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PRACTICES TO HELP ENABLE CIRCULAR ECONOMY  
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# DEVELOPMENT OF IMPACT ASSESSMENT PRACTICES TO HELP ENABLE CIRCULAR ECONOMY PROGRESS

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## **Development of Impact Assessment practices to help enable Circular Economy progress**

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## ABSTRACT

As a result of human activities, the environmental burden has increased exponentially in the past decades. The challenge of today stands with the urgency to fulfil society's needs within the limits of the planet. To achieve such accomplishment, a demand to shift human development towards sustainability arises, where the environmental, social and economic dimensions are balanced in a harmonious way.

The Circular Economy (CE) concept has been appointed as an approach that will help drive society into a more sustainable path, as it drifts from the traditional model of "take-make-use-dispose" to a course that allows the decrease of environmental pressures without limiting the economy, ensuring at the same time, social equity and fairness, for the present and future generations.

The path to sustainability does not rely only on changes in the production, distribution, and disposal systems. It also relies on changes in environmental processes that evaluate and allow the implementation of major developments, namely the EIA process. The Environmental Impact Assessment (EIA) is an important mechanism that ensures that all major projects are implemented with the most sustainable settings as viably possible.

In this line, an interlink of values and goals between CE and EIA starts to appear. However, this is still an underexplored field, where important scientific knowledge gaps exist, such as the potential contribution that the EIA might have towards CE, and in the understanding of the connection between these two fields.

This research aims to develop a set of impact assessment practices that would enable the transition towards circularity and contribute to improving the EIA procedures. The exploration of the connection between these two fields culminated in a conceptual framework that displays this linkage and is accompanied by a variety of proposals that integrate CE and EIA.

To accomplish this goal, a systematic review of the literature has been performed, followed by the development of a conceptual model and a diversity of practices harmonizing these subjects, incorporating a variety of principles and circular practices into the EIA procedures. As this study comprehends an exploratory nature, a questionnaire has been conducted, intending to probe and gather experts' opinions and information on this topic.

It was found that the incorporation of these subjects may create a synergic relationship, where they can benefit from one another's strengths, in addition to contributing to the advancement of both these fields. Although the response level on the questionnaire performed was lower than expected, the expert's reaction and judgment to the proposals were widely positive, drawing attention to the potential of harmonizing and incorporating these topics. The results

of the questionnaire demonstrate that the majority of respondents agree that both the principles and strategies applied, and the proposed practices are appropriate to incorporate into the EIA process, and have the potential to contribute to its improvement and to foster the transition to CE.

Acknowledging that the theme is underexplored, both in the academic and practical fields, a wide range of possible aspects that can be enriched and improved is recognized, highlighting the assessment and evaluation of the link between these areas in future developments, in particular in existing barriers in the EIA process that CE can help to overcome, and in the development and improvement of appropriate and beneficial circular practices to incorporate into the EIA procedures.

**Keywords:** Circular Economy (CE), Environmental Impact Assessment (EIA), Sustainability, Conceptual Framework



## RESUMO

Como resultado das atividades humanas, as pressões ambientais têm vindo a sofrer um aumento exponencial nas últimas décadas. O desafio dos dias de hoje prende-se com a urgência de satisfazer as necessidades da sociedade dentro dos limites dos sistemas naturais e sociais. Para alcançar tal objetivo, é necessário transformar os padrões de desenvolvimento humano em caminhos mais sustentáveis, em que as dimensões económicas, sociais e ambientais são integradas de forma equilibrada.

O conceito de Economia Circular (EC) tem sido explorado como uma abordagem que poderá impulsionar a sociedade a realizar a transição para a sustentabilidade, uma vez que se distancia do modelo tradicional de “*take-make-use-dispose*” para um curso que permite a redução dos impactes ambientais sem inviabilizar as atividades económicas, ao mesmo tempo que garante a equidade e justiça social para as gerações presentes e futuras.

No entanto, o caminho para a sustentabilidade não está apenas ligado a mudanças nos sistemas de produção, distribuição e gestão de resíduos. Este caminho está também ligado a alterações nos procedimentos ambientais que avaliam e permitem a implementação de grandes desenvolvimentos, como por exemplo, a Avaliação de Impacto Ambiental. A Avaliação de Impacto Ambiental (AIA) é um mecanismo importante que garante que determinados projetos sejam implementados em condições mais sustentáveis.

Nesta linha, uma convergência de valores e objetivos entre a EC e AIA tem vindo a emergir. Contudo, ainda é um campo pouco explorado, existindo importantes lacunas de conhecimento científico neste domínio, nomeadamente o potencial contributo que a AIA pode ter na transição para a EC e o aprofundamento e entendimento da relação entre estes dois campos. Assim, esta investigação procura examinar a associação entre dois domínios, assumindo como objetivo principal o desenvolvimento de um conjunto de práticas de avaliação de impactes que facilite a transição para a circularidade. Este trabalho procura ainda contribuir para o aperfeiçoamento dos procedimentos da AIA, explorando a ligação entre estes dois temas, culminando num modelo conceptual que exhibe esta união, sendo acompanhada por uma variedade de propostas que integram EC e AIA.

Para a concretização deste estudo efetuou-se em primeiro lugar uma revisão sistemática da literatura, seguindo-se o desenvolvimento do modelo conceptual e das diversas práticas que integram estas matérias, incorporando diversos princípios e práticas circulares nas diferentes componentes do processo da AIA. Uma vez que este estudo compreende uma natureza exploratória, realizou-se um questionário, com o intuito de explorar e recolher opiniões de especialistas e informação sobre este tema.

A integração destes dois domínios, AIA e EC, cria uma ligação sinérgica, onde estes temas podem beneficiar dos pontos fortes um do outro, contribuindo assim para o seu desenvolvimento. Embora o nível de resposta ao questionário tenha sido inferior ao esperado, as reações e opiniões dos especialistas às propostas realizadas foi amplamente positiva, destacando o potencial para a harmonização e integração destes tópicos. Os resultados do questionário demonstram que a maioria dos inquiridos concorda que tanto os princípios e estratégias aplicados, como as práticas propostas são apropriados para incorporar no processo da AIA, e têm o potencial para contribuir para a sua melhoria e fomentar a transição para a EC.

Constatando que o tema se encontra pouco explorado, tanto no campo académico, como no prático, é reconhecido um vasto campo de possíveis aspetos passíveis de serem enriquecidos e aprimorados, salientando-se o aprofundamento e avaliação da ligação entre estes domínios em desenvolvimentos futuros, nomeadamente em relação às barreiras existentes no processo da AIA que a EC poderá ajudar a ultrapassar e ao desenvolvimento e melhoria de práticas circulares adequadas e pertinentes a serem incorporadas nos procedimentos da AIA.

**Palavras chave:** Economia Circular (EC), Avaliação de Impacte Ambiental (AIA), Sustentabilidade, Modelo Conceptual



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## LIST OF ABBREVIATIONS AND ACRONYMS

CE – Circular Economy  
EIA – Environmental Impact Assessment  
IA – Impact Assessment  
IAIA – International Association for Impact Assessment  
EEA – European Environmental Agency  
EMF – The Ellen MacArthur Foundation



## 1.1. Context and motivation

The main challenge of today's society stands for the responsible exploitation and use of the planet's resources while satisfying the socio-economic needs of the population (Josimovi et al., 2021). Along with this, there has been a growing concern about environmental matters and new strategies to approach these barriers.

The circular economy (CE) concept is an emerging approach for dealing with the current sustainability challenges, that shifts from the present linear model of "take-make-use-dispose" into a circular resource management model (Klein et al., 2020). This idea suggests that it is possible to reduce the environmental burdens without limiting the economy, by retaining the value of products, materials, and components and by fostering inner loops (van Loon et al., 2021).

However, there is no consensus on the CE definition, in the scientific and practitioner's community. With this barrier in mind, Kirchherr et al. (2017) analysed 114 different definitions and defined CE as

an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. (Kirchherr et al., 2017, p.224)

Nevertheless, circularity poses its own limitations, for example, burden-shifting and rebound effect (van Loon et al., 2021). The former occurs when the reuse of resource-consuming products or services, avoids the burdens of production, but leads to an expansion of the lifespan of older and less efficient products, generating additional impacts during other life-cycle phases, whereas the latter can be defined when a CE strategy leads to a decrease of a product/service price, motivating an increase of consumption, and therefore, counteracting the initial resource savings (Boldoczki et al., 2021).

Difficulties as such may be suppressed by the implementation of a comprehensive and holistic approach, such as an environmental impact assessment (EIA), in order to guarantee the best harmonization between the environmental, economic, and social performance. The International Association for Impact Assessment (IAIA) defined the EIA as “a formal and systematic process that includes identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made” (International Association for Impact Assessment (IAIA), 2020, p.1).

The main function of an EIA process is to determine the potential positive and negative impacts of a project in advance. Regarding the adverse effects on the natural and socio-economic environment, different mitigation measures or paths are identified beforehand. This facilitates the avoidance and/or minimization of impacts and turns the projects environmentally friendly and acceptable to the community (Mekuriaw & Teffera, 2013). This process strengthens the relationship between science and policy, since it provides means through research that could inform decision making, delivers an analysis of policy-relevant questions, and could also influence the goals and actions taken, powering institutional changes (Coppens et al., 2015).

Nonetheless, the EIA process also presents numerous challenges, some of them in a broader view, such as the lack of a standard methodology, specific indicators for sector/area, evaluation methods to assess the significance of indicators, in order to allow a fair comparison between plans, projects, products, and services. Alongside this, the effectiveness of the process also relies on the expertise of the team selected (Coppens et al., 2015; Wood et al., 1996). In a more practical view, the EIA process poses different barriers such as practitioners’ subjectivity and judgement, difficulties with criteria and methods, lack and uncertainty about guides, manuals, institutional frameworks, legal regulations and instruments, time-frames and resources, amongst others, (Morgan, 2012; Püttgen, 1996; Zhang et al., 2013), further described more thoroughly in the sections ahead.

The application of CE principles into the EIA procedures could present a beneficial approach for both sides since it promotes the transition to a more circular economic model and enhances the effectiveness of the EIA process. Therefore, integrating these two topics raises an opportunity to increase attention to resource conservation in these processes and improve the quality of economic growth (Yijun & Ying, 2011). Additionally, impact assessment (IA) tools can also be used to evaluate whether these principles help deliver sustainable development (Fothergill & Murphy, 2020).

Although these two topics have been the target of several studies, through our research it became evident the scarcity of investigations harmonizing these two subjects, thus, highlighting the need to further contribute to the knowledge and awareness of merging these fields.

## 1.2. Problem and objectives

As mentioned before, the relationship between Circular Economy (CE) and Environmental Impact Assessment (EIA) is still an underexplored research topic that requires further advancements on how to unify CE principles, strategies and approaches to EIA processes and tools.

The main aim of this research is to analyse how circular economy and impact assessment could be integrated and how they could benefit and accelerate each other's developments and effectiveness towards a higher performance for sustainability. With this study, the intent was to propose different practices that can enable the integration of CE into the EIA process which culminated in the development of a conceptual model that incorporates different circularity topics in impact assessment practices.

## 1.3. Approach and contribution

The approach for this investigation, see Figure 1, started by conducting a systematic review of the literature, in addition to an independent and targeted search and gathering of pertinent literature collected through a bibliography snowball process. This intended to confer an overview of the state of the art on the EIA process, as well as on the CE approach, including principles, strategies and indicators.

With all the information assembled the conceptual model that illustrates the connection between these two fields was developed and a set of practices embodying the integration of these concepts was proposed. Subsequently, a questionnaire has been conducted to EIA professionals, with the intention to explore expert views on this topic, as the CE and EIA fields represent significant themes concerning the management of environmental challenges.

Lastly, the results have been evaluated and triangulated with international policy documents on CE, in order to strengthen and deepen the analysis.

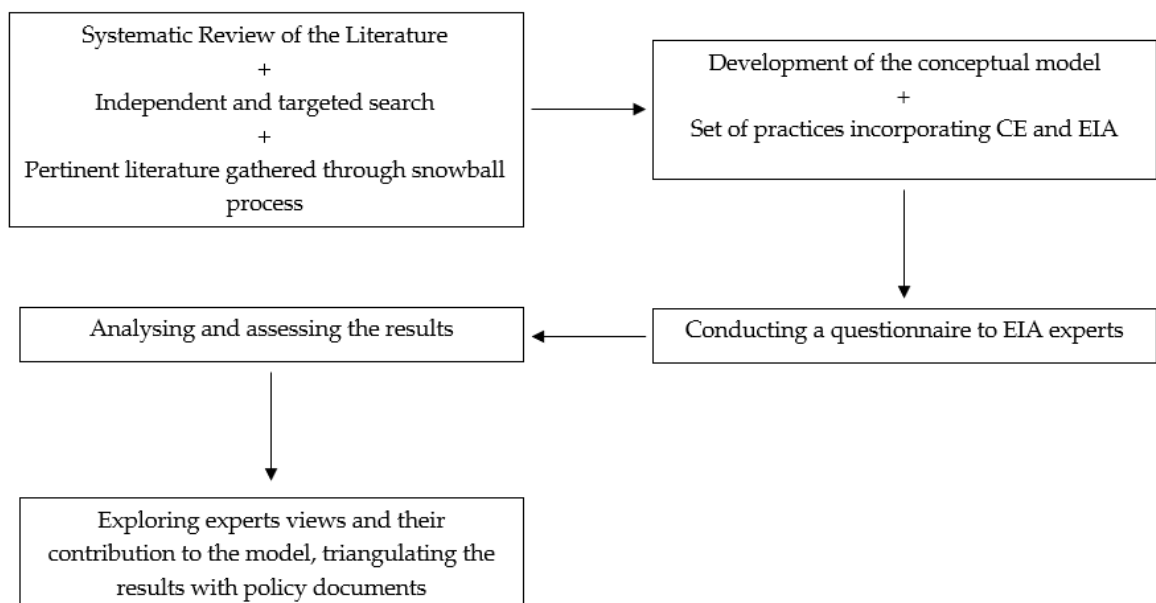


Figure 1 – Approach conducted throughout the study.

## **1.4. Structure of the thesis**

After this introductory chapter, the thesis is structured as follows: i) the findings of the literature review, targeted search and pertinent information on the EIA and CE matters are presented, ii) the research design is described, iii) the results are illustrated and discussed, and lastly, iv) the conclusions of the study are stated.

## LITERATURE REVIEW

### 2.1. Environmental Impact Assessment

Before explaining Environmental Impact Assessment (EIA), it is fundamental to define and understand the concept of Impact Assessment (IA). While several interpretations of IA exist, they all appear to be in the same vein of thought, acknowledging this notion as a “systematic analysis of the lasting or significant changes— positive or negative, intended or not— in people's lives brought about by a given action or series of actions” (Roche, 1999, p.21). This conception portends that identifying and evaluating impacts is equivalent to assessing and considering change (Streatfield & Markless, 2009) and that IA should not focus on activities or deliverables, but on pathways towards change (Simister, 2017).

Posing this definition, IA acts as an umbrella for several specific forms of impact evaluation, such as Social Impact Assessment (SIA), Environmental Impact Assessment (EIA), Health Impact Assessment (HIA), Regulatory Impact Assessment (RIA), among many other (Morgan, 2012). In this paper, the main focus is on Environmental Impact Assessment (EIA).

Environmental Impact Assessment (EIA) can be defined as a “formal and systematic process that includes identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made” (International Association for Impact Assessment (IAIA), 2020).

The EIA process emerged in the United States with the National Environment Policy Act (NEPA) of 1969 (UN Environment, 2018), which arose from public demand, as the environmental damage caused by human activity started to become undeniable. Political activism and public concern drove the US Congress to take action (Ortolano & Shepherd, 1995). The purpose of the NEPA was to “fulfil the responsibilities of each generation as trustee of the environment for succeeding generations” (Jay et al., 2007, p.289). It stated that when conducting major projects (e.g., harbours, highways, airports, etc.), a detailed statement of the environmental impacts of a proposed action had to be emitted. The necessary document was called Environmental Impact Statement (EIS). Later, the Environmental Impact Assessment was defined as the process necessary to achieve the EIS.

Contextualizing the EIA into Europe, the process began to be implemented in 1985, under the EU Directive (85/337/EEC). Since then, it has been amended three times, in 1997, 2003 and 2009, and has undergone several modifications. These directives have been codified in 2011, and the current directive relates to 2014 (Directive 2014/52/EU), where environmental

procedures have been simplified, specific time-frames have been established and proposals that embody substantial negative impacts require mandatory monitoring programs (European Commission, 2021).

Although the EIA process has been implemented in more than 100 countries (Morgan, 2012; Noble, 2011; Sadler, 1996) over the last years, academics and scholars still debate over the purposes of the EIA. The most accepted intent is to predict, minimize and avoid the significant environmental impacts of a proposal, prior to entrusting to an action or a course of actions (Cashmore et al., 2004; Wood, 2003). However, other authors argue that the main purpose of the EIA is to address and incorporate environmental propositions in the planning and decision-making process (Noble, 2011), aiming to achieve arrangements that will preserve, safeguard, rehabilitate and improve the state of the environment (Steinemann, 2001), ultimately enhancing the quality of decisions (Jay et al., 2007; Ortolano & Shepherd, 1995).

In the next subsection of this review, the EIA process, entailing the procedural stages and principles for best practice will be further detailed.

### **2.1.1. EIA Process**

This section aims to demonstrate and clarify the several stages of the EIA process. The traditional procedures on how to conduct an EIA have been discussed in the literature and there is a general consensus on how to proceed. The conventional stages of this process are Screening, Scoping, Examination of alternatives, Impact Analysis, Mitigation and Impact Management, Evaluation of significance, Review of the EIS, Decision-Making and Follow-up. Starting with the stage of Screening, this step acts as a preliminary assessment (Noble, 2011; UN Environment, 2018) as the main goal is to determine whether a proposal should be subject to an EIA, and what level of assessment and detail is required (Sadler & Brown, 1999; Wood, 2014).

The subsequent stage is Scoping, which includes a detailed characterization of the project. This step specifies the scope of the EIA process (Wood, 2014). It should cover all possible effects of a proposal, the ones that stand as key issues and need to be prioritized and addressed (Sadler & Brown, 1999; UN Environment, 2018). The baseline condition, terms of reference, and a set of alternatives to the proposal should be defined (Noble, 2011; Ross et al., 2006).

Succeeding this point, some authors include a distinct consideration of alternatives phase (Glasson & Therivel, 2019; Zhang et al., 2013), while others comprised that step under the scoping procedures (Morris & Therivel, 2009; Noble, 2011; Sadler, 1996). In our research, the examination of alternatives has been contemplated separately from the Scoping phase. In the Examination of Alternatives, the aim is to ensure the consideration of feasible and viable options for the proposal, generally regarding location, processes, scales, operational conditions or layout (Glasson & Therivel, 2019), pondering favourable environmental alternatives without compromising the achievement of the project's objectives (Sadler & Brown, 1999).

After this examination, the following stage is the Impact Analysis, where the intent is to identify, predict and evaluate both adverse and beneficial effects of the proposal, regarding the environmental, social, and economic dimensions (UN Environment, 2018; Wood, 2014),

based on the previous scoping stage, where the baseline conditions and terms of reference have been established (Morris & Therivel, 2009; Noble, 2011).

