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Review article

Circular and green economy: the state-of-the-art

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ABSTRACT

Circular and green economy are relevant issues in the agricultural sector, and animate the academic and policy debates: they contribute to identify and address the environmental and social problems raised by the economic development of the global economy. This study aims at reviewing the literature on circular and green economy, with a particular emphasis on the agri-food systems and their supply chains. It includes a systematic literature review and a bibliometric analysis, based on 1,061 documents that are indexed in the Scopus database. The bibliometric analysis identifies dominant thematic research areas, such as "Circular Economy", "Green Economy", "Food Waste", and "Environmental Impacts". The analysis of publication patterns and emerging topics suggests that future research should focus on the nexus "food waste and environmental impacts", and emphasizes the need to adopt a multidiscipinary approach to investigate the complex nexus between the food waste and the environment.

1. Introduction

The concept of circular economy dates back to 1966 when Boulding [1] proposed to organise the economy as a circular system to ensure a sustainable development. However, the framework has been formalised a few decades later, in 1989, by Pearce and Turner [2], and is mainly based on the so called 3R's Principles: i.e., reduction, reuse, recycle [3, 4]. According to the logical scheme, the economic agents act as if they were in a life cycle perspective, minimising inputs and production waste, while improving inter-sectorial synergies. Following this scheme, any by-product should be transformed into a new resource for another productive cycle. The ultimate aim is to limit net impacts on the environment [5]. A more recent conceptualization of the green economy has been introduced after the 2012 UN Conference on Sustainable Development in Rio de Janeiro and relies on the concept that the environmental conservation benefits both the economy and the society [6].

The concepts of circular economy and green economy share the same principle: i.e., "*adapt to or transform the current economy towards a more sustainable one*" [5, pp. 716–717], also named as "circular economy". This new economic model has been developed to defeat the traditional model based on the principle "*take, make, and dispose*" [7], also named as "linear economy". While the traditional economic models suggest that uneven production and consumption patterns are desirable welfare outcomes, it is well-known that the economic systems are interlined with the environment [8]. This awareness pushes for an increasing attention on sustainability: same applies to agriculture. The agri-food system should pursue a sustainable intensification, increasing production while avoiding adverse environmental impacts. Following a sustainable intensification, the agri-food systems may obtain desirable outcomes (i.e., produce more and safer food) while improving environmental conditions [9]. Reaching a sustainable management is a strategic goal to enable farmers and producers to establish greener production-consumption systems, based on reuse and recycle [8]. The greener agri-food systems encourage the use of raw materials, known as technical and biological nutrients[1] [10], that do not have detrimental impacts on the environment [8].

Focusing on circular and green economy is promising for future research, and would allow us to better understanding the environmental and social challenges posed by a fast-growing economic development [7]. The purpose of this study is to review the emerging issues on the circular and green economy literature. Particular focus is devoted to the agri-food systems and to supply chains, due to the increasing concerns for the impacts that food production and consumption may have at the environmental, social, and economic levels and the awareness that the agri-food sector should be based on sustainable development models. The existing review studies have deveoted little attention to the implications of circular and green economy on agri-food systems and supply chains. For instance, Ahumada and Villalobos [11] review the main contributions in the field of production and distribution of agri-food products

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[1] In a circular economy perspective, biological materials may be reused and recycled, whereas technical materials cannot be reintegrated into the cycle [10].

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based on agricultural crops, focusing on successful planning models. Bhagat and Dhar [12] focus on the critical factors affecting the management of agricultural supply chains. Routroy and Behera [13] synthesize the literature on agricultural supply chains and put emphasis on several (and general) dimensions such as scope, objective, wastages, driver, obstacle, outcome: the article contributes to the understanding of the academic research on circular and green economy, combiningn the protocol for a systematic review of the literature and the techniques of the bibliometric analyses, a promising approach to conclude on the state of the art [38].

