

Supplementary Materials - The concept of circular economy in agriculture. A review of the literature and a possible way forward

1. First stage literature review

The first stage of the literature review was collecting definitions of circular economy applied to the agricultural sector. The documents selected aim to define circular economy in agriculture, state a definition of circular economy and present cases in which circularity is applied in agriculture or farms, followed by indicators to evaluate circularity at the micro level with measurements applicable to agriculture. Documents published in any year up to October 2025 were included, as this research aims to assess a global concept of circular economy in agriculture.

Academic literature was retrieved from the Scopus database from Elsevier, in October 2025. The expressions searched were:

- “circular economy” AND “definition” AND “agriculture”
- “circularity” AND “definition” AND “agriculture”
- “circular economy” AND “meaning” AND “agriculture”
- “circularity” AND “meaning” AND “agriculture”
- “circularity” AND “farm level”
- “circular economy” AND “farm level”

Additional academic and grey literature was identified using the “snowball” method, by reviewing the reference lists of publications eligible for full-text review. First-level references were screened, applying the same inclusion criteria as for the database-collected documents. We included grey literature since significant contributors to the development of the circular economy involve non-academic entities (Schut et al., 2016; Velasco-Muñoz et al., 2021). Additional grey literature was retrieved from the Ellen MacArthur Foundation¹ webpage, due to the relevance of this organisation targeting the conceptual and practical development of the circular economy.

The list of academic and grey literature retrieved was skimmed according to the following criteria: i) exclusion of documents that focus on the application of the circular economy without first explicitly analysing its definition, or ii) exclusion of documents that analyse circularity in other levels of the value chain, not agriculture or farm level (see Figure 1 in the main document for the resulting excluded items). Table S 1 shows the 22 final documents analysed.

¹ The Ellen MacArthur Foundation is a non-profit organisation committed to creating a circular economy. It works with business, academia, policymakers, and institutions to mobilise systems solutions, produces evidence-based research, offers formal learning opportunities, and develops resources to support effective policies, innovative business models, and better product design (Ellen MacArthur Foundation, 2025).

Table S 1. Database containing the reviewed literature about the circular economy in agriculture.

No.	Authors and Year	Document title	Link
1	Barañano et al., 2021	Contextualization of the bioeconomy concept through its links with related concepts and the challenges facing humanity	https://www.mdpi.com/2071-1050/13/14/7746
2	Barcelos et al., 2021	Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons	https://www.sciencedirect.com/science/article/pii/S0301479721014353
3	Bos & Broeze, 2020	Circular bio-based production systems in the context of current biomass and fossil demand	https://onlinelibrary.wiley.com/doi/full/10.1002/bbb.2080
4	Burgo-Bencomo et al., 2019	The Economy circular a sustainable alternative for the development of agriculture	http://bdigital2.ula.ve:8080/xmlui/bitstream/handle/654321/6527/a19v40n13p02.pdf?sequence=1&isAllowed=y
5	De Rosa et al., 2021	The Root towards More Circularized Animal Production Systems: From Animal to Territorial Metabolism	https://www.mdpi.com/2076-2615/11/6/1540
6	EIP-AGRI, 2015	EIP-AGRI Workshop ‘Opportunities for Agriculture and Forestry in the Circular Economy’ Workshop Report 28-29 October 2015	https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_ws_circular_economy_final_report_2015_en.pdf
7	SYSTEMIQ & Ellen MacArthur Foundation, 2017	Achieving ‘growth within’	https://www.ellenmacarthurfoundation.org/achieving-growth-within
8	Ellen MacArthur Foundation, 2019a	Cities and Circular Economy for Food	https://emf.thirdlight.com/link/7ztxaa89x15cd30so/@/preview/1?o
9	Ellen MacArthur Foundation, 2019b	Completing the Picture: How the Circular Economy Tackles Climate Change	https://emf.thirdlight.com/link/w750u7vysuy1-5a5i6n/@/preview/1?o
10	Ellen MacArthur Foundation, 2022	A circular economy for food will help people and nature thrive	https://ellenmacarthurfoundation.org/topics/food/overview
11	Fassio & Tecco, 2019	Circular Economy for Food: A Systemic Interpretation of 40 Case Histories in the Food System in Their Relationships with SDGs.	https://www.mdpi.com/2079-8954/7/3/43
12	Freeman et al., 2022	On-farm circular technologies for enhanced sustainability: The case of Uruguay	https://www.sciencedirect.com/science/article/pii/S0959652622030517
13	Hens et al., 2018	On the evolution of “Cleaner Production” as a concept and a practice	https://www.sciencedirect.com/science/article/pii/S0959652617327427
14	Jun & Xiang, 2011	Development of Circular Economy Is A Fundamental Way to Achieve Agriculture Sustainable Development in China	https://www.sciencedirect.com/science/article/pii/S1876610211011982
15	Jurgilevich et al., 2016	Transition towards circular economy in the food system	https://www.mdpi.com/2071-1050/8/1/69
16	Kristensen et al., 2016	Enabling Sustainable Agro-Food Futures: Exploring Fault Lines and Synergies Between the Integrated Territorial Paradigm, Rural Eco-Economy and Circular Economy	https://link.springer.com/article/10.1007/s10806-016-9632-9
17	Pimbert, 2012	Fair and sustainable food systems: from vicious cycles to virtuous circles	https://www.iied.org/sites/default/files/pdfs/migrate/17133IIED.pdf
18	Ruiz et al., 2019	Measuring the circular economy: Frameworks, Indicators and Impact Management	https://foretica.org/wp-content/uploads/informe_medida_economia_circular_foretica.pdf

