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Circular economy in Brazil and alignment with the SDGs: Interfaces, gaps and opportunities for future research

Economia circular no Brasil e alinhamento com os ODS: Interfaces, lacunas e oportunidades para pesquisas futuras

Economía circular en Brasil y alineación con los ODS: Interfaces, brechas y oportunidades para futuras investigaciones

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ABSTRACT
The objective of this work is to analyze the profile of Brazilian dissertations and theses that deal with circular economy and its alignment with the Sustainable Development Goals (SDGs). A systematic literature review was developed with a portfolio of 96 theses and dissertations published in the Brazilian Digital Library of Theses and Dissertations (BDTD). The results suggest that SDGs 9, 12 and 17 have a closer synergy with the circular economy in the bibliographic portfolio analyzed. Based on the existing gaps for engagement with the other 14 SDGs, a research agenda was prepared with 93 research opportunities and 6 exploratory theoretical propositions for future validation in theoretical-empirical studies.
Keywords: sustainability; sustainable development; global solutions; local engagement; SDG.

RESUMO
O objetivo deste trabalho é analisar o perfil das dissertações e teses brasileiras que tratam da economia circular e seu alinhamento com os Objetivos de Desenvolvimento Sustentável (ODS). Foi desenvolvida uma revisão sistemática da literatura com um portfólio de 96 teses e dissertações publicadas na Biblioteca Digital Brasileira de Teses e Dissertações (BDTD). Os resultados sugerem que os ODS 9, 12 e 17 apresentam maior sinergia com a economia circular no portfólio bibliográfico analisado. Com base nas lacunas existentes para engajamento com os outros 14 ODS, foi elaborada uma agenda de pesquisa com 93 oportunidades de pesquisa e 6 proposições teóricas exploratórias para futura validação em estudos teórico-empíricos.
Palavras-chave: sustentabilidade; desenvolvimento sustentável; soluções globais; engajamento local; ODS.

RESUMEN
El objetivo de este trabajo es analizar el perfil de las disertaciones y tesis brasileñas que tratan sobre la economía circular y su alineación con los Objetivos de Desarrollo Sostenible (ODS). Se desarrolló una revisión sistemática de la literatura con un portafolio de 96 tesis y disertaciones publicadas en la Biblioteca Digital Brasileña de Tesis y Disertaciones (BDTD). Los resultados sugieren que los ODS 9, 12 y 17 presentan mayor sinergia con la economía circular en el portafolio bibliográfico analizado. Con base en las brechas existentes para el compromiso con los otros 14 ODS, se elaboró una agenda de investigación con 93 oportunidades de investigación y 6 propuestas teóricas exploratorias para su futura validación en estudios teórico-empíricos.
Palabras clave: sostenibilidad; desenvolvimiento sustentable; soluciones globales; participación local; ODS

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1 INTRODUCTION

Increasingly, society charges and funding entities encourage the carrying out of impact research (Okon et al., 2021), generating social transformations (Nicli et al., 2020) and improvements in different organizational and social contexts (Sehnem et al., 2022a). An incentive for new reflections and discussions that can contribute to generating social, environmental, economic, cultural, political and institutional transformations (Sehnem et. al. 2022b) in favor of a humanized society that allows a dignified life for all and that is committed with the reduction of poverty, vulnerability and asymmetries between people and countries (Rubio, 2021). That instead of reducing, have damage reversal potential. And that contribute to the proliferation of ecosystem biodiversity (Ridaura, 2020).

Several critical issues are addressed and have become objectives and goals of the Sustainable Development Goals (Kumar et al., 2022), namely: poverty eradication, hunger eradication, quality health, quality education, gender equality, clean water and sanitation, renewable and affordable energy, decent work and economic growth, industry, innovation and infrastructure, reducing inequality, sustainable cities and communities, sustainable production and consumption, climate action, protection of marine life, peace, justice and effective institutions, and , partnerships to implement the objectives (SDG, 2015).

Considering this context, curiosity arises to know how Brazilians are engaging in this process of social transformation through scientific research at the stricto sensu level. We know that scientific research is an important way to discover ways, alternatives and possibilities to generate real solutions to problems of society in general. Are we effectively fulfilling our role in generating impact through research? We are strengthening ties and generating synergy between the global development agenda for the coming years and the opportunities and facilities that the circular economy provides to generate an economic transition that promotes regeneration, positive cascading effect, efficient use of resources and circularity of products and materials, in a way that increases efficiency, contributes to the use of clean energy, green chemistry and the generation and retention of value in production chains. Thus, the following research questions emerge:

- RQ1: What is the profile of Brazilian dissertations and theses that deal with circular economy?
- RQ2: What is the alignment of Brazilian dissertations and theses that deal with circular economy with the SDGs?
- RQ3: Which sustainable development objectives have been a priority in Brazilian research?
- RQ4: What gaps and opportunities emerge from the panorama of previous Brazilian research on circular economy and SDGs?

The justification that motivates this study is associated with the role of human beings to generate applied solutions capable of contributing to the minimization of pollution (Lim et al., 2022), which contributes to minimizing the negative effects of climate change (Crecente et al., 2021) and that make relevant stakeholders of production systems (Nazmul et al., 2021) the protagonists of an effective transition to a society that generates fewer negative impacts and has a restorative potential for the losses and damages it has already generated for planet Earth . In the meantime, innovation plays a strategic role capable of creating disruptive and efficient alternatives and solutions (Sehnem et al., 2022b). We have an indicator that only 8.6% of our planet is circular (Circularity Gap Report, 2021), which shows the size of the bottleneck that exists and that can be supplied with creative research that promotes transformations for society.

The paper is structured in sections. After the introduction, a brief theoretical review was prepared that deals with circular economy and Sustainable Development Goals (SDGs). Then, the methodological procedures adopted to conduct the research are presented. Soon after, the presentation and analysis of data, which is followed by final considerations and references.

2 CIRCULAR ECONOMY AND ODS

The circular economy is defined as an industrial system that is restorative and regenerative by intent and design (Ellen MacArthur Foundation, 2012). It includes production and post-consumer strategies designed to close, slow down, or narrow resource cycles. The maximization or extension of the resource's utility directly implies the aggregation of continuous value to materials, which remain active in the production system for a longer time (Deshpande & Haskins, 2021). Closing production cycles promotes the connection of the post-use stage to its re-entry in the initial stage of production, which directly reduces the energy loss of already processed components and human intervention in natural environments for the extraction of virgin raw material. The possibility of extension of use derives from the design and idealization of the product with the aim of prolonging its life and enabling repairs/remanufacturing (Do et al., 2021). Improving the design of products towards a more efficient model allows for the standardization of processes, which benefits society, especially the base of the pyramid, and reduces the possibility of depletion of sources of resources and scarcity of materials (Mercader-Moyano, Porras- Pereira, & Levinton, 2021).