2. Materials and methods

I have conducted a systematic literature review on circular and green economy following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol [14, 42]. The bibliometric analysis considers documents indexed in the Scopus database, covering publications up to 2020. Following this approach, the study provides insights on the publication patterns in time and space, and the keywords and topics emerging from the literature on circular and green economy. The approach has allowed to derive a cursory review of the existing body of work covering the four major aspects of the issue, emerged from the analysis: circular economy, green economy, food waste, environmental impacts. The search for significant documents indexed in the Scopus database has been conducted in January 2021. I have extracted relevant documents using a Boolean string resulting from the combination of the two sets of keywords consistent with the research objective: i.e., the terms "circular economy" and "green economy" allowed me to identify the broader topic covered by this study; sector-related terms have been applied to restrict the search to the agri-food systems and supply chains, considering possible form variations of the keywords (e.g., "agri-food" or "agro-food"). The final syntax, reading as follows ("circular economy" OR "green economy") AND ("agriculture" OR "food" OR "agri-food" OR "agro-food"), was used as search key in titles, keywords, and abstracts of documents indexed in Scopus. This search has resulted in an initial sample of 1,254 documents. No time limits has been set in the bibliographic search [15]. I have further limited the search to peer-reviewed articles (i.e., omitting conference papers, book chapters, editorials) published in academic journals (i.e., excluding conference proceedings, books, book series, trade journals), considered as validated knowledge with a greater impact in the field [16]. I have considered only documents published in English, the most adopetd language used to spread the scientific knowledge [17]. After the selection of "Article" and "Review" documents in "Journal", the number of collected documents has been equal to 1,060[2].

In line with existing studies [43, 44], it has been adopted a bibliometric technique of terms co-occurrence to analyse the terms included in the title and abstract (i.e., variable of interest) of each document in the sample (i.e., unit of observation). Conceptually, the co-occurrence signals the links among concepts that are addressed by scientifical studies. Following the approach proposed in van Eck and Waltman [18], it has been used the VOSViewer programme to extract the terms from the title and the abstract of each document in my sample. It has been chosen a binary counting method which considers only the presence or the absence of a term in a document, without taking into consideration the number of occurrences of the term in the same document. The method identified a total of 26,831 terms in the sample of documents. After defining 53 as minimum number of occurrences of a term[3] (equal to picking 5 percent of the documents in the sample) 90 out of the 26,831 terms have been extracted: for each of these 90 terms, the relevance score has been computed, and the most relevant terms have been identified (54 terms, accounting for 60%). After removing the irrelevant terms (see table A1 in Appendix A), the final number of terms has resulted in 35 (Table 1).

Starting from the final selection of terms, it has been possible to derive several networks of term co-occurrence, reported linkages among terms and classified the terms in thematic clusters. The distance across terms sharing a network proxies the interconnections among them: the shorter the distance, the stronger the interconnections within the research agendas. Thematic clusters are defined through the frequency of co-occurrence of terms: those that are in the same thematic cluster tend to be more closely related than the terms belonging to different thematic clusters [19].

3. Results

The sample of documents on circular economy and green economy consists of 1,060 peer-reviewed studies (79% Articles, 21% Reviews) published since 1996 until 2020 (Figure 1, a). Hartman [20] has been the first, in 1996, to introduce myths and realities of the new green economy. However, only during the last decade, we observe a growing attention of the scientific community on topics connected to the circular economy and the green economy. The number of peer-reviewed documents published in academic journals has increased exponentially since 2010 and has reached its maximum peak in 2020, with 446 published documents (Figure 1, a). The *Journal of Cleaner Production*, the *Sustainability (Switzerland)*, and the *Science of the Total Environment* are among the leading source titles which have hosted documents on circular and green economy (Figure 1, a): joint with the *Resources Conservation and Recycling* and *Waste Management*, they have collected one-third of the current knowledge on those topics. The selected documents cover 26 different subject areas as shown in the picture (Figure 1, b).

The top 5 most cited documents are listed and described in Table 2: some studies are conceptual [9, 21, 22], while others are empirical studies [8, 23].

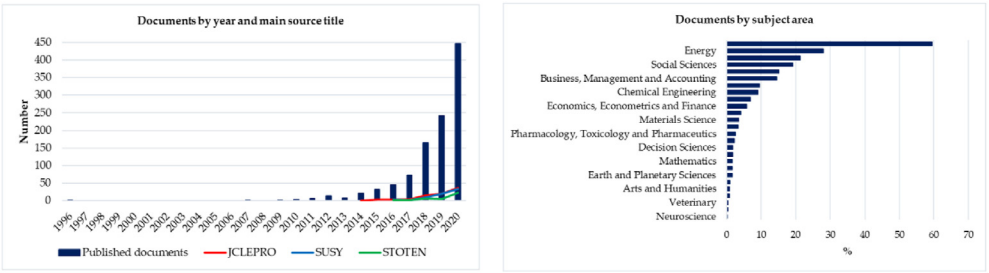
The European countries are those with the greatest number of published articles, especially in Italy (23%), Spain (12%), and the United Kingdom (11%). A large share of articles has been produced in China (9%) (Figure 2). The interest on this topic is likely to be animated by the policy debate. In Europe, the adoption of a circular economy approach is preparatory to decouple the economic growth from an over-consumption of resources. As discussed by Yu et al. [24], Italy and the United Kingdom have experience of absolute decoupling, such as the Domestic Extraction Use, that is the input from the natural environment (i.e., the annual amount of raw material excluding water and air) to be used in the economy. The European Commission has adopted the Europe 2020 Strategy for smart, inclusive, and sustainable growth. In this respect, the Circular Economy package, launched in 2015 and renewed in 2020, may contribute to the achievement of a green growth for Europe. A strong

Table 1. List of the 35 terms included the bibliometric analysis.