Upon the identification and evaluation of the impacts, for those considered as adverse and likely to present significant effects, mitigation measures should be determined to avoid, minimize, remedy or compensate the effects (Glasson & Therivel, 2019), and when appropriate integrate them into management plans or systems (Sadler & Brown, 1999).

The following stage is the Evaluation of Significance, where for the major impacts identified and for those that could not be mitigated or termed as residual effects, their significance and acceptability is established, defining their potential severity, duration, and irreversibility. These effects are also interpreted according to their importance to the communities affected and ecological functions (Morris & Therivel, 2009; Sadler, 1996).

With all the information gathered and analysed, the Environmental Impact Statement (EIS) is prepared. This report presents all information produced regarding the project impacts and their significance assessment, the proposed mitigation measures and the effects and concerns of the affected public (Ross et al., 2006).

Before reviewing the EIS, the report is subject to public consultation and participation, where the public's opinions are considered and taken into account before the decision-making process. This stage provides the platform where the information about a proposal is shared with the public, aiming to obtain their input regarding the development, which contributes to the acceptance, quality and success of both the project and the EIA process (Glasson & Therivel, 2019; Morgan, 2012)

Following the public consultation step, this document is subject to analysis and review with the intent to assess if the necessary level of detail is met, if the methodologies applied were suitable, if the terms of reference were accomplished and if it contains all the relevant information to sustain and support an informed decision (Sadler, 1996; Sadler & Brown, 1999).

After reviewing the report, the project is up to approval or rejection by the relevant authorities (Glasson & Therivel, 2019; Wood, 2014) and the terms of implementation are defined.

The last stage of the EIA process, is the Follow-up, where this post-decision step aims to monitor the identified impacts, analyse whether the mitigation measures applied are efficient and verify if the contingency and management plans are in motion, suitable and effective (Ross et al., 2006; UN Environment, 2018).

### **2.1.2. EIA Barriers**

Multiple obstacles that decrease the effectiveness of the EIA process have been highlighted by the literature. These barriers can differ in their nature, where some regard technical issues, while others relate to legal and institutional instruments or are correlated with practitioners' perspectives of the EIA.

The technical challenges concerning the process can vary from problems with screening thresholds and criteria, lack of tailored methods, scarcity of guidelines and manuals, difficult resource allocation, shortage of monitoring data, and times-frames which may be too early to accurately infer long-term effects, among others.

In the Screening stage, it is determined if a proposal requires an impact assessment and the level of detail that is necessary (Sadler & Brown, 1999). When performing this step, several

techniques are available, which can lead to uncertainty over the most suitable method or approach for the project (Glasson & Therivel, 2019). In addition, this stage is the first line of quality control, acting as a filtering mechanism (Nielsen & Christensen, 2005; Sadler, 1996), thus, if not accomplished properly, there is a possibility of compromising the quality of the process and the implementation of the project.

When it comes to impact assessments, the way impacts are determined and evaluated constitutes a key point in the excellence and performance of the entire process, therefore, lack of tailored methods or if the applied techniques are inappropriate or obsolete (Kruopiene et al., 2009) pose as significant constraints, as if the effects are not assessed accurately, the loss of relevant and crucial information could occur, influencing the process of decision-making (Toro et al., 2010).

The decision-making process and the quality of the decisions rely also on how precise and explicit the guidelines and manuals are presented. Additionally, international guidelines and specifications are essential, so that standardized conditions/performances can be established (Sadler, 1996). An important message is made for the stages of Screening and Scoping as inadequate guidance and protocols seem to befall as a noteworthy obstacle to the EIA process (Pr, 2013).

The literature mentions that as professionals identify, predict and appraise the impacts, being able to modify the proposals, their judgement may impact the success of the process (Noble, 2011; Ortolano & Shepherd, 1995; Ross et al., 2006). Furthermore, their judgement is performed accordingly to their know-how and expertise (Sadler, 1996), and for that, their training and capabilities present as an influential characteristic to the project's outcome. Their knowledge and experience weigh in the over or under-prediction of impacts (Ali, 2007; Zhang et al., 2013), thus influencing the EIA procedures.

As previously mentioned, the EIA process may serve a variety of purposes, as the professional background may influence expert's perspectives over the functions of the EIA, impacting the quality, objectives and effectiveness of the process, since their experience affects and determines the principles, will, and attitude when conducting an impact assessment (Morgan et al., 2012).

Also, as the effects of a proposal are generally predicted early in the process, and those deductions are sometimes made based on existent monitoring data, which combined with the level of uncertainty associated with the process, strengthens the possibility for not predicted long-term effects to occur (Morris & Therivel, 2009; Wood et al., 2000; Zhang et al., 2013).

Time frames and resources are always an inherent part of every project or proposal, whether they are financial funds, legal or institutional assets, staff/experts resources or material reserves. Several researchers argue that qualified and competent professionals, along with financial resources constitute a central point to the adequate accomplishment of the process stages, as well as the project's implementation (Ahmad & Wood, 2002; Toro et al., 2010; Wood et al., 2000). Apart from the number of resources, when to apply them and where to allocate them, also represent a vital element of the EIA (Cashmore, 2004; Fitzpatrick & Sinclair, 2009).

Authors have also expressed that weak institutional frameworks and legal instruments pose a significant obstacle to the process (Morgan, 2012; Ross et al., 2006), as their adequacy

and validity may influence the performance and implementation of the EIA, reinforcing the perspective that they are not always complied with (UN Environment, 2018).

Additionally, practitioners play a key role when conducting an impact assessment, and since there is a lack of guidelines and manuals, or they seem to be short in clarity and precision (Wood, 2014), associated with deficient legal instruments, professionals often find themselves uncertain about regulations (Sadler, 1996; UN Environment, 2018).

Bureaucratic will and commitment may influence the practical procedures of the EIA (Ahammed & Harvey, 2004), as planning authorities may intervene with exhaustive and complicated requirements, compromising the project's implementation (Snell & Cowell, 2006). Several studies also emphasize the importance of clearly defining the obligations and responsibilities that each actor and involved parties need to fulfil and exercise, in order to avoid duplicating work and improve and promote the EIA's progress and development (Fitzpatrick & Sinclair, 2009; Sadler, 1996; Zhang et al., 2013).

Due to the nature of the process, the EIA is also an economic reliant procedure, and with so, practitioners are often subjected to influence or persuasion regarding their predictions, actions or principles. Thus, a prominent argument stated in several articles is for the review body to be independent of the project's proponent (Ahammed & Harvey, 2004; Cashmore, 2004; Sadler, 1996; UN Environment, 2018).

Pondering now over how the human/social interactions may impact the process, the communication and cooperation between actors, or the absence of it, may also be mentioned as a challenge to the EIA system. The way the different parties interact and cooperate between themselves opens the possibility to adjust or modify the proposals, hence, there is a potential opportunity to enhance and improve the performance of the process (Morgan, 2012; Morris & Therivel, 2009; Nielsen & Christensen, 2005; Ross et al., 2006; Wood et al., 2006).

Also in the cooperation and interaction dimension, several articles state that if the political will and stakeholder engagement do not promote and support the different views and perspectives of the actors involved, the projects or proposals success may be compromised, as the EIA has a strong political core (Cashmore, 2004; Glasson & Therivel, 2019). Furthermore, it is fundamental for the public and stakeholders to engage and input in the different steps of the procedure, to achieve a general agreement and satisfaction over the projects (Jay et al., 2007; Pr, 2013; Ross et al., 2006; Snell & Cowell, 2006; UN Environment, 2018).

Lastly, the way and the amount of information delivered to the public could also constitute a constraint to accomplish the project's objectives, since transparent, open and clear information over the available data to the public promotes a favourable outcome to the EIA (Ahammed & Harvey, 2004; Baker & McLelland, 2003; Cashmore, 2004; Ross et al., 2006).

## 2.2. Circular Economy

Recently, the Circular Economy (CE) concept has been in the spotlight as a transition pathway towards a more sustainable course (Geissdoerfer et al., 2017; Henry et al., 2020; International Energy Agency, 2011) that empowers society to deal with some concerning and pressing environmental issues like resource depletion, biodiversity loss, GHG emissions, energy poverty, water scarcity, pollution and contamination of several natural resources (International Energy Agency, 2011; Jackson, 2009; Meadows & Randers, 2004; Rockström et al., 2009), along with the fact of having an economic core also facilitates the tackle of a number of economic challenges, such as deficient markets, financial instabilities and weak incentive structures (Ghisellini et al., 2016; Jackson, 2009), while at the same time enhancing and promoting better societal settings like generational equity, improved working conditions, decrease social vulnerability, inequalities and gaps (Geng et al., 2012; Yap, 2005).

The CE concept, or similar versions of it, have been mentioned and discussed by academics for some time. The origin of the concept is uncertain, with early developments from Boulding (1966), where the earth is described as a circular and closed system, with limited capacities, and argued that the environmental and economic dimensions should exist in a balanced and harmoniously manner. This perspective later inspired the work of Pearce and Turner (1989), where it is stated that natural resources supply the production and consumption lines, and play an important role in the output system, and therefore have a strong potential to impact the economy.

The recent developments of CE have integrated a diversity of disciplines and influences like the cradle-to-cradle (McDonough & Braungart, 2002), industrial ecology (Ehrenfeld, 2000; Graedel, 1995; Socolow et al., 1996), performance ecology (Walter R. Stahel, 2010), biomimicry (Benyus, 2002), eco-innovation (Rennings, 2000; Kemp, 2010), regenerative design (Lyle, 1996) and blue economy (Pauli, 2010).

The CE development has been strongly reinforced and supported by Europe and China (Geissdoerfer et al., 2017; Henry et al., 2020), since, in 2008, China released the Circular Economy Promotion Law defining the concept as “a generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation and consumption” (National People’s Congress, 2008). In 2014, the European Commission released the programme “Towards a Circular Europe: A Zero Waste Programme for Europe”, implying that circular systems provide benefits for the three sustainability dimensions, such as the increase of employment, higher resource productivity and economic growth (European Commission, 2014). This programme was taken as a waste management strategy, being then updated in 2015, to the package of “Closing the Loop – An EU Action Plan for the Circular Economy”, and later, in 2020, to “A New CE Action Plan for a cleaner and more competitive Europe” (European Commission, 2015, 2020).

With the CE concept being further developed and studied, some authors argue that most definitions and perspectives do not engage and support the social dimension (Frey & Stutzer, 2002; Geng et al., 2012; Murray et al., 2017). As circular systems have been promoted as a way to achieve sustainable development (Geng et al., 2012; Geng & Doberstein, 2008; Henry et al., 2020; Läpple, 2007; Murray et al., 2017; The Ellen MacArthur Foundation, 2013),

this missing argument has been appointed as a strong setback to the application and acceptance of CE (Dacin et al., 2010).

This section of the CE concept will unfold into principles, strategies and indicators. The principles are perceived as values or goals that embody the message of the concept. The strategies are taken as a set of actions to achieve those values or goals. To understand if these goals have been achieved and monitor their performance and evolution, a set of metrics is required, which are represented by the indicators.

### 2.2.1. CE Principles

As previously mentioned, the CE concept has been contested and its principles have no mutually accepted definition (Reike et al., 2017; Yuan et al., 2008). Several lines of thought have diverged in this subject, with a variety of academics defending that the 3R framework is the core and foundation of this concept (Brennan et al., 2015; Lett, 2014; Lieder & Rashid, 2016; Reh, 2013; Sakai et al., 2011; Su et al., 2012; Yuan et al., 2008). The 3R's stand for Reduce, Reuse and Recycle, and function in a hierarchical system, in a manner that the Reuse principle would have a higher priority than the second and third principle (Reike et al., 2017; Sihvonen & Ritola, 2015).

Although this R-hierarchy has been the most applied framework (Kirchherr et al., 2017), numerous scholars have contributed to the enhancement of these principles, in the attempt to embody a larger number of propositions that best capture the values of CE and sustainable development.

Consequently, academics have then proposed the 4R's framework (Kazerooni Sadi et al., 2012; Loomba & Nakashima, 2012), followed by the 6R's (Go et al., 2015; Jawahir & Bradley, 2016; Yan & Feng, 2014) and ultimately the 10R's framework (Potting et al., 2017; Sihvonen & Ritola, 2015; van Buren et al., 2016).

To succinctly clarify them, the 4R's constitute for R (1) reduce, R (2) reuse, R (3) recycle, and R (4) recover, wherein the 6R framework the R (5) stands for re-design and the R (6) for re-manufacture. Lastly, in the 10 R's several changes have emerged, with the hierarch alterations being R (0) refuse, R (1) rethink, R (2) reduce, R (3) reuse, R (4) repair, R (5) refurbish, R (6) re-manufacture, R (7) repurpose, R (8) recycle, and R (9) recover.

However, as the variety of these frameworks increases, so does their complexity, in addition to the uncertainty of whether they work as principles or strategies, which takes over the chance of them being more generally acknowledged and accepted as a foundation of the CE concept (Reike et al., 2017).

The critiques started to expand, expressing these principles were perceived as waste management strategies. Other criticism suggested that the implementation of CE was mainly focused on the economic perspective, leaving the environmental and social dimensions behind, contrasting with the theoretical purposes of circularity (Harris et al., 2021; Velenturf & Purnell, 2021).

Subsequently, scholars developed different standards, aiming to establish a set of values that embrace and integrate the intention and function of CE. For instance, an interesting approach was made by Velenturf & Purnell (2021). The authors proposed several principles for a sustainable circular economy, as CE presents a strong potential to drive society towards

sustainability, but it is critical to integrate it within sustainable development in a holistic way, being fundamental to reconsider the concept and the available paths to achieve it.

Affirming this, the study defines ten sustainable CE principles, which were based on the three traditional values of circularity, environmental quality, economic prosperity and social/individual well-being, with the principles unravelling as (1) beneficial reciprocal flows of resources between nature and society, (2) reduce and decouple resource use, (3) design for circularity, (4) circular business models to integrate multi-dimensional value, (5) transform consumption, (6) citizen participation in sustainable transitions, (7) coordinated participatory and multi-level change, (8) mobilise diversity to develop a plurality of circular economy solutions, (9) political economy for multi-dimensional prosperity, (10) whole system assessment.

When it comes to the most common basic propositions of CE, which have been discussed and referred to in the literature numerous times (Antikainen et al., 2018; De Pascale et al., 2021; Elia et al., 2017; Harris et al., 2021; Manninen et al., 2018), the Ellen MacArthur Foundation (EMF) stands as an important pillar to the knowledge, development and implementation of circularity. The three principles described by the EMF (2015) are clarified as (1) preserve and enhance natural capital by controlling finite stocks and balance renewable resource flows, (2) optimise resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycles, (3) foster system effectiveness by revealing and designing out negative externalities.

With all the discussion and attention over this topic, authors manifest that the EMF perspective has a strong focus on business models and targets mainly companies and organizations (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Reike et al., 2017).

In order to give this concept a stronger environmental dimension, reinforcing the idea that CE could be an appropriate approach to fulfil society's needs, without pushing the environment beyond its limits, in 2016, the European Environment Agency (EEA) (2016) proposed five key characteristics or principles for a circular economy, defined as (1) less input and use of natural resources, (2) increased share of renewable and recyclable resources and energy, (3) reduced emissions, (4) fewer material losses/residuals, (5) keeping the value of products, components, and materials in the economy.

Starting with (1) less input and use of natural resources, this principle implies the minimization and optimization of the exploitation of raw materials while providing more value from fewer materials, by reducing the import dependency on natural resources and by using them efficiently.

Subsequently, the (2) increased share of renewable and recyclable resources and energy refers to the replacement of non-renewable resources for renewable ones, within the sustainable levels of supply, replacing the share of virgin materials for recycled and recyclable ones, by closing the material loops and sustainably sourcing the raw ones.

The (3) reduced emissions principle involves the reduction of emissions within the entire material cycle by sustainable sourcing and decreasing the use of raw materials, as well as reducing the levels of pollution by using clean material cycles.

The (4) fewer material losses/residuals refers to keeping the incineration and landfill to a minimum and minimizing the waste build-up and dissipative losses of valuable resources.

Lastly, (5) keeping the value of products, components, and materials in the economy implies the extension of the lifetime of products by keeping them in use and by reusing their components and preserving the value of materials in the economy by high-quality recycling.

There is a vast amount of literature and debate regarding CE, sustaining the idea that this concept and its principles have not been truly endorsed yet (Reike et al., 2017; Yuan et al., 2008).

### 2.2.2. CE Strategies

In this segment, we aimed to analyse the current and available strategies, approaches or techniques that are able to put the circular concept and principles into action, materializing the transition to the CE model.

In the previous topic, the R-hierarchy has been referred to by authors as core principles of CE. However, this hierarchy has also been mentioned numerous times (Blomsma et al., 2019; Chakrabarty & Nandi, 2021; King et al., 2006; Kirchherr & Piscicelli, 2019; Lozano et al., 2021; Moraga et al., 2019; Okorie et al., 2018; Potting et al., 2017) as strategies, encompassing actions in order to achieve targets that ensure the main goals of circularity, the economic prosperity, environmental quality and social equity (Morseletto, 2020).

In light of that statement, this R-framework will also be discussed through the perspective of strategies, with the aim to comprehend this standpoint, since they have been appointed as some of the foundation propositions for this concept.

The 10 R's framework developed by Potting et al. (2017) appears to be the base of several studies, where authors have contributed and enhanced these strategies. Herewith, this framework has three main categories, (1) smarter use and manufacture of products, (2) extension of a products and components lifespan, and (3) useful application of materials.

The first category, smarter use and manufacture of products, embodies the R (0) refuse, R (1) rethink, and R (2) reduce. These strategies intend to transform a product in order to make its function redundant, make its use more intensive or make the manufacture more efficient by consuming fewer natural resources.

The second category, the extension of products and their components lifespan, entails the R (3) reuse, R (4) repair, R (5) refurbish, R (6) re-manufacture, and R (7) repurpose. These strategies aim to preserve consumed goods and their components in the economy, to enhance and sustain their value.

The last category, useful application of materials, integrates the R (8) recycle and R (9) recover. This group targets the waste component of the cycle, that would have been sent to landfill or incinerated.

As mentioned, other scholars have adapted and improved the 10R framework in their studies. For instance, Blomsma et al. (2019), developed a conceptual model, involving strategies such as reinvent, rethink and reconfigure, restore, reduce and avoid, and recirculate.

Continuing on this note, Moraga et al. (2019), grouped the strategies from the 10R framework into six strategic categories according to what they measure.

The first category relates to the preservation of a product's function, incorporating the refuse, rethink and reduce strategies. The second one, details the preservation of the product

itself comprehending strategies like durability, reuse, restore, refurbish, and re-manufacture. The third category concerns the preservation of a product's components by reusing, recovering, and repurposing them. The fourth aims to preserve materials by way of recycling and downcycling. The fifth category has the intention of preserving the embodied energy as a result of energy recovery through incineration and landfill. The last category has a different nature, as it relates to the measurement of the linear economy as a reference scenario, to show the state, progress or regress towards CE.

