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REVIEW

The social impacts of circular economy: disclosing epistemological stances and methodological practices

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Abstract
The essence of circular economy is about closing the loop of material flows by reducing, reusing, recovering and recycling, ensuring the economic prosperity without any detriment for the environment. However, few information is available about the contribution of circular systems to the social dimension of sustainability (such as well-being, quality of life), how these aspects are evaluated and why they are deemed as important. The purpose of this study is to review those scientific studies that dealt with the social sustainability evaluations of circular systems to highlight new aspects: not only which are the most applied methodologies, which impact categories and indicators are mostly taken into account, but, above all, which is the most diffused epistemological position underlying the evaluation of social aspects of circularity. This last aspect is often disregarded but of utmost importance because it shapes the approaches and procedures choice, and legitimate and justify the insights provided: indeed, they can be the most diverse when dealing with social sciences, which are *multiparadigmatic* sciences. To the best of our knowledge, no studies have so far emerged that directly investigate the epistemological basis of social impacts within the circular economy. A systematic and hermeneutic review of the scientific literature has been led through a two steps method. The first step, dedicated to search and acquisition, consisted in a standardized replicable process called Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). In a second phase, a hermeneutic review has been conducted on the selected publications. Among the 42 studies reviewed, 7 papers were framed within the post-positivism paradigms, while 83,3% were based on interpretivist paradigms, showing how it is difficult to find consensus on standardized quantification methods for social impacts in circular economy studies. The most recurring qualitative methods relied on personal interpretations, perceptions or observations.

Keywords Social sustainability · Circular economy · Social evaluation · Scientific paradigms · Epistemology

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1 Introduction

Current scientific literature emphasizes the importance of considering social sustainability alongside environmental and economic aspects of the circular economy, suggesting a growing recognition of the need to understand and address the social impacts of Circular Economy (CE) practices. However, current approaches to circular economy design often overlook social sciences and prioritize technological solutions, often recurring to the application of dominant paradigms; this habit has been criticized by some researchers, hinting at the need for a more nuanced understanding of human behaviour, social systems, and values, which aligns with the importance of considering different epistemological perspectives (Lofthouse & Prendeville, 2018). Inigo and Blok (2019) also proposed to strengthen the socio-ethical foundations of the circular economy drawing lessons from responsible research and innovation, which are focused on stakeholder engagement, anticipation of potential impacts, and reflexivity, aligning with key principles of certain epistemological positions.

Until now there is a gap in research directly addressing the epistemological foundations of social impact assessment in the circular economy. Therefore, there is a need for an accurate reflection about how different epistemological positions shape the identification and assessment of social impacts in CE transitions, the implications of different knowledge systems in understanding and addressing social issues in CE, and if and when participatory and context-based methodologies—that are grounded in diverse epistemological perspectives—can be suitable.

The literature reviews here proposed explicitly addresses these questions, trying to contribute to a more robust and inclusive understanding of the social dimensions of the CE starting from epistemology of studies reviewed, i.e. the study of knowledge and justified belief that shapes how we gather, interpret, and apply knowledge to understand and address social issues.

1.1 The concept of circular economy

The conventional economic model, based on linear material and energy flows, i.e. from raw materials extraction to waste disposal, has been strongly criticized in the last decades (Millar et al., 2019; Sala et al., 2015; Velenturf & Purnell, 2021). This entailed a growing attention to sustainability topics, in particular the concept of circular economy (CE), focused on the perspective toward more sustainable consumption and production models. CE attracted the attention of many practitioners, policy makers, private decision-makers, and academics and scholars (Korhonen et al., 2018a, 2018b). The most quoted definition of CE is that by Ellen MacArthur Foundation (2012) who defined the CE as a production system that, by intention and design, is restorative or regenerative, reducing waste from the design of materials, products, systems, and, within these, business models. It does this by replacing the "end-of-life" notion with restoration, shifting to the use of renewable energy, avoiding toxic chemicals.

Worldwide researchers agree that the core issue of circular economy is about closing the loop material flow, reducing, reusing, recovering and recycling, ensuring the economic prosperity without any detriment for the environment (D'Amato et al., 2017; Kirchherr et al., 2017; Korhonen et al., 2018a and b; González Forastero, 2023).

The conceptual roots of circular economy date back to Boulding (1966), who affirmed that circular systems were the only solutions to ensure human life in the long run (Geisendorf & Pietrulla, 2018). In nature, the elements' cycles consist in that the output of one system turns into input for another one: the same should be done in the anthropic and technical environment, providing "technical nutrients" for new products, from a system to another, without contaminations (McDonough & Braungart, 2002). The shift from linear to circular systems entails, therefore:

- Reducing the utilization of raw materials, the production of waste, and the loss of mass and energy;
- Recycling materials and products, that means turning an item into raw material to be elaborated one or more times for completely new products;
- Reusing a product or discarded object for the same function;
- Repurposing a product or a discarded object for a new function;
- Valuing by-products and co-products, such as by transforming process by-products into marketable products;
- Waste valorisation, recovering components from wastes to be transformed for new items;
- Energy recovery, usually from biomass incineration, compost or anaerobic digestion (Stillitano et al., 2021).

However, the scientific research around CE concepts still seems superficial and unorganized; the relationship of CE with the concept of sustainable development is often implied or taken for granted, and not scientifically demonstrated (Korhonen et al., 2018a & b). This lack of explicitness is blurring the conceptual contours of CE and sustainability, affecting both the efficacy of scientific and operative approaches, with possible detrimental implications for the advancement of sustainability science and the dissemination of circularity practices (Geissdoerfer et al., 2017).

Some researchers highlighted the inversely proportional relationships between circularity and sustainability. For example, Andersen (2007) discussed how the costs incurring in circular structures should elude possible value losses. Allwood (2014) revealed a range of possible concerns that CE can bring, such as the technical unfeasibility of closing some circles when, for example, the energy required to recycle materials is even higher than the linear counterpart. Indeed, from the thermodynamic point of view, circular systems too consume resources and produce impacts, and sometimes these impacts are shifted from a life cycle phase to another. Rebound and boomerang effects are therefore possible and shifting to circular business models can entail remodelling the organisational structures, and last, but not least, the link between CE and sustainability is more culturally and socially constructed than scientifically demonstrated (Korhonen et al., 2018a & b; Niero et al., 2021).

Murray et al. (2017) affirmed that even if circularity has a positive effect on certain features of sustainability, other domains are often disregarded, such as the social domain. Similarly, Geissdoerfer et al., (2017) underlined that researchers oversimplified the CE notion by disregarding a (required) comprehensive perspective of sustainability and focusing instead on limiting resources input, waste, and emissions.

1.2 Social impacts of circular economy

The above mentioned viewpoint is even more constrained when it comes to the social aspect (social well-being, quality of life) in many CE research (Schröder et al., 2020;

Walker et al., 2021a and b). Quite frequently, the social consequences are only briefly considered, typically related to profession and human health, suggesting that it is unclear how CE may help to improve social impacts (Calzolari et al., 2022). Since there is currently no congruence between circularity indicators and the social component of sustainability, the social implications of circular systems are mostly ignored in the existing research, which primarily tracks correlations between circularity indicators and sustainable development (Pollard et al., 2022).

According to Giampietro (2023), the ontological crisis in sustainability research, which was brought on by the acceptance of out-of-date scientific paradigms, is the cause of the growing popularity of the circular bioeconomy concept.

Social impacts are positive or negative changes (effects) in human well-being that can occur in the short, medium or long term, at all level. Impacts can be actual or potential, depending on if they can be directly measured and verified or only hypothesized. According to UNEP (2020), social performance refers to the outcome of an organization compared to a predefined standard, and can be expressed as a ranking or a scoring. For the purpose of the review, all typologies of effects declared by authors have been taken into account, because the aim of this study is to fill a gap of knowledge concerning the scientific paradigms underlying the impacts evaluation of circular economy systems, in particular those referring to the social dimension, which is epistemologically eclectic.

Compared to their environmental and economic peers, social aspects in CE always strive to be fully considered in sustainability assessments (Murray et al., 2017; Geissdoerfer et al., 2017; Schröder et al., 2020; Arzoumanidis et al., 2021; Walker et al., 2021a and b; Mies & Gold, 2021; Calzolari et al., 2022; Pollard et al., 2022), appearing often as an isolated node, covered or associated with other research themes (Wang et al., 2022).