Terms		
Agriculture	Green economy	Reuse
Anaerobic digestion	Implementation	Sector
Application	Life cycle assessment	Soil
Biomass	Nutrient	Source
Circular economy	Plant	Sustainable development
Climate change	Policy	Transition
Cost	Practice	Treatment
Development	Process	Valorization
Economy	Product	Value
Environmental impact	Protein	Waste
Food industry	Recovery	Water
Food waste	Recycling	

[2] The full reference list is available upon request.

[3] The selected threshold corresponds to the 5% of the total number of documents in the sample.



(a) (b)

Figure 1. (a) Documents by year of publication and source title, acronyms are Journal of Cleaner Production (JCLEPRO), Sustainability Switzerland (SUSY), Science of the Total Environment (STOTEN); (b) Documents by subject area of which source title belongs to. Data have been extracted in March 2021.

Table 2. Top 5 most quoted documents.

Reference	Citations	Aim	Methodology
[21] Mirabella et al., *Journal of Cleaner Production*, 2014	415	Analysis of feasibility and constraints of industrial symbiosis applications in recovering waste from food processing	Conceptual
[22] Scarlat et al., *Environmental Development*, 2015	349	Analysis of policy framework for developing a bioeconomy in the European Union covering energy and climate, agriculture and forestry, industry and research	Conceptual
[8] Genovese et al., *Omega (United Kingdom)*, 2017	321	Comparison of performances of traditional and circular production systems in chemical and food supply chains	Empirical
[9] Pretty and Bharucha, *Annals of Botany*, 2014	252	Analysis of the impacts of sustainable intensification in agricultural systems in developing and industrialised countries	Conceptual
[23] Shi et al., *Journal of Cleaner Production*, 2010	217	Analysis of environmental benefits of the key symbiotic exchanges in the Tianjin Economic-Technological Development Area (China)	Empirical

interest for circular economy is also shown by China due to a top-down political strategy aimed at achieving the green transformation of the society: the ultimate scope is to face the environmental and social challenges posed by the Chinese fast and steadily growing production and consumption patterns [7]. Differently from the top-down approach observed in China, the European countries are targetting bottom-up environmental and waste management policies aimed at achieving synergistic effects with the national strategies [4]. A signal of the strong effort devoted by the European Union is provided by the fact that 15% of the documents in the sample have been sponsored by European funding bodies (e.g., European Commission, European Regional Development Fund, Horizon 2020 Framework Programme).

Apart from the Wageningen University & Research (30 documents), the Italian universities are the most productive organisations on these topics, led by the University of Milan (18 documents), the National Research Council (17 documents), the University of Catania (16 documents), the University of Rome La Sapienza (15 documents), which rank as the top 5 Institutions in terms of number of documents published on circular and green economy.

The authors with the vast majority of articles on these topics are X. Gabarrell (Spain Universitat Autònoma de Barcelona) and A. Petit-Boix (German Universität Freiburg im Breisgau), respectively with 6 and 5 documents recently published (between 2019 and 2020). Their studies focus on the analysis of waste management strategies for the agricultural production (e.g., [25, 26]).

By applying the bibliometric technique of co-occurrence of terms included in the titles and the abstracts of the 1,061 documents composing the sample, four recurrent thematic areas have been identified: i.e., "Circular Economy" (blue cluster), "Green Economy" (red cluster), "Food Waste" (green cluster), "Environmental Impacts" (yellow cluster) (Figure 3, Table 3).

The analysis of thematic clusters (Table 3) reveals that cluster 1 and cluster 2 identify, respectively, circular systems and supply chain greening in the context of the agri-food sector. Cluster 1, associated with keywords such as circular economy, food industry, product, process, and valorisation, corresponds to the research area dedicated to the valorisation of resources in terms of reduction, reuse, recycle, especially in the context of food industry. The cluster 2 collects the research dedicated to the sustainable development of the agricultural sector, and is defined by