Although these frameworks and their adaptations have been relatively applied, their level of implementation is targeted to the micro-level, particularly to products, companies, and consumers. As the present research falls into the meso of CE, the majority of these strategies were not considered suitable or viable to be implemented into our conceptual model, although the repair, refurbishment, re-manufacture and recycling were incorporated into our proposal, but in a slightly different perspective.

In a different perspective, Suárez-Eiroa et al. (2019) have defined a group of operational principles of the circular economy for sustainable development, which have been divided into target operational principles, core operational principles and transversal operational principles.

The proposed seven operational principles are (1) adjusting inputs to the system to regenerate rates (target principle), (2) adjusting outputs from the system to absorption rates (target principle), (3) closing the system (core principle), (4) maintaining resource value within the system (core principle), (5) reducing the system's size (core principle), (6) designing for circular economy (transversal principle) and (7) educating for circular economy (transversal principle)

Within these operational principles, several strategies are proposed for each one of the principles. For the first principle, the authors defined five strategies, (1) substituting non-renewable by renewable inputs, (2) substituting renewable materials with low regeneration rates for others with faster regeneration rates, (3) adjusting taxes and subsidies of technology, products and materials based on their resource regeneration rates, (4) saving energy and materials and (5) fostering renewable mobility.

For the second principle, three strategies have been mentioned, (1) substituting materials and processes which produce technical outputs by those which produce biological outputs, (2) substituting processes for those with lower waste generation rates, and (3) adjusting taxes and subsidies of technology, products and materials based on their waste generation rates.

The third principle includes five strategies, (1) separating biological and technical wastes properly, (2) re-manufacturing products and components, (3) promoting and improving downcycling, recycling and upcycling of wastes, (4) promoting energy recovery by converting waste into heat, electricity or fuel, and (5) promoting extended producer responsibility.

The fourth principle entails four strategies, such as (1) interconnecting stages, (2) promoting industrial symbiosis, (3) increasing durability, and (4) reducing obsolescence.

The next principle comprises five strategies, (1) informing consumers properly, (2) expanding the extended consumer responsibility, (3) promoting functional service economy and

sharing economy, (4) promoting green procurement, and (5) adjusting selling doses to consumer doses.

The sixth principle embraces six strategies such (1) eco-design, (2) designing transparent, reproducible, and scalable products to build the same products in other places based on local resources, (3) thinking about practical utilities and consumer preferences, (4) designing new business models and strategies, (5) designing new methodologies to guarantee a continual improvement, and (6) designing projects to promote sustainable development and circular economy.

The last principle comprehends three strategies, (1) adjusting educational curricula to the current challenges, (2) promoting knowledge, skills, capabilities and values that ensure the proper performance of circular economy, and (3) promoting habits and individual actions in favour of circular economy.

As previously mentioned, the Ellen MacArthur Foundation (EMF) has been one of the backbones of the development of CE. In 2013, the Ellen MacArthur Foundation (2013), started to forge a series of actions to set the CE concept into practice, such as (1) circular design, (2) innovative business models, (3) reverse cycles and (4) enablers and favourable conditions.

With so, the (1) circular design was defined as upgrades in material selection and product design, for example, standardisation/modularisation of components, purer material flows, and design for easier disassembly.

The (2) innovative business models rely on changing from ownership to performance-based payment models, which stand as fundamental in translating products designed for reuse into attractive value propositions.

Subsequently, the (3) reverse cycles strategy implies improving the skills for cascades and final return of materials to the soil or back into the industrial production system, including the delivery chain logistic, power generation, risk management, warehousing, sorting, molecular biology, and polymer chemistry.

Finally, the (4) enablers and favourable conditions strategy include access to financing, supplying a set of international environmental rules, leading by example and driving upscale, collaboration and rethinking incentives.

These strategies have then been updated to compose the ReSOLVE framework (The Ellen MacArthur Foundation, 2015) which stands for (1) regenerate, (2) share, (3) optimise, (4) loop, (5) virtualize and (6) exchange.

Starting with the (1) regenerate, this strategy implies a shift to renewable energy and materials, in addition, to restoring, preserving, and regenerating the well-being of ecosystems, and returning recovered biological resources to the environment.

The (2) share strategy refers to maintaining product loop speed low and boosting utilisation of products by sharing them among consumers, as well as, reusing them throughout their technical lifetime, and maximizing their life through maintenance, repair, and design for durability.

Subsequently, the (3) optimise strategy alludes to the increase of performance or efficiency of a product and eliminating the waste in production and the supply chain.

The fourth strategy, (4) loop, indicates keeping components and materials in closed loops and prioritising inner loops. For example, for finite materials, this implies re-manufacturing of products or components or recycling as a last resort. For renewable materials, this strategy involves anaerobic digestion and the extraction of biochemicals from waste.

The (5) virtualize aims to deliver virtual utility for consumers.

Lastly, the sixth strategy, (6) exchange, intends to replace old materials with new and advanced ones, apply new technologies and opt for new products and services.

These actions symbolize significant business opportunities for companies and organisations, embedded in the three essential values, enabling economic prosperity without compromising the environmental quality and social equity.

Another important organization to mention on this topic is the European Environment Agency (EEA) (2016), and similarly to the Ellen MacArthur Foundation, the EEA also proposed seven enabling factors, which portend as a set of changes required to drive the transition to a circular economy. In this report, these strategies have been detailed and clarified on the way they would advance the transition towards a circular model for society. The strategies presented are (1) eco-design, (2) new business models, (3) repair, refurbishment and re-manufacture, (4) recycling (5) eco-innovation, (6) governance, skills and knowledge and (7) economic incentives and finance.

Beginning with the (1) eco-design strategy, the products are designed based on sustainable and minimum use of natural resources, facilitating high-quality recycling of the materials at the end of a products life. They are also designed for a longer lifetime, promoting their upgrade, reuse, refurbishment and re-manufacture and by substituting the hazardous substances in their components and processes to enable cleaner material cycles.

The (2) new business models strategy focuses on offering product services instead of products ownership, collaborative consumption, and industrial symbiosis, where there is a collaboration between companies/sectors thus the waste or by-products of one become materials for another.

In the (3) repair, refurbishment and re-manufacture strategy priority is given to the repair, refurbishment and re-manufacture of products, components, and materials, enabling their reuse.

Subsequently, the (4) recycling strategy directs to high-quality recycling of much waste as possible, avoiding down-cycling (converting waste materials/products into new materials or products of less quality), using recycled materials as secondary raw materials, building a strong market for secondary raw materials, and avoidance of mixing and contaminating materials.

The (5) eco-innovation refers to facilitating and encouraging technical, social, and organisational innovation.

The (6) governance, skills and knowledge imply raising awareness about changing lifestyles and consumption patterns, participation, stakeholder interaction and experience, improving education and enhancing data, monitoring, guidelines and indicators.

Lastly, the (7) economic incentives and finance focuses on shifting taxes from labour to natural resources and pollution, phasing out environmentally harmful subsidies, internalisation of environmental costs, extended producer responsibility, and enabling finance mechanisms that support circular economy approaches.

Leaning over the available CE strategies, we came across a database developed by Kalmykova et al. (2018), embodying forty-five CE strategies that may be applied in several points of the value chain, as well as a set of implementation cases, including more than one hundred studies.

The relevancy of this study to our research was the overview of the techniques/methods available, where the approaches were divided into nine points of the value chain, such as material sourcing, design, manufacturing, distribution and sales, consumption and use, collection and disposal, recycling and recovery, re-manufacturing and circular input.

Most of the strategies described in the EEA report (2016) are represented in this database, however, divided and detailed in a different degree as well as their application on the value chain. For instance, Kalmykova et al. (2018), separated the recycling strategy into more specific techniques, such as incentivized recycling, separation, functional recycling and high-quality recycling.

A relevant note in this paper is the inclusion of several strategies from a social perspective, like community involvement, sharing, socially responsible consumption and stewardship, which are often overlooked.

### **2.2.3. CE Indicators**

As the awareness of the circular concept expands, academics have been devoted to developing a variety of indicators that are able to assess different areas of CE. As expected from the myriad of definitions, principles and perspectives regarding this topic, numerous tools and approaches have emerged to evaluate and measure circularity, as the absence of indicators and key criteria has been scrutinized and highlighted as a limitation to the implementation of this concept (De Pascale et al., 2021; Geng et al., 2012).

In order for CE to thrive, it is fundamental to develop a base that allows the evaluation of key aspects of the systems, ensuring their best performance, as well as their contribution to the pillars of circularity (Zhijun & Nailing, 2007).

Acknowledging that CE has a flexible and adaptive nature, depending on the dimension evaluated (environmental, economic, social), the level of implementation (micro, meso, macro) or the type of public targeted (policy-makers, economists, academics, companies or general public), Pintér (2006) stated that is essential to have an explicit system of indicators to evaluate each action, at every level of implementation.

Additionally, indicators provide critical information for decision-makers in order to effectively establish policy instruments (Geng et al., 2012; Su et al., 2012), which stand as a fundamental aspect for the success and validation of CE.

With this, China has been one of the countries boosting the implementation of the concept (Ghisellini et al., 2016), and in 2007, the National Development and Reform Commission

(NDRC) released a set of national CE indicators, becoming the first country to implement these tools.

These indicators have been targeted for the meso and macro-level, with 12 and 22 indicators respectively, classified into four groups (resource output rate, resource consumption rate, integrated resource utilization rate and waste disposal and pollutant emission). For the micro-level, a clear absence has been noted (Geng et al., 2012), where the key role played by businesses and companies to support and enable CE cannot be disregarded.

Stating this, several authors have made important critical analyses and contributions to the Chinese indicators system, aiming to clearly understand them and clarify the benefits and barriers to their implementation (Geng et al., 2009, 2012, 2013; Geng & Doberstein, 2008; Pintér, 2006; Su et al., 2012; Zhijun & Nailing, 2007).

In the European context, the European Commission (2018) proposed a monitoring framework for the circular economy, which integrated ten indicators, but since then has been expanded to twenty-three indicators. These metrics have been grouped into four main categories, (1) Production and consumption, (2) Waste management, (3) Secondary raw materials, and (4) Competitiveness and innovation.

The main purpose of this framework was to assess trends and patterns on different elements of CE, as well as their evolution so that success factors in the State Members could be identified and evaluate whether the necessary actions had been implemented. The proposed measurements are appraised and displayed for the EU aggregate states, and in some cases for State Members individually.

Additionally in this dimension scholars also have developed a diversity of indicators. For instance, Di Maio et al. (2017) created the CE Index (CEI) which is designed for the recycling of car materials, the Ellen MacArthur Foundation (2015) proposed the Material Circularity Indicator (MCI) that grants companies the identification of the additional circular value of their products or materials.

Further adding, Huysman et al. (2017) designed the CE Performance Indicator (CEPI) that targets the treatment of post-industrial plastic waste, Haas et al. (2015) formulated Circularity Indicators based on the MFA approach, Mayer et al. (2018) proposed monitoring tools of material flows in CE at the macro-level and Smol et al. (2017) established regionals indicators of eco-innovation.

Moreover, there have been further important contributions to this field, such as Zaman & Lehmann (2013), who have proposed the Zero Waste Index, which evaluated the performance of waste management systems, intending to achieve zero waste cities. Also, Park & Chertow (2014) established and tested an indicator for the reuse potential in order to manage waste as a resource.

An important note to Potting et al. (2017) who developed a framework regarding the importance of innovation in circular economy transitions in product chains, focusing on what needs to be measured instead of how should the measures be accomplished, to assess the kind of information that is needed to evaluate the CE progress.

As the number of indicators increases exponentially, an important review was made by De Pascale et al. (2021), grouping the measuring tools according to the level of implementation (macro, meso, micro), and then regarding the 3R framework.

The results show that the micro-level has the highest number of indicators, counting with 29, whereas the meso and macro-levels had 15 and 17, respectively, reviewing a total of 61 indicators, presenting a relevant overview of the available tools for measuring CE.

The relevancy of this topic to our research signifies the number of circular indicators reviewed, detailed, and explained throughout the articles, giving a deeper understanding and knowledge of the CE metrics available, as well as their aim and classification, in order to aid in the development of our framework.



## RESEARCH DESIGN

This research proposes a conceptual framework that incorporates Circular Economy (CE) into the EIA process, aiming to analyse how to integrate these two topics, and how these dimensions could benefit each other's, in order to improve and progress their developments and application.

This model intends to aid professionals involved in the EIA process to integrate circular principles and strategies into impact assessment. To develop the conceptual framework, the methodological approach was divided into four stages.

In the first stage, a systematic literature review was carried out, combining several keywords related to the study topics, seeking to support the development of the model. In the second step, a draft of the framework was designed employing the concepts and arguments collected from the literature review. In the third phase, a questionnaire was developed and applied to EIA professionals, to assess the framework developed. In the last stage, a variety of European and Chinese policy documents were reviewed to evaluate the status quo of the institutionalized policies. The methodological approach conducted is further disclosed below:

### 3.1. Systematic Literature Review

To conduct a critical review of the literature the approach of Saunders et al. (2016) and an adaptation of the PRISMA statement (Preferred Reporting Items for Systematic review and Meta-Analysis protocols) by Moher et al. (2015) were followed, see Figure 2, where a set of keywords were applied to an online database to identify relevant publications and to restrict the search to academic literature. The database used for this stage was SCOPUS from Elsevier, and the keywords were "environmental assessment" and "circular economy".

Subsequently, the results were limited to journal sources, articles, and reviews, in the English language as suggested by Fischer & Onyango (2012), collecting a total of 93 publications. The studies were then manually screened by title and abstract, to evaluate their fit into the purpose of the research (Neuman, 2013), resulting in the exclusion of 65 papers. Despite the large volume of articles retrieved, most of the publications were outside the scope of this research, an issue also highlighted by Fischer et al. (2015).

As the content analysis presents a path to assemble ideas and arguments into categories that are content-related (Elo & Kyngäs, 2008), this issue became noticeable when the evaluation of the results by full text was proceeded, as we concluded that a considerable number of

articles identified did not cover the subjects of “environmental assessment” and “circular economy”, but instead focused on the assessment of environmental categories (e.g. climate change, emissions through circular accounting methods (e.g. life cycle assessment, material flow analysis), resulting in a total of 28 publications reviewed.

Considering the goal of the search was to gather papers that combined EIA topics with circularity matters and as previously mentioned, most of the results did not conform with the investigation scope, a targeted search was conducted to collect information on the topics required, but at an individual level, focusing on EIA procedures, barriers and actors, and then an exploration was performed on publications that aim the attention to CE principles, strategies, and indicators, enclosing material on both dimensions, which was essential to the next phase of the investigation.

Furthermore, a variety of bibliographies from the identified articles were examined, through a snowball process, with the intention to collect additional and relevant literature to support the research.

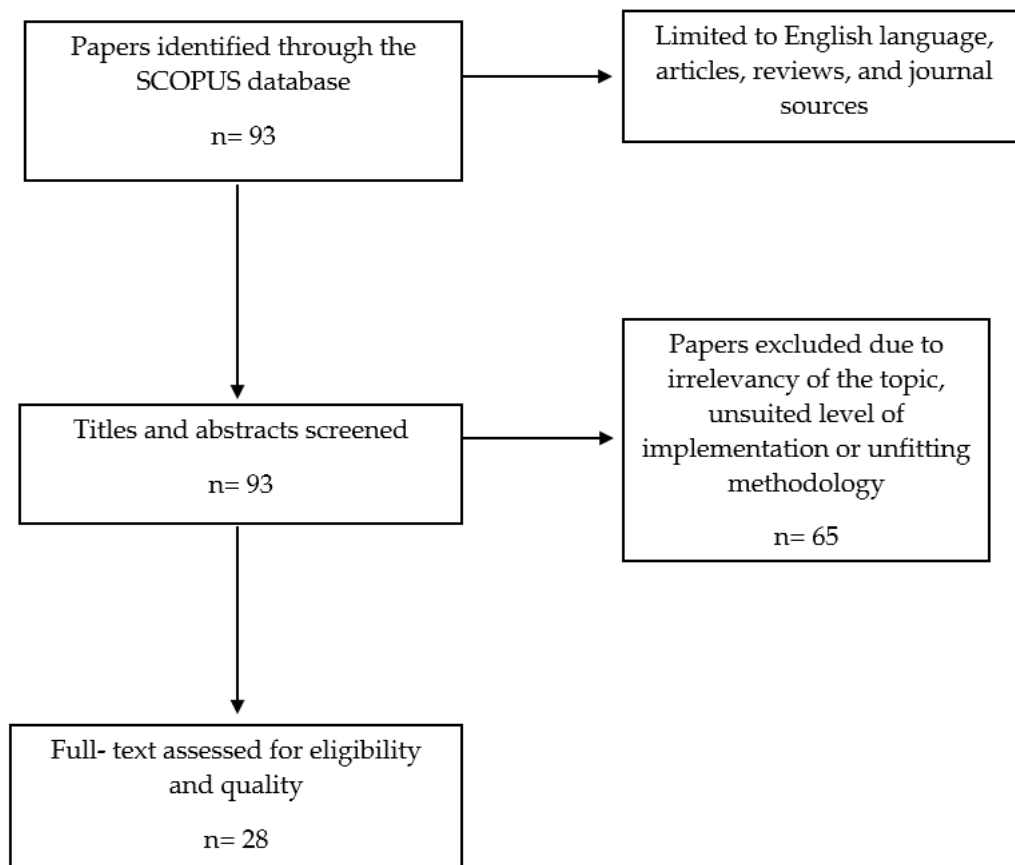


Figure 2 –Research design followed for the systematic review of the literature. Adapted from PRISMA-P 2015 statement (Moher et al., 2015).

## 3.2. Development of the Conceptual Framework

Conceptual frameworks can be taken as concept maps that concede the visualization and organisation of knowledge’s structural aspects. It stands for a graphical tool where associative networks are visually represented in space. Usually, the networks integrate two components, concepts and the relations between them, termed links (Lanzing, 1998).

Concepts are designated as regularities in objects or events, classified by a label. When several notions are connected by links and compose a meaningful statement, they constitute a proposition (Novak & Cañas, 2008). According to Calude et al. (2005), the visualization of information is an effective strategy, that has proven to strengthen individuals into managing complex knowledge and information scenarios.

The steps followed to develop the conceptual framework were based on the methodology from Polido et al. (2018), which integrated techniques of several authors (Maxwell, 2005; Miles & Huberman, 1994; Novak & Cañas, 2008; Novak & Gowin, 1984) on how to elaborate concept maps. The steps unfold as:

### Step 1: Define the focus question

With the intent to clarify the investigation topic and restrict the study context, this step is inherently linked with the aim of the research, and for this case, the focus question was stated as “What practices could incorporate circular economy and impact assessment, advancing both fields?”

### Step 2: Identification of key concepts and connections

The key concepts stand for the arguments on which the framework is drawn upon. The main ideas and the connections between them were listed and identified from the previous stage of the research, the literature review. Subsequently, two tables were elaborated with the concepts and links retrieved, and the respective literature reference they were based on, see Table 3.1 and Table 3.2.

Table 3.1 – Key concepts and references.

