How does the circular economy contribute to the pursuit of Agenda 2030? A systematic literature review

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Abstract. The present study aims to understand the current state of knowledge on how the circular economy contributes to achieving the 2030 Agenda for Sustainable Development Goals, also analysing the effects of the Covid-19 pandemic. The paper develops a systematic literature review highlighting the bibliometric characteristics and summarizing the research gaps detecting potential implications and relevant insights for service literature. The results highlight that the CE has links to many of the SDGs as no poverty (SDG1), responsible consumption and production (SDG12), sustainable cities and communities (SDG11), and the promotion of inclusive and sustainable industrialization and innovation (SDG9). The European Union can pursue sustainable development by implementing initiatives that make an economy more circular. The pandemic has highlighted the close relationship existing among social, natural and economic systems. The analysis of the existing literature has highlighted that some circular economy indicators are correlated with some SDGs. For instance, sustainable product design (ecodesign, packaging, product optimization, durability, etc.) and citizen education to safeguard the environment and conserve resources are principles of the circular economy crucial for implementing the SDGs. The study provides policymakers, companies and researchers with insights to promote sustainable development.

1 Introduction

The interest of researchers and public opinion in the circular economy to promote sustainable development is constantly growing. The United Nations has also included the circular economy (CE) in Agenda 2030, the UN strategy that sets the sustainable development goals countries should follow to pursue sustainable development. Based on the Sustainable Development Goals (SDG) of the 2030 Agenda, the circular economy plays a fundamental role in sustainable development, as it represents a new model of production and consumption instead of the current one of the linear economies [1]. The linear economy envisages the exploitation of resources to produce consumer goods without worrying about the sustainability of these processes, weighing exclusively on economic growth, while CE offers an alternative to this unsustainable model while maintaining economic, environmental, and social balance [2]. The circular economy has proven to reduce the amount of final waste and decrease the use of virgin natural resources while increasing the efficiency of the product while respecting the environment [3,4]. In addition, it enables the design of sustainable products with a longer life cycle and the reuse, remanufacturing, and recycling of products. According to MacArthur [5], the circular economy is a regenerative model in which resources are utilized for as long as feasible, extracted for maximum value while being used, and then recovered and renewed at the end of their useful lives.

The circular economy concept based on reduces, reuse, and recycle (3R) approach can optimize social and economic benefits that mitigate planetary boundary pressures [6,7].

Among the 17 goals of the 2030 Agenda, the one focusing on the circular economy is SDG 12 "Ensuring sustainable models of production and consumption", specifically focusing on water, energy, and food. In particular, with this goal, the UN has set goals that states should achieve by 2030 [1]:

-sustainable management and efficient use of natural resources;
-substantial reduction in waste production through prevention, reduction, recycling and reuse interventions;
-support companies to adopt sustainable practices and implement sustainability information in their annual reports;
-ensure that every person has adequate information and is aware of the importance of a lifestyle compatible with nature and sustainable development.

In detail, SDG 12.5 proposes a significant reduction in waste production through prevention, reduction, recycling, and reuse activities. The first measurement of global circularity revealed that it was 9.1% and has now dropped to 7.2% [8]. However, no systematic reviews emerge from the literature on how the implementation of the circular economy contributes to achieving the goals of the 2030 Agenda. Indeed, our research aims to understand the current state of knowledge on how the circular economy (CE) contributes to achieving the 2030 Agenda for Sustainable Development Goals (SDG), also

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analyzing the effects of the Covid-19 pandemic. The research aims to analyze the main results proposed in the reviewed studies, identify research gaps and provide future research opportunities for practitioners and academics [9,10.11].

The authors adopted a systematic literature review (SLR) methodology for transparency, repeatability, and rigor of synthesis to conceptualize the current state of knowledge on the results of circular economy implementation on the SDGs. The study provides policymakers, companies and researchers with insights to promote sustainable development. Indeed, the systematic literature review provides a roadmap for future research recommendations. In addition, the results of our study can support policymakers and businesses in promoting the switch towards this new economic model focused on sustainable development. Companies must reorganize processes following the principles of environmental, social and economic sustainability, and therefore according to a circular model capable of guaranteeing all well-being and protecting the environment and natural resources.

The paper is organized as follows: Section 2 describes the research methodology adopted. The results are discussed in Section 3. Section 4 presents a discussion on the main critical issues in the circular economy literature. Section 5 concludes the work and examines the limitations of our review and future research.

2 Methodology

The paper develops a systematic literature review (SLR) following the Tranfield et al. [10] guidelines. This methodology allows capturing the state of current knowledge on specific topics [10] identifying, and synthesizing research findings and gaps for future research [12]. The SLR is based on three main phases: 1. Review planning; 2. Conduct the review; 3. Reporting and Dissemination [10].

