



A framework for a responsible circular economy

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ABSTRACT

The move towards a Circular Economy (CE) from the perspective of a 'just transition' necessitates an approach which deems stakeholder knowledge and agency as central. Under this paradigm the transition to a CE is conceived not as a technocratic challenge, but as a process of socioeconomic transformation grounded in principles of social and environmental justice. We suggest that Responsible Research and Innovation (RRI), as an approach for considering the relation of science to wider society, in particular the constituent concepts of anticipation, inclusion, reflection, and responsiveness (Owen et al., 2013), presents itself as a lens through which we can embed considerations of justice within CE practices. In exploring these dimensions with a critical view to how the CE discourse has often failed to consider who will benefit from the transition to a CE, we present a framework for supporting the design of responsible CE practices. We argue that such a framework can provide a starting point for future refinement and enrichment of the decision context faced by the relevant groups in the course of the transition to a just CE.

1. Introduction

In the last decade, the Circular Economy (CE) has gained increasing attention within business, policy, and academic spheres to describe a range of approaches and practices which seek to reduce dependence on 'linear' models of societal production and consumption. The CE is a concept with various understandings, and definitions vary conceptually in terms of core principles, objectives, and normative perspectives. Thus we understand CE as an 'umbrella term' whose openness for meaning allows for its adoption by various actors with often competing political and ideological interests (Korhonen et al., 2018; Homrich et al., 2018). Following a review of 114 studies, Kirchherr et al. (2017) define the CE as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes" (p229). Of course various understandings of a CE may be more comprehensive than this definition which perhaps magnifies the neglect of particular features relating to the social systems into which the CE must be embedded. Necessarily, various critical strands have arisen in the academic literature which question the frameworks of value which underpin 'mainstream'

narratives of circularity (Lowe and Genovese, 2022; Genovese and Pansera, 2021), and crucially question the desirability and feasibility of a 'circular' future which doesn't centre on principles of environmental and social justice (Harris et al., 2021; Lonca et al., 2018).

It is our belief that the transition to a CE must therefore be a *just* transition (Velicu and Barca, 2020), looking beyond recycling, waste management and technological 'fixes' to centre on the transformation of wider social structures. The implementation of a CE faces the danger of creating or exacerbating existing injustices, and certain groups or individuals may be disproportionately affected by its implementation. For example, minority ethnic groups and low-income communities are often disproportionately affected by environmental hazards (Massey, 2004). The implementation of a CE could perpetuate such injustices if relevant communities are not effectively embedded in decision-making processes, or if hazardous waste management and recycling facilities are placed without proper consultation, compensation, or mitigation. Transition to a CE also raises social issues relating to employment practices, the distribution of wealth, and the effectiveness of current forms of government (Moreau et al., 2017). It has been argued that a CE will necessitate a shift from material expenses to labour expenses

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(Lüdeke Freund et al., 2019), and reshape employability patterns across various industries (Horbach et al., 2015); there is thus danger here of businesses taking advantage of CE principles in a way that exploits workers by cutting costs, reducing wages, and increasing workloads. Moreover, the transition to a CE may lead to greater competition for resources, which could result in increased prices for raw materials and make it more difficult for small businesses and low-income households to access them. Without proper regulation and oversight, the implementation of CE concepts could lead to greenwashing with businesses taking advantage of these without really implementing them in their practices (Kopnina, 2019).

A just transition to a CE refers to the process of shifting to a sustainable and equitable economic system where the needs and rights of all stakeholders are taken into account. Responsible Research and Innovation (RRI) principles can play an important role in supporting a just transition to a CE by ensuring that the transition is socially responsible, inclusive, anticipatory, reflexive and takes into account the needs and values of all stakeholders. Therefore, to better answer who *should* benefit from the transition to a CE, we draw on RRI as a process which emphasises the centrality of social actors and local communities as active participants in the development of new practices. By embedding a critical consideration of CE within the ‘anticipation, inclusion, reflection, and responsiveness’ (AIRR) dimensions of RRI (Owen et al., 2013), we suggest a framework to support the design of responsible CE practices. Such a framework has relevance for engendering a more just approach to the CE in both academic and practice-oriented areas such as business and policy-making. By expanding the scope of CE initiatives beyond one-dimensional consideration of profit-driven environmental solutions, the integration of RRI principles create space for imagining a transformative transition with broader social benefits. Inigo and Blok (2019) successfully set the ground for a more-strongly socio-ethically grounded CE by integrating RRI as an innovation governance framework. In this work, we extend their approach over discussions on how each of the AIRR dimensions can support better addressing social challenges raised by CE and enhance our understanding of how the major problems, possibilities, and constraints of the CE conceptually can be tackled in its implementation beyond recycling and technological research.

We propose a holistic approach for integrating RRI principles into the CE paradigm, which takes into account the complexity of CE systems and the multiple stakeholders involved. This holistic approach ensures that RRI principles are applied in a systematic and comprehensive way. Our framework also provides clarity and consistency in the integration of RRI principles into the CE paradigm, helping to ensure that CE activities are socially responsible, inclusive and take into account the needs and values of all stakeholders. The suggested framework makes an attempt at sketching a conceptual approach for a just transition to CE, with the goal of addressing the major problems that could strengthen the CE transition process over environmental, social, ethical, and fairness values. The framework also offers a systematic approach to guaranteeing thoroughness and reliability in the understanding of socio-technical issues which underpin the decision-making process in the CE transition. Our intention is not to present a comprehensive recipe or solution to socio-technical issues raised by the transition, but to provide a starting point for future refinement and enrichment of the decision context faced by relevant groups.

Section 2 presents an overview of RRI, outlining the AIRR framework and grounding its dimensions within the wider literature. We follow this, in Section 3, by presenting a critical assessment of the CE paradigm alongside each of these dimensions in turn, considering how they can engender a just and responsible approach to the CE transition. Section 4 brings together these critical assessments to present our tentative framework for embedding RRI practices into the development of CE initiatives. Section 5 concludes the paper.

2. Overview of RRI concept and dimensions

RRI is an umbrella term that conveys a number of different ways of framing the relation between science, technology and innovation institutions with the rest of society. According to von Schomberg (2013), RRI should be recognised as “a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products” (p39). This strategy necessitates wider foresight and impact assessments for technological advances further than their projected market benefits and risks. RRI reflects a variety of goals, including avoiding unintended effects, bringing innovation in line with society’s expectations, and democratising research by exposing it to a broader range of viewpoints, especially when research goes against fundamental values (Ribeiro et al., 2017).

While the underlying principles of RRI have been defined in a variety of ways by different authors, they all have one thing in common: the desire to draw on a wide range of viewpoints, both scholarly and public, to better understand and address the unidentified biases and assumptions that often drive technological progress. Critics have pointed to the requirement to incorporate the ethical and political significance of an unpredictable future into innovation management in their attempts to define what such growth in democratic power may entail. The UK tradition of Responsible Innovation has forwarded the principles of anticipation, inclusion, reflexivity, and responsiveness as central to RRI by the scholars, research funding agencies, and policy actors who have taken up this issue (Stilgoe et al., 2013). The AIRR framework (Owen et al., 2013; Stilgoe et al., 2013) is one conceptualisation of RRI, with transparency sometimes included as a fifth feature (Ravn et al., 2015). The AIRR framework is based on a line of questions that have emerged as crucial in public discussions regarding cutting-edge fields of science and technology (Stilgoe et al., 2013).