19	Therond et al., 2017	A new analytical framework of farming system and agriculture model diversities. A review	https://link.springer.com/article/10.1007/s13593-017-0429-7
20	Velasco-Muñoz et al., 2021	Circular economy implementation in the agricultural sector: Definition, strategies and indicators	https://www.sciencedirect.com/science/article/pii/S0921344921002275
21	Paño Yañez, 2021	Viability of circular economy in no industrialised countries and its adjustment to a proposal based on transformative economies: an approach to the Latin-American scenario	https://ojs.uv.es/index.php/ciriecespana/article/view/15979/18378
22	Yuille et al., 2022	UK Government Policy and the Transition to a Circular Nutrient Economy	https://www.mdpi.com/2071-1050/14/6/3310

The time horizon covered is 2011-2025. While we did not define a time limit during the search of literature, the time frame covered by the identified documents is relevant, as 2011 marks a turning point in the development of the framework. The Ellen MacArthur Foundation's active work began in 2011, popularising the discussion of this concept not only in research but also among businesses. Similarly, the European Commission's *Roadmap to a Resource Efficient Europe* was released in 2011, which is considered the first formal step toward a circular economy policy framework in the EU.

The review included publications in English and Spanish. Spanish-language documents were analysed in their original language. Relevant concepts were translated into English during the coding process. All coding and framework development were conducted in English to ensure terminological and conceptual consistency across sources.

2. Coding process

We defined a coding scheme to classify the information of the definitions and facilitate the analysis. A coding scheme provides a structured approach to categorising and interpreting verbal data, converting it to numeric data suitable for analysis (Bourque, 2004). The coding framework is developed through an iterative process, departing from existing knowledge followed by inductive coding of the collected literature, where additional categories emerge. Our coding scheme is based on the framework used by Kirchherr et al. (2017), who summarised the concept of circular economy based on 114 definitions and defined their coding framework using experts' opinions, literature review and inductive refining. It consists of three dimensions: core principles, aims, and enablers.

