JUST2CE

A Just Transition to Circular Economy

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CHAPTER 6

Stakeholders' engagement and decision-making process: methodologies and techniques to assess strategies towards a Just Circular Economy

Chapter 6. Stakeholders' engagement and decision-making process: methodologies and techniques to assess strategies towards a Just Circular Economy

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Abstract

The transition to a CE is now a necessary step to address pressing environmental challenges such as climate change, resource depletion and biodiversity loss. Consequently, it is of growing interest to characterise decision support methods that can guide analysts towards more sustainable investment choices. However, despite increasing research efforts, the literature on economic-environmental assessments and decision-making processes related to CE is still limited and fragmented. Current visions of the circular economy are narrowly focused on economics and technology, while there is an apparent lack of reflection on political and socio-cultural dimensions as well as justice issues (social, environmental and gender). In this context, stakeholders' involvement, which to date is passive and unstructured, becomes a key factor for the transition to a socially conscious circular economy. Therefore, this contribution intends to address the issue of the still marginal stakeholder involvement at all stages of the decision-making process.

This paper has a twofold aim. First, we provide a brief overview of existing research on methods and techniques for the economic, environmental, and multi-criteria evaluation of strategies for the transition to the CE, highlighting their limitations and strengths. Secondly, we outline a methodological approach that can support decision-makers: (i) in assessing the economic and socio-environmental performance of a single CE strategy; (ii) in selecting the most sustainable CE alternatives, considering the targets of the different stakeholder groups involved. In other terms, we propose a methodological framework, structured in different steps, to identify the stakeholders and apply integrated indicators to evaluate the CE strategies and their impacts (environmental, economic, and social). This methodological approach not only represents a valuable tool for policy makers, but also becomes necessary to promote shared decision-making processes within the CE transition.

Keywords: CE strategy; stakeholders' engagement; economic evaluation; socio-environmental assessment; multicriteria decision making.

> The approach defined in this contribution represents a potential support to the decision-making process, making it possible to consider the different perspectives of the stakeholders involved and to integrate the multiple dimensions of CE.

In recent decades, phenomena such as urbanisation, globalisation and consumerism are more and more leading to the loss of biodiversity, increasing greenhouse gas emissions and the depletion of natural resources. In this regard, it is estimated that by 2050 natural resource consumption and waste generation could double compared to today (IPCC, 2022; Kulakovskaya et., 2022). In the latest International Energy Agency (IEA) report (2022), global electricity demand is expected to grow by 2.4 % per year for the rest of this decade, reaching more than 30,600 TWh by 2030. Furthermore, in 2021, the rapid post-pandemic economic recovery not only led to an additional demand for energy but, due to adverse energy market conditions, the use of coal increased at the expense of renewables (IEA, 2021). This resulted in an overall growth of more than 2 Gt in greenhouse gases compared to 2020 levels, offsetting, among other things, the decrease in emissions of about 1.9 Gt recorded during the pandemic. In sum, global CO2 from energy production and industrial processes reached 36 Gt, thus adding 6% to the 2020 level (IEA, 2021; Bruno et al., 2023).

Actions and strategies anchored in the CE paradigm represent a promising way to pursue the Sustainable Development Goals (SDGs) defined in the Paris Agreement (United Nations, 2015) and to address the environmental and climatic challenges (Kirchherr et al., 2017; Kulakovskaya et., 2022). Scholars, entrepreneurs, and decision-makers agree on the need to move from a linear economy, based on production-consumption-waste patterns, to a circular economy, based on production-consumption-reuse patterns (Ellen McArthur Foundation, 2013; Garcia-Bernabeu et al., 2020).