Only recently, academics have become interested in the issue of the social component of CE. A report by Social Circular Economy (2017) defined social CE as the fusion of circular business models (closed loop production systems) with social enterprises, or companies with a social mission, in 2017. To ensure that economic operations do not negatively impact society or the environment, social CE is seen as a successful model. It is also seen as a practical way to achieve more UN Sustainable Development Goals than simply those relating to responsible consumption and production, which CE alone already addresses.

In order to demonstrate that the CE conceptually lacks the social and institutional elements, Moreau et al. (2017) explained the CE from a sociological and biological and physical viewpoint, and suggested that the concept of labour be revisited to account for the percentage of lost material and energy flows that cannot be economically recovered. Indeed, the authors, quoting Georgescu-Roegen and Cohen-Rosenthal's seminal studies, as well as Stahel's work, underlined the need to re-establish labour as fundamental in the economy because of its renewable nature. They suggested the social and solidarity economy as a helpful and real-world model of the CE, supporting participatory governance for a more equitable CE, boosting labour-intensive enterprises while enhancing the features and diversity of human labour utilized in recycling and remanufacturing, and lowering labour taxes in favour of resource consumption.

Hobson (2019) explored how CE interacts with commonplace norms, practices, and meanings. The author made the case that the mainstream CE discussion is undermined by an inadequate understanding of how we relate to complex material cultures, which in turn is posing obstacles to change. Therefore, a cultural shift is required in order to make global concerns like climate change relevant in people's daily lives. For the CE consumer-user, it should be taken into account how the capacity to embrace new habits is severely constrained by social, material, and cultural configurations.

Some scientific studies have been published about the sustainability evaluation of circular systems, and delivered an overview of indicators, listing them according to several criteria, such as the field of application (a specific productive sector) or the sustainability fields (society, economy, environment) (Murray et al., 2017; Iacovidou et al., 2017; Babbit et al., 2018; Saidani et al., 2019; Padilla Rivera et al., 2020; Tognato de Oliveira et al., 2021; Walzberg et al., 2021). Luthin et al. (2023) highlighted in a review that half of the studies focused on social impacts of CE were about positive impacts.

How circular economy can lead to a social change within companies has been investigated by Gallardo-Vázquez et al. (2024), finding that reaching the Sustainable Development Goals requires specialized trained human resources. Concerning the methodologies, Bhatnagar et al. (2024) highlighted that Social Life Cycle Assessment (SLCA) can measure the impacts of CE on specific stakeholders groups but it needs improvements to cover all impacts; they did not investigated the significance of the indicators reviewed and why authors chose them among others.

However, it would be important to understand the reasons behind the choice of indicators, and the rationale underlying the assessment perspectives of circular systems; and, at our knowledge, this field has never been investigated.

In order to examine how social components have been taken into account and incorporated in CE, particularly social repercussions and how circular systems might affect society and policymaking, Padilla-Rivera et al. (2020) conducted a thorough assessment of the scientific literature. Despite being promoted as a tool to assure sustainability the authors came to the conclusion that it is unclear if present CE practices can promote social well-being or how they may enhance quality of life. As other authors noticed, they confirmed the uncertainty whether the circular economic models are always more sustainable than the linear ones. The most cited social aspects considered in the CE studies were found to be employment, human health and safety, participation; there is no consensus on a suitable framework to consider and evaluate social aspects, which remain the lesser-attended aspect of CE studies. In a further research, Padilla-Rivera et al. (2021) surveyed CE specialists to create a list of potential impact categories to assess societal implications related to CE. Their results showed that consumer health and safety, poverty, food security, and governance were the most pertinent areas. Walker et al. (2021b) studied the perspectives and experiences about social assessment of frontrunner companies actively involved with CE, studying how they feel the importance of assessing the social dimension of CE practices, which barriers do they encounter while conducting social assessment, and which kind of knowledge they have concerning the evaluation of social sustainability impacts of their companies and supply chains. Authors' findings revealed that even if the social dimension is considered relevant to CE and sustainability assessments, most of the firms interviewed did not conduct any type of social evaluation.

Mesa Alvarez and Ligthart (2021) analysed the social impact assessment methodologies applied within the Social Life Cycle Assessment (SLCA) framework, to highlight the main differences among approaches and the linkages with CE. Their findings highlighted that the link between SLCA and CE is not so established: only 25% of SLCA studies analysed have been dealing with circular topics such as recycling, reducing and recovering (reusing was not found).

Even though CE is frequently framed under the triple bottom line concept of sustainability, little consideration is given to social ramifications (Niero et al., 2021). This lack of social concerns and social context makes CE a target for criticism.

Because indicators are essential to monitor progresses and area of action for the shift to circularity models, Poponi et al. (2022) proposed a dashboard to be used at several spatial

levels (micro, meso and macro) to guide the agri-food sector toward a CE and sustainable development, by identifying relevant indicators grouped into three possible dimensions of sustainability.

However, as stated in a research by Garcia-Saravia Ortiz-de Montellano and van der Meer (2022), there isn't a single paradigm to evaluate CE in terms of its social, economic, and environmental performance, but rather a spread confusion about circular impacts. Conducting a review of previous studies, the authors described the CE contribution to social development as the promotion of employees' education, engagement and satisfaction, as well as supporting consumers' patterns and institutions that collaborate with communities for the improvement of policies and social welfare. Recycling, reusing, reducing, recovering, etc., make sense only for the long-term objective of attaining sustainable development (Garcia-Saravia Ortiz-deMontellano and van der Meer, 2022). This is a significant distinction between circular processes and circular impacts.

Understanding how CE might enhance certain social, economic, and environmental aspects of sustainability in practices is therefore crucial. It is methodologically difficult to include the social and human components into CE analyses and practices, and doing so puts into question the epistemological underpinnings of both CE and sustainability research itself (Stillitano et al., 2021).

The purpose of the present study is to provide a further contribution to the discussion about the analysis of social impacts of circular economy, paying attention to the underlying scientific paradigms on which the reviewed studies are based, and as a consequence, the typology of methods applied. To our knowledge, this is an unexplored aspect in scientific literature. To fulfil this purpose, a systematic and hermeneutic review method has been applied, to mix the rigour of a systematic approach and the interpretative effectiveness and adaptability of a hermeneutic analysis. Scientific studies that dealt with the social sustainability evaluations of product or service produced by circular systems and companies have been reviewed to highlight:

- Which are the most applied methodologies for social assessments of circular systems and which impact categories and indicators are most taken into account;
- Which is the most diffused epistemological position underlying the evaluation of social aspects of circularity.
- How the epistemological position shapes the methodological choices, and how the different methods address specific problems and sustainability assessments.

Answering these questions enable justifying and legitimating the choice of methods and indicators, and therefore choosing the appropriate ones to address a research and evaluation question.

2 Material and methods

2.1 Scientific paradigms in social research

When a scientific community shares the same set of theoretical assumptions and methodological approaches, Kuhn (1962) utilized this to describe "normal science" (Iofrida et al., 2018). A paradigm is so-called because it comprises three main elements: ontology, epistemology and methodology. Ontology is a philosophical stance that underpins the

research process and pertains to the researcher's idea of the nature of reality. It poses the question of what reality is and if there is just one single, intelligible reality or whether reality is instead a manufactured idea that takes on several shapes based on the perceptions and interpretations of actors (Denzin & Lincoln, 2005). Epistemology relates to the research process itself and explores how the construction of true knowledge operates. Additionally, it involves the examination of the nature of knowledge and justification, as well as the idea of the connection between the researcher's goals and the subject of the study (Allard-Poesi & Perret, 2014; Guba, 1990; Phoenix et al., 2013).

Research design, data collection, and analytic procedures are all shaped by methodology, which is the formalization of a philosophical viewpoint into practices. The techniques produce data, which in turn provide the knowledge (Iofrida et al., 2018) by way of information.