The circular production system aims to integrate the pillars of sustainable development (economic, environmental and social) through a symbiotic logic to recover or maintain energy and materials in the system, generate resources from waste, design sustainable and durable products, as well as how to prolong the life of systems (Sharma et al., 2021). The impact of actions and intentions on the three pillars produces a regenerative model, which has the potential for a balanced integration of

economic performance, social inclusion and environmental resilience, for the benefit of current and future generations (Geissdoerfer et al., 2016). The circular economy brings together the most notable set of practices regarding the implementation of sustainable development (Ellen MacArthur Foundation, 2013). By proposing the reduction of human intervention in the natural environment and the addition of value to resources, the objectives stimulated by sustainability and sustainable development are integrated into practical actions and align with socio-environmental issues Geissdoerfer et al., 2016; Ajwani-Ramchandani et al., 2021). In this sense, the circular economy can be a tool to achieve the Sustainable Development Goals (SDGs) stipulated by the United Nations (UN) (Walker et al., 2021). The 2030 Agenda for sustainable development published by the United Nations provides a guide to achieving the goals of peace and prosperity for the planet (United Nations, 2019). The agenda establishes an action plan that includes 17 Sustainable Development Goals, and establishes demands and goals for all countries, regardless of their stage of development, regarding the articulation for the development of economic issues in balance with aspects of health, justice, pollution, equality, among others (Ajwani-Ramchandani et al., 2021).

The main effects of the circular economy reflect with greater affection the economic and environmental dimensions, while the social dimension is not fully developed and is referenced in the literature as lacking solid empirical evidence (Suárez-Eiroa et al., 2019). Therefore, it is relevant to evaluate circular economy practices in the light of the SDGs as a possibility to overcome an evident weakness not only in theory, but also in practice that involves the transition to circularity. By taking the process of changing the production logic to the circular model, an analysis of the consumption model is encouraged from a perspective focused on sustainable development in a holistic sense (Panchal, Singh, & Diwan, 2021). Although the improvements made in the economic and social dimension produce impacts in the social field and vice versa, it is paradoxical that the social dimension is not a direct focus of circular practices, considering that the principles of circular economy are very close to sustainable development (De Pascale et al., 2020). Essentially, the SDGs are centered on the development of human beings and the promotion of decent living conditions for people (Superti et al., 2021). Of the practices encouraged as objectives, the insertion of circular economy principles implies direct collaboration between companies and supply chains, to close production links and reduce resource outflows (Rashed & Shah, 2020). Thus, being circular demands actions in a chain and in a systemic way, in circular networks (Walker et al., 2021), so that the impacts are perceived along a supply chain and the costs and benefits are distributed. Any incidents or violations of objectives or principles can reflect impacts throughout the chain (Walker et al., 2021).

Awareness and responses to challenges are global, as positive or negative results reflect in a systemic way (Molocchi, 2021). Planning in a circular fashion and in line with the SDGs indicates a concern with ensuring the survival and future sustainability of the environment and, consequently, of the human species (Rodrigo-González et al., 2021). The European Commission's Circular Economy Package initiative, by way of example, emphasizes closing the cycle of material use throughout the life cycle to achieve sustainability (Ragossnig & Schneider, 2019). It encourages the creation of zero waste strategies and the promotion of policies that seek environmental sustainability. In fact, setting growth objectives where there is full recognition of limits is logically correct, since it demands planning and optimization of the resource's utility (Hoehn et al., 2021)

Of the various Sustainable Development Goals, SDG12 focuses on sustainable development with responsible consumption and production. In addition to this, SDG6 deals with access to potable water and sanitation, which is strictly related to sustainable industrial operations, waste disposal and outputs from the production system, among others. SDG7 addresses the production of impa energy and its broad access to populations. SDG8 deals with decent work and economic growth, associated with the social and economic dimension (El Wali, Golroudbary, & Kraslawski, 2021). Other objectives address defined goals for economic growth, social equity and preservation of natural resources, in line with principles of sustainable development. Therefore, the connection between circular economy practices and the SDGs is remarkable, both associated with sustainable development and the promotion of more dignified living conditions and less aggressive to the environment.

3 METHODOLOGICAL PROCEDURES

To answer the established research questions, a systematic literature review is performed. The research model was adopted from the process proposed by Tranfield, Denyer and Smart (2003). The main research objective is the identification and systematization of works in accordance with the previously defined scope. To achieve this purpose, the following steps were followed:

a) Planning: During the planning phase, the basic process of systematic literature review was defined. This included defining the search terms, the search field, as well as the time period, language, and publication types. As this research aims to capture the current understanding of the structure of circular economy studies. The search terms 'circular economy' and 'circular business models' were selected. The scope of the review included dissertations and theses published in the Brazilian Digital Library of Theses and Dissertations (BDTD). This is the most complete database of Brazilian dissertations and theses available to researchers.

b) Realization: The research and assembly of the bibliographic portfolio were carried out on June 26, 2021. 92 results were found for the term 'circular economy' and 5 results for 'circular business models'. Excluding the duplicates and considering only the documents that could be accessed in full (some are under data protection and do not allow full access), 87 documents remained. Finally, 6 more works were added that are known to the authors of this study, and that have not yet been made available in the BDTD. The search was redone on January 29, 2021 and 3 more new results were found, creating a bibliographic portfolio of 96 complete documents for analysis. Therefore, the initial inclusion criterion corresponded to all dissertations and theses published on the topic of circular economy. There were no exclusion criteria regarding the time period. This allowed the inclusion of scientific writings published in the period from 2006 to 2021. Therefore, the inclusion criteria considered scope aligned with the circular economy, availability of the work in full and studies of knowledge of the authors and that have already been completed and defended before public banks. Thus, 96 studies were analyzed.

c) Report: the reporting phase comprised two stages, namely the descriptive phase or bibliometric analysis and then the thematic and categorical analysis, as suggested by Bardin (2011). During the first stage, the MS Excel software package was basically used, which is a freely available computer program that can be used to build and analyze bibliographic mapping. This bibliometric analysis will answer RQ1 and RQ2, which concern the general body of knowledge and the current flow of research in the circular economy knowledge field. Thematic and categorical analyzes aim to answer RQ3 and RQ4, and therefore, use a content and categorical analysis to systematize and identify definitions, conceptualizations, scope of alignment with the SDGs. The study selection process, as detailed above, is illustrated in Figure 1.