In 2014 the EU adopted a framework for RRI in the Horizon 2020 research funding programme. This framework is based on six pillars: ethics, governance, gender equality, open access, public engagement, and science education. Although many of these pillars intersect and overlap with the principles and processes advocated by the AIRR framework, they have been criticised for being a simplified institutionalised adaptation of the notion of responsibility that risks favouring a tokenistic approach in the way RRI is operationalised (Owen and Pansera, 2019; Owen and Pansera, 2019). The number of women involved in research groups, open access papers, the compliance to institutional ethical procedures, or conduction of public engagement exercises are all very important activities but do not guarantee that research is conducted responsibly. For these reasons, in this paper we focus exclusively on the AIRR framework as the main guiding principles to imagine a just transition to a CE. In developing our framework, we focus on AIRR because of its ability to cover the lines of questioning in responsible innovation (See Table 1 in Stilgoe et al., 2013), which we find highly relevant to the current open questions in the course of transition to a just CE. Each dimension in the AIRR framework is briefly explained below; readers may refer to Stilgoe et al. (2013) for a more detailed description of the terms, as well as further conceptual and policy background, and methods and strategies that could provide criteria and circumstances for successful innovation governance and communication of the dimensions in practice.

2.1. Four dimensions of responsible innovation (AIRR)

Fundamentally future-oriented, research and innovation have enormous potential to shape and influence our collective future (Grinbaum and Groves, 2013). This necessitates *anticipation*: a contemplation of the future that involves theorising on the wide-ranging effects of current research and innovation activities and a reflection of our principles and functions in these actions (Owen et al., 2012; Stilgoe et al., 2013; von Schomberg, 2019). Anticipation is not the same as predicting the future,

Table 1Summary of AIRR principles for supporting the transition to a just CE. Adapted from [Stilgoe et al. \(2013\)](#), [Lubberink et al. \(2017\)](#), and [Van de Poel et al. \(2017\)](#).

AIRR Dimension	Issues regarding the just transition to a CE	Key objectives of the dimension	Potential strategies	Operational techniques and approaches
Anticipation	High level of uncertainty (Kirchherr et al., 2017)	Determining desired impacts and outcomes of the CE transition	Monitoring the innovation environment	Foresight studies
	Unawareness of unfavourable side effects (Wright et al., 2011)	Preventing or mitigating negative impacts	Identifying and understanding societal and/or environmental needs	Technology assessment
	Unclear contributions to environmental and social sustainability (Murray et al., 2017 ; Corvellec et al., 2022) Jevons Paradox (Korhonen et al., 2018 ; Schröder et al., 2019 ; Siderius and Poldner, 2021)	Development of roadmaps for impact	Determining the outputs and impacts Determining the social, environmental and/or economic value Assessing risks and impacts of the innovation	Horizon scanning Scenario building Vision assessment
	Broad scope of CE practices (Geissdoerfer et al., 2017 ; Kirchherr et al., 2017 ; Murray et al., 2017 ; Clube and Tennant, 2020 ; Padilla-Rivera et al., 2020) Time dimension (Geng et al., 2013 ; Geissdoerfer et al., 2017 ; Jakobsen et al., 2019) Geographical scale (Gutberlet et al., 2017 ; Schröder et al., 2019 ; Wright et al., 2019 ; Friant et al., 2020 ; Corvellec et al., 2022)		Assessment of possible negative consequences of the innovation Developing forward and backward scenarios Developing and determining roadmaps Aligning business strategies with the impact vision	Socio-literary techniques Life cycle assessment Creating imaginaries and indicators Anticipatory measures (Reike et al., 2018)
AIRR Dimension	Issues regarding the just transition to a CE	Key objectives of the dimension	Potential strategies	Operational techniques and approaches
Inclusion	Diverse sets of stakeholders (Gregson et al., 2015)	Involvement of stakeholders at different stages	Living lab inclusion	Consensus conferences
	Power asymmetries (Van Lente et al., 2017 ; Jenkins et al., 2020)	Provision of resources and capital	Community involvement	Citizens' juries and panels Focus groups
	Absence of stakeholder engagement and a fragmented vision (Winans et al., 2017 ; Inigo and Blok, 2019 ; Salvioni and Almici A., 2020).	Raised commitment and contribution	Formal role of the end-user in the company Alliances with NGOs Expert involvement for epistemic problems External research and evaluation Multi-stakeholder involvement activities	Science shops Deliberative mapping Deliberative polling Lay membership of expert bodies User-centred design Open innovation
			Bridging and bonding with experts Official role in organisation for users and focus group with wider public User-driven innovation Community visiting Representation of stakeholders for anticipation Balancing transparency and openness in relationships and the innovation process Receiving inputs from external actors Fair relationships regarding the tasks and returns for stakeholder input Role recalibrations as roles change over time and need to be readjusted Working with actors sharing the same or different values	Stakeholder mapping strategies Stakeholder engagement strategies Stakeholder dialogues Public dialogues User-centred design
AIRR Dimension	Issues regarding the just transition to a CE	Key objectives of the dimension	Potential strategies	Operational techniques and approaches
Responsiveness	Unclear implementability (Velis and Vrancken, 2015 ; Kirchherr et al., 2017 ; Khan et al., 2021)	Making sure that one can respond to changes in the environment	Mainstreaming/customising to satisfy stakeholder needs	Constitution of grand challenges and thematic research programmes Regulation
	Limited practicalities (Holmes et al., 2021)	Actual response to changing environments	Collaboration for fast and effective response	
	Lack of clear discussion or consideration of system boundary limits (Korhonen et al., 2018a ; Inigo and Blok, 2019).	Addressing grand challenges	Defining nature, pace and impact based on interactions with the innovation system	Standards
	Technocentric perspective (Friant et al., 2021)	Mutual responsiveness	Changing the environment	Open access and other mechanisms of transparency Niche management
	Neo-colonialism (Velis, 2018 ; Kettunen et al., 2019 ; Genovese and Pansera, 2021 ; Schröder, 2020).		Responding to social and environmental issues Responding to economic issues Preventing detrimental effects	Value-sensitive design Sustainable design

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Table 1 (continued)

