org/10.1016/j.jclepro.2020.121115.

[64] Banerjee, S. B. 2012. “A Climate for Change? Critical Reflections on the Durban United Nations Climate Change Conference.” *Organization Studies* 33 (12): 1761-86. https://doi.org/10.1177/0170840612464609.

[65] Böhm, S., and Dabhi, S. 2009. *Upsetting the Offset: The Political Economy of Carbon Markets*. Christchurch: MayFlyBooks. https://www.researchgate.net/publication/239642909%0AUpsetting.

[66] Allwood, J. M. 2014. “Squaring the Circular Economy.” In *Handbook of Recycling*. New York: Elsevier, pp. 445-77. https://doi.org/10.1016/B978-0-12-396459-5.00030-1.

[67] Therivel, R. 2020. “Impact Assessment: From Whale to Shark.” *Impact Assessment and Project Appraisal* 38 (2): 118-21. https://doi.org/10.1080/14615517.2019.1676070.

[68] Kirchherr, J., Bauwens, T., and Ramos, T. B. 2023. “Circular Disruption: Concepts, Enablers and Ways Ahead.” *Business Strategy and the Environment* 32 (3): 1005-9. https://doi.org/10.1002/bse.3096.

[69] Salguero-Puerta, L., Leyva-Díaz, J. C., Cortés-García, F. J., and Molina-Moreno, V. 2019. “Sustainability Indicators Concerning Waste Management for Implementation of the Circular Economy Model on the University of Lome (Togo) Campus.” *International Journal of Environmental Research and Public Health* 16 (12): 2234. https://doi.org/10.3390/ijerph16122234.

[70] Bellezoni, R. A., Adeogun, A. P., Paes, M. X., and de Oliveira, J. A. P. 2022. “Tackling Climate Change through Circular Economy in Cities.” *Journal of Cleaner Production* 381 (12): 135126. https://doi.org/10.1016/j.jclepro.2022.135126.

[71] Maiurova, A., Kurniawan, T. A., Kustikova, M., Bykovskaia, E., Othman, M. H. D., Singh, D., and Goh, H. H. 2022. “Promoting Digital Transformation in Waste Collection Service and Waste Recycling in Moscow (Russia): Applying a Circular Economy Paradigm to Mitigate Climate Change Impacts on the Environment.” *Journal of Cleaner Production* 354: 131604. https://doi.org/10.1016/j.jclepro.2022.131604.