The concept of CE has been developed by scholars in environmental economics, functional service economics and industrial ecology since the 1960s (Boulding, 1966; Daly, 1996; Graedel, 1996; Lifset and Graedel, 2002), only attracting the interest of policy makers and industry at the beginning of the 21st century. To this day, CE remains a difficult concept to define, having been jointly developed in various fields, such as engineering, economics, or politics, and on various levels: micro, meso and macro (Mazur-Wierzbicka, 2021). For this reason, multiple definitions of the CE have been proposed over the years, in some cases even conflicting. Suffice it to say that it has been interpreted both as a strategy, and as a new economic paradigm (Haas et al., 2015; Bocken et al., 2016; Calisto Friant et al., 2020). Some authors have defined it as an industrial model or an industrial system (Yuan et al., 2006; Hobson and Lynch, 2016). According to others, however, it can be understood as a new business and development model (Ghisellini et al., 2020) or an economic system (Liu, 2012; Murray et al., 2017).

Among the most interesting interpretations is that of the MacArthur Foundation (2012), according to which: "A circular economy is an industrial system that is restorative or regenerative by intention and by project. It replaces the concept of "end of life" with restoration, moving towards the use of renewable energy, eliminating the use of toxic chemicals, which compromise reuse, and aims at the elimination of waste through the best design of materials, products, systems and, internally, business models". According to Ghisellini et al. (2016), the CE concept emerges as an alternative system aiming to decouple economic growth from resource constraints. Reike et al. (2018) point out that a CE action requires an absolute reduction of resource inputs as well as a balance between the different dimensions of sustainability. Again, Bocken et al. (2017) highlight that CE strategies aim to maximise the utility of products, components, and materials by extending their useful life through reuse, recycling and closing resource cycles. It is precisely the importance of 'closing of resource cycles' that has led to an evolution of the

principles on which CE is based. In fact, initially the CE was anchored exclusively to the 3Rs principle: Reduce, Reuse and Recycle; then, it moved to the broader 4Rs principle, which also adds the concept of 'Recover'; finally, the more comprehensive 6Rs framework was outlined, which also includes 'Redesign' and 'Remanufacturing' and signals the transition from Circular Economy to Helical Economy. This 6R principle can offer a 'closed' product life cycle system, which becomes the basis for more sustainable production (Jawahir and Bradley, 2016; Yang et al., 2017; Ghisellini and Ulgiati, 2020).

It is evident that CE is becoming an important field of academic research and is attracting increasing interest from scholars, decision-makers and even companies producing goods and services (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). This also applies to national governments. It suffices to mention, among others, the European regulations on waste management and recycling of end-of-life vehicles (Council of the European Communities 1993; 1999), the Sixth Environment Action Programme (European Parliament and of the Council, 2002), the Thematic Strategy on the Sustainable Use of Natural Resources (Commission of the European Communities, 2005), or Roadmap to a Resource Efficient Europe (European Commission, 2011). In this context, 'Closing the loop - an EU Action Plan for the Circular Economy' is the most important document of the Commission of European Communities (2015): the aim is to define actions and strategies to be implemented by the Member States to contribute to the transition from a linear to a CE model.

Policymakers, academics, and business community recognize the definition and implementation of programs and strategies aimed at the transition towards the CE as a priority and urgent action. It therefore becomes essential to evaluate the environmental, economic, and social performance of circularity alternatives. However, most of the current methods and tools for the evaluation of CE strategies focus only on one of the dimensions of sustainability, on a limited number of indicators and the perspectives of the stakeholders involved are analysed individually. In summary, the literature still lacks a quantitative and integrated methodological approach capable of considering the perspectives of the different groups of stakeholders and which helps decision makers to select the most sustainable alternatives that allow a just transition to the CE. This contribution therefore proposes a methodological framework, structured in several steps, useful for: (i) identify stakeholders and apply integrated indicators to assess CE strategies and their impacts (environmental, economic and social); (ii) promote shared decision-making processes within the transition to the circular economy.

6.2 Circular Economy: Critical issues and challenges

The concept of CE and the principles on which it is based are not without criticism and challenges, despite its growing acceptance by academics, politicians and business leaders. In this regard, the lack of consideration of socio-technical issues is one of the main criticisms levelled at CE, as highlighted by the H2020 project 'JUST2CE' (A JUst Transition TO the CE).