AIRR Dimension	Issues regarding the just transition to a CE	Key objectives of the dimension	Potential strategies	Operational techniques and approaches
			Aligning stakeholder interests with the overall innovation objective Investment of resources by involved stakeholders Willingness to recalibrate the roles and responsibilities for sustaining stakeholder relationships	Moratoriums Stage-gates Alternative intellectual property regimes Gradual scaling-up Adaptive risk management Living labs and social experimentation Flexible and adaptive design
AIRR Dimension	Issues regarding the just transition to a CE	Key objectives of the dimension	Potential strategies	Operational techniques and approaches
Reflexivity	Unrealistic claims about the prospects of the CE (Strand, 2022) Pressure from existing imaginaries and indicators (Hobson, 2019; Casson and Welch, 2021; Strand, 2022; Corvellec et al., 2022) Power asymmetries (Van Lente et al., 2017; Jenkins et al., 2020; Hofstetter et al., 2021) Overconcentration on technicalities (Kirchherr et al., 2017; Korhonen et al., 2018; Inigo and Blok, 2019; Pansera et al., 2021)	Actions and responsibilities Values and motivations Knowledge and perceived realities	Third party critical appraisal inclusion Informal (self-) assessment culture Prioritisation of values and motivations Thinking about the effect of specific values on innovation governance and on its outcome(s) Determining how to deal with incompatible values and/or motivations Scrutinising the presence, absence and subjectivity of information Assessment of the knowledge and abilities Becoming aware of different perceived realities between actors Starting co-evolving processes between technology and society (Pearson et al., 2016).	Multidisciplinary collaboration and training Embedded social scientists and ethicists Ethical technology assessment Codes of conduct Moratoriums Rethinking moral division of labour Enlarging or redefining role responsibilities Connections made between research practice and governance

but rather describing and analysing both intentional and potential (but unintentional) impacts under economic, social, or environmental contexts (Owen et al., 2012). Scenario planning, ethical technology assessment, vision analysis, constructive technology assessment, and anticipatory approaches to governance have been developed in the past to think forwards in science and technology (Klaassen et al., 2017). To avoid reinforcing certain visions and turning them into predefined guidelines or trajectories, these tools not only aid stakeholders in communicating their expectations, but also provide ways to examine alternate outcomes and consequences that would otherwise be disregarded. Knowing how current dynamics and values affect the development of research and innovation is crucial for foresight. It is thus important to consider not only the possible outcomes of scientific achievements and what may go wrong, but also the motives of those involved and the roles they play (Owen et al., 2012).

Inclusion refers to the expansion of research and innovation dialogues from top-down governance systems and a larger involvement of stakeholders, including the public (Ravn et al., 2015). Incorporating stakeholder viewpoints into technology development has been recommended as a means of enhancing stakeholder confidence in the innovation process (Asveld et al., 2015). As examples of different approaches, transdisciplinary procedures, openly soliciting critical input, and facilitating transformative mutual learning are all characteristics of inclusive practices highlighted by Wickson and Carew (2014). User-centred design, focus groups, citizen panels, and governance with a layperson's perspective are also techniques that promote inclusion (Stilgoe et al., 2013).

Reflexivity is defined by Stilgoe et al. (2013) as “holding a mirror up to one’s activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held” (p1571). The usefulness of various sources of information and views is enhanced through the process of reflexivity, which

requires awareness of “the assumptions which tacitly affect our understandings and interactions” (Chilvers, 2012, p295).

Responsiveness refers to the ability of institutions to reflect and respond to new knowledge, emerging perspectives, views and norms (Stilgoe et al., 2013). Extracting over a shared understanding in the literature, Nielsen (2016) defines responsiveness as: “the ability of one actor to develop an answer (response) and react (respond) to external developments caused either by other actors (stakeholders in R&I) or the natural environment” (p833). From this perspective, societal challenges can be seen as opportunities for positive social and economic change, which, according to RRI, can be achieved through innovation so long as there is work being done to identify and define the “appropriate impacts” and “right processes” for implementing them in society (Zwart et al., 2014). Responsiveness in the AIRR context mainly refers to the capacity to respond to the other three dimensions in terms of the ability to reply to the feedback, requests, issues that emerged in the other three dimensions (Owen and Pansera, 2019). Being responsive also represents the interaction between innovators and other members of society. In this connection, cooperation and proactiveness are highlighted by the actors’ shared responsibility for shaping and guiding innovation in the direction of achieving the “correct impacts” (Sonck et al., 2017). This definition rules out practices like “pushing” information about new technologies to the public in one way, or “drawing” essential information or trust or trust in the public’s acceptance in the other (Lee and Petts, 2013).

3. A critical discussion of CE literature under RRI dimensions

The notion of the CE, as it exists now, appears to prioritise the economic system with a focus on ‘environmental’ advantages (either resource efficiency or environmental efficiency), and only implicit rewards for social components. Only a limited number of authors

emphasise the inclusion of social aspects in CE (Genovese and Pansera, 2021). Korhonen et al. (2018) is an example of some of these voices, stressing the significance of incorporating social objectives. Kirchherr et al.'s (2017) definition also suggests that a CE needs to promote "social equality". However, how these aspects are included is not intuitive, and is open to dispute. Other authors, such as Borrello et al. (2020), Padilla-Rivera et al. (2020), Inigo and Blok (2019), and Pansera et al. (2021), criticise CE for failing to explicitly address the social dimension. All of these authors agree and realise the importance of incorporating the social dimension into the CE agenda in order to support the global transition to a responsible CE. Thus, the transition to a CE must be seen via a socio-technological transition paradigm, in which existing production systems, business models, products, and consuming behaviours experience profound change. It would be crucial to check the plausibility of the necessary re-adjustment of human activities across various levels of analysis, including individuals, households, individual economic activities, economic sectors, and national economics, when developing scenarios for the transition to a CE. Incorporating RRI into the CE paradigm can be a promising step in achieving a responsible transition to a just CE in regards to consideration of diversity, inclusiveness, distribution of income and wealth, and conditions of employment. Table 1 summarises the most relevant arguments for the relevance of the four AIRR dimensions in the context of a just transition to a CE; it summarises the key objectives, potential strategies and operational techniques, and approaches for operational appraisal. The next four subsections outline in detail, with reference to the literature, how these four dimensions relate to the realisation of a just transition to a CE.

3.1. Anticipation

One of the key components of RRI is the identification and consideration of potential future consequences and outcomes. Asking 'what if' questions and being open to different alternatives are necessary for anticipation. In this dimension, it is crucial to consider potential futures systematically while comprehending the unforeseen and ambiguous mechanisms that control CE. As the generation of beneficial results for stakeholders is the goal of RRI, anticipation necessitates knowledge of the external environment and how it may interact with advances in the CE domain. For instance, how would CE affect social ideals like privacy and equality? For answering similar questions in a just transition to a CE, a sophisticated analysis is required. No matter whether a modelling or simulation-based approach, or qualitative data/experience-based approaches is used, a thorough understanding of the wider implications of a CE is necessary. This is particularly difficult for CE discourses relative to a standard technological transition, the reasons for which are twofold.

First, there is a high level of uncertainty in the socio-technical environment of a CE. It is difficult to examine and evaluate circular systems' socio-economic and environmental effects holistically. The "circular economy system diagram" from the Ellen MacArthur Foundation is a prime example of how discussions of the CE all too frequently depict the world as an engineering model with flows appearing to travel directly from consumer to collector, to secondary processor to manufacturer, and back to consumer (MacArthur, 2013). The issue with this viewpoint is that it fails to recognize that CE is not just a limited domain technology, but a new economic system (Kirchherr et al., 2017). Almost in every stage of a CE, there is a market for final products, end-of-life items, unprocessed or semi-processed waste, recycled materials, refurbished products, second hand repaired items, and so on. This is significant because primary and secondary items directly compete in each of these marketplaces. Under this aspect, the CE seems promising because of the rivalry between primary and secondary commodities on the market; this competition gives rise to the possibility that primary goods and materials may be produced less as a result of secondary goods and materials. However, it also makes it harder to foresee how primary and secondary items would interact than an engineering diagram would

imply (Zink and Geyer, 2017).