KEY CONCEPTS	REFERENCE
EIA PROCESS	(Glasson & Therivel, 2019; Morris & Therivel, 2009; Noble, 2011; Ross et al., 2006; Sadler, 1996; Sadler & Brown, 1999; UN Environment, 2018; Wood, 2003; Zhang et al., 2013)
EIA BARRIERS	(Ahammed & Harvey, 2004; Ahmad & Wood, 2002; Cashmore, 2004; Fitzpatrick & Sinclair, 2009; Glasson & Therivel, 2019; Kruopiene et al., 2009; Morgan, 2012; Nielsen & Christensen, 2005; Pr, 2013; Ross et al., 2006; Sadler, 1996; Snell & Cowell, 2006; Toro et al., 2010; UN

	Environment, 2018; Wood et al., 2000; Zhang et al., 2013)
CE PRINCIPLES	(European Environment Agency (EEA), 2016)
CE STRATEGIES	(European Environment Agency (EEA), 2016; The Ellen MacArthur Foundation, 2013)
CE INDICATORS	(Elia et al., 2017; Geng et al., 2009, 2012, 2013; Geng & Doberstein, 2008; Ghisellini et al., 2016; Pintér, 2006; Su et al., 2012)
CE SYSTEM THINKING	(Fothergill & Murphy, 2020)

Table 3.2 – Links/Connections and references.

LINKS/CONNECTIONS	REFERENCE
EIA ENABLES TRANSITION TO CE	(Fothergill & Murphy, 2020; Yijun & Ying, 2011)
CE IMPROVES THE EIA EFFECTIVENESS	(Fothergill & Murphy, 2020; Yijun & Ying, 2011)
ACTORS' COMMUNICATION TO EIA DIMENSION	(Morgan et al., 2012; Morgan, 2012; Zhang et al., 2013)
ACTORS' EXECUTION IN THE EIA DIMENSION	(Bice, 2020; Cashmore et al., 2004; Coppens et al., 2015; Fothergill & Murphy, 2020; Marshall et al., 2005; Morgan et al., 2012; Morgan, 2012)
ACTORS' ABILITY TO CHANGE THE EIA AND CE DIMENSION	(Fothergill & Murphy, 2020; Morgan, 2012; Yijun & Ying, 2011)

### Step 3: Sketching the concept map

As stated in the literature and reinforced by Wheeldon & Faubert (2009), conceptual maps may be designed in several styles. Traditionally, they tend to be represented through hierarchical connections, but they may also be represented in a freer form, through different graphic modes, such as linking words, directional arrows, overlapping circles and connecting lines. The free form maps tend to illustrate relationships between concepts in a non-hierarchical connection.

In this study, a mixed approach was taken, where two main dimensions, CE and EIA, include smaller concepts classified in clusters (process, barriers, principles, strategies, indicators) and are connected through directional arrows and linking words (transition, effectiveness, communication, execution, ability to change).

Additionally, there is an external cluster, the actors, who are viewed as the active agents, with the ability to change and execute and transform processes in the EIA and the CE dimensions.

For drawing the conceptual framework, the Miro platform was used, which is an online collaborative whiteboarding platform, that allows users to create a diversity of maps and diagrams, with different connectors and flows, while working individually or in teams.

### 3.3. Development of the questionnaire survey

Upon the development of the conceptual model, a questionnaire was elaborated, see Annex A, with the intention to evaluate and adjust the model. Questionnaire research aims to induce information about a population by studying a sample of that universe (Rea & Parker, 1997). The survey conducted had three purposes, i) collect experts' opinions on the harmonization of CE and EIA, ii) understand if the framework developed would aid practitioners integrating CE into the EIA process, and iii) if the model is comprehensible and appropriate, and whether it includes all the necessary information/recommendations to incorporate these topics.

The main criteria for selecting the respondents were individuals involved in the EIA process and were intended to collect experts' opinions based on their experience and expertise. The survey was open between 20 of September and 11 of October of 2021 and was sent through IAIA Connect<sup>1</sup> to 1056 members of the IAIA organisation.

As the IAIA organisation is a respected international community that holds researchers, practitioners, and decision-makers in the impact assessment field from a variety of countries and backgrounds, the survey sample was their member community, as we could not reach every individual related to the EIA process.

As stated in the literature by Rea & Parker (1997) and supported by Bethlehem (2009), the survey comprehended mostly closed-ended questions, in order to compare answers and improve the response level. The closed-ended questions were developed using a five-point Likert scale, according to the level of agreement (Vagias, 2006), ranging from Strongly disagree (1) to Strongly agree (5). Additionally, optional open-ended questions were included, so the respondents could comment or suggest further recommendations on the research topics.

As endorsed by Bethlehem (2009) and Lietz (2010), the questionnaire was structured into five topic sections, assembling the questions into content-related areas, bearing in mind the respondents find it easier to provide answers, improving the quality of the data collected, see Table 3.3, which intended to gather opinions on the several dimensions of the designed conceptual model. Having into consideration that the participants may not have extensive in-depth knowledge of the circular economy, the questions were conceived to be clearly comprehended and relevant to the investigation topic, while not being generic or overly specific.

For analysis purposes, when evaluating the responses, the "Strongly agree" and "Agree" alternatives were considered as the consenting opinions, as the selection of these options presents the acceptance of the integration of the principle into the EIA stage.

Correspondingly, the "Strongly disagree" and "Disagree" alternatives were acknowledged as the rejecting opinions, as their selection suggests a disapproval judgement on the incorporation of the principle into the EIA phase.

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<sup>1</sup> IAIA Connect is a networking, communications, and collaboration tool for IAIA members

Consequently, the “Neither agree nor disagree” alternative was perceived as the indifferent preference, as no demonstration of consent or rejection could be gathered from the selection of this option.

Table 3.3 – Structure of questionnaire section topics.

QUESTION SECTION TOPIC	RATIONALE	REFERENCE
1. CE BACKGROUND	This section intended to understand the general opinion of the respondents on the CE topic.	(Kirchherr et al., 2017)
2. CE PRINCIPLES AND EIA PROCESS	Wide-range questions on where the respondents would integrate the CE principles into the EIA process.	(European Environment Agency (EEA), 2016; Sadler & Brown, 1999; Zhang et al., 2013)
3. CE STRATEGIES AND EIA PROCESS	Set of questions on where and how the respondents would incorporate the CE strategies into the EIA stages.	(European Environment Agency (EEA), 2016; Sadler & Brown, 1999; Zhang et al., 2013)
4. CONNECTING EIA AND CE THINKING	Set of questions on several pathways to integrate CE thinking into the EIA process.	(Morgan, 2012; Pr, 2013; Sadler & Brown, 1999; Zhang et al., 2013)
5. PERSONAL INFORMATION	Demographic information	

Following the suggestion by Bethlehem (2009) and Rea & Parker (1997), intending to guarantee the usefulness, eligibility and clarification of the questionnaire, as well as the time to conclude the survey, a pre-test was conducted, between 6 of August and 31 of August, and was forwarded to ten different scholars/ practitioners in the EIA and CE field.

Ethical issues regarding the survey were considered, see Annex B, based on Allum & Reid (2021) and Koskimäki, (2021), ensuring the surveyees that they were free to withdrawal at any time until the submission of the responses at the end of the questionnaire, and all the information provided previously would be deleted and not employed in the investigation.

### 3.4. Review of Policy Documents

One of the purposes of the circularity concept is to ensure environmental quality, protection, and conservation (Kirchherr et al., 2017; Lieder & Rashid, 2016; Liu et al., 2009; van Buren et al., 2016) by undertaking a diversity of actions with the aim to decouple economic prosperity and growth from environmental resource use and burden (European Commission, 2013; Ghisellini et al., 2016; Wiprächtiger et al., 2020). In line with these goals, the EIA process also aims to guarantee environmental protection and resource conservation, as well as economic efficiency, when developing a project or proposal (Fitzpatrick & Sinclair, 2009; Loomis & Dziedzic, 2018; Morgan, 2012; Sadler, 1996).

With this statement, it was crucial to understand if the CE regulations and legal requirements that are and have been institutionalized comprehend the EIA dimension and procedures. To accomplish that purpose, European and Chinese CE policy documents have been reviewed, see Table 4.6, with the intention to understand the status quo of the legal guidelines/regulations/requirements regarding the harmonization of these fields.

The criteria to select both European and Chinese documents was based on them being the dominant contexts where CE has been most debated and implemented, as China was the first country to institutionalize this notion into their policies in 2008, followed by the European Commission state members in 2015.

The European policy documents have been retrieved from the EUR-lex platform, while in the Chinese context, they were gathered from a variety of websites, where the full text and translation were available.

Additionally, these documents were triangulated with the questionnaire results, which strengthens the study's credibility, as this process increases the research's depth, complexity and richness (Neuman, 2013; Saunders et al., 2016; Yin, 2015).

The triangulation technique stands as a method of cross-checking data, sources, or theories (Saunders et al., 2016). This procedure reinforces validity, allows the conceptualization of a deeper perspective on the topic and explores different views of the subject researched (Nightingale, 2020; Yin, 2015). As the nature of this study falls into the exploratory field this technique provided a set of suitable and useful tools to expand and intensify the perceptions of the integration of the CE and EIA dimensions.



## RESULTS AND FINDINGS

### 4.1. Conceptual Framework

The proposed conceptual model divides into three categories, (1) actors, (2) EIA dimension, and (3) CE dimension, see Figure 3. The actors involved in these processes are mainly consultants, both in private or public held companies, practitioners, stakeholders, decision-makers, a diversity of agencies, and the general public, as the public participation role has been raising in awareness in the last years (Fitzpatrick & Sinclair, 2009; Fothergill & Murphy, 2020; Morgan, 2012).

Because consultants, practitioners, stakeholders, decision-makers, agencies and the general public are active agents in EIA and the CE they have the power to transform the other two dimensions. In the first place, they possess the ability to change these fields (Morgan, 2012), as they have the capacity to execute the processes that involve CE and EIA topics, making them capable to support, promote and enforce those changes. Additionally, they present the power to communicate those changes between themselves, and through the CE and EIA processes, turning them into central points, and agents of change in the progress and development of these areas.

The second category, the EIA dimension, is divided into two sub-categories. First, the EIA process, which comprehends the different stages that are required when conducting an environmental impact assessment, and second, the EIA barriers, which were attained after an extensive literature analysis, representing the challenges and constraints to the process, both defined and detailed in the previous section of the literature review.

The last category, the CE dimension, is divided into four sub-categories, (a) the CE principles, which portray the different values of this concept, (b) the CE strategies, which indicate a set of defined actions in order to materialize and accomplish the principles, (c) the CE indicators, that represent a system of metrics/criteria, that allows the measurement and evaluation of the status and progress of concept, and (d) system thinking, which is perceived as a way to look and engage with systems.

As endorsed by Yijun & Ying (2011), the incorporation of CE into EIA may be beneficial for both fields, as it enables the transition of environmental practices into a more circular model. Because the CE concept has been suggested by many scholars (Henry et al., 2020; Kirchherr et al., 2017; Murray et al., 2017; Velenturf & Purnell, 2021), as a path to achieve a

more sustainable development, the incorporation of this notion into the EIA could also improve and enhance the effectiveness of the process. By upgrading and improving the EIA practices, through the application of CE subjects and techniques, there is an opportunity to strengthen the procedural stages or suppress some of the barriers that limit the process.

An important note to make is that the CE concept has different levels of implementation, where it can be targeted to products, companies and consumers, to eco-industrial parks, or to higher levels, such as policy and programmes (Harris et al., 2021; Kalmykova et al., 2018; Kirchherr et al., 2017; Vinante et al., 2021; Yuan et al., 2008).

Additionally, this concept may be perceived according to an economic, environmental or social perspective (Fothergill & Murphy, 2020; Kirchherr et al., 2017). For this study, the main focus was the environmental dimension of the CE concept and the meso level of implementation. From the variety of available CE principles, strategies and indicators, a selection of the ones that presented the most suitable to the study context and objective was performed.

The principles, strategies, and indicators that have not been incorporated into the model, do not stand as incorrect or erroneous, they were only not viable or appropriate to be implemented into the context of our research and model, as they were not suitable to accomplish our targets and objectives.

The CE and EIA dimensions considered will be further detailed and defined, as well as the proposed pathways to integrate and harmonize these fields.

#### 4.1.1. Principles

As previously mentioned in the literature review, there are no commonly accepted and clearly defined CE principles (Reike et al., 2017; Yuan et al., 2008), but to develop the conceptual model, a diversity of available and proposed principles were analysed, with the intention to determine which values embodied the CE ideals the better, and were appropriate to the context and research.

For this study, the principles required a strong environmental component, as the focus and aim of the EIA process is environmental protection and quality (Fitzpatrick & Sinclair, 2009; Loomis & Dziedzic, 2018; Sadler, 1996). However, the principles could not be too broad and general, but neither too specific, so they could be incorporated in different stages of the EIA, and at different levels.

With so, the proposed CE principles by the European Environment Agency (EEA) (2016) posed as the most suitable to be integrated into an environmental impact assessment. However, these principles have been perceived in a different perspective to better suit the study's context.

The defined five principles, (1) less input/use of natural resources, (2) increased share of renewable/recyclable resources and energy, (3) reduced emissions, (4) fewer material losses/residuals and (5) keeping the value of products, components, and materials in the economy, will be further detailed according to how they were applied in the model.

- (1) **Less input/use of natural resources:** When developing a project, the use and input of raw materials should be kept as minimum as possible, in order to decrease the environmental burden of the proposal in the environment. The resource's use should be

accomplished efficiently, so their value may be captured, avoiding their waste, and therefore increasing their potential benefits.

- (2) **Increased share of renewable/recyclable resources and energy:** When relating to energy matters, projects should be designed to be supplied by renewable sources as much as possible, always keeping in mind the sustainable levels of supply. Concerning the resources, the use of raw materials should be minimum, as mentioned in the previous principle, and only applied if there is no option to replace them with recycled or recyclable ones, also ensuring their sourcing is taken into account, safeguarding they have been sustainably sourced. By increasing the share of resources for recyclable and recycled ones, it encourages and supports the closure of the material loops.
- (3) **Reduced emissions:** This principle can be understood as an aftermath of the previous ones, in the circumstances of sustainable sourcing being considered and applied, as well as the use of raw materials kept to a minimum by using recycled, and recyclable resources, and the use of renewable energy sources, which all strengthen the utilization of cleaner material cycles, and therefore contributing to diminishing the levels of pollution and emission, not only at the project scale but also at higher levels of the system.
- (4) **Fewer material losses/residuals:** When developing a project, the waste build-up is always an outcome, whether in the construction, functioning, maintenance or disassembly phase. It should be projected to minimize the amount of waste as much as possible. Additionally, the generated amount should be sent for recycling, particularly high-quality recycling, in order to decrease the losses of valuable resources, thus, capturing their value, and avoiding their incineration or landfill.
- (5) **Keeping the value of products, components and materials in the economy:** Although this principle refers to products, it has been incorporated into the conceptual model at the project level. The proposals should be designed for longer lifetimes, with the ability of their infrastructures, materials, components to be reused, refurbished, remanufactured, or recycled, with the intention of preserving and capturing their value, by keeping them in the economy for longer.

#### 4.1.2. Strategies

Upon the review of a variety of strategies proposed by numerous academics, the majority of them were targeted to products, companies, and consumers, which did not align with the aim and focus of the present research. With so, we have adapted some of these strategies, taking them into a different perspective and context, allowing them to be integrated into our framework.

Realistically, it was assumed and accepted the impossibility of finding a set of strategies that would suit fully and wholly the conceptual model proposed. With so, we have merged several strategies that were discussed by various authors, intending to embrace a more comprehensive and holistic set of actions, to achieve and accomplish our goals in the most advantageously approach possible.

Stating this, nine strategies were adapted to incorporate our conceptual model, particularly based on the European Environment Agency (EEA) (2016) and The Ellen MacArthur Foundation, (2013), as they pose as predominant references in this field. The strategies comprehended unravel as (1) eco-design/circular design, (2) new business models, (3) repair, refurbishment and re-manufacture, (4) recycling, (5) eco-innovation, (6) governance, skills and knowledge, (7) economic incentives and finances, (8) reverse cycles, and (9) enablers and favourable system conditions.

- (1) **Eco-Design/Circular Design:** Analysing this strategy, it is presented mainly for products by many scholars, however, when integrated into our conceptual model, it was targeted for projects, in the way of the proposals being designed and developed according to minimum use of natural resources, the materials and components applied into their construction, functioning, maintenance and disassembly should be free of hazardous substances, thus, enabling cleaner material cycles. Additionally, the projects should be designed for longer lifetimes, with the ability to be upgraded, reused, refurbished, re-manufactured, and at the end of their lifetime, the materials and components should be sent for high-quality recycling.
- (2) **New Business Models:** This strategy presented several relevant points in our research, as collaborative consumption and industrial symbiosis represent important strategies when applying circular economy practices to the project level. When integrating these two methods into projects, we are referring to infrastructures, resources, materials, components, by-products, waste management systems, and a variety of other factors/elements that are common or have the capacity to be shared in numerous projects, businesses, and sectors, creating a network of “win-win” aspects and practices that contribute for a circular economy, but also to a more sustainable development.
- (3) **Repair, Refurbishment and Re-manufacture:** We have integrated these strategies into our model, as the projects infrastructures, resources, materials, and components should be designed and able to be repaired, refurbished, and re-manufactured into similar or different projects, promoting, and supporting their reuse, and thus contributing to a more circular system.
- (4) **Recycling:** This strategy is evidently a waste management strategy, but inherently to every project, whether is in the construction, functioning, maintenance or disassembly phase, there is the generation of waste. With so, it should be planned and arranged for that waste to be sent for recycling, but particularly, for high-quality recycling. Additionally, it should be proposed for the materials and components used to be from recycled materials, thus, also contributing to building a strong market for secondary raw materials. Furthermore, the avoidance of mixing and contaminating materials should be taken into account.
- (5) **Eco-Innovation:** As the world keeps forging and discovering new and improved ways to develop solutions and practices, it is important for projects, as generally, they play a key role in this topic, to support, promote and integrate technical, social

and organisational innovations into their plans, practices and proposals, in order to strengthen and advance the knowledge and development of new solutions.