In fact, the current visions of the CE are predominantly focused on economics and technology, with a clear lack of reflection on the political and socio-cultural dimensions, as well as the justice issues (social, environmental and gender) that the transition to the CE would entail (Zwiers et al., 2020). The shift from a linear to a CE represents such a radical change that it implies a major transformation of current production and consumption patterns,

which in turn will have a significant impact on the economy, the environment and society. Therefore, CE will always have to be addressed in all its complexity, as a political and social concept. Although some definitions of CE emphasise its social dimensions, recent studies show that the social dimensions (labour, gender, justice) have been consistently neglected (Hobson and Lynch, 2016; Mies and Gold, 2021).

As pointed out in the introductory section, another issue of great importance but still insufficiently investigated is that of stakeholder involvement. This theme represents a key element of a socially aware CE, because stakeholders actively contribute to the achievement of societal welfare. They are not passive actors as in the case of neoclassical market economics, where they act in a context of limited rationality and where the welfare of society is left exclusively to the 'invisible hand' of the market.

According to some authors, the lack of stakeholder involvement represents one of the major barriers to the implementation of CE (Farooque et al., 2019; Vermunt et al., 2019).

Stakeholder theory has often been applied in the sustainability literature and has been recognized as crucial to understanding how to implement CE into an organization's practices and supply chain (Shah and Bookbinder, 2022). However, research to date mainly focuses on specific elements of stakeholder engagement, while only a limited number of studies have considered stakeholder engagement from a global perspective for CE implementation (Tapaninaho and Heikkinen, 2022). In this regard, some scholars call for a better understanding of stakeholder engagement in the CE context and how it can be established to facilitate the transition from linear to circular resource flows (Allen et al., 2021). This paper aims to fill these research gaps by exploring how the role of stakeholders is crucial in the decision-making process regarding actions and strategies aimed at CE (Fobbe and Hilletofth, 2022).

Although several issues have already been explored from different perspectives, a comprehensive framework of methodologies and techniques for the economic-environmental assessment of circular systems is still lacking (Sassanelli et al., 2019; dos Santos Gonçalves and Campos, 2022). According to some authors, analysis methods should fully evaluate CE strategies, including environmental, social, and economic performance. According to others, only a few studies refer to multidimensional analyses, as most evaluations of CE strategies focus on the environmental dimension alone and often not even all impact categories are included (Ghisellini et al., 2018; Hossain et al., 2020). Instead, to adequately assess circularity, it is necessary to define a quantitative and integrated methodological approach able to address the needs of all involved stakeholders. In this regard, research has shown how stakeholder engagement is a critical factor in the implementation of sustainability principles, but there is limited knowledge on stakeholder engagement practices in a CE context (Fobbe and Hilletofth, 2023).

6.3 Literarature Review

Ensuring CE principles is becoming a fundamental requirement to be achieved right from the design phase of new products. It follows that the evaluation of design solutions is also changing significantly in this direction, as it is becoming increasingly essential to consider new aspects in the relevant analyses (Spreafico, 2022).

In the literature, several authors have identified and classified strategies, methods and tools useful for the design of products to facilitate the transition to CE. These studies have highlighted the number and heterogeneity of possible supporting approaches and their evaluation criteria, which can often also differ significantly depending on the application field (Bocken et al., 2016; Mestre and Cooper, 2017; Spreafico, 2022). According to Sassanelli et al. (2019), many of the current methods and tools for the evaluation of CE strategies focus on only one of the dimensions of sustainability, on a single or a limited number of indicators, individually analysing the perspectives of the sthekholders involved. In this respect, products and strategies of CE are mainly evaluated through:

(i) environmental assessments conducted mainly by implementing methods such as LCA, material flow analysis, emergy/exergy analysis, input-output analysis, system dynamics (Walzberg et al., 2021);
(ii) economic analyses, aimed at estimating the costs and benefits of intervention strategies, according to a Life Cycle Thinking (LCT) approach (Fregonara and Barreca, 2022);
(iii) multicriteria decision analysis, employed for measuring different CE aspects at different levels (micro, meso, and macro) (dos Santos Gonçalves and Campos, 2022).