In other words, it is not enough to link the outputs of one operation to the inputs of another and assume that this would result in less pollution. Instead, it's important to consider the knock-on effects of increased secondary output across all conceivable causes and effects in order to understand the impact of a CE on the environment (Zink and Geyer, 2017). Engineering models alone cannot predict the impacts of increased secondary production, that is a potential CE rebound effect. On the other hand, not all CE intentions are for the environment. For example, CE is generally viewed by profit-seeking companies as a chance for arbitrage, rather than in terms of perceived ecological benefits. According to McKinsey and Company (2014), maximum profit will be made, if secondary goods, components, and materials are marketed in a way that doesn't compete with current sales (i.e., doesn't replace primary manufacturing). This indicates that just bringing the CE concept to free markets and profit-maximising businesses would almost certainly result in a rebound. Improved manufacturing efficiency leads to lower production costs and, in turn, cheaper final goods. The result is increased consumption. The early environmental benefits brought about by increased efficiency may be more than cancelled out by the total expansion of the economy (Korhonen et al., 2018). The resolution of this problem, the so-called Jevons paradox, is crucial to the successful implementation of a CE that does not have unintended negative consequences on the environment and society.

Second, the scope of CE practices are too broad to capture in an anticipation model. Numerous definitions of the CE appear to disregard social implications and stress mainly economic problems, while simplifying the environmental factor (Geissdoerfer et al., 2017). Kirchherr et al. (2017) found that economic growth was the most often cited objective among the practitioners, whereas social components like equality and the welfare of future generations were rarely addressed. Similarly, Murray et al. (2017) note that the current CE research is essentially mute on the social dimension. There is also a lack of agreement on what the social advantages of a CE might be, how they may be realised, and how a CE can eventually contribute to sustainable development, all of which serve to deepen this neglect (Clube and Tennant, 2020). Although the CE concept has a number of potential advantages for society, it is unclear how its operational instruments are conceptually related to its social effects (Padilla-Rivera et al., 2020). This also makes it almost impossible to thoroughly predict the social effects of CE adoption across stakeholder groups. Moreover, the most important aspect of anticipation, the time dimension, is excluded from most CE discussions (Geissdoerfer et al. (2017). Kirchherr et al. (2017) reported that only a single definition (by Geng et al., 2013) out of the 114 CE definitions reviewed, takes time into account.

Another open question in understanding the potential socio-economic and environmental impacts of a CE is in its geographical scale. For example, there are still a lot of questions about whether adopting CE techniques in the 'Global South' will have a positive impact on sustainable development, job creation, and economic growth. Whereas the driving force towards a CE for the EU countries is the scarcity of natural resources and environmental sustainability, for low- and middle-income countries, an additional driver may be the 'extraction of value' from waste as a source of secondary material, providing income, creating jobs, and eliminating poverty (Wright et al., 2019). Despite opportunities associated with a CE transition in terms of generating wealth from waste, especially among poor, marginalised communities, such a transition potentially entails negative outcomes such as environmental health risks particularly for vulnerable groups.

These issues present difficulties for CE research, innovation, and the broader diffusion of CE practices with respect to anticipating and avoiding any negative effects. In this setting, the *ceteris paribus*¹ condition, which is used in the modelling of many engineering systems, rarely

¹ 'all other things being equal'.

holds; uncertainty increases as soon as we try to understand the mechanisms in a transition to a CE, as we are considering a highly complicated system with several intricately interconnected subsystems. In this context, the anticipatory measures of RRI would undoubtedly be helpful in bringing some of the forthcoming difficulties to light, and giving CE practices the depth and systemic thought they need to facilitate the transition to a sustainable system (Reike et al., 2018). Even though the anticipatory component of RRI has been disputed, with some arguing that such future anticipation is speculative and doesn't adequately mitigate the dangers of uncertainty (Groves, 2015), a broad system transformation like the one maintained by the CE would always include some uncertainty. Indeed there are many causes of uncertainty in CE systems; nevertheless, concentrating on these sources may allow for the delay of actions that are necessary for a just CE transition. Uncertainty is not merely an issue of lacking data or models; it is also a problem of ignorance, which may be decreased with more research and the participation of different stakeholders, cultures, and practices (Kovacic et al., 2019). Even though it may not be feasible to fully anticipate the environmental, social, and economic impacts of CE on all impacted groups due to the complexities of the system, rather than being neglected, uncertainties in the CE transition must be examined in a consistent and methodical manner, both in terms of drivers of effects, and of benefits associated with policy alternatives. Therefore, integrating RRI's anticipatory measures will assist in addressing the wider implications of the CE transition process (Inigo and Blok, 2019).

Nevertheless, utmost precaution is necessary in linking RRI with CE in order not to fall into the misleading pre-assumption that CE will bring broader societal benefits as long as the transition process has been responsible. It would be naive to think that technology creators are aware of every impact of their research; developers of technology are often taken by surprise by unfavourable side effects (Wright et al., 2011). The initial response to uncertainty is the 'Precautionary Principle' (PP), which suggests to stop any innovation if full scientific knowledge of its consequences are not known. However, PP is probably not the best approach for a CE transition, as it is overly restrictive, particularly in terms of policy making, limiting key technical and economic breakthroughs due to the uncertainty of foresight. The EU strategy heavily relies on the 'Innovation Principle', as the need to consider the impacts on innovation of any regulatory or policy intervention (Hemphill, 2020). Therefore, the RRI represents a middle ground between the PP and the Innovation Principle to some extent (Jenkins et al., 2020).

Even though anticipation is a core element in RRI, the question of how to deal with uncertainties, particularly when the realisations are different to the expected outcomes, remains a focus of academic and policy debate. Current RRI literature lacks methods and ideas for analysing how innovations affect society as a whole and a comprehensive analysis of how to comprehend and manage the societal and environmental effects of economic growth (Jakobsen et al., 2019). As a result, research on a just CE transition would benefit from an interaction with the other areas of innovation and technology assessment studies, which investigates topics such as, innovation and inequality (Cozzens and Thakur, 2014), inequality in the allocation of innovation benefits (Fløysand and Jakobsen, 2011), Social Life-cycle Assessment (Jørgensen et al., 2008), Constructive Technology Assessment (CTA) (Schot and Rip, 1997; Rip, 2018), Future Oriented Technology Analysis (FTA) (Haegeman et al., 2013), Value Sensitive Design (VSD) (Friedman et al., 2013), Anticipatory life-cycle assessment (Wender et al., 2014), and ethical technology assessment (eTA) (Palm and Hansson, 2006).

3.2. Inclusion

An important lesson from RRI is the value of involving the appropriate stakeholders. A stakeholder is defined as "a major decision maker, actor, or sector that may benefit or suffer as a result of the change in question" (Sherman and Ford, 2014, p421). Due to the multi-scale

nature of the CE, there are numerous stakeholders relevant to the transition. By addressing diverse groups' specific needs and experiences, localised networks emerge as collaborative platforms that can influence transition plans and actions. Collaborative discussions should cultivate political groups in order to gain legal recognition of self-determination on a global scale (Urzedo et al., 2022). When significant interactions among policymakers, industry, and society groups are established, the necessary technical, financial, and political resources may initiate a just CE transformation.