The core principles include the R's² and the systems perspective. The R's principles have long been used (Blomsma & Brennan, 2017) and recognised as fundamental to circular economy (Reh, 2013; L. Zhu et al., 2010; Q. Zhu et al., 2010). The composition and suggested order for the application of the R's principles vary in different studies. Reike et al. (2018) suggest that divergent perspectives on value retention options (R's principles) originate from the discipline of application: 3R's are used in the Circular Economy studied in the 2010 and over, while 4 to 6Rs dominate in studies on Reverse Logistics and Closed-Loop Supply Chain Management. Furthermore, the authors summarise a product "concept, design, and use" R's framework into 10 principles: R0 Refuse, R1 Reduce, R2 Re-sell/Ruse, R3 Repair, R4 Re-furbish, R5 Re-manufacture, R6 Re-purpose, R7 Re-cycle, R8 Recover energy, R9 Re-mine.

² The R's principles refer to actions aimed at managing waste, most commonly include the 3 Rs: reduce, reuse, and recycle (Ghisellini et al., 2016; Kirchherr et al., 2017), but they have been extending to 4 or more Rs to include additional actions like recover (European Commission, 2008; Potting et al., 2017; Sihvonon & Ritola, 2015).

Additionally, since the early literature on circular economy emphasised a systems perspective (Davis & Hall, 2006; Zhijun & Nailing, 2007) and highlighted the need for fundamental changes, Kirchherr et al. (2017) specify that the circular economy requires a systems perspective, which implies change occurring at multiple levels. The principle of a systems perspective is classified into macro level (economy-wide structural changes), meso level (regional and supply-chain changes), and micro level (firms, products, and consumer changes).

Regarding aims, sustainability was identified as the primary objective, continuously highlighted by scholars, practitioners, and policymakers (Ellen MacArthur Foundation, 2013; European Environment Agency, 2016; Ghisellini et al., 2016). Finally, for a broad definition, Kirchherr et al. (2017) included two enablers: consumers and business models.

For our coding process, we used the software NVivo®. The departure coding framework was adapted to the current research to include the main dimensions of the definitions assessed. An iterative coding process ensured consistency in assigning the codes to the coding scheme. In Table S 2 we present examples of how text was assigned to the different codes.

Table S 2. Example of coding process application.

Text excerpt	Code	Rationale
“Circular economy is the road to achieve the harmonious development between economy and environment.” (Jun & Xiang, 2011)	Environmental aims of Circular Economy used in Agriculture	Natural resources protection and productivity
	Economic aims of Circular Economy used in Agriculture	
“The defining elements of a circular bioeconomy are the production of goods and the offer of services, based on bioresources, with high added value, and the planning on the use of bioresources/biomaterials in a cascaded way” (Barcelos et al., 2021)	Cascading	Maximising resources value by using them according to the cascading principle
“a circular economy searches for a balance between economic growth and environmental issues, through efficient resource utilization and recycling” (De Rosa et al., 2021)	Efficiency	Based on efficient resource use and recycling
	Recycling	
	Environmental aims of Circular Economy used in Agriculture	Economic and environmental aims
	Economic aims of Circular Economy used in Agriculture	

Source: our elaboration

Finally, we studied the coding results using figures and quantitative summaries. NVivo automatically calculated the number of references coded under each theme and sub-theme, we exported and graphed these results using MS Excel.

We acknowledge that a single-coder analysis may increase interpretative bias; hence, the structured coding protocol, theory-driven framework, transparent use of NVivo, and peer discussions were designed to mitigate this risk.

3. Second stage literature review

For the last section of this research concerning the comparison of the definition of circular bioeconomy to the definition of circular economy in agriculture, we performed a literature review in the Scopus database from Elsevier to identify the main principles and aims that define the circular bioeconomy. We looked for the expressions:

- “circular” AND “bioeconomy” AND “definition”
- “circularity” AND “bioeconomy” AND “meaning”

The literature retrieved was skimmed according to the following criteria: i) exclusion of documents that focus on the application of the circular bioeconomy without first explicitly analysing its definition, ii) exclusion of documents that present the opinions or perspectives of interviewees about the application of the circular bioeconomy without explicitly analysing its definition, or iii) exclusion of documents that analyse the circular economy or the bioeconomy definitions as separate terms only. Documents published in any year up to October 2025 – date of this search – were included, as this research aims to assess a global concept of circular bioeconomy. Figure S 1 in the main document shows the selection process followed, while Table S 3 shows the final documents analysed.