2.1 Review planning

The literature search was conducted in the Scopus database in March 2023. The literature search was conducted only on one database to ensure the process's clarity, rigour, and replicability, avoiding redundancy and overlapping [13]. The Scopus database indexes the contents of all other databases with potentially relevant content. The search was conducted using the following search query:

TITLE-ABS-KEY ("circular economy" AND "Agenda 2030").

The literature search resulted in a total of 33 records.

2.2 Conduct the review

The authors included the records identified in Scopus considering these criteria [9]:

1. The search included conference papers, articles in journals, reviews and book chapters;
2. The research has no time limits;
3. The research papers must be written in English;
4. Papers must be mainly focused on circular economy and Agenda 2030;
5. Articles must be available in full text and must be already published;
6. Technical and engineering papers are excluded.

A total of 15 articles were excluded: two studies were not in English, five studies did not have full text available, seven studies had a technical/engineering scientific context, and one was a book. Thus, the final body of literature consists of 18 papers.

2.3 Reporting and dissemination

The selected papers were analyzed first author-centrically and then concept-centrically to extract relevant information [14]. The authors collected, synthesized and analyzed the study results through content analysis. The review highlights the bibliometric characteristics (year of publication, document type, study approach, research' country) of selected papers, the effects and benefits of the circular economy on the pursuit of sustainable development promoted by the 2030 Agenda. The researchers identified the main themes addressed in the reviewed articles and summarized the research gaps detecting potential implications and relevant insights for practitioners and academics. Two researchers conducted the analysis simultaneously, while the other two evaluated the entire process to guarantee the work's accuracy and rigor.

3 Results

3.1 Bibliometric results

The bibliometric details of 18 studies were summarized in a table with Microsoft Excel Software. As shown the Figure 1, the distribution of papers over time has shown that academic interest in the subject has developed since 2019 and is constantly growing.

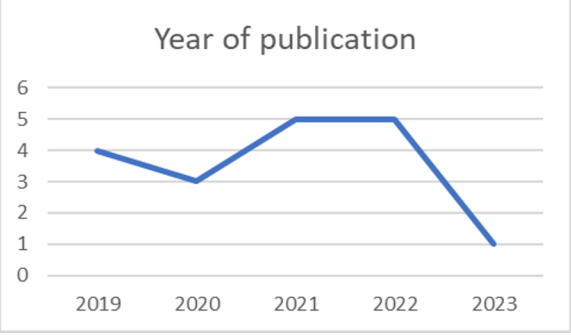

Fig. 1. Distribution of publications according to the year of publication.

As shown in Table 1, most reviewed studies are articles (14), 3 are reviews, and only one is a book chapter.

Table 1. Distribution of publications for document type

Document type	Frequency	Study
Article	14	[15-28]
Review	3	[29,30,31]
Book chapter	1	[32]

From the analysis and as shown in Table 2, it emerged that the study approach most used is empirical research (13); two articles are conceptual, and three studies are literature reviews.

Table 2. Distribution of publications for research approach

Research approach	Frequency	Study
Conceptual	3	[22,30,32]
Literature review	2	[17, 20]
Empirical	13	[15,16,18,19,21,23,24, 25,26,27,28,2931]

Concerning empirical research, most of the studies were conducted in Italy (7), Finland (2), and England (2) (Figure 2).

Fig. 2. Distribution of publications according to the research country

The most frequent keywords utilized in the reviewed papers were: circular economy (12), Sustainable Development Goals (7), sustainability (5), waste management (3) and climate change (2).

3.2 Themes' analysis

In order to extract, synthesize and analyse the results of studies, we used content analysis to classify the reviewed papers. In particular, the title, abstract, author's keywords, context, aim and research gap of the 18 papers were reviewed and coded. First, the authors identified the main themes addressed in the reviewed papers. Then, we extracted, summarized and analysed the results of the studies to identify the main findings and further research. The authors identify five themes describing the link between circular economy and Sustainable Development Goals (Figure 3): circular transition [24,30,25,26,31]; waste management [15,16,17,18]; circular economy' progress and challenges [20,23,28]; supply chain management [19,22]; circular food systems [21,27,32] and sustainable automotive industry [29].

Fig. 3. Themes connected to Circular Economy and Agenda 2030

In the following sub-paragraphs, we explain the contents of the identified themes.