In order to provide guidelines to stakeholders such as scholars, policy-makers, entrepreneurs, and non-profits organisations, we provide a brief overview of existing research on methods and techniques for economic, environmental and multi-criteria evaluation of strategies for the transition to the CE.

6.3.1 Environmental analysis

In recent decades, there has been a growing interest in the development of methods for assessing the environmental performance of products, services, processes, and intervention strategies. The most widely used methods in the literature are: LCA, Environmentally Extended Input-Output Analysis (EEIOA), Material Flow Analysis (MFA), emergy/exergy analysis.

LCA is a standardised method (ISO, 2006a,b) that aims to quantify the environmental impacts of products and services from raw material extraction to end-of-life. An LCA study is based on four steps: (i) definition of the objectives and scope, in which the FU for which the environmental impact is measured and the boundaries of the system under analysis are identified; (ii) inventory, which results in the quantification of input and output flow data for each stage of the product life cycle; (iii) impact assessment, in which the information from the previous step is classified and aggregated into the different environmental impact categories; (iv) interpretation of the results and definition of recommendations for the containment of environmental impacts (ISO, 2006a,b). It is a widely recommended method for assessing, among others, the environmental performance of services (Chen and Hiang, 2019), industrial products and systems (Rosa et al., 2019; Gribaudo et al., 2020), and building and construction projects (Dong and Ng, 2015; Rosado et al., 2019). A strand of recent literature has identified four main limitations in the application of LCA: 1) difficulties in comparability, 2) lack of sufficient and qualified data, 3) issues scaling up the data, and 4) uncertainties and communication of uncertainty (Moni et al., 2019). In addition, the standardised LCA (ISO, 2006 a,b) is typically implemented with reference to a static system. Therefore, all impacts are evaluated (and averaged) over space and time, which limits their use in the case of EC strategies that often involve complex and evolving systems (Walzberg et al., 2021). Finally, since LCA is limited to the assessment of environmental externalities, other methods have been developed to analyse the economic and social impacts of a product's life cycle, respectively life cycle costing (LCC) and social life cycle assessment (S-LCA) (Fauzi et al., 2019).

EEIOA quantifies the environmental impacts related directly or indirectly to a product or service, but not always including the use or end-of-life phases (Jeswani et al., 2010). While LCA provides a detailed analysis of each process involved in the life cycle or in a product system, EEIOA brings together national inventories to describe the interdependence between economic sectors (Miller and Blair, 2009).

MFA consists of "a systematic assessment of the flows and stocks of materials within a system defined in space and time" (Elia et al., 2017). The MFA aims to understand the material processes of a system to make better decisions regarding, for instance, waste management. To implement MFA, the system boundaries must first be defined, then all relevant processes and flows in the system must be modelled. In MFA, processes are generally more aggregated than in LCA and EEIOA. Compared to LCA, MFA does not focus on environmental impacts and usually focuses on a small set of materials rather than all related materials and energy flows of a product (Walzberg et al., 2021).

An alternative approach to those mentioned above is that of emergy/exergy analysis. The concept of Emergy was developed in the 1980s by the American ecologist H.T. Odum (Odum 1986, 1996) as the total available energy (exergy) of one kind that was required (used up) directly or indirectly in the work of making a product or a service (Brown and Ulgiati 2016 a,b). Emergy can thus aggregate flows of energy and matter of different kinds into a common unit, using conversion factors called Unit Emergy Values (UEV). They express the amount of equivalent solar energy invested in the production of a unit quantity of a supplied resource and are usually measured in solar emjoules per joule. Marvuglia et al. (2018) argue that although emergy-based indicators probably fail to account for all the elements needed to assess EC systems as a whole, they do allow for resources that would otherwise be ignored using material balance approaches.