A just CE should aim to identify all relevant parties, i.e., a wide range of agents and consequently, a wide range of liabilities. Inclusivity in the context of the CE has two dimensions. First is the participation of the people who are directly involved in the production process, for example workers having a voice in processes and decisions that determine practice. Second is the participation of the groups that can be potentially impacted by the CE transition process, such as public society or local communities. Furthermore, as many people as possible should be informed of the findings of an evaluation of CE practices. The specific social groups to be addressed determine the involvement and communication tactics. Future technology design and selection shouldn't be limited to a well-educated and articulate elite. Furthermore, increasing stakeholder engagement in decision-making extends beyond direct interactions with public entities and the business sector. Scientists, public society, and nonprofit groups have several opportunities for enhancing cooperation for a just transition to a CE. Establishing trust is essential to understanding and incorporating the diverse needs and roles of different stakeholders in establishing collaborations and local leadership in this process.

Effective stakeholder engagement is however difficult for a number of reasons. First, interactions between stakeholders are generally limited in size and scope. When looking at a project or a CE practice as a whole, it may be easy to overlook important issues about power relations and regulations. Inclusion can present the opportunity to talk about the broader impact of the developments in the course of a CE transition, but these conversations are more likely to be limited if they aren't relevant at a broader scale. This could mean two things: first that important questions can't be asked, and second, that researchers overestimate how much reflexivity can change their behaviour and norms. Second, and maybe more importantly in the course of the CE transition, involving stakeholders brings up the question of representation. The tools used to help people get involved don't always try to include people who represent "the whole society" (Van Lente et al., 2017). Instead, they focus on people who have a more immediate stake in the issues being talked about. But it's hard to say whether the invited actors have the same concerns and interests as those who aren't there. The criteria for the variety of groups included is interesting, but it doesn't help much in real life, especially for something novel like a CE whose publics haven't been formed yet. This could make these inclusion exercises less valid when public money or public decisions are at stake. More seriously, RRI doesn't consider which opinions to include, how to deal with the variety of ethically bound beliefs and values, and, more specifically, what to do when two different values (or conflicted opinions) can't be incorporated at the same time (Correljé et al., 2015). There may also exist strong power asymmetries in the current neoliberal world of misallocated governance. Therefore, stakeholder engagement should be seen as a critical component of governance of innovation rather than as a replacement for policies and guidelines (Jenkins et al., 2020).

It can be even more challenging to engage stakeholders effectively in developing nations, because of a significant amount of poverty, weak institutions, a lack of funding, and conflicting interests to reconcile more urgent issues relating to underdevelopment and poverty. According to Barnett and O'Neill (2010), disruptive pathways can occur when coping mechanisms lead to high opportunity costs, diminished incentives, an unfair burden on the most vulnerable, or an increase in environmental problems. It is crucial to understand these complex underlying aspects in stakeholder engagement and CE transition interventions because

vulnerability is primarily caused by a dynamic set of various factors (Sherman and Ford, 2014).

In this context, RRI can be seen as an attempt to build a public sphere (Pearson et al., 2016) where different actors can debate and shape the process of transition to a just CE. Reflection on the principles and purposes that a CE is meant to realise is the ethical component of this process. This method aids in justifying the selection of the primary action points, which may be regarded as constructing a CE public sphere in which an educated public can take part. In light of this consideration, the criteria for selecting the methodology should be justified by the need to advance the overarching goal of contributing to the realisation of a CE public sphere. In this situation, including stakeholders by making the CE transition process more open and reflective, would not only raise awareness about the issues in societal transformation towards a CE (Inigo and Blok, 2019), but also could help to mitigate negative societal impacts, or conflicts between diverse stakeholders (Mies and Gold, 2021).

3.3. Reflexivity

A third dimension in which RRI can be seen as a support for a just transition to a CE relates to reflexivity: a reflection on the societal circumstances, and opportunity for the consequent reassessment of practices and adjustment of initiatives. Reflexivity also comprises actors' ability to assess the success of their efforts and the numerous - and potentially unintended - consequences of their actions, and to adapt appropriately. Reflexivity is also highly related to anticipation since it reflects the anticipatory capacity to deal with unexpected occurrences. But reflexivity also means asking why we do what we do, and what our values, motivation and purposes are. In this sense, a reflexive CE should ask not only how we produce but *why* we produce, whether this is fair and just, and *for whom*?

As discussed in the anticipation section, the CE has many issues with respect to tackling economic, political, and sociocultural issues that may hamper a reflexive approach to and during the transition period. First and foremost, the business environment that shapes the CE transition has been shaped by unequal power relations in a way that does not allow a true exercise of reflexivity to be fully realised. A global CE transition is mostly reliant on the reexamination of global supply chains, which are currently under the authority of strong nations and multinational corporations, who are likely to keep taking up the resources and capital they require, exacerbating already existing inequities even in a circular system (MahmoudGonbadi et al., 2021). Global lead enterprises, especially major purchasers or producers from the Global North, appear to be in a position to play a significant role in managing the transition to a CE as rule-setters (Hofstetter et al., 2021). The negotiating power of these few giant enterprises is likely to be higher in the case of a conflict amongst stakeholders on social and economic benefits (or harms) of CE associated decisions. Due to the economic bottom line taking precedence over other interests, the major role played by these enterprises in the CE transition may make it more difficult for other societal actors to participate fully in the transition process. Furthermore, the move to a CE will need significant resources, requiring both public and private sector investments, but the tools to evaluate which firms or projects to support are immature. The transition trajectories may get trapped in ways that worsen power dependencies, widen the gap between high-income and low-income nations, cause rebound effects, or fail to take actions needed for strong sustainability (Hofstetter et al., 2021).

Second, as criticised widely by the academic literature (Korhonen et al., 2018; Kirchherr et al., 2017; Inigo and Blok, 2019; Pansera et al., 2021), one risk in the transition to a CE is that the stakeholders become overly concentrated on the technicalities of a CE and lose track of the larger goals or the social consequences of accepting a suggested technology. In summary, the stakeholders may fail to exercise reflexivity when considering the development's goals and objectives. To prevent this, RRI suggests the use of socio-technical scenarios, which can be used

to motivate stakeholders to consider the societal consequences of their decisions about CE related projects and investments. Socio-technical scenarios put the emphasis on a variety of potential scenarios and encourage avoiding commitment to specific instances of the future. RRI places a strong focus on broadening the viewpoints of many stakeholders, encouraging reflection and learning, and (in the long run) starting co-evolving processes between technology and society (Pearson et al., 2016).

Present CE strategies do not adequately address the concerns of trade inequality. There is rising concern in the literature about the CE being predominantly employed as a protectionist approach to achieve economic advantage over other nations, rather than as a tool to meet concerns for sustainable development, given the present geopolitical environment (Barrie and Schröder, 2021). Developed nations import raw resources extensively from low-income nations. The implementation of a CE would impact trade flows of basic raw materials, including extraction in foreign nations (Kettunen et al., 2019). Ideally, reducing resource demand will alleviate environmental strain in developing nations, improving environmental sustainability. However, exporting raw materials remains crucial to the economies of many low- and middle-income countries. The transition to circularity is likely to have a negative impact on such countries that heavily rely on 'linear' industries like mining, the production of non-repairable fast-moving consumer goods, textiles, and agriculture, as well as the export of these goods to higher-income nations. If international commerce in established goods falls in the medium to long term, these nations will require help from the international community through tailored aid programs (Schröder, 2020). A just CE must offer answers to the numerous problems at a global scale. Therefore, a just transition will be shaped in a large part by international collaboration to develop efficient and equitable governance institutions and policy coordination at regional, national, and local levels. As a response, it will be necessary to develop and implement multilateral technical assistance programs, especially to aid low- and middle-income nations.