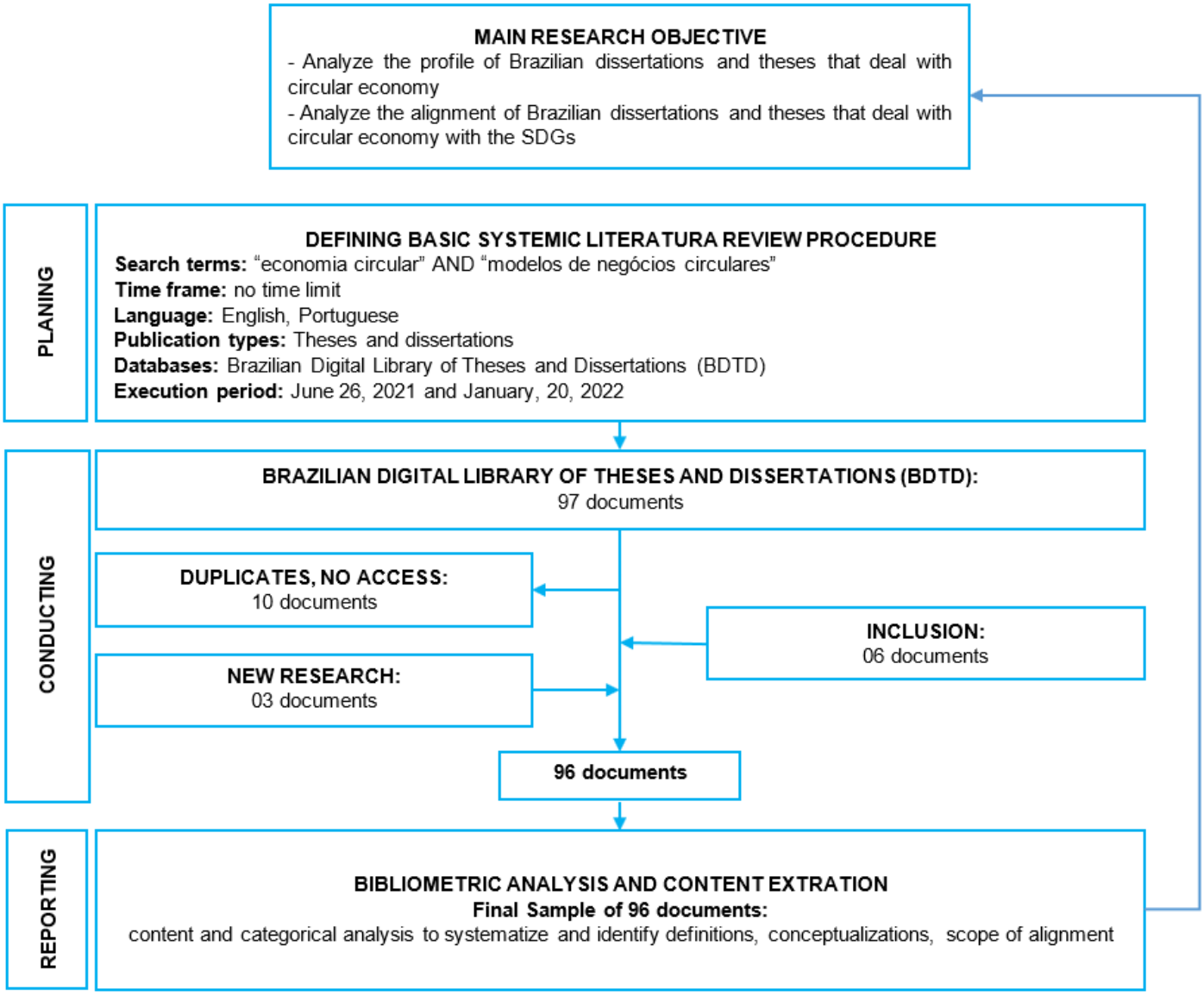

Figure 1. The study selection process
Source: Elaborated by the authors.

4 DATA PRESENTATION AND ANALYSIS

Following, Figure 2 presents the distribution of publications by year.

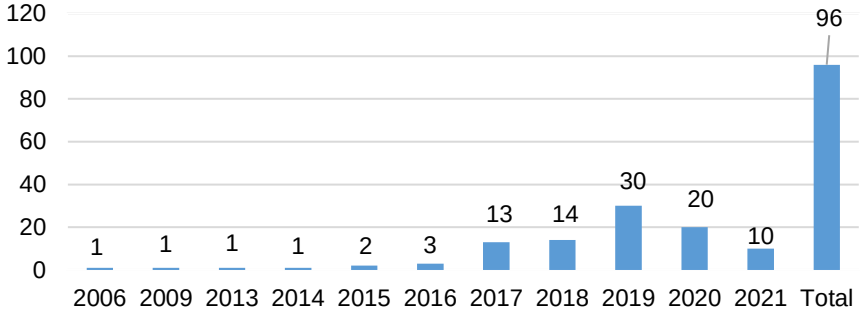

Figure 2. Distribution of publications by year
Source: Elaborated by the authors.

It can be seen in Figure 2 that since 2017 there has been an increase in adherence to the circular economy theme. The year 2021 does not yet have all the documents published and, therefore, cannot yet be adopted as an analysis parameter. The study reveals that the most representative four-year period for circular economy studies in Brazil is from 2017 to 2020, a period in which 77 works were published. This corresponds to 80.21% of the analyzed studies. Soon after, Table 1 presents the higher education institutions (HEIs) that published the studies that were analyzed.

Table 1 shows that USP and UFRGS are at the forefront of publications dealing with circular economy in Brazil. They are followed by UFPR and UTPR. However, there is an engagement of 33 educational institutions, covering all geographic regions of the country. This shows that the circular economy theme has been understood as relevant to the Brazilian context and has aroused interest in different research groups.