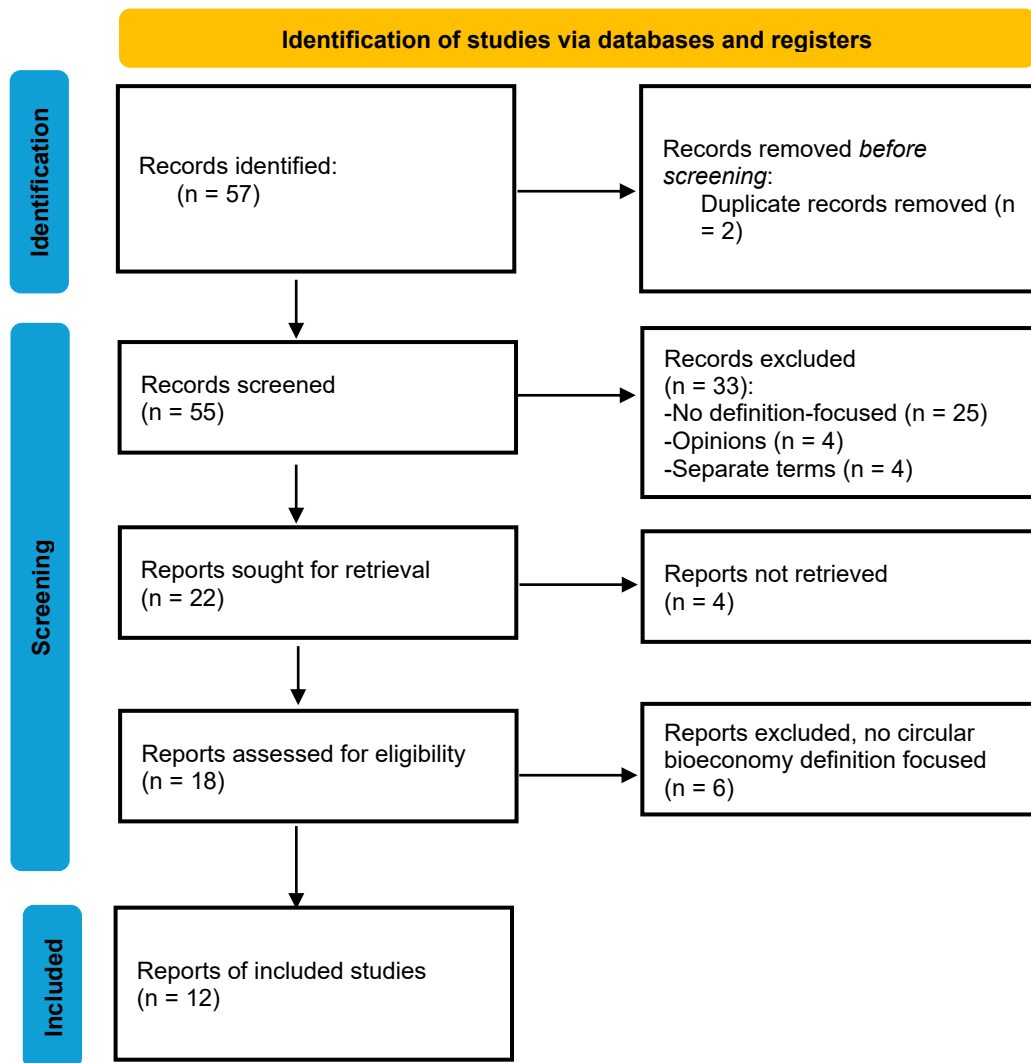


Figure S 1. PRISMA 2020 flow diagram of the systematic review of definitions of circular bioeconomy. Source: our elaboration based on the format of Page MJ, et al. BMJ 2021;372:n71. Doi: 10.1136/bmj.n71. This work is licensed under CC BY 4.0.

Table S 3. Database containing the reviewed literature about the circular bioeconomy.