3.4. Responsiveness

The final dimension, responsiveness, refers to the ability of institutions to reflect and respond to new knowledge, emerging perspectives, views and norms (Stilgoe et al., 2013). From this perspective, societal challenges can be seen as opportunities for positive social and economic change, which, according to RRI, can be achieved through innovations so long as there are (ongoing) efforts to discuss and define the societal "right impacts" and "right processes" for putting them into action (Zwart et al., 2014). The major debate over how to make the CE more responsive is whether the transition process could be made adaptable enough to take into account shifting contextual factors and observed immediate impacts. There is some concern that, despite the process of anticipating the potential outcomes in a more open discussion of some significant decisions through RRI, such discussions might only serve to justify decisions that have already been made rather than the more reflexive outcome of actually considering changing the objectives or results.

Thinking about larger socio-technical systems that might have an impact on the development and dissemination of the CE is another factor for responsiveness. Recognising such approaches is a key way to gauge the degree to which a CE can be adapted at various stages of its development and use on a socio-technical level. RRI may assist a fair CE transition by supporting partners in becoming responsive and attentive to potential social, economic, and environmental effects and/or misconceptions in the process. Technically focused initiatives run the risk of stakeholders making the mistaken assumption that just outlining the development's advantages to external parties will convince them to use its offerings (Pearson et al., 2016). Through exposure to probable misconceptions and even hostile responses, the stakeholders can be prepared for the reality of achieving societal impacts, which may be a more

complicated process than they first assume.

4. A framework for a responsible CE

A summary of the literature relating to the relevance of each AIRR principle to a just transition to a CE is presented in Table 1. This section turns to outline the design of a conceptual framework that would integrate RRI into the CE transition process to develop a shared understanding of the concepts, techniques, and instruments necessary to produce positive societal impacts, or motivate the ‘right’ processes to achieve just and fair CE goals. Fig. 1 presents a schematic illustration of the conceptual framework we propose. The procedural part of the framework is very similar to those widely used for supporting the governance of transition processes, such as the sustainable development governance framework by Loorbach (2010). It takes the **decision context** for the implementation of CE practices (box W) as its central unit of critical consideration, which in the context of a just CE transition may be, for example, a business organisation reviewing its supply chains, a local policy unit investigating a scheme for incentivising repair activities, or an eco-industrial park exploring a new waste management strategy. This decision process is informed by consideration of the **four responsible innovation dimensions** outlined in Section 3 (box X), a set of normative ‘**Responsible CE Principles**’ (box Y), and various supporting **tools and concepts** found within the critical literature (box Z).

RRI may support a just CE by addressing the growing concerns about the societal benefits of CE practices at all levels. Such consideration is relevant at all territorial/governance levels, and in particular provokes consideration of Global North-South dynamics which are often missing from debates here (Muchangos, 2022). Thus RRI, which we have conceptualised here in terms of the four AIRR dimensions, has a role to play in shaping the **values and visions** of what we may consider as a just CE (arrow between boxes X and Y). As discussed in Section 3, these four dimensions build the grounds for understanding the potential impacts of both current and future developments (anticipation). They push for the consideration and involvement of actors beyond the ‘usual suspects’ (inclusion), and encourage reflection on societal circumstances: what and why do we want to produce? Is it just and desirable? for whom? (reflexivity), and creating a space for adapting to new developments and findings (responsiveness). Informed by these considerations, such values and visions of the society, which are inherently normative and may be

contested, are necessary to lay out in order to explicitly contextualise the type of CE transition that the practitioner conceives. Together then, these values and visions form what we term ‘**Responsible CE Principles**’ which are necessary to understand the decision context under which implementation of CE practices is considered (arrow Y to W).

Actions and policies are necessary for the transition to a just CE, and *targets* may have a vital role in guiding this transition. Existing CE targets focus primarily on technical measures (i.e., those adopted by governments and organisations), examine specific indicators (e.g., targets on recycled materials), have a limited geographical focus, and refer to specific sectors or industries (e.g., energy or waste management) (Morsetto, 2020). *Responsible CE principles* guide the development of **responsible CE targets**, intending to produce positive societal impacts by asking: which targets represent the societal and ethical values in the transition towards a CE? In this context, novel objectives are possibly developed considering requirements and challenges in the economy and society. They are then elaborated by stakeholders from a variety of perspectives, such as in terms of resources, operating models, industries, or CE strategies, regardless of economic sectors or geographical boundaries. Such a holistic consideration of targets brings into focus a wide range of complex phenomena relevant to a responsible and just CE, and should thus not be limited to definition in terms of quantifiable indicators (Purvis and Genovese, 2023). In the consideration of responsible CE targets, the four RRI dimensions initiate a discussion about how a CE might be achieved in an ethical, inclusive, and democratic manner (arrow X to W). Similar to the *values and visions*, the responsible CE targets will largely vary according to the decision context represented and the axiological positions adopted. Here RRI prompts conversations on ‘desirable’ societal targets since it focuses on issues like how to guarantee the ‘right’ social outcomes from the CE transition.

We acknowledge that CE targets may in practice be defined by the boundaries set by a long list of stakeholder groups, which may also vary significantly according to the sectoral and geographical context of implementation. In relation to the CE, the framework thus constitutes several decision contexts which can have different objectives. In a business perspective, which is based on the stakeholder theory of Freeman et al. (2004), typical stakeholders include employees, customers, shareholders, suppliers, communities, and governments (Hillman and Keim, 2001). In the context of CE, Millette et al. (2020) classify key stakeholders as entrepreneurs, existing firms, government, and CE