3.2.1 Circular transition theme

The Circular transition theme highlights the importance of changing production and consumption models [30]. The attention is focused on the negative impacts of pollution and climate change, which affect most of the world's urban agglomerations. The COVID-19 pandemic has reinforced the need to accelerate efforts to address climate change. Therefore, within this framework, new models of urban development are needed. The circular economy model is proposed as capable of reducing the negative impacts of urban transformations [25]. The circular economy model is proposed as a model capable of reducing the negative impacts of urban transformations [24,25].

The research conducted by Fabbricatti and Biancamano [26] identifies the relationship between circularity, productivity, and resilience as an effective key to achieving the objectives of Agenda 2030. In detail, the research identifies the landscape as an indicator of sustainability, inclusiveness, security, and resilience for cities as supported by the 2030 Agenda (SDG 11). The research highlighted the need to enhance the resources and potential of sites through circular dynamics based on the strengthening and regeneration of collective identity, the ability to innovate and self-sufficiency. The example of Torre Annunziata, in the Gulf of Naples, underlines the importance of the circular transition in order to activate social, economic and environmental synergies. Andrade et al. [31] identify the technological or practical barriers that hinder the development of solutions for smart cities and optimal solutions in the use of Internet of Things. Indeed, cities can experiment with circular economy strategies for resource optimisation, waste reduction, reuse and recycling. Now it has attracted the interest of researchers because it is an open standard and contributes to the development of sustainable smart cities, as they are

related to circular economy concepts. The circular economy drives new business models and interactions in the city. Using the data generated by IoT solutions, it is possible to directly create benefits for industry and local governments [31].

3.2.2 Circular economy progress and challenges theme

The Circular economy' progress and challenges theme evaluates the progress of the sustainable development agenda (Belmonte et al., 2021) by analyzing the research gap considering three globally integrated sustainability concepts: Circular Economy, Green economy, and Bioeconomy (D'Amato et al., 2019). The analysis shows that the Circular economy (CE) concept is omnipresent and homogeneous in all companies and sectors. Green Economy (GE) is the second most frequent concept in contexts such as forests and mines. Bioeconomy (BE) was underrepresented in all reports except the forestry sector. Indeed, the challenges to achieving a circular economy and bioeconomy in a digital age are identified (De Felice 2021). The CE-BE connection appeared to be the strongest, efficiency-wise and recycling of biological resources. CE can be directly linked to practices addressing climate change (energy saving, emission reduction) [28]. The study by Belmonte et al. [20] highlights the need to address SDG concepts as they are not sufficiently addressed by academia. To achieve sustainable development, it is crucial to harmonize three key elements: economic growth, social inclusion, and environmental protection. Considering the objectives proposed by the 2030 Agenda, the research highlights the importance of developing an organizational culture to promote digitization and innovation from the perspective of sustainability [23].

3.2.3 Waste management theme

The Waste management theme explores the circular economy and sustainable waste management (SWM) relationships considering the sustainable development goals [15,17]. Understanding the links between circular economy and SDGs in waste management is an integral part of creating innovative long-term solutions for developing multi-sectoral measures for waste prevention, ecodesign, and material reuse. Sustainability and circular economy have Sustainable Waste Management's progress as a common thread, as the more waste is generated, the more significant the TFP reduction will be [15]. The EC is a sustainable model that allows optimizing materials' use and minimizing waste. Approaches to minimizing construction waste include design, reuse and recycling, construction methods, business models, waste and energy measurement tools and policies. While all these measures would reduce waste, integrating them into construction projects could achieve the goal of sustainable construction and sustainable development [17]. The theme also includes the study conducted by Barchiesi et al. [16] to investigate the effect of compliance with environmental legislation by Italian municipalities on the total cost of municipal solid waste management, filling a need for bibliographic studies on the issue. The results show that environmental compliance leads to cost reductions in the northern regions, thanks to more efficient separate management of collection and recycling activities in the downstream stages of the process. Separate collection management is relevant in both environmental and economic terms, being a matter of public finance with governance entrusted to local authorities (municipalities). Furthermore, Mihai et al. [18] provide a broader analysis of the plastic pollution threat and rural waste management challenges worldwide and then highlight the importance of waste management and circular economy research in rural regions. The study findings highlight the importance of engaging rural communities on plastic pollution and the circular economy, in general, to help governments reduce public health and environmental threats and to catalyse circular initiatives in rural areas. Rural communities around the world, including the least-developed community.