- (6) **Governance, Skills and Knowledge:** This strategy could be referred to as one of the central points of our conceptual model. As mentioned in the literature numerous times, there is an urgency to change the way humanity perceives and lives life, as there is demand for a path that allows the fulfilment of society's needs without compromising the environment, with various authors suggesting the circular economy concept as a way to achieve sustainable development. With so, projects and proposals should be targeted and endorse a more circular perspective, so they may contribute to transforming lifestyles and raise awareness to more sustainable approaches. Additionally, some of the EIA barriers mentioned are directly correlated with the aim and focus of this strategy. By increasing the quantity and quality of public participation, by improving stakeholder interaction and experience, by advancing and enhancing the available data, the monitoring plans and procedures, the existent guidelines and indicators, and by educating for CE and environmental quality and protection, it is possible to improve the effectiveness of the EIA process and enable the transition to the CE model.
- (7) **Economic incentives and finances:** As both CE and EIA dimensions have economic roots, to accomplish these fields values and objectives, it is required to change their economic and financial practices. By shifting taxes from labour to natural resources and pollution, phasing out environmentally harmful subsidies, internalisation of environmental costs, and enabling finance mechanisms that support circular economy approaches, it is possible for projects/proposals to comply and enforce economic prosperity, environmental protection and quality and social equity.
- (8) **Reverse Cycles:** This strategy has a more technical focus, as projects should propose and endorse higher quality collection and treatment systems, so that materials and components do not escape out of the system, risking the circular economy and design. To do so a review and adoption of better solutions for delivery chains logistics, power generation, risk management and others should be performed so that projects or proposals may be fully circular and sustainable, as well as successful.
- (9) **Enablers and favourable system conditions:** Although this strategy seems similar to (7) economic incentives and finances, the focus is entirely different. Access to financing is referred to new and innovative projects in environmental or social perspectives being financed and supported, with the intention to incentivize different and more sustainable solutions that integrate circular economy mechanisms or approaches. Standardized environmental rules is a relevant point, mentioned by several authors, as each country is able to propose different standards, thus, increasing the global environmental impacts, risking environmental protection and quality. Additionally, political will and stakeholder engagement play an important role in the EIA process and leading by example and driving upscale with strong environmental values is a vital point to encourage and promote change. Also, collaboration and rethinking in-

centives should be given to people, organizations, or others that develop or implement innovative practices or projects that contribute both to CE and sustainable dimensions.

### **4.1.3. Connecting CE Principles and strategies**

In order to accomplish the proposed CE principles, several strategies have been defined, aiming to achieve both the circularity and research goals. In this section, we will demonstrate how these principles and strategies are connected.

These principles and strategies are deeply connected and intertwined, which sometimes may appear similar or repetitive. However, it is that association that composes the circular model, as there are several paths to accomplish or achieve these principles using different strategies.

For instance, there are several paths to retain materials, resources, components, and other elements in the economy for longer, preserving and capturing their value.

By integrating eco-design, new business models, directing waste into recycling, particularly to high-quality recycling, enabling the use of repaired, refurbished and re-manufactured elements, into projects or proposals, promote a minimum use of input/use of raw resources, allowing them to be replaced by renewable, recyclable/recycled and reused (repaired, refurbished, re-manufactured) ones, as well as constituting an opportunity to create a sharing network between projects, where they may commonly use a variety of elements.

These strategies apart from contributing to keeping elements in the economy for longer, also support and encourage the accomplishment of less input/use of raw resources, decrease the levels of emissions, pollution, losses and residuals, increase the share of renewable/recyclable/recycled elements, and contribute to the closure and efficiency of material loops.

Opening the mind to new technical, social or organisational solutions, there is potential and opportunity to apply innovative practices or develop projects that require less input of natural resources, or that apply them in a highly efficient way, that intensify the share of renewable and recyclable resources and energy, or that employ new and innovative ways to reduce the levels of pollution, emissions, residuals and losses.

By raising awareness about consumption patterns and lifestyles projects can target and endorse CE principles. Additionally, increasing the levels of participation, stakeholder interaction and experience may also encourage and enforce the development of projects that integrate these principles into their proposals.

Also, enhancing data, improving monitoring plans and procedures, guidelines and indicators, gives projects and the actors involved important information that will allow them to efficiently incorporate CE values in the proposals, as well as support the development of new solutions.

Shifting taxes from labour to natural resources and pollution, phasing out environmentally harmful subsidies and internalising environmental costs, will enforce projects to incorporate CE principles into their proposals, in order to decrease costs and not risk the project's approval.

When high-quality recycling is not possible, cascading materials, resources and components before returning them to the soil or back into the industrial system is a pertinent and

viable option. These techniques advance the closure of material loops and reduce the number of emissions, losses and residuals, and keep the materials and resources in the economy.

When projects or proposals incorporate CE principles or strategies, innovative paths to deal with environmental burdens, they should be able to be financed and supported, so that sustainable and circular approaches are incentivized.

Additionally, standard environmental rules, leading by example, collaboration and re-thinking incentives may help drive the integration and endorsement of CE principles into projects and proposals.

#### **4.1.4. Indicators**

As the awareness over the CE concept arises, not only the debate on the circularity principles and strategies has been increasing but also the number of indicators has been expanding. Notwithstanding, the EIA process has a reasonably large capacity and room for experts' judgement. By deepening and strengthening their knowledge and understanding of CE aspects and features, opens the possibility for practitioners to apply their judgement and expertise (Fothergill & Murphy, 2020) to establish and conceive a list of circular indicators, from the variety of available metrics, that are appropriate to the project's scale, sector, and objectives.

Focusing now on the conceptual model proposed, the indicator sub-category displayed is divided into the main areas that a project might require to measure. For this classification, the Elia et al. (2017) taxonomy has been used as a base for this research, because even though the mentioned study is targeted to the micro-level, we have acknowledged that the main categories stated in this article could be appropriate and useful to be evaluated at the project level, as proposals generally address impacts/processes in the material, energy, land use and consumption or overall system areas.

This acknowledgement was part of the rationale over why we chose to include this categorization into our framework. Additionally, the study embodied both the European Environment Agency (EEA) (2016) and The Ellen MacArthur Foundation (2015) circularity principles as their base, which align with our research.

Despite that the metrics involved in the study did not exactly fit the scale and scope of the model, their general classification provided a good base to divide and group project indicator areas. For instance, material flow methodologies may comprehend the analysis over natural, renewable, recyclable/recycled, reused (repaired, refurbished, re-manufactured), financial, human resources and a variety of others.

With the development of indicators for project type, scale, and sector, they may be grouped and classified according to this taxonomy, giving an overview of the area measured.

Admitting the matter that the present research does not recommend or propose project indicators, but singularly mentions and discusses a variety of available ones, as we preferred not to "paste" metrics which contexts, aims, validity and accuracy have not been entirely defined, analysed, and approved.

#### 4.1.5. System Thinking

System Thinking is not particularly a CE dimension, but instead a characteristic or approach on how to look and engage with systems (Hynes et al., 2019; Pauliuk, 2018; Perdicoúlis, 2016; Terry Bahill, 1998). This approach acknowledges the call and demand to interconnect, collectively and collaboratively (Hase & Hou Tay, 2004; Hynes et al., 2019; Pauliuk, 2018; Perdicoúlis, 2016) in projects to achieve the highest performance and results, enabling the progress towards CE.

This feature is deeply embedded into the circularity concept, since the beginning and origin of CE started with scholars recognizing that earth and its processes operated in a cyclic manner (Boulding, 1966). As the human impact has driven the environment, to and over its limits, by undertaking damaging practices and behaviours (European Environment Agency (EEA), 2016; Ghisellini et al., 2016; Meadows & Randers, 2004), the need for sustainable development has long been addressed and widely established.

Stating this, the CE concept has been suggested as a viable and suitable path to drive society towards sustainable goals, as circularity's values appear to embrace the three pillars of sustainability, the environment, the economy, and society (Kirchherr et al., 2017; Murray et al., 2017; Smol et al., 2017; Velenturf & Purnell, 2021; Yuan et al., 2008).

Nevertheless, the success for efficiently applying the CE concept into activities lies in the understanding of the connections and linkages between these three dimensions, their repercussions and how decisions affect the system that they are part of.

To accomplish this, a broader perspective on how to engage with systems is required, and that is where system thinking comes in, being a way to view natural, economic and social processes and mechanisms, expanding their borders, by means of comprehending their structures, operations and interactions, to effectively and accurately implement measures that safeguard their availability, function and quality, ensuring economic prosperity, environmental quality and social equity, for the present and future generations, improving today's and tomorrow's quality of life.

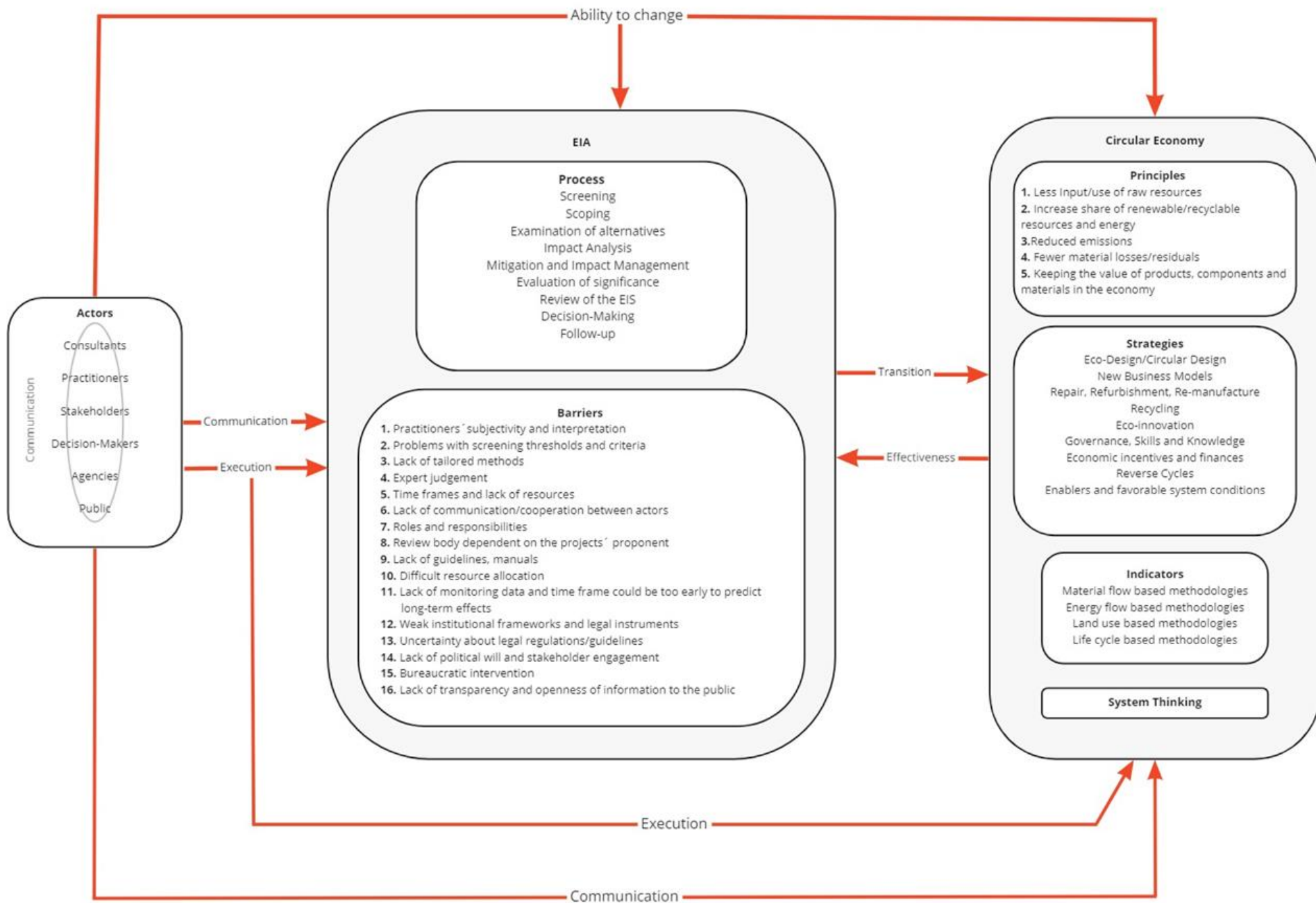


Figure 3 – Conceptual model developed

#### 4.1.6. Pathways to Integrate CE Into the EIA stages

As the conceptual model illustrates the several links and connections between the different dimensions involved, the study also establishes various approaches to integrate circularity topics into impact assessment practices. This section focuses on incorporating CE subjects into the EIA stages, intending to improve the procedural steps.

The table below, see Table 4.1, displays in the left column, the various stages required when conducting an EIA process. Additionally, a small description of each step is presented, with the intention to understand the aim and objectives of each phase. In the right column of the table, the proposed pathways to integrate CE into the EIA stages are represented, all of which will be further detailed and portrayed below.

The first step of conducting an EIA process is the Screening stage, with so, the proposal for this phase is to broaden the project's scale, by applying a more systematic thought, as suggested by Fothergill & Murphy (2020), as the need arises to shift these assessments from project-to-project approaches into more network-connected methodologies.

A path to do so is to connect the proposals with other projects, businesses, or sectors, where a shared platform of infrastructures, materials, resources, and other elements are commonly used. This path will allow decreasing the proposals environmental burdens and costs, which are some of the EIA's practical purposes, and therefore increase the effectiveness of the process.

Subsequently, in the Scoping stage, all possible impacts are described. With the main effects defined, efforts should be made to connect them with the CE principles and strategies that suit the proposal the most. Afterwards, a list of circularity indicators, that will allow the evaluation of the performance and progress of the project should be assembled.

At the Examination of alternatives stage, the available options should be evaluated according to how they meet and perform on the CE principles, strategies, and indicators, which have been defined as fitting and appropriate in the previous stages.

Gathered that information, the selected alternative should be the one, that not only accomplishes the proposal's objectives, but also the one that met and performed at the highest level in the CE topics assessed.

Following, in the Impact Analysis stage, both beneficial and adverse impacts are predicted. Because the CE concept ensures the maintenance of natural capital and avoids the loss of critical capital, as stressed by the European Commission (2019), evaluating the effects of a proposal in the light of the CE concept allows increasing the systems/projects effectiveness and sustainability, as they embody environmental protection and quality (Kirchherr et al., 2017), points that pose as key aspects to guarantee the projects and the EIA process success (Sadler, 1996).

Regarding the impacts considered adverse and significant, mitigation measures are established, intending to avoid, mitigate, minimize, or compensate those effects (Glasson & Therivel, 2019; Morris & Therivel, 2009). When establishing mitigation measures, circular strategies should be considered, as they prevent "end-of-pipe" approaches and undertake

techniques that seek to avoid the impacts as upstream as possible (Fronzel et al., 2007; Ghisellini et al., 2016; Røyne et al., 2015).

Furthermore, efforts should be taken to understand the connections and links between the negative and cumulative impacts, using overlapping mapping methods, to identify and foresee interactive effects, as stated by Foley et al. (2017) to propose circular metrics and strategies to evaluate, remedy and avoid those burdens and repercussions.

After the conclusion of the Environmental Impact Statement (EIS), this report is subjected to analysis and review, aiming to ensure that the reference terms were met (Sadler & Brown, 1999). In this stage, it should be also verified if the CE principles, strategies, and indicators identified were taken into account and met through the whole process, as well as being accurately and adequately documented, to safeguard the best decision possible.

Upon this stage, the proposal is up to approval or rejection by the competent authorities, and the terms of implementation are to be established (Glasson & Therivel, 2019; Sadler & Brown, 1999; Wood, 2014). Before committing to any decision, the authorities should weigh in the CE approaches and the way they were applied in the approval or not of the project.

The last step of the process is the Follow-up stage, where the purpose lies in guaranteeing the approval conditions, monitoring the evolution of the impacts, overseeing if the mitigation measures enforced are efficient and corroborating if the contingency and management plans are *en route*, appropriate, and effective (Glasson & Therivel, 2019; Ross et al., 2006; UN Environment, 2018; Wood, 2014).

The proposal for this phase is to apply circularity indicators and metrics not only to evaluate the progress and performance of the impacts but also to monitor the status and advancement towards CE. Furthermore, monitoring data, relevant connections and information should be collected, as they may represent a foundation to establish priorities towards long-term goals and targets, so future EIA's may be improved and enhanced regarding circularity matters, in addition to increasing the overall effectiveness of the process.

Table 4.1 – Proposals for CE integration into the EIA stages.

EIA Stage	Description	CE Integration Pathway
<b>Screening</b>	Evaluate if the proposal should be submitted to an EIA, and to what scale and level of detail	Broaden the project's scale by applying system thinking, and if possible, connect the proposals with other businesses/sectors
<b>Scoping</b>	Pinpoint the main challenges and impacts that are expected to occur and establish the terms of reference for the EIA	Connect the CE strategies and principles to the impacts of the proposals, to create a list of CE indicators that are able to evaluate the performance and progress of the project
<b>Examination of alternatives</b>	Determine the best environmentally option to achieve the proposed objectives	Evaluate the alternatives according to their performance on the CE strategies/principles/indicators. Then select the option that meets the objectives the best (environmentally, economically, and socially)
<b>Impact Analysis</b>	Distinguish and foresee the possible environmental, social and economic impacts, as well as other related effects of the proposal	Increase the project's effectiveness by applying the CE principles, strategies, and indicators. These principles avoid the loss of environmental "critical capital"
<b>Mitigation and Impact Management</b>	Establish measures to avoid, minimize and mitigate the negative impacts, and when suitable incorporate them into environmental plans or systems	Identify the CE strategies that could be applied to avoid or mitigate the adverse effects and establish the connections between them. Abandon "end-of-pipe" measures by applying CE strategies to mitigate and avoid the impacts as upstream as possible. Map overlapping to identify the potential interactive effects and determine recommended CE indicators for those impacts
<b>Evaluation of Significance</b>	Define the relative importance and tolerability of the residual effects	-

<b>Environmental Impact Statement (EIS)</b>	Clarify unambiguously and objectively all the impacts of the proposal, the mitigation measures established, the evaluation of the significance of the effects, and the apprehensions of the public and the involved communities in the project	-
<b>Review of the EIS</b>	Verify if the report accomplishes the terms of reference established, and if it contains all the information necessary for the best decision making	Evaluate if the CE principles and approaches identified in the beginning were met and well documented so that the process of decision making is well informed
<b>Decision-Making</b>	Accept or not the proposal and define the terms for implementation	In the condition of implementation, the CE concepts should weigh in the approval or rejection of the proposal
<b>Follow-up</b>	Guarantee the accomplishment of the terms of approval, monitor the impacts and their evolution, the effectiveness of the mitigation measures, to strengthen future EIA implementation, and when mandatory, proceed with environmental audits so that the environmental management could be optimized	Use the CE assessments to document and evaluate the progress, as well as different connections noticed to increase the effectiveness of the project and for information for future EIAs

#### 4.1.7. Overcoming EIA barriers through CE Integration

In this section, the table below, see Table 4.2, will be further detailed and described, as the left column portrays the different identified barriers to the process. A description of these limitations is presented, with the purpose to contextualize and characterize these challenges. In the right-side column, the proposed pathways to overcome and suppress some of the EIA constraints by integrating CE topics are defined.

The first barrier identified relates to how guidelines and regulations are expressed and communicated, as they often appear equivocal (Wood, 2014), leaving the EIA process exposed to practitioners' subjectivity and interpretation. Apart from the urgency to concretely and concisely revise and rephrase these guidelines and regulations, practitioners should robust their knowledge on the circular economy concept, deepening and strengthening their understanding of the CE approach, as mentioned by Fothergill & Murphy (2020), so they may apply it correctly and effectively into projects and proposals.

Screening thresholds and criteria for prediction, evaluation and monitoring may frequently present ambiguity, leading to a high level of uncertainty in these fields, compromising the effectiveness of the process (Glasson & Therivel, 2019). Withal, circularity criteria and thresholds should be defined for each main project/sector/area, combined with a CE checklist and reference frameworks to reduce the chance of uncertainty and subjectivity. Notwithstanding, there is the acknowledgement of the inexistence of thresholds and criteria or uncertainty over the ones available. This proposal is targeted to the new development of these topics or the review of the existent, stating the call for these circularity matters to be considered and embraced.