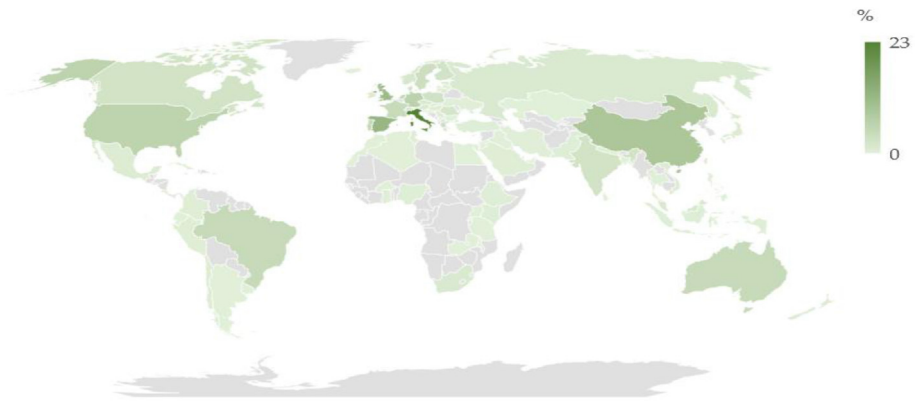


Figure 2. Documents by country. The figure highlights the countries (darkers) from which a vast majority of articles have been published.

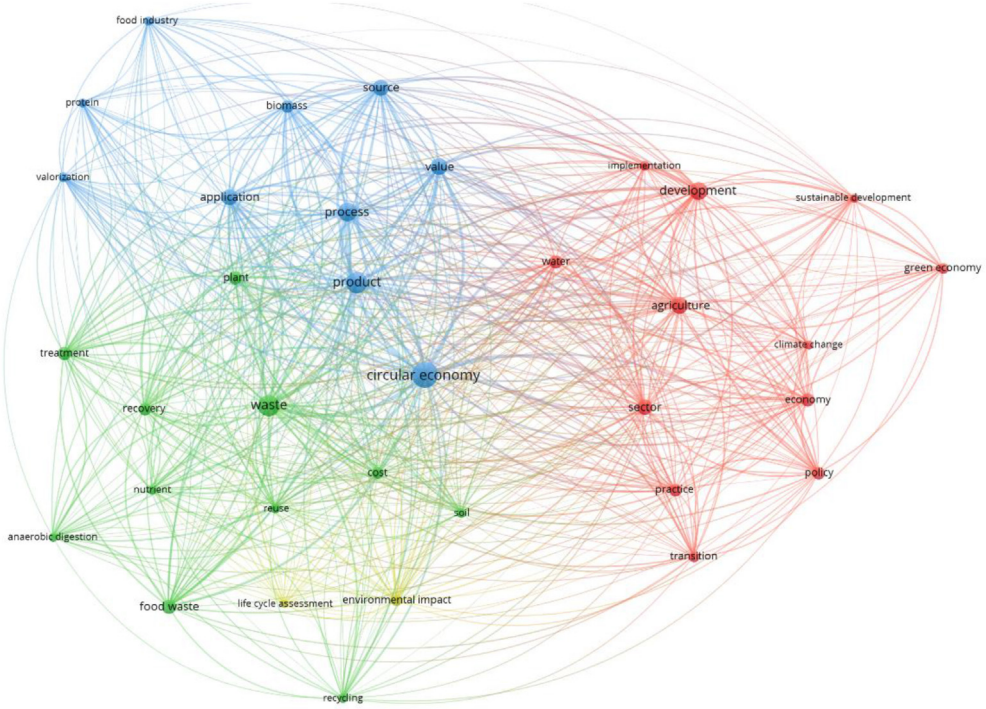


Figure 3. Networks of term co-occurrence. Clusters are identified with different colors. The links are shown through the lines connecting the keywords, which also represents the nodes.

Table 3. Thematic clusters in literature.

Cluster	Theme	Keywords
1	Circular Economy	Application; biomass; circular economy; food industry; product; process; protein; source; valorization; value
2	Green Economy	Agriculture; climate change; development; economy; green economy; implementation; sustainable development; policy; practice; sector; transition; water
3	Food Waste	Anaerobic digestion; food waste; nutrient; plant; recovery; recycling; reuse; soil; treatment; waste
4	Environmental Impacts	Environmental impact; life cycle assessment

keywords such as agriculture, climate change, development, economy, transition, water. The cluster 3 is shaped by keywords inherent to the food waste (e.g., anaerobic digestion, nutrient, plant, waste). The cluster 4 appears to be more methodological oriented, concerning techniques for evaluating the environmental impacts associated with the agri-food systems and the supply chains, especially in the context of life cycle assessment.