The planning, design, and execution of research are shaped by these factors, which are intricately connected (Carter & Little, 2007). Within the so-called hard sciences (mathematics, physics, chemistry, etc.), the typical research methods are rigorously based on observation, empirical testing, and hypothetic-deductive models, which were for a long time considered the only "scientific methods". When the social and cultural aspects, the contexts, and the interactions among actors become noteworthy, the rigid rules of natural sciences are difficult to apply (Avenier & Gavard-Perret, 2012), because social phenomena are multi-layered and, in social sciences, many worldviews can be held. This is certainly the reason why there is such a great variability of methodologies when assessing the social sustainability of a system, whatever it is a linear or a circular one.

Boda (2021) argues that while it is reasonable to classify sustainability science as a separate area of problem-driven and solutions-oriented research, this does not imply epistemological unanimity because it can also occur in related interdisciplinary fields (such as Development Studies) or even disciplines that are part of the so-called "hard sciences" (such as Physics).

2.2 The systematic and hermeneutic literature review

A mixed-methods literature review has been chosen among all the possibilities (see Supplemental Material SM-1) to fulfil the purpose of this study, by combining the analytical approach of systematic review and the qualitative approach of the hermeneutic review (Fig. 1), which entails a critical and hermeneutical analysis to support the interpretation of literature. Indeed, systematic reviews allow to analytically study and search for specific elements, and therefore are highly suitable for descriptive items. The hermeneutic reviews were designed for situations where a body of literature hasn't been thoroughly examined or is too large, complex, or heterogeneous to be subjected to a more thorough systematic review. When a new type of analysis is performed on a body of literature that has not yet undergone a thorough review or when the subject under study exhibits a complex or heterogeneous nature that is not readily amenable to a more precise systematic analysis of the evidence, hermeneutic reviews are particularly helpful (Peters et al., 2015).

To assess the breadth of evidence (quantitative and/or qualitative) that is available on a topic, the review described here unifies the objectives of the hermeneutic method with the purposes of a systematic review to synthesize the evidence from diverse research designs (Peters et al., 2015). The review has been conducted by means of a two iterative steps (Fig. 1). The first step, dedicated to search and acquisition, consisted in a standardized replicable process called Preferred Reporting Items for Systematic Reviews and

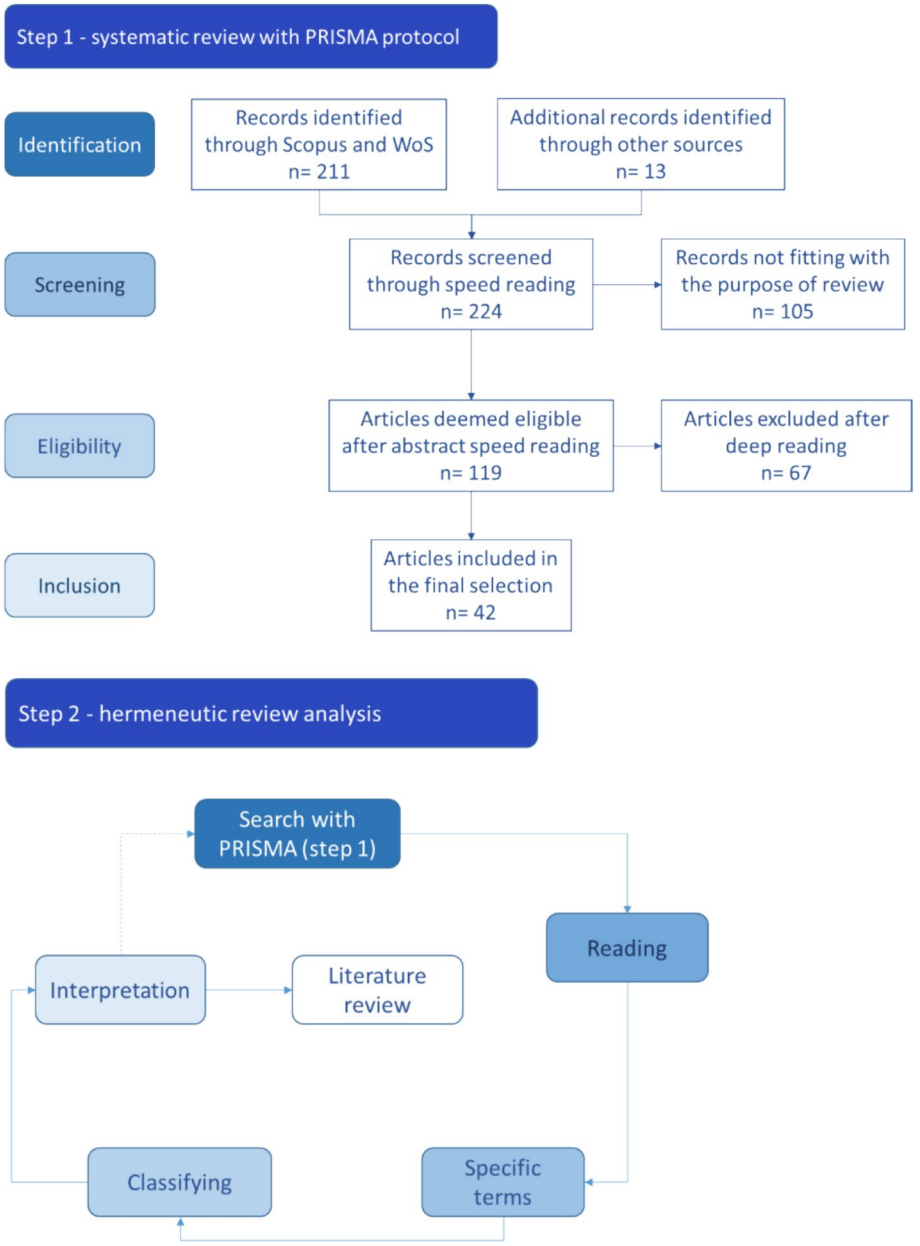

Fig. 1 Systematic and hermeneutic literature review procedure

Meta-Analyses (PRISMA) (Moher et al., 2009), a well-known and robust protocol for conducting such systematic analyses (Page et al., 2021; Desiderio et al., 2022). The choice of PRISMA among other possible models is due to the endorsements and acknowledgements that this protocol received at academic level, being cited in more than 60,000 times in almost 200 journals across all disciplines (Page et al., 2021). This protocol ensures a

systematic review through a transparent, complete, and accurate procedure based on a checklist of recommended items (Moher et al., 2009; Page et al., 2021; Rethlefsen et al., 2021).

The second phase was a hermeneutic study to evaluate how social implications have been taken into account in the evaluation of circular models and to what extent. This step was conducted by critically reading the papers, screening them in search of elements that allowed to recognize the epistemological underpinnings of the studies. This iterative task has been a time consuming and delicate operation, because it entailed looking for elements not always explicitly declared. Indeed, the hermeneutic analysis addresses the critical search for issues and meanings in texts; it aims to improve understanding of a field by creating clarity via an iterative process of reading and comparing, progressively doing so by a deep intellectual engagement with significant texts (Boell & Cecez-Kecmanovic, 2014).

A collection of keywords regarding the assessment of the social sustainability of CE was chosen in accordance with the research topics of this study, and the search was carried out using Boolean operators (AND/OR). The following search terms was used to access the scientific databases:

(TITLE-ABS-KEY (social) AND TITLE-ABS-KEY (circularity) AND TITLE-ABS-KEY (indicators) OR TITLE-ABS-KEY (assess*) OR TITLE-ABS-KEY (evaluat*)).

Scopus, Web of Science and Google Scholar were the database explored, which are among the most used abstract and indexing catalogues of scientific publications; the task was conducted in May 2022, papers published in the last 5 years where selected, obtaining 211 documents. A snowballing approach was used to find more references ($n = 13$), such as for example papers that were cited in the records analysed, allowing to capture additional and emerging methodologies. The literature search and snowballing were carried out until no new publications (fitting within the scope of the review) were found (de Oliveira et al., 2021). All the 224 abstracts were analysed through a speed reading process, to ensure the matching of their topics with the purpose of the review, while non-fitting papers were discarded ($n = 106$). This first screening led to a selection of 119 eligible papers; then, a more thorough reading allowed to further select the papers according to specific criteria inherent the purpose of the study.