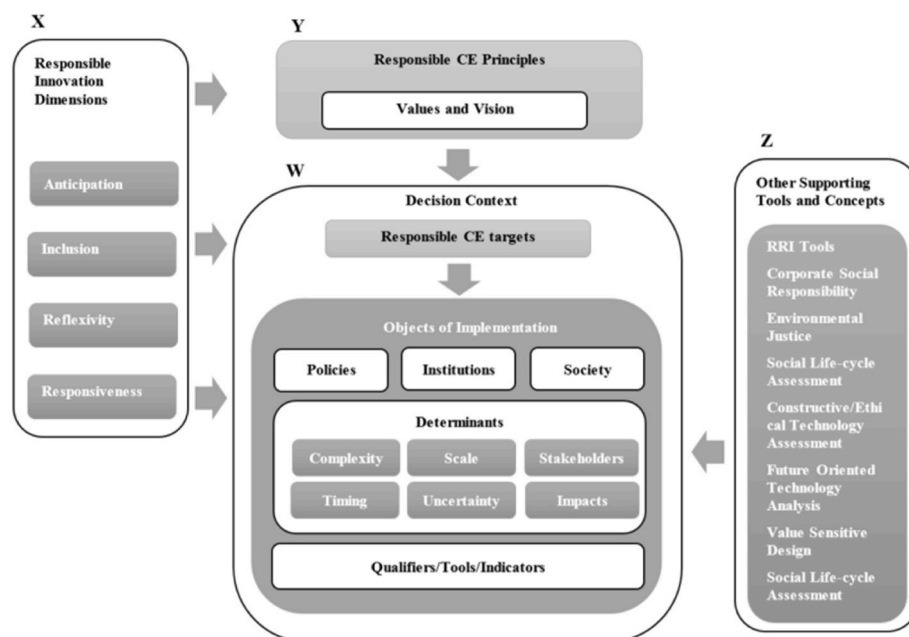


Fig. 1. Conceptual framework for a responsible CE

researchers. [Shah and Bookbinder \(2022\)](#) and [Tate et al. \(2019\)](#) identify the main stakeholder groups of CE as producers (including workers), consumers, scavengers, and decomposers. Both of these sets are technical extensions of the traditional stakeholder grouping of suppliers, customers, and producers ([De Gooyert et al., 2017](#)). In the perspective of a framework built upon principles of justice however, we define a stakeholder as a person, group, or organisation with a direct or indirect interest in the decisions made in the context of transition to CE. This definition includes a wide range of stakeholders, such as [business and industry \(such as resource suppliers, manufacturers\)](#), employees, social economy actors (such as cooperatives, mutuals, associations, foundations and social enterprises), municipalities, regions and regional development agencies, governments and public institutions, academics and researchers, financial institutions, [citizens and consumers](#), NGOs and sustainability experts, and other affected groups.

For the sake of simplicity in the framework representation, we group these stakeholders under three major categories of **policies, institutions, and society**, according to the decision context they share. *Policies* cover the governance structures at various levels that have an impact in creating policies and regulations that affect the CE, such as incentivising sustainable practices and investing in recycling infrastructure. *Institutions* refer to the businesses that are responsible for designing and producing products and materials that can be reused, repaired, refurbished, or recycled. *Society* includes groups with a vested interest in a company and can either affect CE related decisions (such as consumers or NGOs), or be affected by them (such as vulnerable groups). In the transition to a CE, the needs, interests, means, and objectives of these groups will be different as well as their responsibilities, action capabilities, and tools for response. We expect to see much variation in the definition of just CE goals across these stakeholder groups.

It is here that our framework and the integration of RRI principles can create space for arriving at a more concurrent set of targets through the consideration of values and visions, and responsible CE principles. Here, RRI helps create platforms for reflection and prompts broader involvement in the decision-making mechanisms of the CE transition process. Through this, space is created for the motivations behind CE and its possible consequences to be discussed in more depth. It is crucial for individuals who are impacted by the associated developments to be a part of the thoughtful discussions, not just those who are actively engaged in the process. RRI may also be used to redefine the idea of responsibility in CE. RRI advocates for an extended range of legitimate stakeholders with the ability to guide the CE transition processes. [Von Schomberg \(2008\)](#) frames this notion as ‘collective responsibility’, which is a larger understanding of the players accountable for ensuring the positive impacts of CE transition activities.

The decision context is additionally bounded by various **determinants**, referring to the issues regarding the just transition to a CE, such as uncertainty and complexity, as discussed in Section 3 and summarised in column 2 in [Table 1](#). Even though it may not be feasible to fully anticipate the environmental, social, and economic impacts of CE on all impacted groups due to the *complexities* of the system, RRI ensures that, rather than being neglected, *uncertainties* in the CE transition must be examined consistently and methodically; both in terms of drivers of effects, and the benefits associated with policy alternatives. It takes into account the responsibility aspects of CE, in terms of distribution of the costs and benefits of transition process across various social groups (by income, skin colour, gender, age, ability, etc.) and various spatial scales (from the centres to the peripheries of the global economy) for now and for the future. The framework, therefore, suggests shaping the decision context under the chosen ‘responsible CE principles’, encouraging stakeholder engagement in decision-making, such that scientists, public society, and nonprofit groups have multiple opportunities for enhancing cooperation for a just transition. The transition to a CE can only move forward and be as inclusive as possible with well-designed public policies.

The decision context also includes the **qualifiers, tools, and**

indicators that may be used to implement the actions and policies and comparatively assess their impact on the CE transition process. CE assessment tools have come under scrutiny for many of the reasons already discussed above. In particular, it has been questioned how far tools which narrowly focus on ‘circularity’ as the goal itself can engender a transition to a desirable future ([Moraga et al., 2019](#); [Corona et al., 2019](#)). Rebound effects aside ([Zink and Geyer, 2017](#)), it appears now to be commonly accepted that assessment of circularity must be complemented with a broader consideration of sustainability ([Ellen MacArthur Foundation & ANSYS Granta, 2019](#); [Oliveira et al., 2021](#)). Yet, studies which assess these broader frameworks point towards a lack of attention given towards social dimensions, which when they appear are usually reduced to shallow quantitative indicators such as employment numbers ([Padilla-Rivera et al., 2020](#); [Calzolari et al., 2022](#)).

A variety of other social development and RRI tools also provide a good basis to identify relevant tools and indicators to be the primary tools promoting a CE with the greatest social advantages. A commonly contested element in the literature relating to sustainability assessment more broadly relates to how such tools should be developed and deployed in a manner which engages and empowers communities and marginalised actors ([Turcu, 2013](#); [Kaika, 2017](#)). By embedding RRI and responsible CE principles into the development of such tools we become cognizant of the pitfalls we must navigate in order to produce and operationalise these in a responsible manner.

Finally, the framework benefits from an interaction with the **other supporting tools and concepts** such as RRI Tools (based on the six keys defined by the European Commission), Corporate Social Responsibility (CSR), Environmental Justice, Social Life-cycle Assessment (SLA), and Future-Oriented Technology Analysis. The list in [Fig. 1](#) is not exhaustive, and can be extended, but it shows examples of major tools and concepts that may support policy making and organisations both in terms of technical and conceptual aspects. For example, organisations may highly benefit from the tools and techniques suggested by CSR, which aims at ensuring corporations’ domestic and international business actions are guided by moral principles and adhere to the highest ethical standards. Similarly, SLA can be a useful tool for evaluating CE impacts ([Reinales et al., 2020](#)).

4.1. Application of the framework

Our framework, as outlined above, marks a sketch of a conceptual approach for supporting the decision context in the transition to a just CE. It places itself as a response to the critical literature, which calls for the CE discourse to place a greater emphasis on issues of justice through the holistic incorporation of elements relating to environmental, social, and ethical values. It is not intended to be prescriptive or fully comprehensive in scope, but instead centres dimensions of RRI, demonstrating their relevance and usefulness for confronting the complexities and contradictions of a just transition towards a CE. [Table 1](#) outlines the most relevant arguments in transition to a just CE in relation to the four AIRR dimensions, summarising key objectives, potential strategies and operational techniques, and approaches for operational appraisal of each dimension in the context of supporting the design of responsible CE practices.

In the context of the design of a tool to explore the ‘circularity’ of supply chains whilst incorporating elements of justice (as detailed in [Purvis et al., 2023](#)), the above outlined framework was used to inform various choices that were made in the scoping of this tool. Informed by a grounding in responsible innovation dimensions, deliberation among the project consortium through a series of stakeholder workshops led to broader understanding of the shared visions and values underpinning the group’s conception of a responsible CE. These adopted CE principles were then used to inform the context in which decisions were made relating to elements which took priority in the construction of the tool, such as which dimensions and indicators relating to social and environmental impacts to prioritise, which stakeholders to actively target,

and how to handle determinants. The RRI dimensions of anticipation, inclusion, reflexivity, and responsiveness were useful in informing each decision made throughout the process. Additionally a review of other supporting tools and concepts informed the design of the tool, with the focus on the specificity of the decision context allowing the benefits and shortcomings of each tool to be analysed for their suitability to our purposes.