Within the cluster named "Circular Economy", a central topic seems to be the relationship between the principles of circular economy and the product-process applications [e.g., [27]]. Differently, the analyses on the valorisation of agricultural systems [28] and on the principles of the circular economy in the food industry are less relevant. The cluster also includes studies on the relationship between the circular economy and the use of biomasses, as well as on how the circular economy enhances the value of the agri-food systems and of the supply chains [e.g., [10]]. In the thematic cluster "Green Economy" the area that has been explored the most by researchers is the relationship between the agriculture and the (sustainable) development [e.g., [29, 30, 31]]. In the red cluster, besides the importance given to the transition to a green economy, the focus is on climate change and on the environmental policies. In the "Food Waste" cluster, the emphasis is on the relationship between waste and reuse/recycling/recovery [e.g., [32, 33]], and on the recovery of nutrients [e.g., [34]]. A minor cluster, the yellow one, is focused on the understanding of the environmental impacts associated with the agri-food systems and the supply chains [35], through the application of a life cycle assessment approach [45]. This methodology has been extensively adopted to quantify the potential environmental impacts related to the agricultural and production systems [36]. The empirical studies based on the life cycle assessment contribute to the academic debate on circular and green economy by highlighting the best practices to promote the environmental sustainability and an efficient production.

4. Discussion

Circular and green economy already is, and will be, a central agricultural issue in the future academic and policy debate [7, 10]. It has been presented a bibliometric analysis of topics related to circular and green economy in the agri-food systems and supply chains.

The growing number of documents published on these topics during the last decade signals an increasing interest for this line of research. Based on the bibliometric technique of term co-occurrence [18, 19], the following four thematic clusters have been identified: "Circular Economy", "Green Economy", "Food Waste", and "Environmental Impacts". While the issue of circular economy is mostly related to the food industry, with a particular attention to the product-process perspective, the issue of green economy pertains predominantly to the agricultural sector, with a focus on the transition to a (sustainable) development of the sector. Differently from other clusters, where a plethora of research topics tend to prevail, the "Environmental Impacts" cluster covers a well-defined thematic issue and is rather focused on the environmental impacts by mean of a life cycle analysis approach.

The vast amount of literature on circular and green economy did not allowed to be comprehensive. Accordingly, it has been maintained the discussion of the literature intentionally brief, referring only to exemplary documents, literature reviews, and recent novel papers. Potential limitations related to the methodological choices are associated with the selection of keywords for the systematic bibliographic search. To overcome this concern, it has been used a rigorous and reproducible

methodological protocol for the systematic search, with a filtering process as flexible as possible in order to avoid the omission of relevant literature.

5. Conclusions and future research orientations

Based on the findings on publication patterns and on the key topics emerging from the literature on circular and green economy, several suggestions for future research can be provided.

In particular, the purpose of this research has been to investigate the state-of-the-art of the literature on circular and green economy in the agri-food sector and identify trending topics addressed by scholars. Given the strong interdisciplinary roots of the issue, it is advisable to further explore the effects that the principles of circular and green economy will have in the agri-food systems, and along the supply chains, in connections with sectors other than the agricultural one. A multidiscipinary approach would allow to conclude on the complex nexus between the food waste and the environment. Moreover, because the agri-food systems face challenges such as the need to ensure food security, while pursuing a sustainable development at the global level, the agri-food system will need to orient consumption and production towards supply chains that have a green approach, that tend to avoid food waste and to reduce the impacts on the environment. As argued in Santeramo et al. [37], the agri-food system "*should be more oriented towards the protection of the environment, the preservation of the natural resources, in order to facilitate the emergence of strategies able to promote the circular economy and to reduce food wastage*". At the policy level, there is a need to manage the life cycle of natural resources in the perspective of the 3R's Principles of circular economy (i.e., reduction, reuse, recycle), where nothing is wasted, and support eco-friendly businesses. A greener economy, based on eco-design, eco-innovation, waste prevention and the reuse of raw materials, means smart, inclusive, and sustainable growth. The benefits would be for the economic activities, the social wellbeing of citizens, the environment: the scientific debate may contribute with a new research agenda [39, 40, 41]. The interested readers should not limit their attention to the present cursory review, but rather consider that the literature is so rapidly evolving that several other recent reviews and applied papers on circular economy have been published [46, 47, 48, 49], a further proof of the relevance of the themes that have been described in this paper.

Declarations

Author contribution statement

Fabio G. Santeramo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

No data was used for the research described in the article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendix A

Table A1. List of the 19 irrelevant terms omitted from the bibliometric analysis.

Terms		
Addition	Country	Review
Amount	Effect	Role
Area	Example	Way
Article	Model	Work
Case study	Opportunity	World
Challenge	Paper	
Consumer	Potential	

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