The application of eligibility criteria allowed the identification of 42 peer-reviewed scientific papers. Eligibility was based on a speed reading of abstracts to find adherence with the purposes of the review, and in particular according to the criteria of inclusion and exclusion listed in Table 1.

The systematic review of publications was done using the criteria illustrated in Table 1. The major goal of a systematic literature review is to provide a transparent and repeatable process of selection, analysis, and reporting of previously done research on a given topic (Merli et al., 2018). It is a method for identifying, evaluating, and interpreting all available research related to a certain research question, topic area, or phenomena of interest. The final selection of 42 articles was organized through Mendeley Desktop® software, a

Table 1 Criteria of exclusion and inclusion used for the literature search

Inclusion criteria	Exclusion criteria
Circular economy as principal topic	Papers not aimed at sustainability assessment
Social evaluation purposes	Papers not assessing social aspects
Social sustainability methodologies	Papers not based on circular economy systems
Availability for download/full text reading	Reviews

reference management tool used to build and organize a research library and a data extraction sheet was developed using Excel® to capture the data from the selected studies (Supplemental Material SM-2). The portfolio was organized according to the criteria described in Table 2.

In the second step, a critical and hermeneutical literature analysis has been conducted on the selected publications. The hermeneutic circle framework has been chosen to overcome the possible deficiencies of systematic review techniques, for example allowing taking into account research questions that can emerge during the reading task. In fact, as the literature evaluation proceeds, a greater knowledge of the study topic is frequently attained, increasing awareness of what questions would be most pertinent or urgent (Boell & Cecez-Kecmanovic, 2010, 2014).

The whole body of pertinent text was investigated, and portions of the text were identified to recognize those components that permitted to recognize the family of scientific paradigms underpinning each selected study. Additionally, the study's environment in which it was founded was taken into consideration. Through questioning and reasoning, a backward and forth movement from a single text to the entire manuscript body improved knowledge and interpretation (van der Wath and van Wyk, 2019).

Understanding the epistemological stances underlying each study and compiling the evaluation spreadsheet required reviewing manuscripts from different disciplines and perspectives, considering various settings and complexity, also considering the effects on several stakeholders (Valentine et al., 2021). Being sustainability literature diversified and heterogeneous, without consensus answers, the hermeneutical approach was believed to be the most appropriate.

To classify papers according to the research paradigm applied for social assessment, an assessment grid inspired to Iofrida et al. (2018) has been used as reference to test the presence of key elements that enabled to recognize the main ontological and epistemological orientation. Many scientific paradigms exist, but their contours can be very blurred; therefore, for the purpose of this review, two main opposite families of paradigms are taken into account, namely the post-positivist and the intepretivist ones. The topical elements of both paradigms groups, with practical examples, are reported in Table 3.

3 Results

The discourse about the social sustainability of circular systems is a trend topic, as showed in Fig. 2: in the period 2017–2021 the number of papers has been constantly growing, and the prediction line indicates that it will probably continue to grow.

'Sustainability', the 'Journal of Cleaner Production' and 'Resources, Conservation and Recycling' are the scientific peer-review journals that most attracted the interest of researchers to publish their studies (Fig. 3).

As the purpose itself of the review was to highlight how social sustainability assessment is put in practice, 64% of selected papers are applicative studies (Fig. 4), while the remaining ones are mainly methodological proposals (19% of studies), or both methodological and applicative (12%).

The field of application that most attracted the attention of researchers (see Supplemental Material SM-2) is Manufacturing (33%), followed by Biomass, Wastes (10% each one), Agriculture and Building (7% each one).

Table 2 Items used for systematic analysis

Unit of analysis	Description
Identification criteria	Progressive number, authors' names, year of publication, title, source reference
Typology of publication	Methodological proposals: description of the procedures of an innovative social impact analysis proposed for the first time; Applicative studies: implementation of an already structured methodology to a new field or context, providing concrete results from case studies; Discussion papers are theoretical investigations that draw on both original research and a broader body of literature to situate their analysis; Conference proceedings: short papers published in the context of an academic conference
Aim of the study	General objectives and purposes of analysis as declared by the authors
Field of application	Specific context where the methodologies are applied or could be applicable (agriculture, manufacturing, building, biomass, etc.)
Circularity topics	Typology of circular process under assessment, classified according to Stillitano et al. (2021) and reported in Table 2, i.e.: reducing, recycling, reusing, repurposing, by-products valorisation, waste valorisation, energy recovery
Methodologies for social assessment	Specific methodologies (name, acronyms, citation, etc.) proposed or applied in the paper, such as for example: multicriterial methodologies (MCDA), corporate social responsibility (CSR) approaches, social life cycle assessment (SLCA), qualitative analyses, material indexes, etc
Categories of social impacts or group of stakeholders evaluated	Areas of interest concerning the social sustainability dimension (e.g. work safety, contribution to wealth, job creation, consumers' health, social cost, land use, governance, etc.) or the stakeholders under assessment (workers, consumers, employees, general society, etc
Social indicators	How the impacts are practically measured within the social categories (unit of measures, percentages, numbers, ratios, factors, indexes, etc
Participatory approaches and actors involved	Specific participative methodology (e.g. Delphi, focus groups, AHP, interviews, etc.) applied to involve any category of actors such as: experts, stakeholders, vulnerable groups of actors, communities, workers, students, etc
Research paradigm applied for social assessment	A research paradigm is a group of shared assumptions and principles that scientists have on how to perceive and approach issues (Kuhn, 1970). For the purpose of this paper, two main opposite groups have been considered, i.e. interpretivism and post-positivism oriented paradigms
Main results and insights may deserve attention	Results and insights that provide new point of view on the topic as declared by the authors of the papers analysed

Table 3 Main characteristics of post-positivism and interpretivism oriented paradigms *Source*: our elaboration on Iofrida et al., (2018:470)

	Post-positivist paradigms	Examples	Interpretivist paradigms	Examples
Ontology	Moderate realism. There is just one objective reality, and it can only be known probabilistically	The study procedure is not based on the researcher's personal beliefs, therefore there is no requirement for direct interaction with affected actors	Relativism. It is impossible to know the true nature of reality. Perceptions are used to create and interpret reality	The researcher is intimately involved in the study process because they are in charge of selecting the assessment criteria and procedures
Epistemology	Researchers are more distanced than totally invested in the subjects they are studying Replications of results are "probably" accurate. The main goal, even though it is not entirely achievable, is the complete explanation of reality	Social performance is explained rather than described Findings are generalizable and not context bounded	Understanding is interpreted. Rather than being explained, reality is grasped and depicted. Researchers take an active interest in the subjects they study	Contact with the impacted actors directly Actors' opinions, claims made by interest organizations, and popular acceptance are all taken into consideration Depending on the context, findings may have a varied interpretation
Methodology	Experimental. Manipulative, primarily quantitative methods. A validation role is played by the scientific community. Statistical investigation. Sampling with probability	Direct relation between input flows and impacts: chains of causes and effects Statistical hypothesis testing Effects prediction, modelling, quantification	Dialectic, hermeneutic. Methods of quality. Sample with a specific goal and several uses. Stakeholders' values and views	Mostly qualitative indicators. Data gathering by means of interviews and surveys Weighting according to social values and actor meanings Findings are strongly context related