From the perspective of the tool's development, *anticipation* meant considering how the tool may be used, and analysing both intentional and unintentional impacts that its use may have. This informed various constraints that were subsequently imposed on the tool's direction, such as ensuring its purpose maintained the values of justice and decoloniality that were arrived upon as 'responsible CE principles' in this case. Nevertheless, the need to anticipate the possibility of the tool being used in ways contrary to agreed upon values and visions was emphasised, as well as steps to mitigate for this. The *inclusion* dimension was reflected in the decision to develop a more general accessible tool that may be used by a wide range of stakeholder groups, rather than taking on a more consultative approach which targets typical 'higher power/influence' stakeholders or businesses. The outreach phase of the tool's rollout is intended to onboard the importance of inclusion as it relates to the accepted visions and values.

Reflexivity in this context meant actively communicating the political elements of the project, how these are realised in terms of core visions and values, and how this brings a novelty to the tool being developed. It was judged important to be mindful of the implications of this framing and how it situates the tool within the wider discourse and related toolkits, and how this influences how the tool could be perceived by different stakeholder groups. Finally, the *responsiveness* dimension was confronted in the evolution of the tool's scope and purpose from the initially proposed design, based upon findings from broader literature scans and deliberation among relevant stakeholders. A period for refining the tool based upon feedback and consideration from users has also been built into the development work plan for the tool.

Our framework thus has both practical and scholarly implications. Whilst at the time of writing, the framework has only been utilised in a single practical context (Purvis et al., 2023), and subsequent intended work from this project, we see its flexibility as offering broad applicability across a wide range of practical uses. The scholarly implications come from building on the work of Inigo and Blok (2019) in integrating RRI principles into the consideration of a just transition to a CE. There is clearly more theoretical work to explore here, some of which is described in the next section.

4.2. Limitations & further work

Whilst we present our framework as a starting point for refining and enriching the decision context that is faced by various actors with a stake in the transition to a just CE, we must acknowledge some of the limitations it presents in its current form. Such limitations provide several avenues in which future work may be taken, both theoretical and practical.

One limitation of the framework relates to the nature of consensus in outlining common values and visions to arrive at a set of responsible CE principles that may be applied, particularly when the decision context may include a diversity of stakeholders. There is much literature problematising consensus and the nature of democracy in this context (see e. g. Macnaghten and Owen, 2011). It is thus unclear whether consensus here is possible, or even desirable. We leave resolutions to this problem to the user of the framework, we do however maintain the importance of a discussion of values and visions and the necessity of explicitly arriving at and outlining core CE principles. Without these there is a danger that the ambiguity of CE will undermine any approach towards making meaningful interventions. Thus, whilst the 'values and visions' are deemed a crucial element, the framework is somewhat silent on how these should be determined in practice.

Another closely related limitation relates to the dynamism and flexibility that several of the RRI principles demand, particularly reflexivity and responsiveness. Given the complexity of many CE transition contexts, it is not necessarily straightforward to pause, change direction, or rethink in response to unfolding developments, particularly when multiple stakeholders are involved. The example we present in Section 4.1 of the development of a decision support tool provides an illustrative case of this. Under this context, whilst we are sensitive to the evolving nature of the work, and take onboard values to anticipate and minimise any potential harm, we are constrained by limited funding, and timelines for delivery that are largely out of our control. Such a scenario is familiar in the academic context and beyond. Here, discourses relating to 'failure' and refusal may be pertinent.

Whilst RRI principles can be applied to the CE, there may be some challenges and modifications needed to fully integrate RRI into the CE paradigm more broadly. One of the main challenges of applying RRI here is that CE is a systems-level approach that involves the entire lifecycle of products and materials, from design and production to use, repair, refurbishment, remanufacturing, and recycling. This complexity poses a challenge for RRI, which has traditionally been applied to specific projects or products, and may require RRI to be applied in a more holistic and systemic way. Another challenge is that the CE requires a paradigm shift in the way we think about products and materials, moving away from a linear, take-make-dispose model to a circular model that keeps resources in use for as long as possible. This shift in thinking may require rethinking of the RRI paradigm to focus on systemic, long-term impacts rather than short-term, project-specific impacts.

We are aware of the fact that our framework faces a variety of obstacles, including those of a structural, cultural, and communicative nature, as well as interactions between these factors. Various outcomes can be expected from the process of applying RRI pillars within CE because the aspects of interaction in each sector, country, or region are uniquely shaped by cultural and historical contexts. We acknowledge that additional data collection would be required to ascertain the conditions under which various implementation tools and policy actions are likely to be effective. We also acknowledge that a more thorough analysis of empirical studies in particular would likely serve as a basis for providing sufficient evidence and insights that emerge from actual implementation rather than the more theoretical literature we primarily focused on. Case studies should be conducted using the framework to show whether or not the theoretical pillars of RRI as presented here are feasible in practice, as would be revealed by a follow-up study. There is thus space for future work to engage in critical discussions relating to the limitations of the RRI paradigm, including its institutionalised nature, with reference to the CE and indeed other paradigms advocating for societal transitions.

5. Conclusion

The CE has been generally presented as a techno-based solution that would be able to combine the imperative of economic expansion, that characterises the neoliberal capitalist mode of production, with environmental concerns. Nevertheless, such a framing of circularity remains highly contested. According to an increasing number of scholars, this manifestation of a CE is likely to be scientifically unsound, it over emphasises the role of technology and it almost totally neglects the social aspects of transition such as gender, labour and global environmental justice. The framework we propose in this work overtly challenges the dominant framing of CE by drawing on the principles of RRI, and presenting them as a means for embedding the CE as a wider societal transformation attuned to values and visions of justice. It aims to provide conceptual guidance to imagine a just CE transition which strikes a balance between the desire for openness in setting normative values across broad stakeholder groups, whilst confronting the complexity of operational issues and policy support.

Thus, the framework encourages alternative thinking and reflection, and the consideration of perspectives from a wide range of stakeholders and contexts. Because democratic decision-making processes may entail the confrontation of societal norms, theories of equality, winner/loser settings, power asymmetries, and other factors that make determining an optimum impossible, much reflexivity is necessary. The goal of the framework is to provide the basis for a methodologically sound and socially justified process for industry, societal, and policy actors to consider and implement procedures that open alternatives and simplify the challenges of anticipation and inclusiveness. Our proposed approach is not meant to be a silver bullet for a just transition to a CE, but instead participates in and aspires to positively inform a developing discourse on CE within the context of the notion of RRI. We acknowledge the limitations of any one framework and suggest the need for future work to further interrogate how RRI may be embedded within the CE paradigm, and particularly the problems this may present. By questioning the boundaries of the CE transition process, and turning the spotlight to its outcomes, our framework hopes to facilitate a better understanding of values and visions that could underpin the CE through macro and micro decision contexts and across environmental, social, and ethical dimensions.

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CRedit authorship contribution statement

Ben Purvis: Writing – original draft, preparation, Methodology, Writing – review & editing. **Dilay Celebi:** Conceptualization, Methodology, Writing – original draft, preparation, Writing – review & editing. **Mario Pansera:** Supervision, Writing – original draft, preparation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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

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