No.	Authors and Year	Document title	Link
1	Barañano et al., 2021	Contextualization of the bioeconomy concept through its links with related concepts and the challenges facing humanity	https://www.mdpi.com/2071-1050/13/14/7746
2	Hodson de Jaramillo, 2018	Bioeconomy: A sustainable future	http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0370-39082018000300188&nrm=iso
3	Giampietro, 2019	On the Circular Bioeconomy and Decoupling: Implications for Sustainable Growth	https://www.sciencedirect.com/science/article/pii/S0921800918317178
4	Jarre et al., 2020	Transforming the bio-based sector towards a circular economy - What can we learn from wood cascading?	https://www.sciencedirect.com/science/article/pii/S1389934118303708
5	Konstantinis et al., 2018	A Definition of Bioeconomy through the Bibliometric Networks of the Scientific Literature	https://agbioforum.org/wp-content/uploads/2021/02/AgBioForum-21-2-64.pdf
6	Liobikienė & Miceikienė, 2023	Contribution of the European Bioeconomy Strategy to the Green Deal Policy: Challenges and Opportunities in Implementing These Policies	https://www.mdpi.com/2071-1050/15/9/7139?type=check_update&version=3
7	Ptak et al., 2022	Sugar Beet Pulp in the Context of Developing the Concept of Circular Bioeconomy	https://www.mdpi.com/1996-1073/15/1/175?utm_source=researchgate.net&utm_medium=article
8	Pyka et al., 2022	Modelling the bioeconomy: Emerging approaches to address policy needs	https://www.sciencedirect.com/science/article/pii/S0959652621039767
9	Robert et al., 2020	Development of a bioeconomy monitoring framework for the European Union: An integrative and collaborative approach	https://www.sciencedirect.com/science/article/pii/S1871678420301357
10	Tan & Lamers, 2021	Circular Bioeconomy Concepts—A Perspective	https://www.frontiersin.org/articles/10.3389/frsus.2021.701509
11	Therond et al., 2017	A new analytical framework of farming system and agriculture model diversities. A review	https://link.springer.com/article/10.1007/s13593-017-0429-7
12	Tolić, 2022	Concepts of bioeconomy	https://www.taylorfrancis.com/chapters/edit/10.4324/9781003223733-2/concepts-bioeconomy-iva-toli%C4%87



Figure S 2. Word cloud principles of circular economy applied to agriculture.
Source: our elaboration