6.3.2 Economic evaluations

Estimating costs and benefits of CE strategies is crucial to support decision-makers and stakeholders in choosing between investment initiatives.

In this context, remains the main tool to identify and assess the impacts of a project on social welfare, comparing positive effects (benefits) with negative ones (costs).

The CBA takes the form of: forecasting the costs and benefits that the investment is able to generate over the period of analysis; subsequently discounting the cash flows; then, estimating the synthetic profitability indicators, namely the Net Present Value (NPV), the Internal Rate of Return (IRR), the Benefit/Cost Ratio, the Payback Period.

However, two critical issues related to this evaluation approach should be noted: (i) CBA requires the transformation of investment cash flows (difference between monetary income and expenditure) into monetary terms to make them comparable and to summarise the result through a single indicator. This is a crucial step when it comes to assessing environmental and social externalities of the project; (ii) the choice of the Social Discount Rate (SDR), which represents the rate at which the community is willing to exchange present consumption for future consumption. The choice of SDR becomes particularly critical when considering projects aimed at achieving CE whose benefits are only evident in the long run. This is because conventional discounting uses constant discount rates over time, leading to an excessive decrease in the present value of the project's costs and benefits for future generations (Nesticò et al., 2023).

Regarding question (i), specific approaches are needed to estimate environmental externalities. The latter, in fact, can be estimated using Willingness-To-Pay (WTP) approaches, which measure the maximum value that people are willing to pay for a given good, service or effect that is considered desirable. Several techniques exist to estimate the WTP: the revealed preference method, the stated preference method and the benefit transfer method. The choice of method depends on the nature of the benefit to be estimated and the availability of data (European Commission, 2014).

To overcome problem (ii), on the other hand, some scholars propose using Declining Discount Rate (DDR) or time-declining discount rate instead of constants, to assign progressively increasing importance to long-term implications (Cropper et al., 2014). According to other scholars, discounting has a critical impact on sustainability.

Therefore, environmental consequences should be discounted differently from economic ones (Gollier, 2011; Almansa and Martínez-Paz, 2011). This means that a dual discount rate should be used in CBAs for projects with significant environmental impacts: one discount rate for strictly financial cash flows; another lower value rate for the valuation of environmental externalities (Gollier, 2011; Nesticò and Maselli, 2020).

Although the use of CBA is fundamental for analysing the economic feasibility of CE strategies, the transition from linear to CE occurs with the inclusion of life-cycle approaches in the evaluation discipline. This means that cost estimation is also extended to the stages preceding and following the design and construction phases of the work (Fregonara and Barreca, 2022). It is in this context that the transition is made from the concept of construction cost, as conceived by classical Property Valuation, to that of Global or Life Cycle Cost (EN 15459-1:2017), in accordance with international energy policy regulations (Directive 2018/844/EU – EPBD). Il Life Cycle Cost sums the present value of all costs over the life cycle, including residual values such as negative costs. According to the Royal Institute of Chartered Surveyors (RICS, 2016), a distinction should be made between Life Cycle Cost (LCC) and Whole Life Cycle Cost (WLCC): the former focuses only on construction, maintenance, operation, occupancy and disposal of the asset; whereas WLCC encompasses a broader economic matrix, including not only construction and other life cycle costs, but also: (a) 'non-construction costs', such as site acquisition, lease or sale costs, procurement costs and the cost of financing; (ii) 'income' from the built asset; (iii) external costs or externalities, including impacts on the environment, to be assessed through LCA and the social impacts of the built asset. Therefore, the WLCC can be understood as a methodology for assessing the economic effects of sustainability, which allows for more comprehensive decision making based on sustainable evaluation rather than initial costs alone (RICS, 2022). Thus, according to a widely accepted classification, three types of LCC can be distinguished: (a) financial (fLCC) or conventional, which considers the internal costs related to a specific product and incurred by a specific actor and which results in the estimation of the Global Cost; (b) environmental (eLCC), which also takes into account monetised environmental externalities and which is embodied in the estimation of the WLCC; (d) social (sLCC), which can further expand the boundaries of the analysis by including direct and indirect costs incurred by society (Jansen et al., 2020).