Table 1
HEIs that published the dissertations and theses analyzed

#	HEIs	Total	#	HEIs	Total
1	Universidade de Campinas – UNICAMP (University of Campinas)	1	18	Universidade do Oeste de Santa Catarina –UNOESC (University of the West of Santa Catarina)	1
2	Universidade Paulista – UNIP (Paulista University)	1	19	Universidade do Oeste Paulista – UNOESTE (University of West Paulista)	1
3	Universidade da Amazônia – UNAMA (University of the Amazon)	1	20	Universidade Estadual do Oeste do Paraná – UNIOESTE (State University of Western Paraná)	2
4	Universidade Católica de Santos – UNISANTOS (Catholic University of Santos)	1	21	Universidade Federal do Amazonas – UFA (Federal University of Amazonas)	2
5	Universidade do Extremo Sul Catarinense – UNESC (University of the Extreme South of Santa Catarina)	1	22	Centro Universitário FEI (FEI University Center)	3
6	Universidade Estadual Paulista – UNESP (Paulista State University)	1	23	Universidade Federal de Santa Catarina – UFSC (Federal University of Santa Catarina)	3
7	Universidade Federal da Bahia – UFBA (Federal University of Bahia)	1	24	Universidade Federal de São Carlos – UFSCAR (Federal University of São Carlos)	3
8	Universidade Federal de Minhas Gerais – UFMG (Federal University of Minas Gerais)	1	25	Universidade Federal de Viçosa – UFV (Federal University of Viçosa)	3
9	Universidade Federal de Pernambuco – UFPE (Federal University of Pernambuco)	1	26	Universidade Estadual Paulista Julio de Mesquita Filho (State University of São Paulo Julio de Mesquita Filho)	4
10	Universidade Federal de Santa Maria – UFSM (Federal University of Santa Maria)	1	27	Pontífice Universidade Católica do Rio de Janeiro – PUC RJ (Pontifical Catholic University of Rio de Janeiro)	4
11	Universidade Federal do Ceará – UFC (Federal University of Ceará)	1	28	Universidade do Vale do Rio dos Sinos – UNISINOS (University of Vale do Rio dos Sinos)	5
12	Universidade Federal do Espírito Santo – UFES (Federal University of Espírito Santo)	1	29	Universidade Nove de Julho – UNINOVE (Nove de Julho University)	6
13	Universidade Federal do Rio de Janeiro – UFRJ (Federal University of Rio de Janeiro)	1	30	Universidade Tecnológica Federal do Paraná – UTFPR (Federal Technological University of Paraná)	7
14	Universidade Federal do Rio Grande do Norte – UFRN (Federal University of Rio Grande do Norte)	1	31	Universidade Federal do Paraná – UFPR (Federal University of Paraná)	7
15	Universidade Federal do Triângulo Mineiro – UFTM (Federal University of Triângulo Mineiro)	1	32	Universidade Federal do Rio Grande do Sul – UFRGS (Federal University of Rio Grande do Sul)	14
16	Universidade Presbiteriana Mackenzie (Mackenzie Presbiterian University)	1	33	Universidade de São Paulo – USP (University of Sao Paulo)	14
17	Universidade La Salle (La Salle University)	1		**Total**	**96**

Source: Elaborated by the authors.

Table 2 shows an engagement of 87 Brazilian researchers with the guidance of dissertations and theses on circular economy. Emphasis is given to Professor Aldo Ometto from USP who supervised 4 works and Professor

Doctor Antonio Carlos de Francisco from UTFPR who supervised 3 works. It is noted that because it is an emerging topic, few dissertations and theses have been defended so far. Certainly, there are works in preparation and which should be published soon and others that are not included in the consulted database and that have already been prepared by Brazilian graduate programs. Then, in Figure 3, the type of work analyzed is presented.

Table 2
Advisors of the dissertations and theses analyzed

#	Advisors	Total	#	Advisors	Total
1	Adriano Lago	1	45	Maciel M. Queiroz	1
2	Adriano Michael Bernardin	1	46	Mara Lucia Calijuri	1
3	Alba Regina Azevedo Arana	1	47	Marcell Mariano Correa Maceno	1
4	Alvair Silveira Torres	1	48	Marcelo Albuqerque de Oliveira	1
5	Alvaro Luiz Mathias	1	49	Marcelo Nogueira Cortimigli	1
6	Amarilis Lucia Castelo Figueiredo Gallardo	1	50	Marcelo Nogueira Cortimiglia	1
7	Ana Cristina de Souza	1	51	Marcia Dutra de Barcellos	1
8	Angela Machado Rocha	1	52	Maria Augusta Justi Pisani	1
9	Antonio Carlos de Francisco	1	53	Maria do Carmo Duarte Freitas	1
10	Carla Schwengber ten Caten	1	54	Maria Fatima Ludovico de Almeida	1
11	Carlos Alberto Mendes Moraes	1	55	Maria Teresa Saraiva de Souza	1
12	Celso Antonio Pacheco Fiorillo	1	56	Marly Monteiro de Carvalho	1
13	Christian Luiz da Silva	1	57	Mauro Mitsuuchi Tashima	1
14	Claudete Catanhede do Nascimento	1	58	Mauro Silva Ruiz	1
15	Claudia Aparecida de Mattos	1	59	Miriam Cristina do Amaral	1
16	Claudia Viviane Viegas	1	60	Moisés Waismann	1
17	Cristóvão V. S. Fernandes,	1	61	Mônica Maria Mendes Luna	1
18	Cyntia Meireles Martins	1	62	Mônica Sarolli Silva de Mendonça Costa	1
19	Daniel Jugend	1	63	Nelson Medeiros de Lima Filho	1
20	Daniel Jugend	1	64	Patricia Borba Vilar Guimaraes	1
21	Ednilson Silva Felipe	1	65	Patrícia Faga Iglecia Lemos	1
22	Elaine Fernandes	1	66	Paulo Cesar Duque Estrada	1
23	Eloy Fassi Casagrande Junior	1	67	Pedro Henrique Augusto Medeiros	1
24	Fábio Gonçalves Teixeira	1	68	Reinaldo Aparecido Bariccatti	1
25	Fernando Gonçalves Amaral,	1	69	Rejane Helena Ribeiro da Costa	1
26	Flavio Horneaux Junior	1	70	Rejane Maria Candiota Tubino	1
27	Flávio de Miranda Ribeiro	1	71	Roberto Sbragia	1
28	Francisca Dantas Mendes	1	72	Rosane L. Chicarelli Alcantara	1
29	George Stanescu	1	73	Sandro Donnini Mancini	1
30	Geraldo Cardoso de Oliveira Neto	1	74	Silvia Helena Prado Betini	1
31	Guilherme Luis Roehe Vaccaro	1	75	Silvia Maria Guerra Molina	1
32	Ivo André Homrich Schneider	1	76	Simone Sehnem	1
33	Jane Maria Faulstich de Paiva	1	77	Tânia Forster Carneiro	1
34	João Alexandre Paschoalin Filho	1	78	Urivald Pawlowsky	1
35	João Estáquio de Lima	1	79	Valéria Gonçalves da Vinha	1
36	José Arnaldo Frutuoso Roveda	1	80	Vander de Freitas Melo	1
37	Juliana Bonomi Santos de Campos	1	81	Wanda Maria Risso Guinther	1
38	Júlio Carlos de Souza van der Linden	1	82	Ângela de Moura Ferreira Danilevicz	2
39	Kadigia Faccin	1	83	Cassiano Moro Piekarski	2
40	Karine de Mello Freire	1	84	Daniela Callegaro de Menezes	2
41	Laurence Schacher e Dominique Adolphe	1	85	Tácio Mauro Pereira de Campos	2
42	Lucila Maria de Souza Campos	1	86	Antonio Carlos de Francisco	3
43	Luiz Antonio Daniel	1	87	Aldo Roberto Ometto	4
44	Luiz Fernandes Rodrugues Pinto	1		**Total**	**96**

Source: Elaborated by the authors.