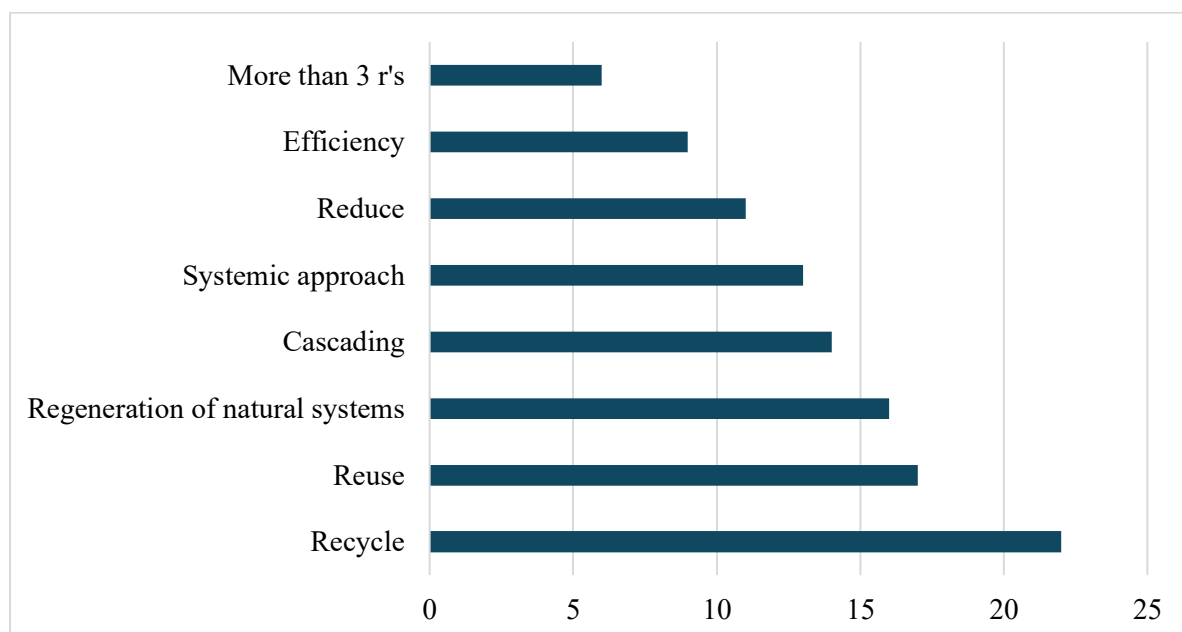


Figure S 3. Column chart of principles of circular economy applied to agriculture. Classified by number of documents coded.
Source: our elaboration

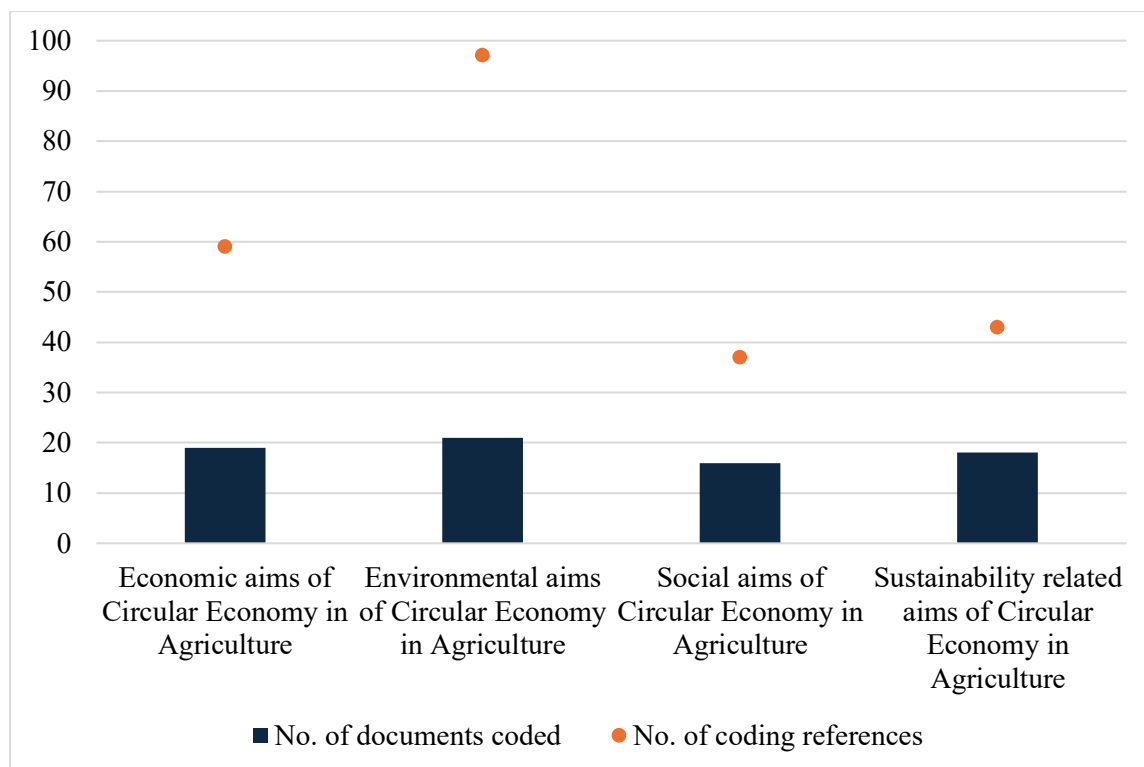


Figure S 4. Aims of Circular Economy in Agriculture: Number of documents coded and coding references.

Source: our elaboration

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