3.2.4 Supply chain management theme

The Supply chain management theme includes Spinosa and Doshi's [22] study on sewage sludge management. The research focuses on goal 6.2 of the Agenda 2030 in order to achieve access to adequate and equitable sanitation and hygiene for all. Indeed, it is necessary to implement a sustainable management considering the growing increase of its production and the difficulty of identifying the treatment and disposal actions responding to more stringent environmental quality requirements. Sustainable sewage sludge management would maximize the benefits of recycling/recovery. Companies must implement economically and ecologically feasible methods to reduce the amount of sludge and thus limit the use of harmful substances and develop concrete regulations. Another example of sustainable supply chain management focuses on managing phosphorus on a regional and global scale, considering the SDGs 1,2,3, 5,8 and 12. Indeed, the study conducted by El Wali et al. [19] highlights that the circular economy influences the flows of phosphorus, contributing to the overall improvement of security for all regions. The circular production model reduces poverty in low- and middle-income areas. It also helps the phosphorus chain meet the employment targets set for Eastern and Northern Europe. The circular economy model for phosphorus promises to maintain 53% global water savings.

3.2.5 Circular food system theme

The Circular food systems theme highlights how it is possible through a circular economy model to implement sustainable production and consumption, in line with objective 12 of the 2030 Agenda [32]. This category includes the research conducted by Yakovleva et al. [21], which aims to identify current and projected supply and demand challenges in regions, map gaps in developing regions and identify approaches to overcome supply

challenges using CE principles, especially life cycle assessment. The research focuses on efficiently using potassium resources to alleviate hunger and poverty for food production in developing countries (SDG 1).

The report recommends six methods to increase the availability of potash fertilizers, including better geological data collection and the discovery of potash ore reserves in places like Africa, Asia, and South America. The second strategy encourages the lookup of alternative sources. The third strategy is to enhance agricultural practice knowledge and trade linkages between nations that produce potash and those that use it. The use of organic fertilizers in large-scale agricultural production is encouraged rather than reduced as part of the fourth strategy. The fifth strategy calls for a change to small-scale closed-loop production, in which the fertilizing nutrients are made from organic manures and agricultural wastes. To create potassium-containing fertilizer ingredients for use in agricultural production, the most recent method recycles all forms of food and agricultural waste. Agri-food production uses conventional food growing and processing technologies and, together with large-scale mined potash production, will strengthen food-producing industries in the Global South. Policymakers must make decisions based on circular economy principles to optimize agricultural production [21]. The food sector is a driver for implementing the circular economy principle and could also provide support in understanding its evolution and adjusting its objectives. Greater coordination between actions and all stakeholders involved within the production and consumption cycles is crucial, as well as long-term economic, environmental, and social growth objectives [27].

3.2.6 Sustainable automotive industry theme

The Sustainable automotive industry theme focuses on the sustainable strategies of leading companies in the automotive sector. The research conducted by Lukin et al. [29] highlights how sustainability strategy and monitoring are crucial in the automotive industry, given the specificities of production in that sector and the long and specific life of cars, but also given the widespread use of vehicles which leads to generating environmental pollution. Sustainable strategy implementation generates "extended customer value". The analysis results show that the Honda automotive company is implementing sustainable strategies in line with the 2030 Agenda. For example, the company contributes to goal 10 by implementing a strategy to create a corporate culture that respects differences and eliminates inequalities. The sector is investing in increasing the range of electric and hybrid vehicles and fuel cell vehicles. Companies invest in employee training to improve the working environment, encourage them to take on new challenges and create a corporate culture that respects diversity. The choice of suppliers considers the environmental impacts and the protection of labour rights. Renewable energy sources are encouraged, and new business models, such as sharing mobility, are promoted. Furthermore, companies in the sector support and promote voluntary actions.

4 Discussion

The systematic literature review reveals that the CE has links to many of the SDGs as no poverty (SDG1), responsible consumption and production (SDG12), sustainable cities and communities (SDG11), and the promotion of inclusive and sustainable industrialization and innovation (SDG9). The European Union can pursue sustainable development by implementing initiatives that make an economy more circular. The pandemic has highlighted the close relationship existing among social, natural and economic systems. The analysis of the existing literature has highlighted that some circular economy indicators are correlated with some SDGs [33]. For instance, sustainable product design (ecodesign, packaging, product optimization, durability, etc.) and citizen education to safeguard the environment and conserve resources [34] are principles of the circular economy crucial for implementing the SDGs. Understanding the links between circular economy and SDGs in waste management is integral to creating innovative long-term solutions for developing multi-sectoral measures for waste prevention, ecodesign and material reuse. Sustainable waste management (SWM) is an essential part of the circular economy (CE) by providing for the reintroduction of waste into the production chain through the recovery of materials, the development of economies of scale and the adoption of circular regeneration initiatives. Among the benefits is the increase in the market value of the products – recovered and recycled, the reduction of waste sites and the supply of raw materials [35].