Figure 3 shows that dissertations defended on the subject still prevail. Considering that the time limit for preparing a dissertation is 24 months, while a thesis is 48 months, this increase in defended dissertations is understandable, which corresponds to 72.92% of the works analyzed in the bibliographic portfolio of this study

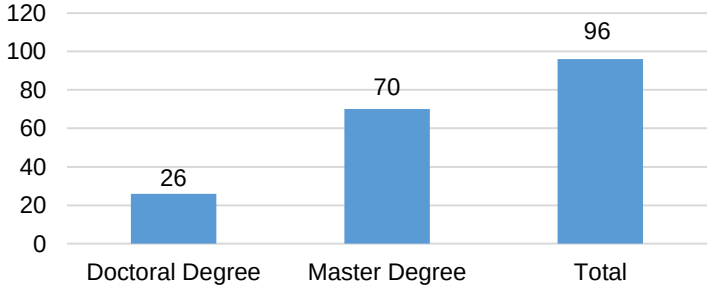

Figure 3. Types of analyzed works
Source: Elaborated by the authors.

Some researchers are engaged with research, programs, study scopes and alignment with the SDGs. Emphasis is given to the fulfillment of 3 ODs in particular - 9, 12 and 17, which had more studies aligned with these SDGs. In terms of courses involved. In terms of programs, Administration and Production Engineering stand out, with the largest number of works developed. However, the diversity of programs that engage with the theme is notorious, including Law, Mechanical Engineering, Metrology, Textile and Fashion, Sanitation, Intellectual Property, Sustainable Development, Water Resources, Agricultural Engineering, Mining and Metallurgical Engineering, Design, Forestry and Environmental Sciences, Materials Technology, Smart and Sustainable Cities, Architecture and Urbanism, Agribusiness, Urban and Environmental Engineering, Civil Engineering, Economics, Soil Science, Chemistry, Urban Engineering, Regional Development, Entrepreneurship, Social Memory and Cultural Goods, Food Engineering, Environment, Health and Sustainability, Structural Engineering, Hydraulics and Sanitation, Nuclear Energy in Agriculture, Production and Systems and Agricultural Sciences. This diversity of areas engaged in circular economy studies portrays how systemic the concept is. At the same time, the concept demands multiple fields of knowledge to have an effect on society

Soon after, Table 3 presents the sectors that were researched in previous studies.

Table 3
Researched sectors

#	Sectors	Total	#	Sectors	Total
1	Residual Waters	1	38	Rural properties	1
2	Foods	1	39	Water quality and reservoirs	1
3	Recycling association	1	40	Reuse of glass	1
4	Post consumption coconut processing	1	41	Tennis recycling	1
5	Biodisel	1	42	Poultry recycling	1
6	Bioplastics	1	43	Glass recycling	1
7	Pig production chain	1	44	Water resources	1
8	Truck (commercial vehicle industry)	1	45	Coal tailings	1
9	Recyclable paper collector	1	46	Electronic Waste (WEEE)	1
10	Craft breweries	1	47	Health Services Waste	1
11	Sustainable cities	1	48	Organic waste	2
12	Culture	1	49	Solid waste	1
13	Packaging in general	1	50	Solid waste from landfills	1
14	Plastic packages	1	51	Technological waste	1
15	Electronic Equipment	1	52	Water reuse	1
16	Sanitary sewage	1	53	Concrete reuse	1
17	Life Cycle Cost	1	54	Automotive sector	1
18	Innovation Hub	1	55	Synctronics (recycling)	1
19	HDI and environmental indicators	1	56	System products service for SMEs	1
20	Aeronautical industry	1	57	Theoretical	1
21	Pulp Industry	1	58	Paints and varnishes	1
22	socio-environmental indicators	1	59	Wastewater treatment	1
23	Metal industry	1	60	Tubes for plant seedlings	1
24	Cheese industry	1	61	Wind turbines	1
25	Local industries (Agro-industrial and forestry, Food and beverage, Mining,	1	62	Tutorial – step-by-step CE	1
26	Civil Construction, Steel, Oil and Gas, Petrochemical, Chemical and Pulp and Paper)	1	63	Fashion retail	1
27	ISO 14.001	1	64	Clothing	1
28	Dairy	1	65	Agribusiness	2
29	Sewage sludge	1	66	Plastic packaging	2
30	Logger	1	67	Textile sector	2
31	Medicines	1	68	Vehicles	2
32	Wastewater treatment	1	69	Fashio sector	4
33	Nonwovens and nanofibers from the keratin of feathers and down	1	70	Eletroeletronics	3
34	Sugar-alcohol	1	71	Waste management	3
35	Wood panels	1	72	Construction	5
36	Photovoltaic solar panel	1	73	Bibliografic	7
37	Paper And Cellulose	1		**Total**	**96**

Source: Elaborated by the authors.

Table 3 shows the diversity of sectors that were surveyed. Even greater prominence for bibliographic studies and the civil construction sector.

4.1 Discussion of Results

It is clear in the dissertations and theses analyzed that the priority scope has been in waste management, especially in civil construction, sustainable fashion, electrical and electronic waste, in the food sector and in agribusiness. The concern with the analysis of the value chain, the engagement of collectors, sectoral agreements, public policies and legislation and in favor of C.E. Only a few studies build the interface between C.E. and ODS, namely, Andrade (2019), Abadia (2019) and Araújo (2020). This

shows how great is the potential for scientific investigation of studies generated by impact in society and that link two emerging and relevant themes for society, generators of disruption, regeneration, closed production cycles, creation and retention of value of resources, sustainable operations and supply chains, cascading use of resources. In short, of a more collaborative and inclusive society and less degrading of nature. There are opportunities to explore the SDGs from the perspective of product planning and design, production and remanufacturing, distribution, consumption, use, reuse and repair, collection, recycling, innovation, challenges for creating a culture for circularity, among others. Next, Figure 4 presents a synthesis of the main themes of previous studies, which indicate important avenues of investigation in the circular economy field.

Figure 4 presents a summary of the predominant axes of previous studies, and Figure 5 shows a syntesis about master dissertations and doctoral tesys analysed.