6.3.3 Multicriteria decision analysis

Multi-criteria Decision Making (MCDM) methods allow structuring and solving complex problems that involve multiple quantitative and qualitative criteria often in conflict with one another (Nesticò et al., 2022). They are decision-support tools, based on five elements: (i) the overall goal to be achieved; (ii) the decision maker or group of decision makers expressing their preferences; (iii) evaluation criteria against which the alternatives are assessed; (iv) the alternatives under evaluation, among which the best alternative is to be identified; (v) scores expressing the value of the alternatives with respect to each criterion. The MCDMs most frequently used in the literature include: the Analytic Hierarchy Process (AHP); the Elimination Et Choix Traduisant la Realité (ELECTRE); the Tecnique for Order Preference by Similarity to Ideal Solution (TOPSIS); the Compromise Ranking Method (VIKOR, from Serbian "Viekriterijumsko Kompromisno Rangiranje"). The choice of one method over another is mainly conditioned by the specificity of the case study, the objective to be pursued, and the availability of useful data to carry out the processing, all factors that may guide the evaluator differently from time to time in choosing the optimal approach (Nesticò et al., 2022). Although the various MCDM methods are based on different mathematical formulations, four main common steps can be distinguished: (a) definition of one or more decision matrices; (b) normalization of one or more decision matrices; (c) assignment of "weights"; (d) calculation of alternative ranking.

MCDM methods, therefore, allow decision-makers to identify trade-off solutions by considering different criteria, types of both quantitative and qualitative information, interest of stakeholders, relative significance of criteria, and decision-maker preference. For this reason, they are increasingly used in the literature to evaluate the performance of circularity strategies. The literature shows that MCDM methods have been employed to evaluate various aspects related to CE, including: waste management, value recovery, R's approach, energy efficiency, social aspects, bioeconomy, efficient use of resources, product design, and product life cycle (dos Santos Gonçalves and Campos, 2022).

Furthermore, studies in the field do not indicate which MCDM method is best to use in the context of CE, however, techniques such as TOPSIS, AHP and PROMETHEE are the most widely used. Moreover, the joint use of different multi-criteria techniques is also an increasingly tried-and-tested avenue as it yields interesting results in the evaluation of CE strategies.

Finally, a crucial step in the implementation of MCDM methods concerns the choice of sustainability indicators and the assignment of criteria weights. The choice of indicators is crucial to more or less correctly evaluate the dimensions of sustainability. However, it emerges from the literature that there is still little attention to the social dimension and that the existing approaches based upon CE metrics are not adequate for the structural change required for a just transition (Calzolari et al., 2022).

Furthermore, the estimation of criterion weights is significantly influenced by the preferences of decision-makers and thus represents a subjective step that may influence the choice of the preferred alternative. Nevertheless, CE indicators integrate well with multi-criteria techniques when the objective is to establish a balance between environmental, social and economic dimensions (Petrović et al., 2019).

6.4 Methodological approach and stakeholders

Starting from the gaps and strengths that emerged for each analysis - environmental, economic and multi-criteria - we define a methodological approach useful to evaluate the performance of a strategy or to select among several EC actions the most sustainable one.