Furthermore, the available and recommended methods for assessment and appraisal are frequently obsolete, unsuited, or inadequate for the proposals, as reinforced by Kruopiene et al. (2009). With so, as the identification and determination of the significance of impacts presents as a crucial aspect in the EIA performance and success, this limitation may result in vital information loss, thus, compromising the decision-making process (Toro et al., 2010). A way to bypass this limitation may be through the application of circularity principles, methodologies, and strategies, predicting and evaluating impacts with circular indicators that embody the different values of CE, ensuring environmental protection and quality. Although we realise this proposal may not suppress the lack of tailored methods, there is an opportunity for practitioners to administer innovative techniques to predict and assess the effects of a proposal, and through their experience and expertise, they may decide and define which CE strategies, methods and metrics are the most appropriate for a project.

As the EIA process poses as a decision-making procedure based on the evaluation of collected data, experts' judgement plays an important role when making and committing to an informed decision (Morgan et al., 2012), certifying the excellence of the performance, success, and effectiveness of a project. With so, experts' knowledge, experience and awareness has a strong influence on impact prediction, as the process may be vulnerable and exposed to over or under-prediction of effects (Zhang et al., 2013). Herewith, experts' judgement may be improved and enhanced by strengthening their understanding and expertise on key subjects to the EIA process.

As both CE and EIA aim to ensure a more sustainable development (Cashmore et al., 2004; Htun, 1990; Kirchherr et al., 2017; Murray et al., 2017; Sadler, 1996), by reinforcing and consolidating professionals' knowledge on circularity fields, advances and promotes their better judgement, providing them with the essential tools to effectively apply CE principles, strategies, and indicators into projects, those which embody economic prosperity, environmental quality, and social equity, and consequently, ensuring the integrity of a proposal.

Additionally, as the impacts are often predicted early in the process, and these evaluations may not be conducted adequately or accurately, as a result of lack of monitoring data combined with the uncertainty associated with the procedures, unpredicted long-term effects (Morris & Therivel, 2009; Wood et al., 2000; Zhang et al., 2013) and repercussions may arise.

Broadening the scope, by implementing and exercising system thinking, constitutes an opportunity to attempt to predict some of the long-term effects. However, there is the underlying need to reduce the lack of monitoring data, but in the interim, academic studies, including CE research may help to reduce and fulfil this gap, by providing relevant information or criteria. There is also the possibility to administer CE methodologies and metrics that require less data or easier material to collect.

Apart from the lack of monitoring data, the scarcity in procedural manuals and methodological guidelines also constitutes a limitation to the process performance (Cashmore, 2004; Sadler, 1996; Wood et al., 1996; Zhang et al., 2013). In addition, the available manuals and guidelines are often short in accuracy and precision, as stressed by (Wood, 2014). With this, standardized methodologies are utterly necessary, as a variety of existent methods has led to a divergence in interpretations and results in the EIA process (Loomis & Dziedzic, 2018; Sadler, 1996). When developing these manuals and guidelines, CE strategies and indicators should be considered and defined, clearly specifying their context, application, and evaluation in project cases/areas.

Resources are always an everlasting crucial point to every project or proposal, whether they rest as financial funds, human resources, natural/material resources, or an array or combination of others (Ahmad & Wood, 2002; Toro et al., 2010; Wood et al., 2000). Their amount, quality, variety, and allocation represent a key aspect to the process performance (Cashmore, 2004; Fitzpatrick & Sinclair, 2009), as their faulty management may constitute a drawback to the project's success. Aspiring to achieve the highest and most advantageous outcome possible, resource handling, administration and oversight should be performed in a careful, thoughtful, and rigorous manner. To assist the surpass of this issue several CE methodologies and metrics may be applied.

For instance, material flow analysis and accounting (MFA), life cycle assessment (LCA), and systems for integrated environmental-economic accounting (SEEA) may provide an overview of various circulation streams, along with their consumption or cost, permitting to pinpoint and assess which areas/stages/flows stand as critical, and thus enabling the application of measures and techniques that will allow an efficient resource allocation, and per chance decrease both costs and resources.

Referring now to the legal and institutional context, several constraints arise, such as an absence of appropriate and significant frameworks and instruments (Morgan, 2012; Ross et

al., 2006), their adherence to the available regulations, or their application under different contexts (Loomis & Dziedzic, 2018; UN Environment, 2018). For the existent guidelines and regulations, uncertainty over their context and formulation is also displayed.

Furthermore, at a higher level, the absence of political and institutional infrastructures (Loomis & Dziedzic, 2018; Sadler, 1996) leaves several aspects of the process into experts' judgement and interpretation, which contributes to the overall ambiguity and distrust over the legitimacy and effectiveness of the EIA (UN Environment, 2018).

Hereby, as CE regulations and legal instruments are starting to be institutionalized, a section for EIAs may be contemplated and comprehended, in addition to the development of clear guidelines that include circularity matters, specifications for their context, application and assessment.

Notwithstanding, the awareness and comprehension prevail over the understanding that not all EIA constraints are able to be suppressed or overcome through the harmonization of CE matters into the EIA procedures.

Throughout the development of this research, we have unearthed various barriers that we could not identify and establish adequate CE proposals, such as tight time frames and resource scarcity, deficient cooperation/communication between actors, unclarity and uncertainty over roles and responsibilities, review body dependent on the project's proponent, insufficient political will and stakeholder engagement, exhaustive bureaucratic intervention and lack of transparency and openness of information to the public.

The majority of the above-mentioned limitations fall out of the CE scope, having no connection or association to circularity matters, due to their nature or context, making it beyond the bounds of possibility to define and recommend circular proposals, in order to overcome or surpass them.

Granting the belief that integrating circular economy topics into the EIA process may improve and enhance the overall performance and success of the process, while at the same time enabling the progress and transition towards CE (Yijun & Ying, 2011), we do not declare or defend that the proposals presented are categorically and unquestionably appropriate, as we do recognize the merit of different judgements and suggestions, contradictory to ours or not, and the potential opportunity for growth, improvement and advancement on these fields.

Table 4.2 – Proposals to overcome EIA barriers through CE integration

EIA Barrier	Description	CE integration Pathway
<b>Practitioners' subjectivity and interpretation</b>	Based on the equivocal language of guidelines and regulations, the EIA process is often subjected to practitioner's interpretation	Robust knowledge on the circular economy approach to apply it correctly and effectively in projects
<b>Problems with screening thresholds and criteria</b>	Uncertainty about the screening thresholds and criteria for prediction and evaluation and well as monitoring, leading to the decrease of the effectiveness of the process	Define circularity criteria and thresholds for each main project sector/area, alongside a circularity checklist and a framework of reference to avoid subjectivity to a minimum
<b>Lack of tailored methods</b>	The proposed methods for assessment are frequently obsolete and inappropriate for the proposal or project, and could represent a barrier for the detection of impacts and could generate a deficit of valuable data	Apply CE strategies and assessment methods and evaluate the performance and progress through circularity indicators
<b>Expert judgement</b>	The expert judgement can influence the prediction of impacts, in a matter of over or under-prediction of negative impacts	Utilize the CE assessment methods and values to ensure the project's integrity
<b>Time frames and lack of resources</b>	The time frame is a crucial point since the delayed start and excessively swiftness of a process will obstruct the contributions and their implementation. Skilled personnel and financial resources are also significant constraints	-
<b>Lack of communication/cooperation between actors</b>	The absence of efficient and effective communication between the different actors and stakeholders can be a constraint to the effectiveness and success of both the EIA process and the project	-

<b>Roles and responsibilities</b>	There is a lack of clarity of the different stakeholders' roles and responsibilities towards the process	-
<b>Review body dependent on the project's proponent</b>	"Bias prediction" – Because the review body is often reliant on the projects proponent, the practitioners are exposed to efforts of influence and can become inclined for certain results	-
<b>Lack of guidelines, manuals</b>	There is a shortage of procedure manuals, methodological guidelines, as well as their context for specific project cases, leading to a not standardized methodology and significant divergence of methods, interpretations, and results in the EIA process	Encourage and facilitate the development of CE manuals and guidelines, with strategies and indicators, as well as when/how/where to apply them and evaluate them
<b>Difficult resource allocation</b>	There are concerns about the financial and temporal costs of conducting the EIA, where to allocate the financial resources and skilled personnel to achieve the highest level of effectiveness of the EIA	By applying CE strategies and assessments (i.e., life cycle assessment) it is possible to evaluate the areas that consume more resources and optimize the project by applying circularity strategies in those points, making the resource allocation more efficient
<b>Lack of monitoring data and time frame could be too early to predict long-term effects</b>	Appraisals are often not conducted out efficiently due to the unavailability of monitoring data, as well as occasionally it can be too early in the process to predict some of the long-term effects and their implications	Try to establish/predict some long-term effects by employing system thinking. Encourage and facilitate studies/evaluations to reduce the lack of monitoring data, or try to use strategies/indicators that require less data
<b>Weak institutional frameworks and legal instruments</b>	There is a shortage of relevant framework and institutional instruments, and how to apply them to the proposal's context, as well as the	Since CE regulations and legal instruments are beginning to be institutionalized, they should also include a section for EIAs

	level of adherence to the applicable regulations. Absence of political and institutional infrastructure	
<b>Uncertainty about legal regulations/guidelines</b>	There is uncertainty about the language and context of the legal regulations and guidelines	Development of legal guidelines with CE topics, specifying how/where to apply and evaluate them
<b>Lack of political will and stakeholder engagement</b>	The absence of involvement and support, alongside the willingness and engagement capacity from the political and stakeholders' part, creates significant constraints to the process	-
<b>Bureaucratic intervention</b>	A significant number of bureaucratic interventions provide different and additional policies to target groups, leading to an abundance of policies, methods, concepts, and criteria creating a barrier to standardized procedures and results	-
<b>Lack of transparency and openness of information to the public</b>	Lack of disclosure of information data and procedures can make the contributions irrelevant and influenced. The access of information to the public is vital for fostering public support	-

## 4.2. Questionnaire Results

The aim of this section is to present the findings of the questionnaire conducted on EIA practitioners and academics. A total number of 12 responses were gathered, displaying a response rate of 1,14%, which is fairly lower than a conventional rate for a self-administered internet survey, which generally presents a response rate of approximately 10% (Saunders et al., 2016).

This lower ratio could be related to the questionnaire being delivered in English, as the IAIA organisation comprehends members from all over the world, with a variety of non-English countries, suggesting that certain language barriers may have arisen. Also, the survey was conducted at the end of the summer, which could relate to the unavailability of the respondents.

Furthermore, the questionnaire required about 25 to 30 minutes to complete, which may indicate that it could have been extensive and perhaps exhaustive or could have been a lack of interest on the topic, leading to a lower response rate than normal and expected.

Although the number of responses retrieved does not allow to generalize the findings to great extent, it provides an overall outlook on how experts opinions could affect the developed conceptual model and proposals. Nevertheless, even if a study attains a response ratio inferior to the normal or expected, it does not imply that the results are biased (Rogelberg et al., 2007).

This study comprehends a qualitative and exploratory nature, with no concern over statistical representativity, as the research topic is unique and underexplored, where a knowledge gap has been identified and no pre-set ideas have been established, with the aim to probe and gather information on the matter (Bethlehem, 2009; Neuman, 2013; Yin, 2015). As so, the present research proposes to explore experts' views and opinions on integrating CE into the EIA process, as very limited studies have been collected and performed on the harmonization of these fields.

This section follows the "Questionnaire section topics", see Table 3.3, except for the demographic information, which has been placed first to contextualize the respondents. With so, this section unfolds as (i) Demographic information; (ii) CE background information; (iii) CE principles and their integration into the EIA process; (iv) CE strategies and their integration into the EIA process and (v) CE proposals and their integration into the EIA process.

### 4.2.1. Demographic Information

The average age and gender of the respondents were 54,5 years and male, with only 1 female responding to the questionnaire. Regarding the country of activity, the sample was particularly heterogeneous, with a variety of countries presented, with 2 responses from Canada and Kenya, whereas the other countries (Zambia, Nigeria, Australia, Netherlands, Colombia, Ghana, and the Republic of Korea) had one answer.

Concerning the highest level of education of the surveyees, 7 presented a master's degree, 4 a doctoral degree and 1 a bachelor's degree. Additionally, the majority of the responses were from practitioners/consultants in privately held companies, with 5 out of 12 participants

selecting this option, and researchers/academics, with 3 out of 12 respondents. The other categories available were retrieved with 1 response.

As the response ratio was below the expected, the validity and credibility of the results rely on the experts' experience level and involvement in the EIA field. With this, 5 of 12 participants had more than 20 years of experience in the EIA dimension, see Figure 4, while 3 had between 10 to 20 years, other 3 had 2 to 5 years, and only 1 presented 5 to 10 years. Additionally, 6 experts had been involved in more than 30 EIAs, 4 between 1 to 10 EIAs, and 2 between 10 to 20 EIAs, see Figure 5. All in all, the respondents presented extensive and considerable professional experience in this field, which robust the confidence level in the results.

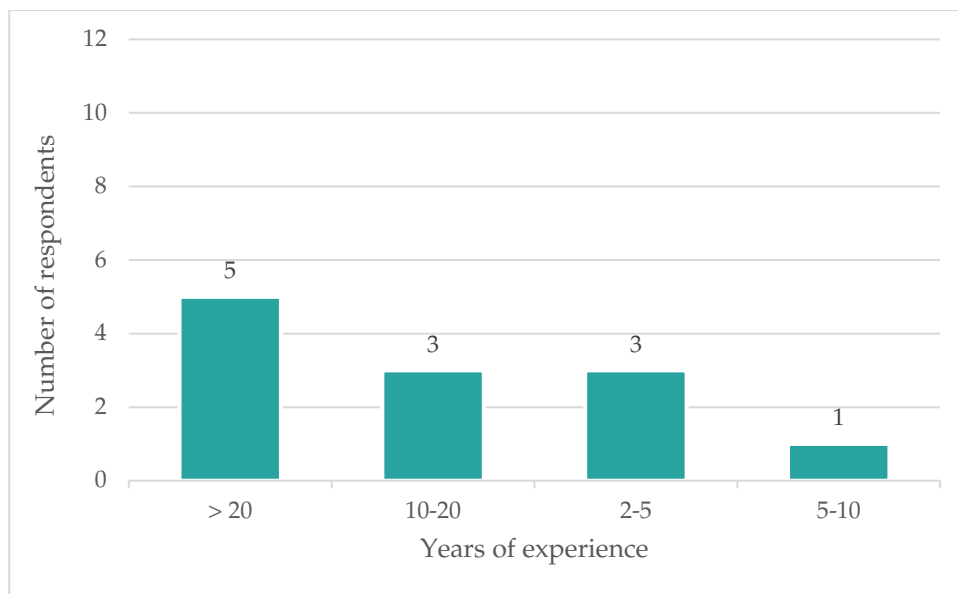


Figure 4 –Years of experience of the respondents.



Figure 5 – Number of EIAs the participants have been involved.

### 4.2.2. CE Background Information

The first section of the questionnaire regarded the respondents' level of acquaintance with the circularity notion, see Figure 6, where they were able to select from a five-point Likert scale, that ranged from "Strongly agree" to "Strongly disagree", the option that transpired their opinion the most.

When inquired how familiarized they were with the CE concept, 4 out of 12 participants pronounced they neither agreed nor disagreed, while 3 experts equally selected the options "Agree" and "Strongly agree" and 2 others marked the "Disagree" alternative.

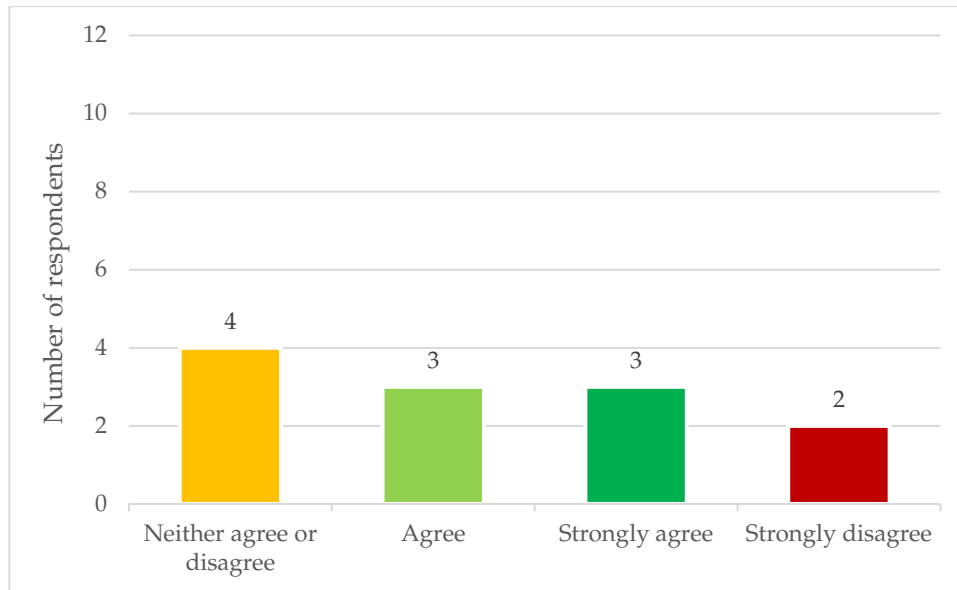


Figure 6 – Level of familiarization with the CE concept of the respondents.

Upon this question, the surveyees had the opportunity to provide their view on the integration of the circular approach into the EIA process, see Table 4.3. In total, four commentaries were retrieved concerning this matter. The responses represented a miscellanea of opinions, varying from CE being suitable only for certain EIAs, to the incorporation of CE and EIA being a good pairing as they seem to share the same goals, or other categories of impact assessment, such as ESIA (Environmental and Social Impact Assessment) also needing CE integration, or even that EIA does not require another "problem" to solve or address.

Table 4.3 – Citations of the respondents

#	Citation
R2	<i>"I consider CE as a concept for choices in projects plans &amp; policy, not suitable for EIA, except maybe for providing potential assessment criteria in certain EIA's"</i>
R3	<i>"The circular economy provides a broad rationale or philosophy that is consistent with precepts of EIA - protecting the environment and human health. It also suggests strategies and mechanisms to address negative impacts and enhance positive ones "</i>

<b>R5</b>	<i>“You are, again as is the case with so many other academic pursuits, trying to load onto project EA yet one more admirable but misguided issue for the project to address or solve when that issue resides in solution forums far beyond the project in question. Stated differently, while perhaps CE may understandably and reasonably apply in some way, given the dominance of assessed projects in providing resources for supply chains (e.g., mining), the issue of CE, as important as it is, needs to be solved and addressed mostly if not entirely outside of regulatory project EA. I am a frontline consulting EA practitioner (I do EA versus only study and critique) and have to question the ability and reasonableness to add “yet one more thing” of a larger national/international societal and economic nature to be added to what I have to provide as evidence regarding proposed applications”</i>
<b>R11</b>	<i>“Am aware of the need for CE integration in ESIA”</i>

Subsequently, the aim was to understand experts’ perspectives if circularity would be a good and useful approach to assess and mitigate the impacts of project EIA. The results were invariable for both questions, as the majority of responses were “Neither agree nor disagree” (5 out of 12), followed by “Strongly agree” (3 out of 12), “Disagree” (2 out of 12) and an equal number of replies of “Agree” and “Strongly disagree” (1 out of 12).