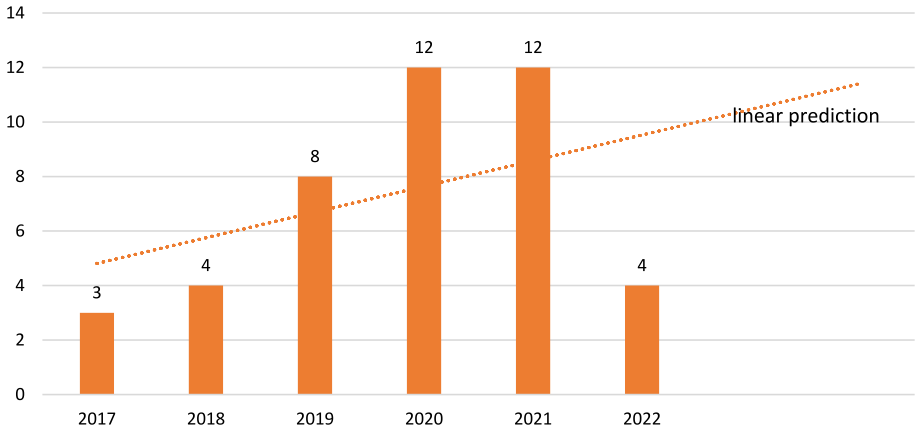

Fig. 2 Number of publications per year. *Source*: our elaborations

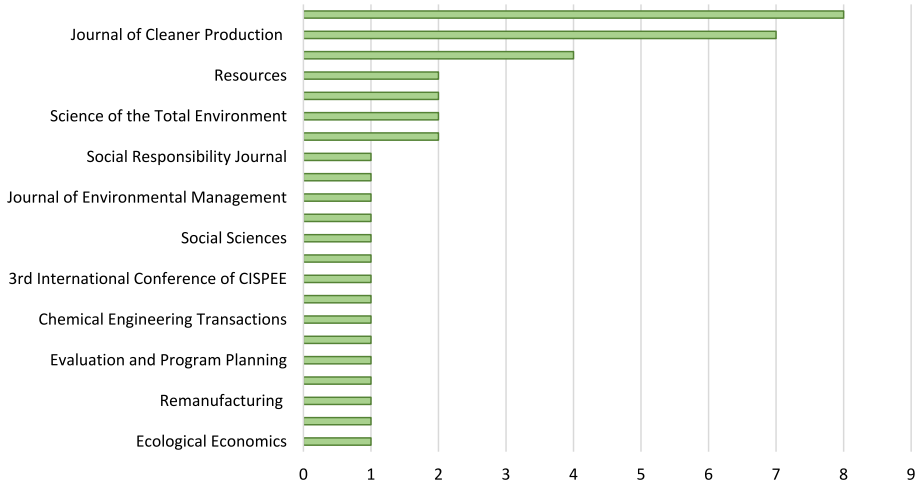

Fig. 3 Main editorial placement. *Source*: our elaborations

Concerning the purposes declared by the authors, there was a great variability; most of the studies reviewed analysed the sustainability of circular systems, models, products or production and consumption strategies considering at the same time the environmental, economic and social aspects of sustainability, always separately. Only ten papers (23,8%) were focused principally or exclusively on the assessment of social objectives. It is noteworthy that just one research (Martín Gómez et al., 2018) attempted to build an ontological framework for CE based on industrial metabolism for product design and manufacture. The authors assert that ontology makes it possible to model and codify knowledge in the field of sustainability, and that it is crucial for integrating the triple viewpoint of sustainability—ecological, economic, and social. A great variability concerned also the circularity aspects taken into account by the authors. Indeed, the discourse itself on circularity is variegated and expanding, as already mentioned in paragraph 2. Beyond the traditional "reduce, reuse,

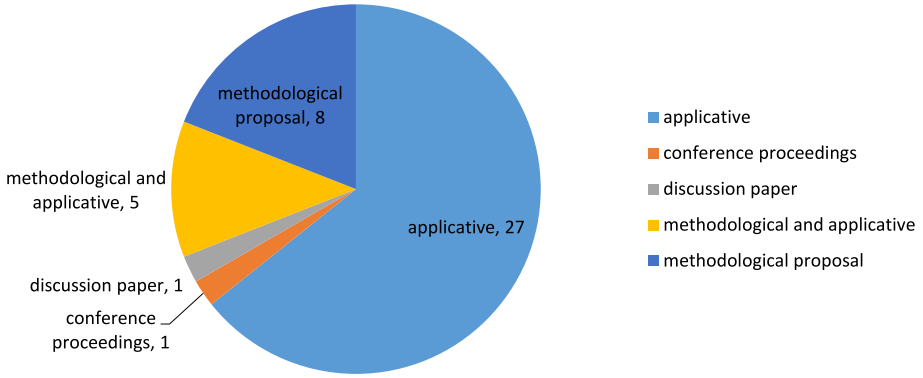

Fig. 4 Typology of studies. *Source*: our elaborations

and recycle" agenda, the discussion is now broadening to include "rethinking the system," "redesigning companies, processes, and products," "introducing more effective technologies, materials, and energy sources," "reconceptualising the usage and consumption patterns of goods," and "repurposing components and by-products" (Vlajic et al., 2021). For the purpose of this review, the distinction made by Stillitano et al. (2021) has been used, as showed in the following Table 4.

Almost all papers reviewed dealt with more than one circular topic (Fig. 5), and in particular 'B-recycling' (24 papers) and 'A-reducing' (20 papers) were the circular scenarios most assessed (Fig. 5); 'C-reusing, repurposing, remanufacturing, regenerating' were covered by 19 papers, followed by 'E-waste valorising', 'F-energy recovering' and 'D-by-products and co-products valorising'. Only six papers dealt with just one specific topic at a time, and the 14% of papers dealt with circularity in general without specifying which kind of circular process was under assessment.

Exploring more in depth the procedures applied to assess the social aspects of circular systems, the panorama is very variegated, ranging from qualitative to quantitative methods, and mixed-methods too (Fig. 6). The most recurring ones were qualitative methods (questionnaires, interviews, Delphi, desk analyses, etc.) and SLCA, followed by quantitative indexes (Garrido Azevedo et al., 2017; Fabbricatti & Biancamano, 2019; Momete, 2020; Hapuwatte & Jawahir, 2021; Mattos et al., 2022).

While qualitative approaches rely on subjective interpretations or observations that describe in depth how individuals think or react within society concerning the subject of research, quantitative methods primarily rely on numerical or quantifiable facts.

The qualitative methods found in the papers reviewed mainly concerned the use of questionnaires, brainstorming, focus groups, desk analyses, surveys, literature research, field investigations, participative methods to gather numerical data or judgements.

Quantitative methods were mainly about circularity indexes (therefore assessing social aspects jointly with other sustainability dimensions), SLCA methodologies, multicriterial analyses, statistical analyses.

The terms "qualitative" and "quantitative" are frequently misused to describe different types of research and their respective epistemological viewpoints; however, this kind of terms is more appropriate to describe the practical aspects of a research paradigm. Indeed, the methods are the practical tools that regardless of their type, can be applied ubiquitously within every theoretical framework, potentially (Guba & Lincoln,

Table 4 Main topics about circular economy systems *Source*: Stillitano et al. (2021)

	Circularity topics	Definitions and examples
A	Reducing	Reducing the volume of input, end waste, or product loss
B	Recycling	The process of converting a product (or any by-products, co-products, or products) into raw materials that may be used again, typically for a entirely new product. Examples include recycling glass or metal, or composting. It does not include energetic goals
C	Reusing, repurposing, remanufacturing, regenerating	The process of reusing goods or things that have been abandoned for the same purpose or a different one by repairing or replacing certain pieces, adapting them to the new use or purpose, and reintroducing them to the economic-productive system. For instance, repurposing wooden pallets; giving clothing or furniture a second life
D	By-products and co-products valorising	Transforming a process's by-product into a marketable sub product. Examples include dairy by-products fed to cattle and agricultural wastes used as fertilizer
E	Waste valorising	Recover components from wastes or losses so they may be used to new projects. Excluding energetic uses. Consider the recovery of nutrients and the extraction of biochemical feedstock
F	Energy recovering	Material incineration with energy recovery, typically including biomass. Examples include anaerobic digestion and composting for energy

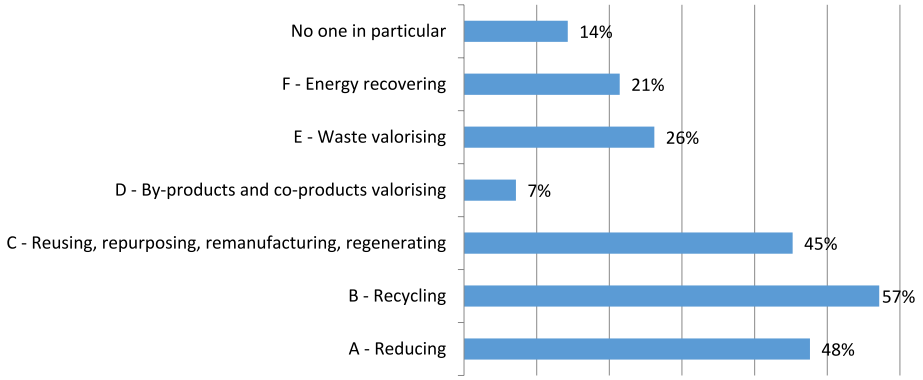

Fig. 5 Main circularity topics mentioned and analysed in the studies reviewed. *Source*: our elaborations