Adopting the EC allows us to minimize waste and therefore pursue the SDGs. EC can reduce pollution, while its adoption and implementation can create jobs and economic growth. All waste-generating stakeholders must apply new innovative technologies, methods and strategies that lead to green change. However, Ogunmakinde et al. [17] research highlighted that government policies are needed to enforce waste minimization and resource efficiency to achieve the SDGs by adopting CE. In addition, implementing circular phosphorus management contributes to poverty reduction in low and middle-income regions and to achieving the employment targets set for Eastern and Northern Europe. The circular economy model for phosphorus aims to sustain water savings of 53% worldwide [19]. With a view to reorganizing the management of the supply chain in a circular way and pursuing objective 6.2 of the 2030 Agenda (to achieve access to adequate and equitable sanitation for all), Spinosa and Doshi [22] research highlights the importance of managing the sludge and maximizing its recycling and recovery, trying to limit the use of harmful substances, optimizing its use through systems with low environmental energy impact. The circular economy model's interrelated urban landscape components enable the identification of innovative, creative, and

collaborative dynamics as well as successful regenerative mechanisms toward inclusive, secure, and resilient cities that are sustainable. Cities and territories, on the other hand, have the potential to offer concrete opportunities to improve the efficiency of natural resources and reduce environmental impacts. From this point of view, the actions undertaken by governments and companies are fundamental in achieving more sustainable objectives because they are closely linked to the territory and urban planning through the definition of material and energy flows that maintain their value by remaining in circulation and outlining flexible and functional areas and spaces for this purpose. Among the articles reviewed, the automotive sector is also experiencing essential changes in its business due to the growing attention to environmental protection and sustainable development of the planet. Indeed, new business models, such as sharing mobility, are being created in the automotive industry using new and renewable materials and innovative production processes [29].

5 Conclusions and future research

The paper performs a systematic literature review on the relationship between circular economy and sustainable development goals, synthesizing the main articles' characteristics and implications to provide a roadmap for future research recommendations. The results of our research show how both companies and academics are implementing strategies and initiatives aimed at implementing, promoting and pursuing a circular economic model in line with the goals set by the 2030 Agenda.

However, the research has some limitations. The authors considered one database (Scopus) to ensure the research quality regarding rigour and relevance. Although the papers were reviewed systematically, the researchers may have missed certain studies that did not use search terms included in our search string or other databases.

Finally, further research is required to understand other contexts where companies reference the SDGs (non-financial reports, economic reports). It is suggested to investigate which sectors organizations have defined sustainability strategies, if and how they monitor them and if they have implemented a system of sustainability indicators for each SDG. Investigate in other contexts, in addition to the automotive one, how and to what extent each sustainable activity contributes in the environmental, economic, and social spheres [29].

Future research will have to experiment with new approaches in managing raw materials and waste in different contexts, including food [27]. There is a need to examine how potassium extraction can improve food safety. Further research may discuss how to overcome the barriers and obstacles to implementing circular economy principles in developing countries and mainly focus on comparing potash supply management across different countries considering the Sustainable Development Goals. The research conducted by Yakovleva et al. [21] highlights the need to analyse the potassium life cycle at an organisation's meso or micro level concerning specific food production.

Future trends related to IoT to build a smart city based on circular economy [31]. Future studies must identify the relationship between circularity, productivity and resilience to achieve the 2030 Agenda objectives and contribute to the regeneration of the urban landscape in different contexts [26]. In general, the academic world will have to analyse environmental and social issues and, with a view to the circular transition, enhance the industrial architectures that deal with the recycling of waste and materials [24]. The study conducted by Girard and Nocca [25] highlights the need to deepen the health implications of the circular model.

Future research must more accurately depict the scope of plastic waste streams in rural communities, supported by credible indicators of rural trash (improved waste statistics, field monitoring and measurements, financial incentives and policies), and must encompass a broad range of geographical regions [18]. Future research could consider the analysis of the costs of separate collection to understand which waste typology has the highest costs and suggest the related policy implications. The researchers will have to carry out a comparison between different countries on how environmental regulations affect waste management [16]. Future research may implement qualitative or quantitative study techniques to analyse links between the CE, construction waste minimization and SDGs [17].

Researchers will have to explore the evolution of the concepts of sustainability adopted by companies, analyse the relationship between financial performance and information on sustainability and how sustainability concepts are adopted, delve into how corporate strategies align with the objectives set at national and regional levels with Circular Economy, Green Economy and Bioeconomy policies [28]. Future research could look for research agendas that create bridges to exploit synergies between SDG Research, Circular Economy, Green Growth and Degrowth [20].

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