If the goal is to evaluate a single CE strategy, we refer to the following logical-operational steps:

a.1) Identification of the stakeholders involved. The transition to a circular economy requires the involvement and collaboration of all stakeholders in society, from the organisations that produce goods and services to the consumers who buy them, from local, regional, and national governments to the community at large. Identifying stakeholders is crucial to analysing the economic, environmental, and social effects generated by the investment initiative.

a.2) Assessment of economic feasibility. The point of view of the operator conducting the assessment must first be specified. If we consider the point of view of the private stakeholder, e.g. the organisation or company producing the product or service, we must evaluate the Global Cost. In addition, the cost evaluation may be supported by a Cost-Revenue Analysis (CRA), which results in the estimation of economic performance indicators, such as: Financial Net Present Value (FNPV), Financial Internal Rate of Return (FIRR), Cost-Revenue ratio; Payback Period.

If we need to assess the economic feasibility of the project from the community's point of view, then we first estimate the WLCC and then evaluate economic performance indicators such as the NPV and IRR. An extended methodological explanation is in Appendix.

a.3) Assessment of environmental and social performance. This phase involves first the assessment of the environmental performance of alternatives, and thus key environmental parameters for circularity: greenhouse gas emissions, energy and water consumption, and resource use. In other words, depending on the product type of the strategies under analysis, one or more methods are implemented jointly, such as: LCA, MFA, EEIOA, emergy/exergy analysis. Thus, the analysis concludes S-LCA for the assessment of social and socio-economic impacts (both actual and potential) associated with the entire life cycle of a product or service.

a.4) Interpretation of results. It allows to synthesise the elaborations carried out in the previous steps and possibly define improvements/changes to the product/service in terms of its capacity to favour the transition to EC.

If the best CE strategy is to be identified among several alternatives, then the methodological steps to be implemented are as follows:

b.1) Identification of the stakeholders, goal, and selection of CE alternatives. After clarifying the actors involved and the goals, the circularity options to be evaluated are defined.

b.2) Choice of economic, environmental, and social criteria and indicators. The decision matrix is defined, i.e. the sustainability criteria and their evaluation indicators are established. The performance indicators summarising the results of: LCC-CBA (i), LCA-MFA-EEIOA-emergy/exergy analysis (ii), SLCA (iii) allow the economic, environmental, and social criteria of each alternative to be evaluated respectively. To guarantee a just transition towards the circular economy, we must give increasingly greater importance to the social dimension, including indicators that allow us to evaluate issues directly connected to work, gender and justice.

b.3) Choice of MCDM methods to be implemented. Depending on the specificity of the case studies, the goal and the availability of data, the most suitable multi-criteria technique is chosen or multiple MCDM methods are jointly implemented.

b.4) Evaluation of the weights and the scores and consistency checks. Once the hierarchical structure of the problem has been defined and the alternatives to be evaluated have been identified, it is necessary to evaluate: (i) the weights of each criterion and sub-criterion; (ii) the score of each alternative with respect to each evaluation criterion. The analytical formulations to be implemented vary depending on the MCDM method chosen.

b.5) Calculation of overall score and ranking of alternatives. The implementation of the MCDM method returns a ranking of the alternatives, allowing the best ones to be identified based on specific environmental, economic, and social performances.

The methodological approach is summarized in **Figure 6.1**.