Environmental Focus	Holistic Sustainability Focus	Focus C.E. and I.4.0	Focus on networking and cooperation
• Waste Management • Reverse logistic • Life Cycle Analysis • Life Cycle Inventory • Remanufacturing • Environmental focus • Green supply chain • Sustainable supply chain • Closed chains • Industrial ecology • Waste recovery • Resource recovery • Resource value retention • Compost • Recycling	• Circular Economy Business Models • Strategic C.E. business capabilities • Innovation • Materiality • Dematerialization • Product Service System • Eco-innovations • Circular Design • Value capture • Upcycling • Systemic view • Holistic vision	• Circular supply chains • Industry 4.0 • IoT • Big data • Green technologies • Technological innovations • Post consumption behavior and digitization	• Network capabilities • Material loops • Sector Agreement • Legislation for C.E. • Social and Environmental Responsibility • Producer responsibility • Reverse cycles • Focus on stakeholders

Figure 4. Framework that summarizes the predominant axes in previous studies.
Source: Elaborated by the authors.

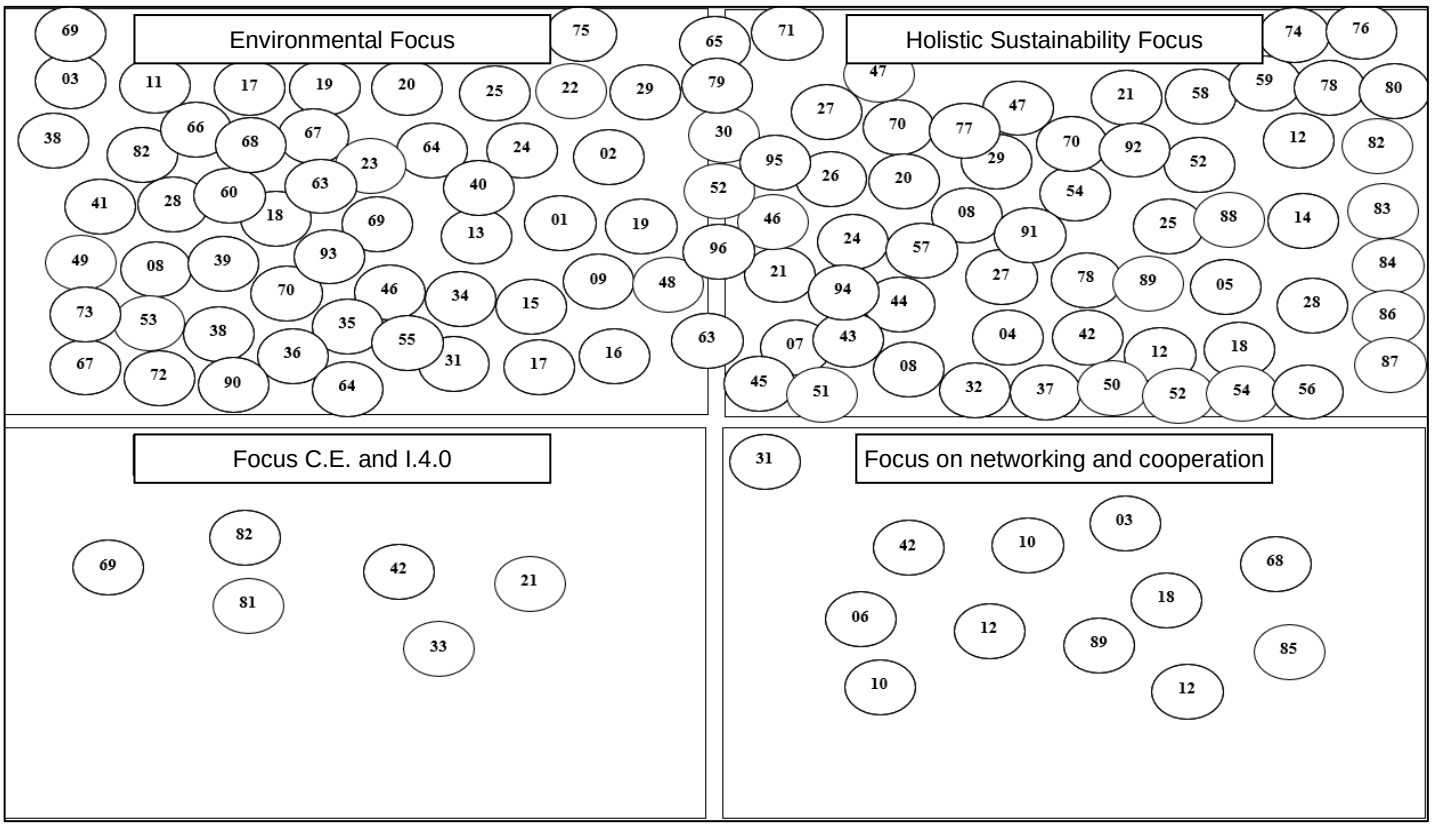

Figure 5. Summary about documents analyzed.
Source: Elaborated by the authors.

It must be remembered that the technological artifacts of Industry 4.0 can become accelerators of the transition to a circular economy. Studies 21, 33, 42, 69, 81 and 82 indicate important premises for the integration of industry 4.0 technologies and the circular economy. They represent the innovative look at sustainable supply chains supported

by connectivity, by large databases that bring together information for assertive decision making for productive chaining, integration and synergy between strategic stakeholders. The circular economy assumes the prerogative of cooperation as an essential element for achieving success. Systems that are synergistically and positively linked tend to obtain superior performances. It must be remembered that the technological artifacts of Industry 4.0 can become accelerators of the transition to a circular economy. Studies 21, 33, 42, 69, 81 and 82 indicate important premises for the integration of industry 4.0 technologies and the circular economy. They represent the innovative look at sustainable supply chains supported by connectivity, by large databases that bring together information for assertive decision making for productive chaining, integration and synergy between strategic stakeholders. The circular economy assumes the prerogative of cooperation as an essential element for achieving success. Systems that are synergistically and positively linked tend to obtain superior performances.

4.2 Future Research Opportunities

Based on the gaps in previous studies, especially the SDGs not met in previous studies, a research agenda (Table 4) and six research propositions were presented to be validated in future studies that intend to investigate the circular economy and its interface with the SDGs. Empirical validation in different sectors and organizational contexts can bring relevant insights to society. In particular, substantial contributions to the generation of equity principles, minimization of environmental impacts, social inclusion, reduction of inequalities, sustainable production and consumption, productive chaining and responsible and inclusive organizations.