Nevertheless, regarding the development of a structure/framework that would provide suggestions to integrate these two fields, see Figure 7, the plurality of responses retrieved were the “Agree” alternative (7 out of 12), succeeded by “Neither agree nor disagree” (3 out of 12) and equivalent reactions of “Strongly agree” and “Strongly disagree” (1 out of 12).

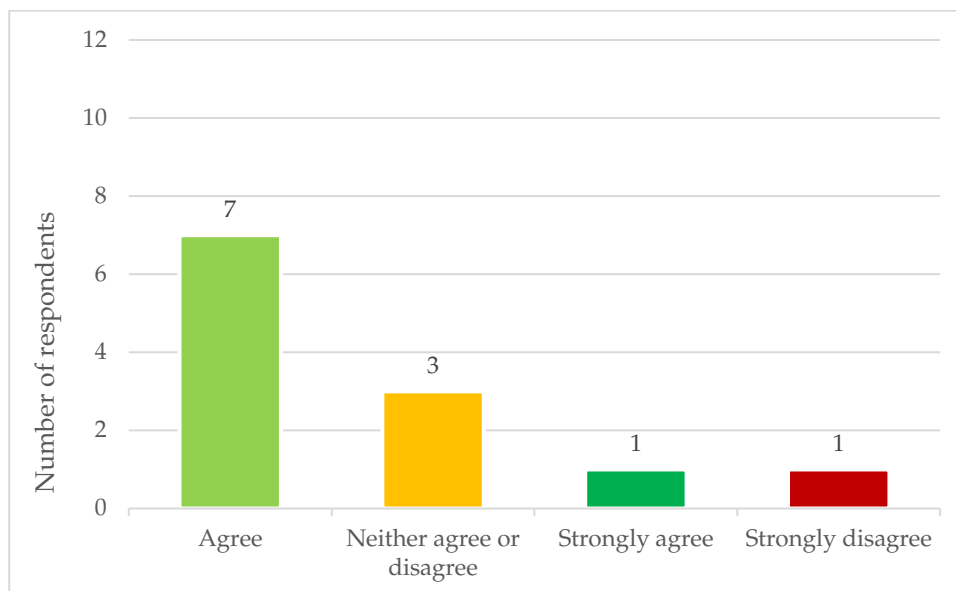


Figure 7 – Opinion of the respondents regarding the relevancy of a framework that integrates CE into the EIA process.

### 4.2.3. CE Principles and their integration into the EIA process

This section intended to understand experts' views on the relevance and suitability of CE principles along the stages of the EIA process. Following the previous section five-point Likert scale, the respondents provided their judgement on how appropriate the principles could be in each EIA stage.

With so, Figure 8, shows the findings of the principle "Less input/use of natural resources", where the number of responses retrieved for each alternative respecting the different stages of the process is displayed.

Overviewing the results, the majority of the replies returned were in the consenting range, with the selection of the "Strongly agree" and "Agree" options outshining in every stage.

The first two steps of the process, the "Screening" and "Scoping" phases, were the stages that comprehended the highest number of "Agree" selected options, with 9 out of 12 and 8 out of 12, respectively. However, the stages of "Examination of alternatives" and "Decision-Making" were the ones that retrieved the highest number of "Strongly agree" responses, with 7 out of 12.

Nevertheless, the step with the maximum number of disagreeable reactions for this principle was the "Evaluation of Significance" phase, with 3 out of 12 disapproving opinions, where 2 participants disagreed and another 1 strongly disagreed with the incorporation of this principle in this step of the EIA process. Despite this evidence, the number of consenting opinions surpassed the disapproving ones, with 6 experts selecting the "Agree" alternative and another 3 marking the "Strongly agree" one.

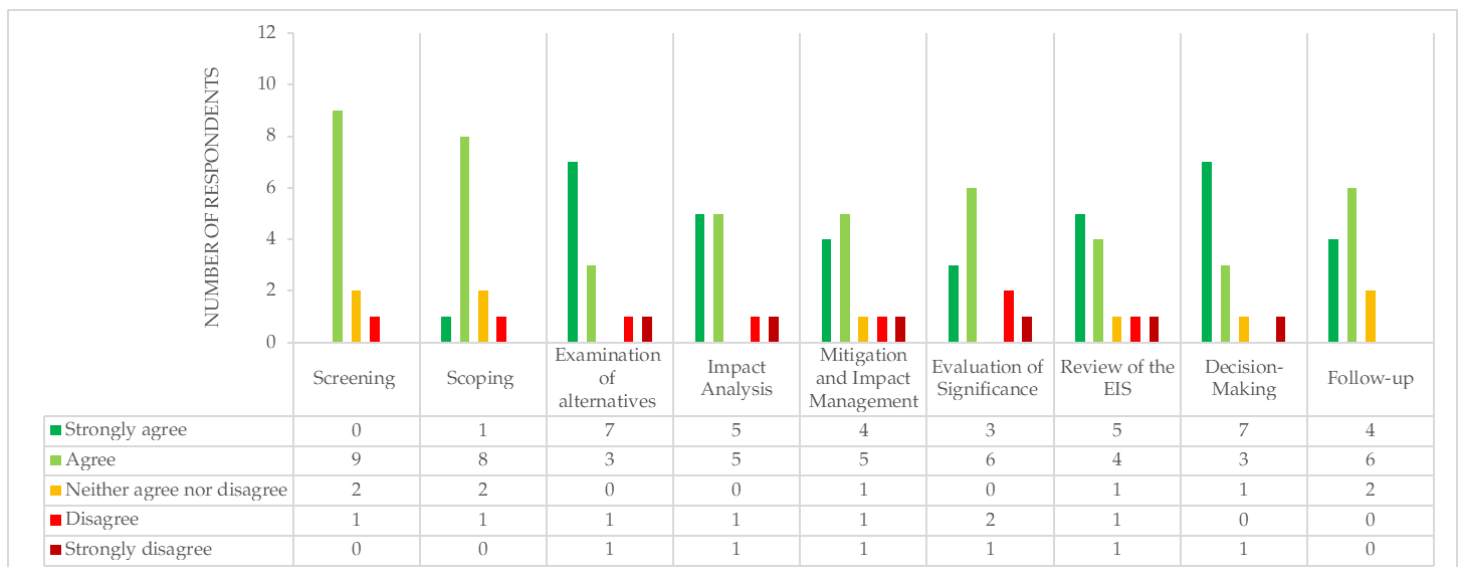


Figure 8 – Results for the integration of "Less input/use of natural resources" into the EIA stages.

The next principle to be inquired was "Increased share of renewable/recyclable resources and energy", see Figure 9. In this question, the number of "Strongly agree" selected responses were lower than in the previous principle, with the stage of "Decision-Making"

being the one with the best performance regarding this option. However, the “Agree” alternative was the dominating one throughout the stages.

Four stages presented an equal, and the highest number of disapproving opinions (2 out of 12), those being the “Screening”, “Evaluation of Significance”, “Review of the EIS” and the “Follow-up” stages. Both the “Screening” and “Review of the EIS” steps had 2 participants who disagreed but no “Strongly disagree” responses. The “Evaluation of Significance” and “Follow-up” phases had equivalent surveyees who disagreed and strongly disagreed, with 1 out of 12 replies in each of these alternatives.

Nevertheless, in the “Mitigation and Impact Management” and “Examination of alternatives” steps, an equal number of experts agreed (5 out of 12) and strongly agreed (5 out of 12) with the incorporation of this principle into those stages. Additionally, the total number of “Neither agree nor disagree” responses retrieved was lower than in the first principle.

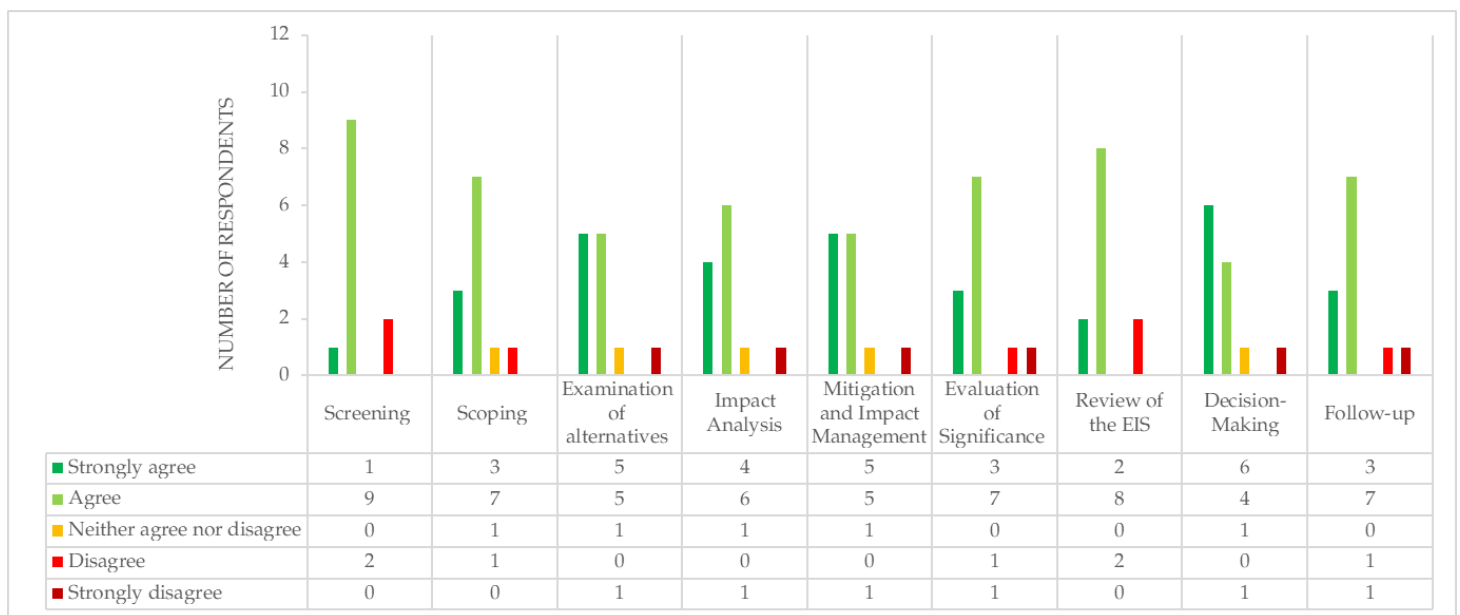


Figure 9 – Results for the integration of "Increased share of renewable/recyclable resources and energy" into the EIA stages.

The following principle evaluated regarded the proposition of “Reduced emissions”, see Figure 10, where similarly to the previous ones, the majority of the feedback was centred in the approving range.

The stage that returned the maximum selected “Strongly agree” option was the “Decision-Making” step, with 7 out of 12 responses. Contrastingly, the phases where the disapproving alternatives were higher, both with 2 out of 12 retrieved replies, were the “Evaluation of Significance” and “Follow-up” steps.

In both stages, 1 participant disagreed, and another strongly disagreed with the integration of this principle into these phases. However, in comparison with the preceding principle, the number of surveyees who neither agreed nor disagreed with the incorporation of “Reduce emissions” into the EIA was higher.

Additionally, both “Mitigation and Impact Management” and “Evaluation of Significance” presented equivalent reactions on the “Agree” and “Strongly agree” options, returning 5 out of 12 responses for each of those alternatives.

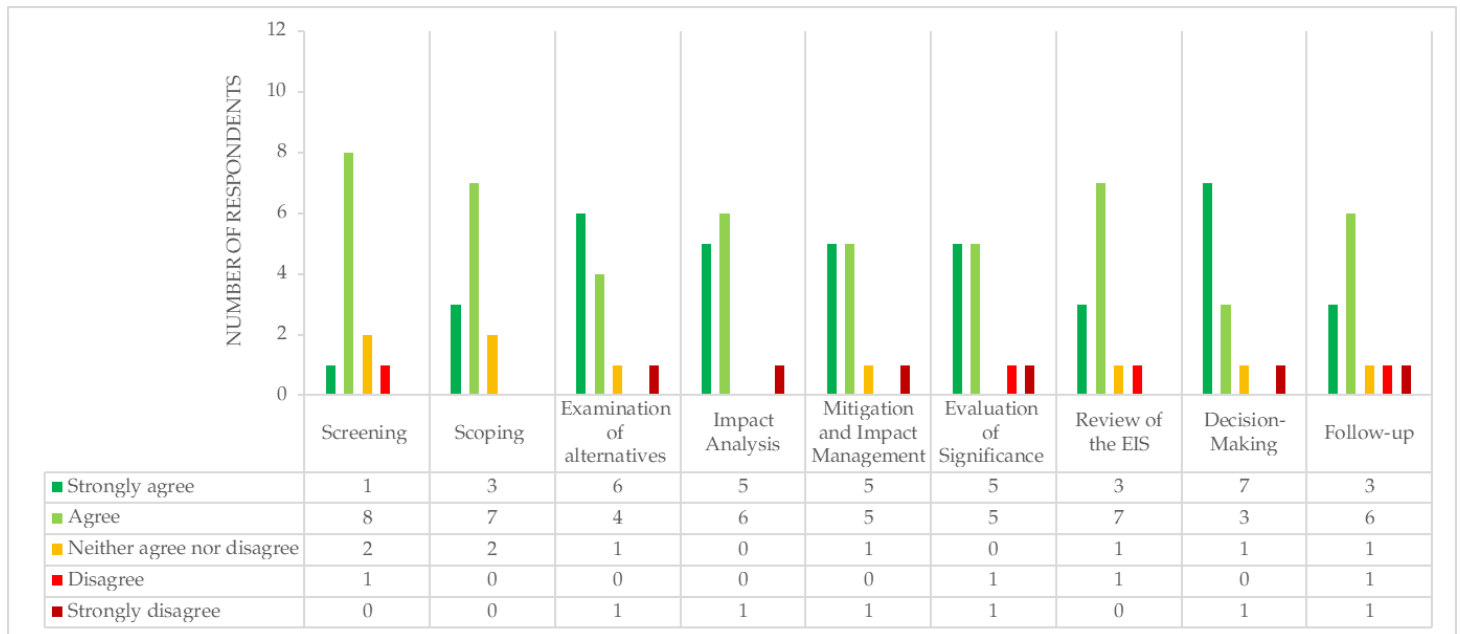


Figure 10 – Results for the integration of “Reduced emissions” into the EIA stages.

Subsequently, the principle “Fewer material losses and residuals” was appraised, see Figure 11. In this evaluation, the “Strongly agree” alternative outshined in the stages of “Examination of alternatives”, (with 6 out of 12), “Mitigation and Impact Management”, (with 6 out of 12), “Review of the EIS”, (with 5 out of 12) and “Decision-Making”, (with 6 out of 12).

However, the stages of “Screening” and “Follow-up” presented as the ones with the highest number of disapproving responses (2 out of 12). In the “Screening” step, 2 participants disagreed with the integration of this principle into this phase, whereas in the “Follow-up”, 1 participant disagreed, and another strongly disagreed.

Nevertheless, the total number of retrieved “Neither agree nor disagree” responses was higher than in the previous principle. In this question, there was no equal feedback on the “Agree” and “Strongly agree” alternatives

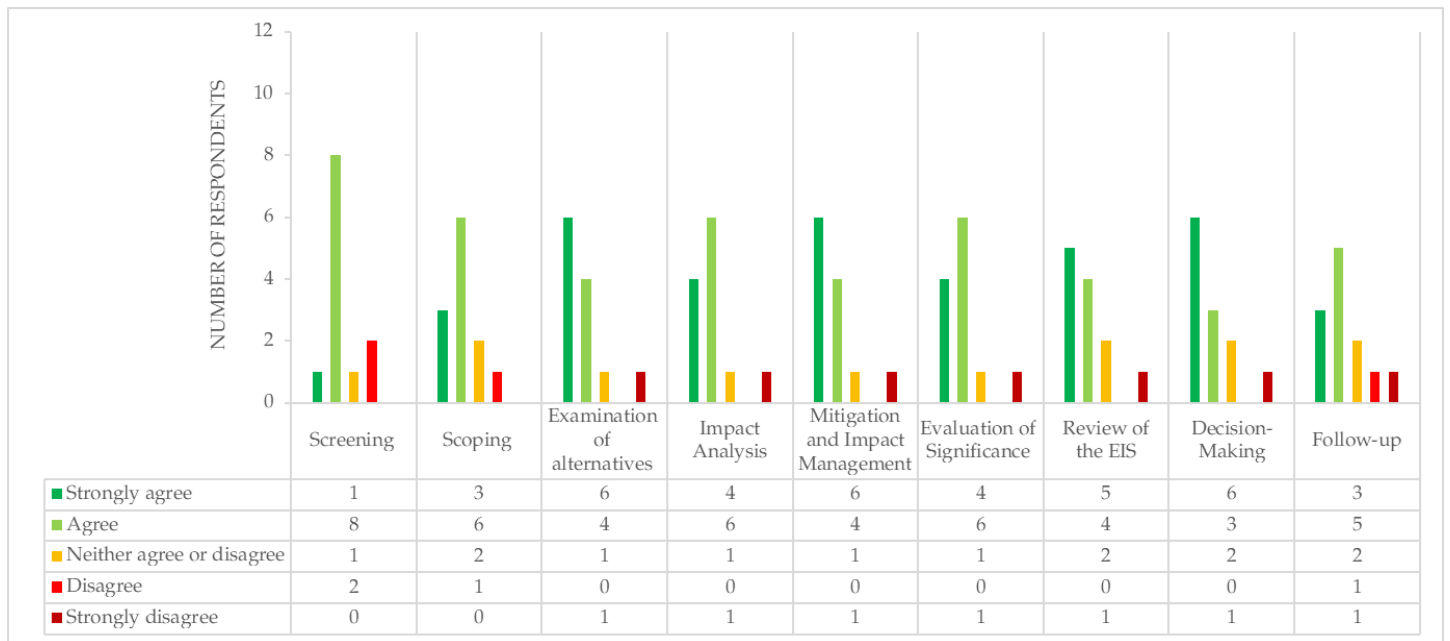


Figure 11 – Results for the integration of "Fewer materials losses and residuals" into the EIA stages.

The last principle to be assessed was "Keeping the value of products, materials and components in the economy", see Figure 12. This principle displayed the lowest number of responses within the approving range, in addition to the highest selected "Neither agree nor disagree" and "Disagree" alternatives.

Despite this evidence, the approving feedback always surpassed the disagreeable one. With so, the stages of "Mitigation and Impact Management" and "Decision-Making" were the steps with the best performance of preferred "Strongly agree" responses, with 5 out of 12.

The "Screening" phase presented the highest results regarding the "Agree" option, with 7 out of 12. Nevertheless, this stage was also one of the steps with the highest number of disapproving judgements, alongside the "Impact analysis", "Review of the EIS", and "Follow-up", all with 3 out of 12 disagreeable responses.