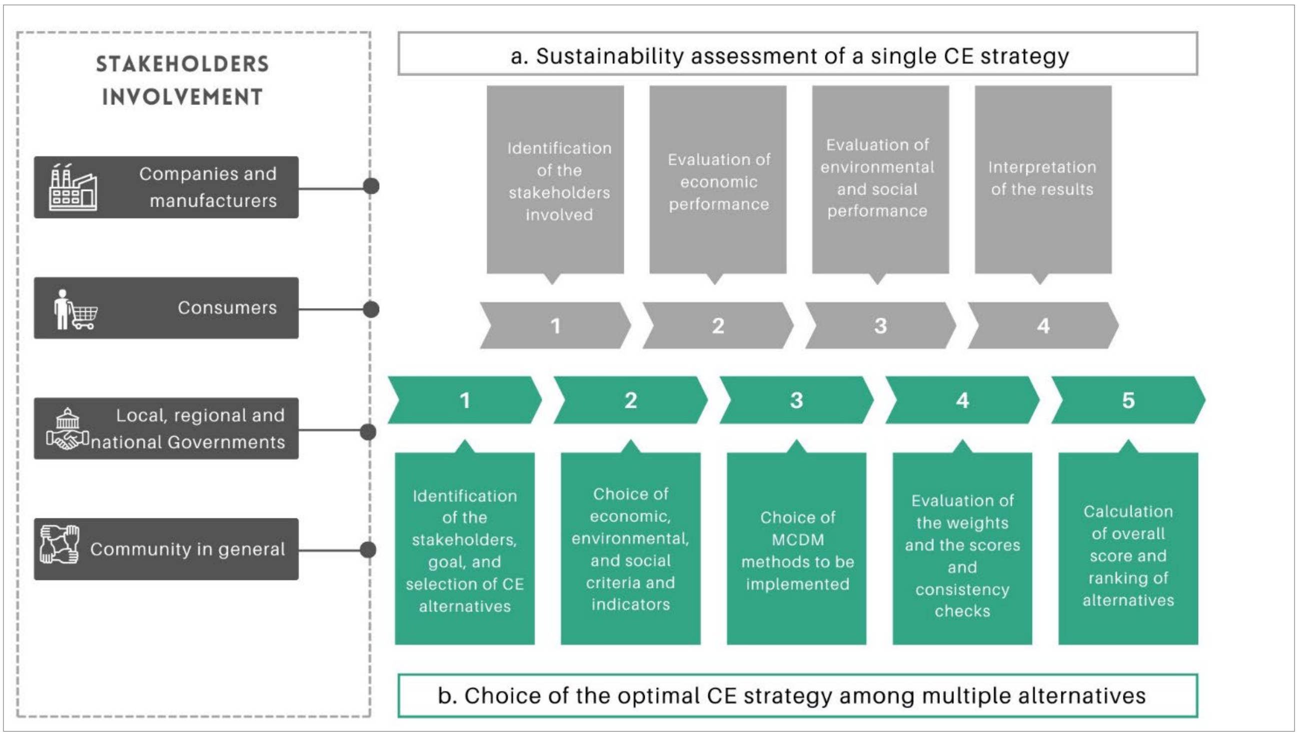

Figure 6.1 Steps of the proposed methodology

6.5 Conclusions and research perspectives

As the literature still lacks a quantitative and integrated methodological approach that can consider the perspectives of different stakeholder groups and help decision-makers select the alternatives that will enable a just transition to the CE, this paper: (i) analyses the shortcomings of current environmental, economic and multi-criteria assessment methods and techniques; (ii) defines a useful methodology to assess the sustainability of circular actions and strategies. It is a methodology that distinguishes: (a) the evaluation of a single intervention strategy; (b) the choice of the best CE strategy among multiple investment alternatives. In case (a), the following logical-operational steps are defined: (1) identification of the stakeholders involved; (2) assessment of economic feasibility; (3) evaluation of environmental and social performance; (4) interpretation of the results.

In case (b), the steps are as follows: (1) identification of the stakeholders, goal, and selection of CE alternatives; (2) choice of economic, environmental, and social criteria and indicators, including metrics that allow us to evaluate issues directly related to labour, gender and justice; (3) choice of MCDM methods to be implemented; (4) evaluation of the weights and the scores and consistency checks; (5) calculation of overall score and ranking of alternatives. The approach thus defined allows first to identify the stakeholders and apply integrated indicators to evaluate the CE strategies and their impacts (environmental, economic, and social). Therefore, it intends to represent a valid support for the decision-making process relating to transition strategies towards the CE, also allowing the different perspectives of the stakeholders involved to be included.

This study represents only the starting point of the research. Applications to real case studies will allow the proposed methodological approach to be tested and validated.

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