Table 4
Research Schedule

SDGs	Research Opportunities
1 - Erradication of poverty	Income distribution and CE; Inclusive systems and CE; Public policies for the empowerment of the subject and CE; Quality education for inclusion in the labor market and CE; Collaborative networks and CE.
2 - Zero hunger and sustainable agriculture	Reduction of food waste; Use of food; Disruptive systems for retaining the nutritional value of food; Discarded food management strategies; The ugly food, the non-standard and the small magazine of a marketing bath; Organic systems and CE; Green agriculture and CE; Urban agriculture and CE; Smart farms and CE; Upycle and agribusiness.
3 - Health and Wellness	Mental health, CE. and SDGs; Integrative health, EC and SDGs; Public health, CE. and SDGs; Humanized health systems, EC and ODS; Public Health Emergency Care Units, CE and ODS; High complexity service, EC and ODS; Pandemic events, CE and SDGs; Well-being and quality of life techniques, CE and ODS.
4 - Quality Education	Educational indicators, education for sustainability and commitments assumed with C.E.; Education for the circular economy; Education for sustainable development; Tools for teaching the circular economy and the SDGs; Games to teach circular economy and SDGs; Circular and sustainable proactive education.
5 - Gender Equality	Empowerment of women and CE; Transition to an organizational culture that gives voice to gender; New genres and engagement with CE; Multiplicity of genres and interfaces with E.C and ODS.
6 - Potable Water and Sanitation	Circular waters; Closed cycle from water to C.E.; Water treatment and C.E.; Water reuse and C.E.; Basic sanitation and C.E.; Sewage and C.E.
7 - Clean and affordable energy	Solar energy; Photovoltaics; Energy from pyrolysis processes; Energy from biocomposting; Biodiesel; Biogas; Energy from the dematerialization of materials; Waste management and energy generation.
8 - Decent Work and Economic Growth	Humanization of work and circular economy; Shared responsibility; Win-win economic alternatives.
9 - Industry, Innovation and Infrastructure	Industries that adopt disruptive innovations that align with the principles of C.E.; Infrastructure needed to implement circular economy business models; Types of innovation and alignment with C.E.
10 - Reduction of Inequalities	Social inclusion strategies through the use of C.E. practices; Empowerment of people with membership of C.E.; C.E. education and C.E. implementation system; Urban community gardens and CE.
11 - Sustainable cities and communities	Circularity metrics for sustainable cities; Citizens' co-responsibility for the success of the C.E. and the SDGs; C.E. mindset in circular cities; Circularity and engagement strategies via public policies.
12 - Responsible consumption and production	Sustainable operations; Sustainable supply chains; Eco-innovations; The role of industry 4.0 for the transition to C.E.; Green chemistry; Green technologies for the success of C.E. and SDGs; Producer responsibility; E.C legislation and stakeholder engagement; Co-responsibility in the implementation of C.E.
13 - Action against global climate change	Climate change and C.E. contributions to impact mitigation; Resource value retention; Zero Waste; Dematerialization of waste and materials; Post-consumption initiatives to increase the circularity of resources.
14 - Life in the water	Freshwater pollution targets and indicators and adoption of circular economy practices for a sustainable transition; 10Rs applied to the context of rivers and seas and dematerialization as an artifact of retention and value proposition in resources; Circular economy business models as an alternative for aquatic waste management; Use of technologies for the transition to C.E. in rivers and seas.
15 - Earth life	Biodiversity targets and indicators associated with the adoption of EC and SDGs; Environmental impact and the role of green technologies for the implementation of circular economy business models aligned with the SDGs.
16 - Peace, justice and effective institutions	The role of the circular economy for a more equitable society; C.E. as a framework to stimulate social justice; Effective institutions in empowering the subject.
17 - Partnerships and means of implementation	Collaboration and partnerships for the transition to E.C and sustainable development; Integration systems, EC and Sustainable Development; Production chain, EC and Sustainable Development; Resilience and trust in production chains; The role of actors for productive engagement; Co-benefits of clusters and clusters engaged with E.C and the SDGs; Interdependence in industrial districts adopting EC and ODS; Synergies generated by partnerships in the transition to EC with an interface with the SDGs; Trade-offs of the inclusive and regenerative circular economy in line with the assumptions of the SDGs.

Source: Elaborated by the authors.

In addition to the suggested research agenda, Table 5 presents potential theories and units of analysis for future studies.

Table 5
Teories and unit of analisys for future studies

SDGs	Suggested Organizational Theories	Sectors/Organizations
1	Evolutionary theory; Institutional theory; Systems Theory; Social Theory; Stakeholder Theory; Hebb's Theory: Higher Mental Processes.	Social NGOs; Municipalities; Social Assistance Programs; Beneficial Social Entities.
2	Agency Theory; Cognitive Theories of Bruner, Piaget and Vygotsky; Cultural Theory; Bandura's Social Cognitive Theory.	Mesa Brazil Program; Foods; Insects used in human food; Slow food; Agribusiness.
3	Activation Theory; Cognitive Theory of Motivation; Instruction Planning Theory; Golemann's Emotional Theory.	Occupational Therapies; Aesthetics; Pet sector; Intensive Care Unit (ICU); Psychology Offices; Sustainable fashion; Slow-fashion.
4	Theory of Thorndike and Hull; Skinner's Theory.	Creative Leadership Schools – Kaospilot; Schools with innovative experiences in education; Pedagogical approach to socio-constructivism; Inclusive schools; Schools that adopt the philosophy of differences.
5	Behavioral Theory; Learning Theory.	Carnival; Music and dance; Company staff; University staff; Small and medium business staff; Staff of the most innovative companies; Staff of the most sustainable companies.
6	Behavioral Theory; Ecological Modernization; Growth Theory.	B companies; Companies that adopt the GRI guidelines - Global Reporting Initiative; Ranking of the most sustainable companies; Ranking of the largest franchises.
7	Stakeholder Theory; Power Theory.	ABSolar; Organic Producers; Startups.
8	Triple Bottom Line; Contingency Theory; Situational Leadership Theory; Maslow's Theory.	Health; Services provision; Agribusiness.
9	Porter's Value Chain Theory; Porter's Five Forces Theory.	Sebrae; Federation of Industries; Local trade and industrial associations; Multinationals; Multilatinas; Globallatinas; Innovation ecossistems; Innovation hubs.
10	Charismatic Leadership Theory; Learning Theory; Transformational Leadership Theory.	Educational programs; Professional education programs; Vocational schools; Entities that work in preparation for work and the labor market; Class entities of different professions.
11	Institutional Theory; Theory of Influence.	Most sustainable Brazilian cities; Most developed cities; Cities with the best human development indicators; Cities with the best economic development indicators; Cities with the best social assistance indicators.
12	Theory of Ecological Modernization; Actor-Network Theory; Learning Theory; Upper Echelon Theory.	Foods; Ecopoints; Startups from different sectors; Waste Treatment Centers; Recycling Cooperatives; PANC - Non-Conventional Food Plants.
13	Structuralist Theory; Bureaucracy Theory; Systems Theory; Resource-Based-View.	Waste management programs; Zero waste programs; Current circular economy projects.
14	Information Theory; Organizational Development Theory; Social Theory.	Government entities; Local residents' associations; Environmental NGOs.
15	Complexity Theory; Evolutionary Theory.	Federal government indicators; Environmental advisory and consulting companies.
16	Organizational Behavior Theory; Human Relations Theory.	ABC System; Sustainable Production Chain; Organic supply chain.
17	Neoclassical Theory; Sociotechnical Approach; Systems Theory; Corporate Governance Approach.	Triple helix – university, government and business; Solidarity economy; Sharing economy; Disruptive technologies; Biomimicry; Bioeconomy.