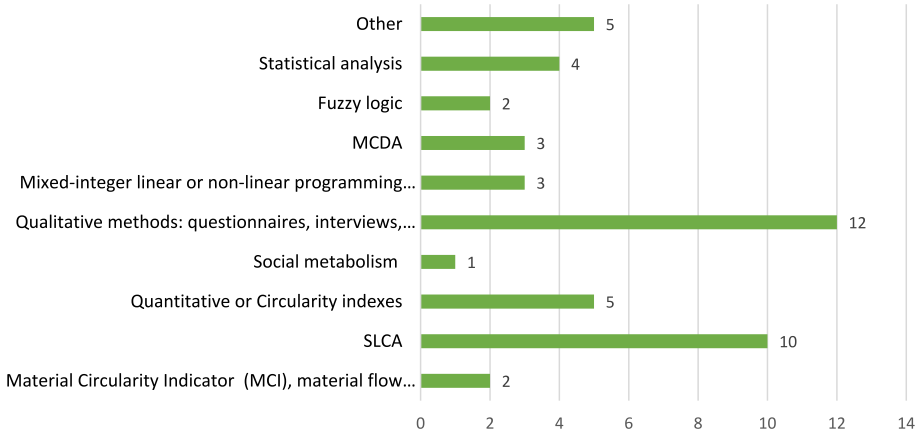

Fig. 6 Methods applied for social assessment of circular systems under study. *Source*: our elaborations

1994). The epistemological viewpoint is revealed by how and why the procedures are employed as well as how findings are used or understood, not by the methods alone, which are insufficient to determine the scientific paradigm (Iofrida et al., 2018). Therefore, to analyse the paradigmatic stances of the 42 papers selected, it was necessary to consider at the same time not only the methods applied, but also how data were treated, with which kind of indicators, and which categories were most paid attention to, as well as if and how stakeholders were involved in the research process (Tables 5 and 6). Full details about the specific indicators applied within the categories of impacts are specified in Supplemental material SM-2.

As showed in Tables 5 and 6, the panorama is very variegated. It is therefore possible to infer that there is no consensus on specific procedures nor theoretical frameworks to assess social effect and consequences of circular systems. Social phenomena can be represented by a wide variety of situations, and researchers are forced to adapt the methodology to the context and the object of assessment. Moreover, the typology of results varies according to the objectives themselves of the analyses.

Table 5 Interpretivism oriented papers *Source*: our elaborations

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
1	Mixed-integer linear programming (MILP) model, Analytic Network Process	Quant	Customers perceived value: social value preference, resiliency	Customers
3	Survey to gather the social importance and preferences on Ecosystem Services	Qual	Provisioning, regulating, and cultural ecosystem services	Interviews to 350 stakeholders with questionnaires
5	Check list	Qual	Consumers acceptance and comparison with current packaging	Not specified
6	Project Based Learning methodology: questionnaire	Qual	Feedback about the students' experience	Students, vulnerable people
7	Desk analysis	Qual	Using reverse logistics techniques; founding a regional agroindustrial cooperative; constructing community biodigesters; and making contributions to the sustainable development targets of the UN	Property owners interviewed for data collection
8	Questionnaires, Exploratory factor Analysis, Fuzzy set theory, Analytic Network Process	Quant & qual	Social mobilization: Green living and civic engagement, intelligent cooperation between stakeholders, technologies that respect the culture of the region, employment possibilities, working circumstances	Experts involvement

Table 5 (continued)

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
9	EPOS (method for Improved performance and energy efficiency in process industry operations through onsite and cross-sectoral symbiosis)	Quant & qual	Actors (central players, periphery actors, external actors); Governance (Actor governing type, leading actors, facilitation); Relationships (links between actors, unofficial linkages, trust, interdependencies, connections between actors, geographic scale, frequency, and intensity of relations, employee involvement, and societal acceptability); motivation (initial drive and charismatic support); effort (time-consuming at first). Indicators of regional worth (social type: employment balance)	Industrial partners of the project
11	Questionnaires, brainstorming, interviews	Qual	Self-consumption, supplemental earnings, Openness (to the production process), Quality olive oil produced, expertise of OOM, and family business management of OOM Costs, hazards to people during production, access to funds, and product differentiation the circular economy green picture, Social occasion, regional economic potential, expansion of local employment Identifying (new potential clients), based on natural resources, olive oil family reunion, climate change, the national economic crises, and foreign investments from rival nations	Consumers, scholars

Table 5 (continued)

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
12	Analytic Hierarchy Process, Likert scale,	Quant & qual	Workers: Human toxicity, Human health, Working conditions, Skills, Equal opportunities Consumer: End of Life responsibility, Human toxicity, Human health, Transparency, Feedback mechanism. General society: Public governance, Green public procurement, End of Life responsibility, Resource efficiency, Social investment Local community: Local employment, Economic development, Human toxicity, Human health, Access to material resources Value chain actors: New value chain, End of Life responsibility, Resource efficiency, Waste disposal cost, Illnesses and accidents cost	Experts consultation (Academics, trade associations, policy makers, waste management companies)
13	SLCA combined with MFA (material flow analysis)	Qual	Workers, Local communities, Society	Not specified
14	GIS, Social Discomfort Index, Building discomfort index, correlation matrix	Quant	Reflectiveness, robustness, redundancy, flexibility, resourcefulness, inclusion, and integration are the seven characteristics of resilience. Categories: civic engagement, cooperative resource management, human capital development, workforce, and demographics	The elucidation of the attributes of resilience for the circular urban regeneration has been aided by meetings between stakeholders of the social and entrepreneurial systems and the research group and facilitators
15	Social life cycle assessment (SLCA) and social readiness level (SRL) methods	Qual	Workers, city/society, value chain actors, consumers	SMART-Plant partners and SMARTech technology providers (for a total number of 15 surveys), focus groups

Table 5 (continued)

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
16	Social Hotspot Database (SHDB)	Quant	Health and safety, human rights, governance, and community infrastructure, together with labor rights and decent work	Policy makers and representatives of different institutes and population group involved through workshops
17	Field investigation, literature research, and triangulation; qualitative parameters	Qual	Product-process adaptability Sustainability; Work safety and health; Inclusion and collaboration	Not specified
18	SLCA focused on categories of stakeholders to which the company is ethically and socially committed	Qual	Private Enterprise, Personnel, Trade Unions, Local Public Institutions, Environment, Suppliers, Trade Channel Operators, Public and Private Organizations, Partners, Competitors, Media, and Final Consumer. According to the factors of power, urgency, and proximity, stakeholders are given priority	Not specified
19	Sustainable Circular Index. Indicators retrieved from literature	Quant	Workers	Delphi method for weighting; 184 experts involved
20	Analytic Hierarchy Process (AHP), weighted linear combination (WLC)	Quant	Extended benefits for the community (Chances to improve the wellbeing of residents) regional employment opportunity (local employment options), Cooperation network (Chances for expanding the network of producers that cooperate)	Producers and millers, Interest groups, Experts, Researchers
21	Metrics-based framework: Product Sustainability Index (ProdSI)	Quant	Stakeholders groups: Customer (product owners, clients of product owners); Manufacturer (primary manufacturer, manufacturer-supporting entities); Society at large (employees and affiliates, non-affiliates and broader population)	Not specified
22	Primary Stakeholder Value (PVS)	Quant	Society-at-large, Manufacturer, Customer	Not specified

Table 5 (continued)