Source: Elaborated by the authors.

To stimulate original and unpublished future studies, we developed six exploratory theoretical propositions, for empirical validation in different sectors and organizations. It is suggested to focus on a sector where there are already studies on circular economy, as can be seen in Table 3.

Proposition 1: Propose alternatives for integrating circular economy practices into the SDGs in the context of emerging countries.

Emerging countries face several structural difficulties, which directly reflect on the possibilities of implementing policies aimed at the SDGs and in alignment with circular economy practices, such as weaknesses in collection logistics and in the material transport chain, processing, composting and recycling of materials, as well as dependence on precarious forms of solid waste disposal (Dwivedi et al., 2021). To address this multidimensional issue, an approach on different fronts is necessary to design a strategy to minimize the problems and enhance the opportunities that each country has. In the environmental, economic and social areas, different aspects can be explored to create viable and implementable alternatives, derived from consistent policies (Fatimah et al., 2020).

Proposition 2: Propose tools focused on poverty eradication and zero hunger policies based on opportunities generated by businesses or circular chains (SDGs 1 and 2).

Access to food and the minimum resources necessary for the maintenance of life is an imperative condition for achieving sustainable development. The combination of new forms of food production associated with the biological cycle of the circular economy, less

expensive and more efficient in the consumption of resources, enables the sustainable management of the inputs necessary for food production. The preservation of natural ecosystems creates favorable conditions for climate stability, which directly reduces the risk to food production. Closing the biological cycles of resources enhances the use and development of more equitable production practices and provides a perspective of potential improvement in access to food (Cecchin et al., 2021).

Proposition 3: Analyze the impact of circular businesses on water conservation and non-contamination in light of the principles of resource reduction and reuse (SDG6).

The circular economy seeks to prioritize the use of resources in cycles with the aim of prolonging their use and promoting continuous value creation. The implication on the use of water resources is direct and produces effects on the conservation of this resource, which is necessary not only for production, but also for the maintenance of societies, fauna and flora (Novoa et al., 2019). Access to drinking water is a necessary condition for the establishment of minimum living conditions for human settlements, so it is relevant to mitigate impacts and damages. generated to water resources. Estimates of losses from misuse in this sector are significant and demand a review of the way in which its use is conceived (Sauvé et al., 2021).

Proposition 4: Analyze the job creation potential from circular businesses (SDG8).

The potential for creating companies derived from circular activities is little explored. The increase in demand for jobs specialized in circular businesses tends to grow, following the growth of companies and of the so-called sustainable supply chains. Significant structural differences are operated by the modification of activities and their development can have direct implications from a socioeconomic perspective and job creation, especially those associated with resource recovery, product repair, reconditioning, among others (Christis, Athanassiadis, & Vercalsteren, 2019).

Proposition 5: Propose alternatives to make urban centers in emerging countries more sustainable and resilient (SDG11).

Urban centers are key areas for the implementation of climate change policies in cities. Especially in cities where economies are based on services or commodity production, creating more efficient systems in terms of resource use makes it possible to implement policies and practices effectively. In this sense, cities are the main centers of decision and movement of resources and energy, which dynamize global production chains (Kapoor et al., 2020). For these centers, it is important to promote the development of actions focused on mobility, reduction of waste generation, humanization of work, access to services and resources. In the case of emerging countries, this emergency becomes even more relevant, given the configuration of the economic and social system (Durán-Romero et al., 2020).

Proposition 6: Analyze policies to combat climate change in emerging countries and their alignment with international agreements (SDG13).

International agreements produce effects, goals and commitments for all signatory entities and governments. Although climate change produces effects on a global scale, the commitment to combating it depends directly on the political propensity to promote changes on a regional scale. Indeed, increasing resource efficiency through slowing, closing and reducing material and energy cycles is critical to mitigating or slowing climate change (Gallego-Schmid et al., 2020). The application of circular economy principles is in line with international protocols and agreements, but emerging or developing countries may experience retractions in this field due to chronic deficiencies in infrastructure and resources (Christis, Athanassiadis, & Vercalsteren, 2019).

5 FINAL REMARKS

This research aimed to analyze the profile of Brazilian dissertations and theses that deal with circular economy and its alignment with the Sustainable Development Goals (SDGs). The bibliographic portfolio analyzed includes 96 previous works. The evidence points to a narrowing of the studies analyzed with SDGs 9 – Industry, Innovation and Infrastructure, 12 – Responsible Consumption and Production and 17 – Partnerships and Means of Implementation. This evidence points to an important gap to be explored by Brazilian researchers to meet the other SDGs. To make an applied contribution to these advances, a research agenda and 6 theoretical propositions for future empirical validation are presented.

The main practical contribution of this study is the diagnosis of the interface of circular economy studies developed in the Brazilian context with the SDGs. The theoretical contribution is to explain avenues and opportunities for future studies that encourage Brazilian researchers to advance and develop new studies on the topic of circular economy and SDGs.

The managerial implications of the research are associated with the opportunities that Brazilian companies can take to make their productive cycles circular. The scientific literature analyzed presents many paths and alternatives for carrying out the transition to the circular economy. This knowledge can generate an important social impact, if it is disseminated to potential users and adopters of the technological solutions that the scientific community has consolidated. Furthermore, governments can be inspired by experiences from other countries, such as those reported by Polzer (2017) and Julkovsky (2021).

The limitations of the research are associated with the limited sample, which comprises only previous studies whose educational institutions previously made available in the Digital Library of Theses and Dissertations of Capes – BDTD. Certainly, many other studies have been developed by Brazilian stricto sensu programs in recent years on the

topic of circular economy. However, due to the lack of knowledge of the authors of this research, it was not possible to include them in the bibliographic portfolio analyzed. As opportunities for future research, the great opportunity for applied implementation of the proposed research agenda is reinforced, as well as the empirical validation of the theoretical propositions presented in this research.

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