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
25	CSR, statistical analyses: Exploratory Factor Analysis, barlett's Sphericity, Kaiser Meyer Olkin, Confirmatory Factor Analysis, Structural Equation modeling	Quant	Preferences and influences on organizational performance of SMEs	Questionnaires and individual interviews (Likert scales) to CEOs, COOs, and CFOs of the SMEs and the firm as the unit of analysis
26	SLCA (UNEP-SETAC guidelines)	Qual	Access to both tangible and immaterial resources as well as participation in the local community Promoting social responsibility through value chain actors Social security, benefit programs, and work habits for employees societal contributions to economic growth and technological advancement	Not specified
27	Social metabolism framework (interaction between society and the natural environment)	Quant	Associated Human Work	Not specified
28	SLCA (PSILCA method)	Quant	Corruption, child labor, forced labor, supply-chain social responsibility, and safety precautions	Not specified
29	Survey for the job creation index	Qual	Occupation	Survey
30	Index of national circularity, statistical analyses	Quant	Employment in recycle and reuse economy, innovation, education on recycle and reuse sectors	Not specified
31	Systems Thinking Approach to Resource Recovery (STARR) framework to assess environmental, economic and social impacts	Quant	Public acceptance and participation	Not specified
32	Survey, focus group, semi-structured interviews, desk analysis of economic data	Qual	Social benefits: opportunities for volunteering, employment, social interaction, sense of community	Interviews to consumers, managers, volunteers and inde- pendent retailers

Table 5 (continued)

#ID	Methods for social assessment	Typology of method*	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
33	Desk analysis	Qual	Neighbourhoods served by each collection; Benefited workers; Educational campaigns	Not specified
34	Delphi, fuzzy logic, judgement elicitation	Quant & qual	Human rights, labour practices, society, product responsibility, and unclassified theme areas	Stakeholders with expertise in CE (from academia, government, industry and NGOs) who were involved through surveys
35	Field investigation, literature research, and triangulation; qualitative parameters	Qual	Supply chain relationships; Circularity; Freedom of choice	Stakeholders' workshop; focus groups. Choice of indicators and assessment process
37	SLCA	Qual	Stakeholder categories include value chain participants, customers, employees, and the local community. Categories: End-of-life responsibility, Consumers' well-being, Community access to material resources, Safe and healthy living conditions, Local Employment, Technology Development, Suppliers' Relationship, Equal Opportunities/Discrimination	Stakeholders from companies: manufacturing, packer, recycling and sorting stakeholders, brand-owners
39	Following several rounds (cycles) and verifying the hypothesis in the real world, the hypothetical-deductive method	Qual	Job creation, increasing income, employee involvement in the circular business model, social market categorization, and stakeholder engagement in decision-making; Changes in mind-set and culture	Expert consulting, user's feedback
40	Desk analysis	Qual	Society, manufacturer, customer	Not specified
41	SLCA (SHDB)	Quant	Labour rights and decent work; health and safety; human rights; governance; community infrastructure	Not specified
42	Material Circularity Indicator (MCI), Sustainability Profit (SP) monetary model	Quant	Employment	Not specified

Table 6 Post-positivism oriented papers *Source*: our elaborations

#ID	Methods for social assessment	Typology of method	Categories of social impacts evaluated or stakeholders groups	Participatory approaches and actor involved
2	Product Recovery Multi-Criteria Decision Tool (PR-MCDT)	Quant	More jobs being created, the degree of customer happiness, how consumers see products, a safe work environment, and customer interactions	Recovery companies, experts
4	Mixed-integer linear programming (MILP), statistical analysis	Quant	Social cost of carbon	Not specified
10	Hybrid LCA (IO analysis)	Quant	Change of sectoral Gross Value Added and employment contribution	Not specified
23	SLCA from endpoint impacts of LCA	Quant	Damage to human health	Not specified
24	Quantitative assessment	Quant	Social welfare due to large landfill areas required for the disposal of residue	Not specified
36	Mixed-integer non-linear programme (MINLP) model	Quant	Social cost (SC): It can be defined as the cost of a negative impact on society due to different kinds of pollution	Not specified
38	SLCA (SHDB); employment is calculated by dividing the amount of clothing processed by the volume capacity per full time equivalents	Quant	Employment effects, justice	Not specified

**Qual* qualitative; *Quant* quantitative

Half of the papers reviewed (50%) recurred to quantitative methodologies. For example, they applied the Social Metabolism framework (Martìn et al., 2018), the Social Hotspot Database for SLCA (Shemfe et al., 2018), Input–Output analysis (Chen et al., 2019), correlation matrices (Fabbricatti & Biancamano, 2019), Analytic Hierarchy Process (Afshari et al., 2020; D'Adamo et al., 2020; Grippo et al., 2019), exploratory factor analysis (Lu et al., 2020). Many authors that applied these quantitative methods, assessed the social impacts jointly with other dimensions of sustainability, such as for example recurring to metrics-based framework (Product Sustainability Index, ProdSI) (Hapuwatte et al., 2021), Systems Thinking Approach to Resource Recovery (STARR) framework (Ng et al., 2020), the Product Recovery Multi-Criteria Decision Tool (PR-MCDT) (Alamerew & Brissaud, 2019). Other studies mixed their social evaluations with specific circularity evaluations such as the Material Circularity Indicators (Zore et al., 2017), the Sustainable Circular Index (Garrido Azevedo et al., 2017), or the index of National Circularity (Momete, 2020).

Some authors calculated complex interactions using high fidelity simulators when they were not explicitly known and were reliant on a number of operational parameters, as in circular systems: The advantage of piecewise linear models is that they may establish linear connections straight from the simulator sample points, which greatly decreases the complexity of the task (Epelle & Gerogiorgis, 2020). Alkhayyal (2019), for instance, used a mixed-integer linear programming (MILP) optimization platform for reverse supply chains that feature a full estimation of emissions to determine the optimal movement of goods within a number of remanufacturing facilities (thereby optimizing net profits while limiting CO_2 emissions) and to look into the social cost components of carbon emissions from actual remanufacturing sites. Similar to this, Afshari et al. (2020) developed a MILP model including the environmental, economic, and social sustainability pillars in the best energy symbiosis network design with the intention of offering a fresh viewpoint on the role of social objectives alone or in combination with other sustainability pillars. For the purpose of minimizing the total cost, which is the sum of operating costs, transportation costs, recruiting costs, environmental costs, social costs, and penalty costs, Rathore and Sarmah (2020) suggested a mixed-integer non-linear program (MINLP) model. Many other papers applied qualitative methods to evaluate the social effects of circular systems, i.e. 17 papers, representing 40% of the selected scientific contributions. They recurred mainly to field investigations through questionnaires, interviews and surveys (53% of qualitative methods papers), whose data were sometimes further verified with literature research and triangulation (Gallo et al., 2021; Pollard et al., 2022). SLCA benefits from a certain appreciation: 5 papers applied the type I of this method (UNEP, 2020), alone (Lu et al., 2017; Garcia-Muiña et al., 2018; Reinales et al., 2020) or in combination with other methods, such as the Material Flow Analysis (El Wali et al., 2021) or the Social Readiness Level method (Foglia et al., 2021). Actually, SLCA has a twofold perspective: The Reference Scale Approach (Type I) and the Impact Pathway Approach (Type II) are two methods used in Social Life Cycle Assessment (SLCA). SLCA Type I evaluates how companies or organizations in a product system perform socially by comparing their actions to a reference scenario, often specific legal regulations, using interpretation. On the other hand, SLCA Type II assesses social impacts by analysing causal or correlation/regression-based relationships within the product or service life cycle, with a focus on quantifiable identification of consequences.

Finally, 4 papers applied mixed methods (qualitative and quantitative ones), such as the Fuzzy logic with other qualitative methods (Bui et al., 2020; Padilla-Rivera et al., 2021), and AHP with Likert scale (D'Adamo et al., 2020).

When dealing with social aspects, they are very common the advocacy for stakeholders' involvement, the participatory aspects, and the attention to public acceptability at different

levels of the assessment, especially because the shift to circularity would mean a change in the production and consumption patterns (Bond et al., 2018). Indeed, among the 42 papers selected, 50% of papers recurred to participative approaches, for different purposes ranging from merely information to data gathering (consultation), collaboration (learning processes) and empowerment, as distinguished by Brandt et al. (2013). In most cases (7 papers), experts are the stakeholders involved to provide opinions about a specific context (e.g. Grippo et al., 2019; Padilla-Rivera et al., 2021; Rossi et al., 2020), while in case of data gathering specific stakeholders have been involved such as consumers and customers (Afshari et al., 2020; D'Adamo et al., 2019; Osterley & Williams, 2019), or actor involved in the productive process such as recovery companies (Alamerew & Brissaud, 2019), property owners (Barcelos et al., 2021), producers and millers (Grippo et al., 2019), industrial project partners (Cervo et al., 2019), among others.

As already mentioned, the typology of methodology alone is not sufficient to identify the scientific paradigm underlying the study. Indeed, among the papers that applied quantitative methods (21 papers), only 7 were recognised as belonging to the realm of post-positivist paradigms, while among the qualitative methods papers (17 contributions) were all recognised as based on interpretivist paradigms (Table 7).

4 Discussion and conclusions

Epistemology is not merely an abstract philosophical concept; it has practical implications for how we assess and strive for social sustainability in circular economy. By critically examining our epistemological assumptions, we can develop more robust, inclusive, and contextually relevant approaches to understanding and addressing social issues in circular systems.

Furthermore, the discourse about sustainability assessment is still far from being consensual, because of its multidisciplinary characteristics that involve expertise from very different disciplines, from life science to economics and social sciences. In particular, the three pillars model does not have a shared theoretically rigorous basis (Purvis et al., 2018), that should take into consideration the strong interconnections between different aspects of sustainability.

As mentioned in the paragraph 1.2, compared to their environmental and economic peers, social aspects in CE always strive to be fully considered in sustainability assessments, appearing often as an isolated node, covered or associated with other research themes.

The transition to circular production models is not without its detractors. According to some writers, CE has dispersed constraints, ambiguous theoretical underpinnings, and practical challenges that must be overcome in order for it to be implemented. Other criticisms centre on policy advocacy for the circular economy that appears to be approbatory,

Table 7 Comparison between papers with different paradigmatic stances *Source*: our elaborations

Paradigms	Total of papers	Qualitative methods	Quantitative methods	Quali-quantitative	Participative approach
Post-positivist	7	0	7	0	1
Interpretivist	35	17	14	4	20

uncritical, descriptive, and strongly normative, without any genuine agreement on the scope of future benefits for the economy, society, and environment that are "win–win-wins" (Aguilar-Hernandez et al., 2021; Corvellec et al., 2022; Giampietro & Funtowicz, 2020; Gregson et al., 2015).

Some authors (like Anselmi et al., 2024; D'Adamo et al., 2024) argued about a contrast between a pragmatic vision of sustainability and an ideological one, which would determine the predominance of a social or ecological perspective, respectively. More than an ideological question, the fulfilment of sustainability objectives is a scientific question, and actions and decisions should be supported by knowledge retrieved from data.

Therefore, specific tools are highly required to validate and objectively substantiate circular systems, especially in a sustainability perspective, which is the finality itself of CE. Due to the multi-layered nature of social phenomena and the multiparadigmatic nature of social sciences, the social elements are the most challenging to assess. Hundreds of social indicators are proposed by many authors, and are continuingly reviewed according to the different typologies of stakeholders and perspectives, such as employees, users and consumers, communities and other members of society (e.g., Garcia-Saravia Ortiz-de-Montellano & van der Meer, 2022).

Furthermore, to prove that CE fulfils with its promise of sustainability, measuring circularity is not per se sufficient, especially when actors with different stakes and desiderata are involved. Many writers concur that establishing closed-loop systems would decouple the growth of the global economy from the finite resource use, reducing environmental damage and having beneficial social effects while promoting economic expansion (Lindgreen et al., 2020). It should also be considered that not all positive effects of a shift to CE come at the same time, nor for the same people: every change has effects in the short and long run. For example, a change towards CE can entail diminishing the provision of an input (not only a waste reduction), and this would have negative consequences, in the short run, for input suppliers of waste managers, in terms of lost employment and incomes.

Social evaluations of CE should clearly take into account where, when and for who benefits are provided.

The variability of models and frameworks provided by social sciences should be taken into account, keeping in mind the main differences (see Guba & Lincoln, 1994; Yeganeh & Su, 2005; Phoenix et al., 2013 and Iofrida et al., 2018). Post-positivism oriented methodologies have the advantage to be context-free and generalizable, providing objective and measurable information; however, on the other side, these kinds of methodologies are poor in values and almost reductive.

On the contrary, interpretism-oriented methodologies allow to catch stakeholders desiderata, their perceptions and values, but are context-bounded, weakly generalizable and provide a descriptive understanding of a phenomenon, without explaining cause-effects relationships.

However, it is of utmost importance to keep in mind that the choice of typology of methods (qualitative, quantitative, or mixed) is not sufficient to shape the ontological and epistemological posture of a sustainability evaluation procedure. There is a mistaken habit of confusing the methodology with the epistemological positions: indeed, methodology defines research topics, aims, and design; it prescribes certain procedures, resonatisolated node, covered or associated with other resees with particular scientific fields, and encourages or discourages the selection of deductive or inductive viewpoints; epistemology directs methodological choices and is axiological. (Carter & Little, 2007). Methods make visible methodological and epistemic choices but are not per se sufficient: a quantitative method can be used to infer qualitative knowledge.

Therefore, according to Carter and Little (2007) and Creswell (2009), the validity and quality of a social assessment stay in attending all the elements of a paradigms, demonstrating internal consistency, especially between the objectives of a social assessment (long term or short terms impacts) and its results.

Concerning the research questions that guided this mixed-methods review, i.e.:

i. Which are the most applied methodologies for social assessments of circular systems and which impact categories and indicators are most taken into account;
ii. Which is the most diffused epistemological position underlying the evaluation of social aspects of circularity;
iii. How the epistemological position shapes the methodological choices, and how the different methods address specific problems and sustainability assessments;

It can be affirmed that, between 2017 and 2022, there is a great methodological variability and quantitative methods are slightly preferred for social impact assessment of circular systems, but the epistemological position most diffused derives absolutely from the interpretivism-oriented paradigms, and therefore allow to make a subjective description of the phenomenon under assessment, in the short run. On the contrary, post-positivism oriented epistemologies allow to understand the cause-effect relationships between social impact and the circular systems under study and the possible repercussions in the long run.

Concerning the implications of our results, it has been found that when a shift from linear to circular economy is implemented, the epistemological position undertaken, and therefore the methodology chosen, can lead to different results. As circular economy is about reuse, recycling, recover products and materials, it would entail, for example, a reduction of input and a less amount of wastes to be managed. From a social point of view, it would entail positive and/or negative impacts, especially according to the time frame considered. For example, in terms of impacts on workers' health, a reduction of raw materials and input production would reduce the hours of exposure to certain working conditions, but also a loss of jobs and incomes in general, in the short run. However, the pollution reduction deriving from circular economy will certainly find acceptance among environmentalists and bring objective improvements in societies in the long run.

In the case of interpretivist research paradigms, whose strength lies in the consideration of stakeholders' desiderata and their perceptions, opposing viewpoints can co-exist about circular economy. For example, a positive perception can occur about waste reduction, cultural improvements about sustainability awareness and negative perceptions can occur about the loss of jobs, the increase of productive costs due to renewable, recycled, or compostable feedstock.

Post-positivist research paradigms seek an objective explanation of social impacts, taking into account all possible effects linked to specific causes, as it is the case of Disability-adjusted life years (DALY), full time equivalents (FTE), Mixed-integer non-linear programme (MINLP) model, among others. This epistemological posture would be probably more suitable and acceptable for different kind of stakeholders, by demonstrating, in the long run, the effectiveness and the real advantages of a shift towards circular economy.

Concluding, it is not possible to affirm that certain epistemological positions are inherently more effective than others for social impact assessment in CE systems. Each perspective can offer valuable insights, with proper strengths and weaknesses, and the most suitable epistemological approach often depends on the specific context and goals of the assessment.

Concerning the limitations of the present study, they can derive from the hermeneutical design that implied a strong effort of interpretation during screening and reading; focus groups, brainstorming, Delphi method and other participative methods could be used to involve the participation of experts in a structured way and improve the feasibility of the task.

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Data availability The datasets generated during and/or analysed during the current study are available in Supplemental Material 2.

Declarations

Conflicts of interest The authors declare no conflict of interest.

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