However, in the phases of "Screening" and "Review of the EIS", all 3 participants disagreed with the incorporation of this principle into those steps, whereas in the "Impact analysis" and "Follow-up" stages, 2 respondents disagreed, and another strongly disagreed with the integration of this principle in these phases.

All stages demonstrated at least 1 response of "Neither agree nor disagree", but a maximum of 2 replies concerning this alternative.

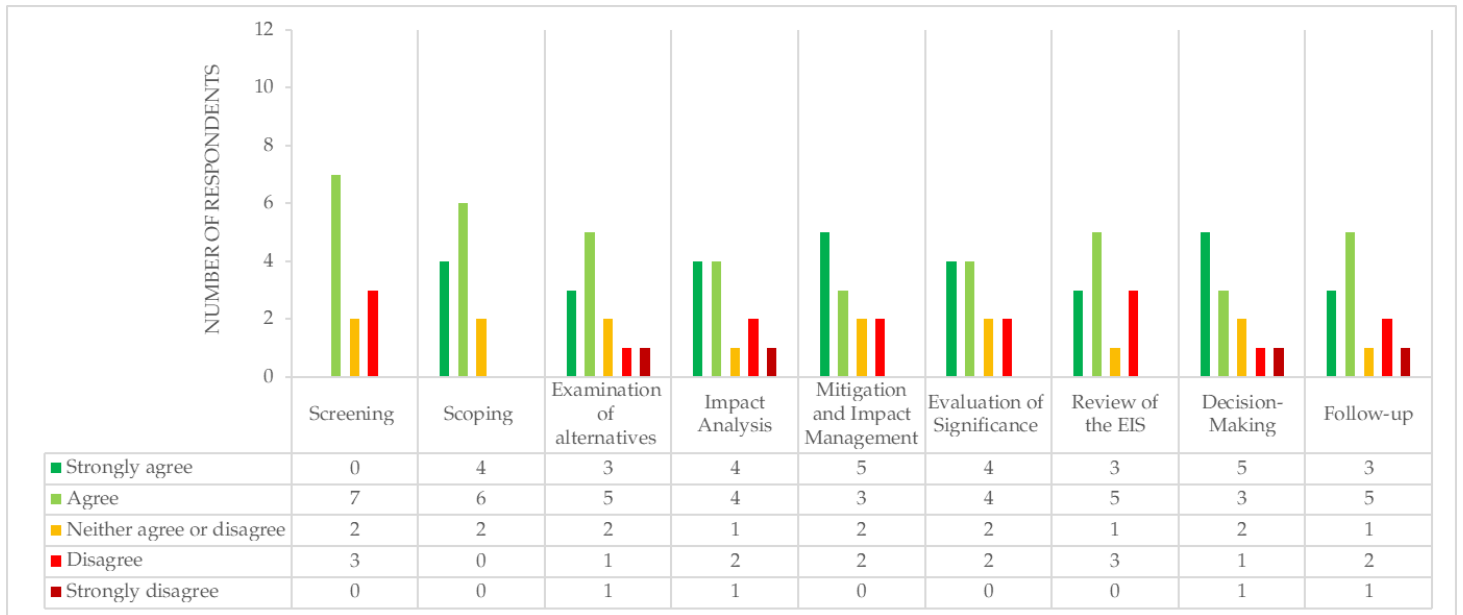


Figure 12 – Results for the integration of "Keeping the value of products, materials and components in the economy" into the EIA stages.

#### 4.2.4. CE Strategies and their integration into the EIA process

In the development of the conceptual model, a diversity of strategies were proposed and suggested to integrate the CE field into the EIA process. This section aims to understand experts' opinions on the appropriateness and usefulness of these actions when applied to the different stages of the EIA procedures.

The first strategy evaluated was the "Eco-Design/Circular Design", see Figure 13. The "Strongly agree" alternative outstood in the "Examination of alternatives", "Mitigation and Impact Management", and "Decision-Making" stages.

All phases returned at least 1 disagreeable response, but a maximum of 3 replies, which corresponded to the "Mitigation and Impact Management" step. Although this stage presented one of the highest numbers of "Strongly agree" and "Disagree" responses, there was an equal number of experts marking the options "Agree" and "Disagree" (3 out of 12).

However, there was no retrieved "Strongly disagree" feedback for any of the stages. Additionally, all steps also returned at least 1 "Neither agree nor disagree" selected alternative, where the phase of "Review of the EIS" presented the highest number of replies regarding this option, with 4 out of 12.

Nevertheless, the approving judgement was always superior, in every stage, to the disapproving one.

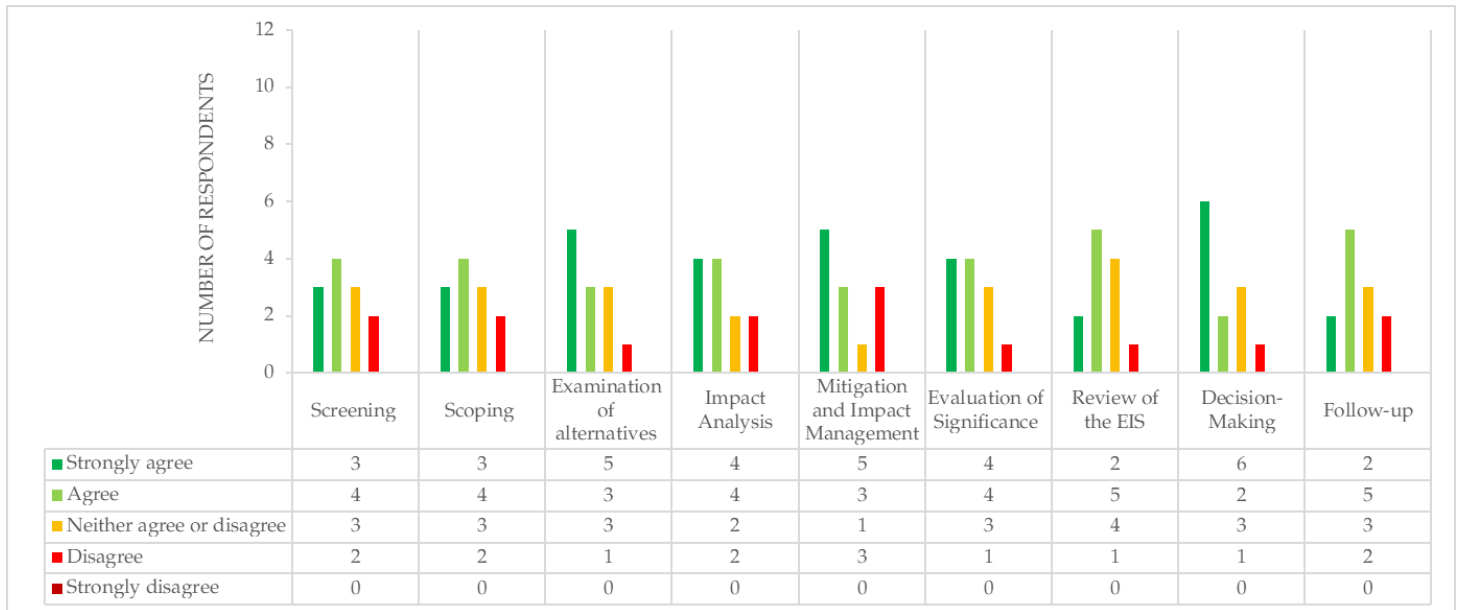


Figure 13 – Results for the integration of "Eco-Design/Circular Design" strategy into the EIA stages.

The next strategy assessed was "New Business Models", see Figure 14. All stages displayed only 1 response of "Strongly disagree". However, the "Follow-up" stage presented the highest number of returned "Disagree" reactions, with 3 out of 12 replies.

Additionally, all steps had a minimum of 1 selected "Neither agree nor disagree" alternative, with the phases of "Screening" and "Scoping" returning the highest feedback regarding this option, with 4 out of 12 responses. Furthermore, the "Screening" stage had no participants strongly agreeing with the incorporation of this strategy into this step.

The highest number of replies retrieved concerning the "Strongly agree" option were situated in the phases of "Examination of alternatives" and "Mitigation and Impact Management", with 5 out of 12 responses. However, in the stage of "Mitigation and Impact Management", an equal number of participants selected the options of "Agree", "Neither agree nor disagree" and "Disagree", with 2 out of 12 responses regarding each alternative.

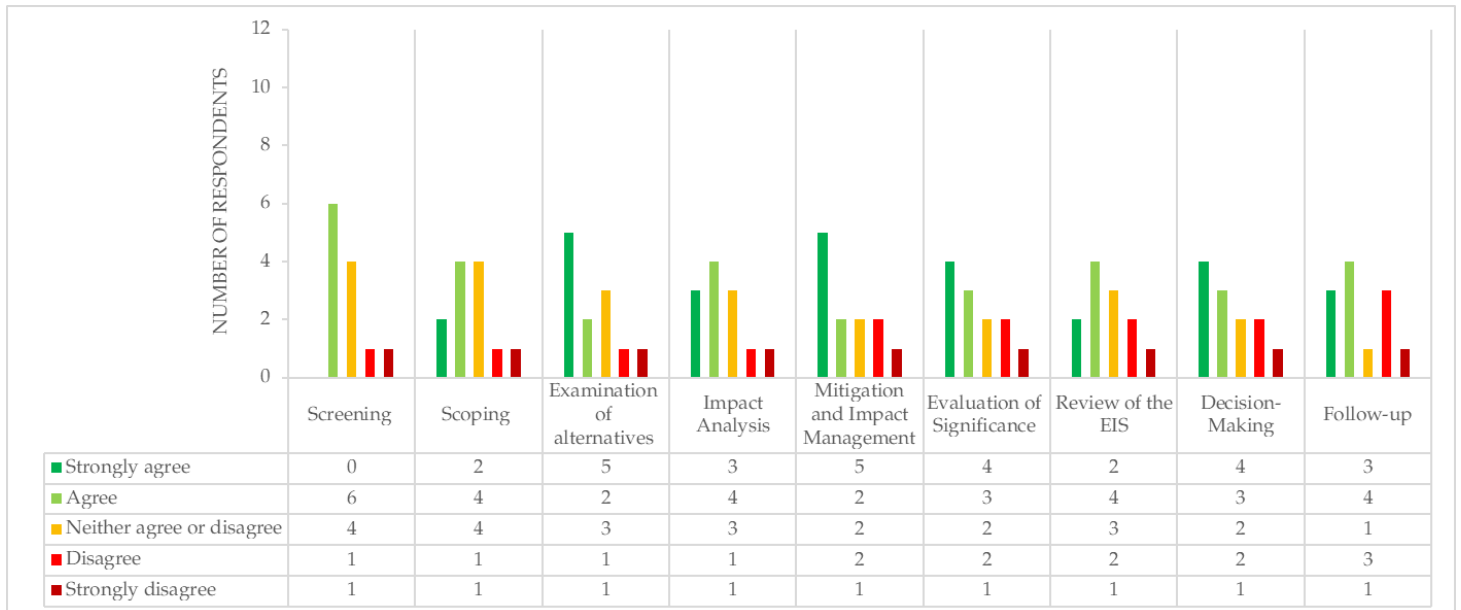


Figure 14 – Results for the integration of "New Business Models" into the EIA stages.

The third strategy inquired was "Repair, Refurbishment and Re-manufacture", see Figure 15. The majority of the stages did not return "Strongly disagree" responses, except the steps of "Review of the EIS", "Decision-Making" and "Follow-up", all with 1 out of 12 replies. Additionally, the "Review of the EIS" phase presented the highest number of selected "Agree" alternatives, with 8 out of 12 responses.

However, the "Screening" step did not retrieve feedback regarding the "Strongly agree" option. Also, this stage in addition to the "Scoping", displayed the superior amount of participants selecting the "Neither agree nor disagree" alternative, with 3 out of 12 respondents.

Further adding, in the "Scoping" phase, 3 surveyees disagreed with the integration of this strategy into this step, representing the scenario with the highest number of replies concerning this option.

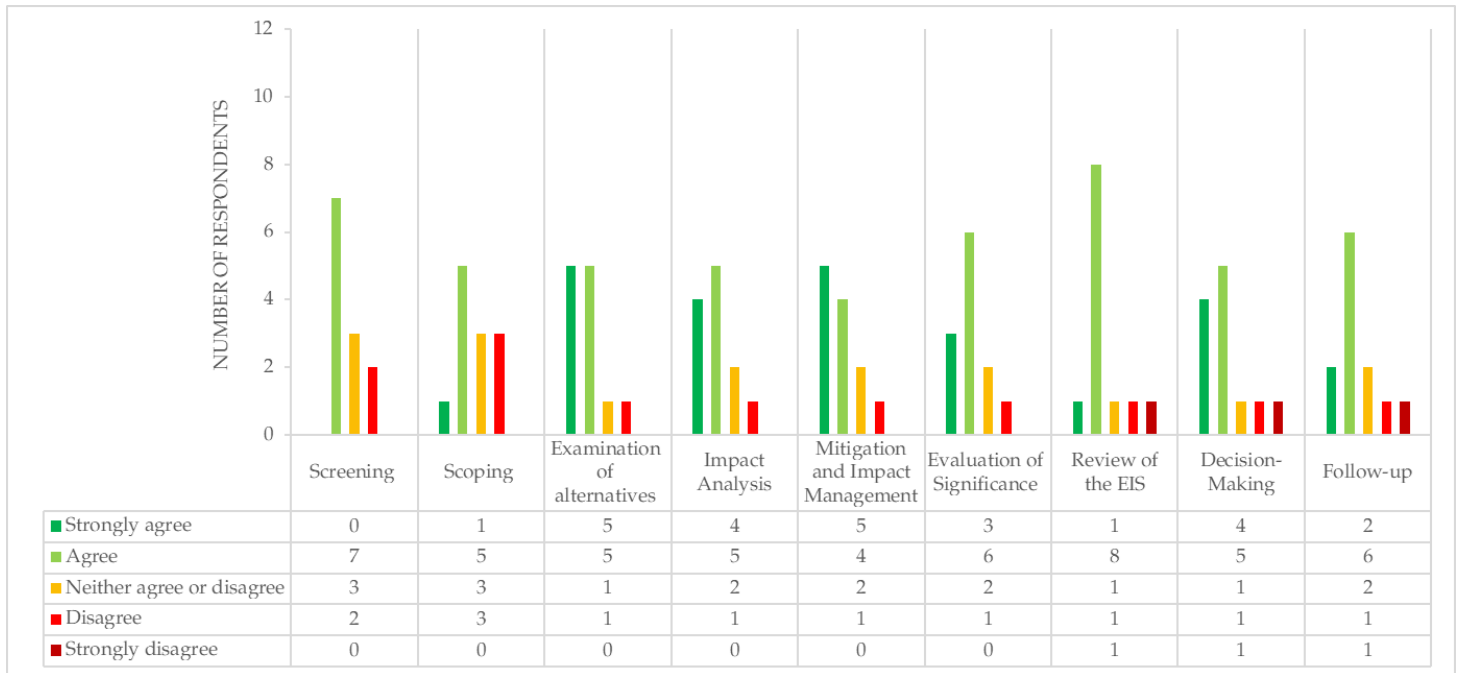


Figure 15 – Results for the integration of "Repair, Refurbishment and Re-manufacture" into the EIA stages.

Subsequently, the "Recycling" strategy was evaluated, see Figure 16. Regarding the "Strongly disagree" alternative, no experts selected this option for any of the stages.

The highest number of "Disagree" retrieved responses were situated at the "Evaluation of Significance" and "Follow-up" phases, with 3 out of 12 replies. However, the "Follow-up" step was also the one with the highest feedback concerning the "Agree" alternative, with 6 out of 12 respondents selecting this option.

The stage of "Examination of alternatives" posed as the one with the highest number of experts strongly agreeing with the incorporation of this strategy into this phase, with 6 out of 12 responses.

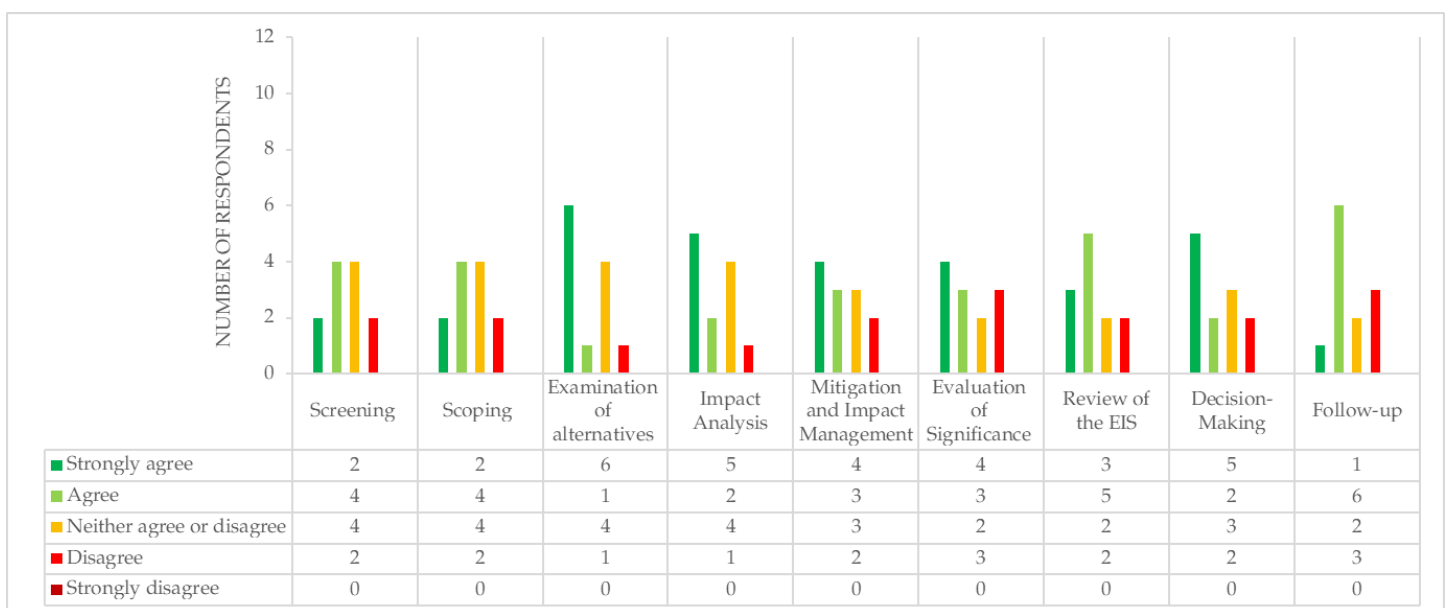


Figure 16 – Results for the integration of "Recycling" into the EIA stages.

Following, the “Eco-innovation” strategy was assessed, see Figure 17. In this strategy, the “Agree” alternative exceeded the other options at every stage, with a maximum of retrieved responses of 8 out of 12, in the steps of “Review of the EIS” and “Follow-up”.

The phases of “Examination of alternatives”, “Evaluation of Significance” and “Decision-Making” had no returned feedback regarding the disapproving range. Nevertheless, concerning the “Disagree” alternative, the maximum selected responses for this option, with 2 out of 12 replies for this step, was the “Screening” phase.

The “Decision-Making” stage presented as the one with the highest number of experts selecting the “Strongly agree” alternative, with 5 out of 12 responses.

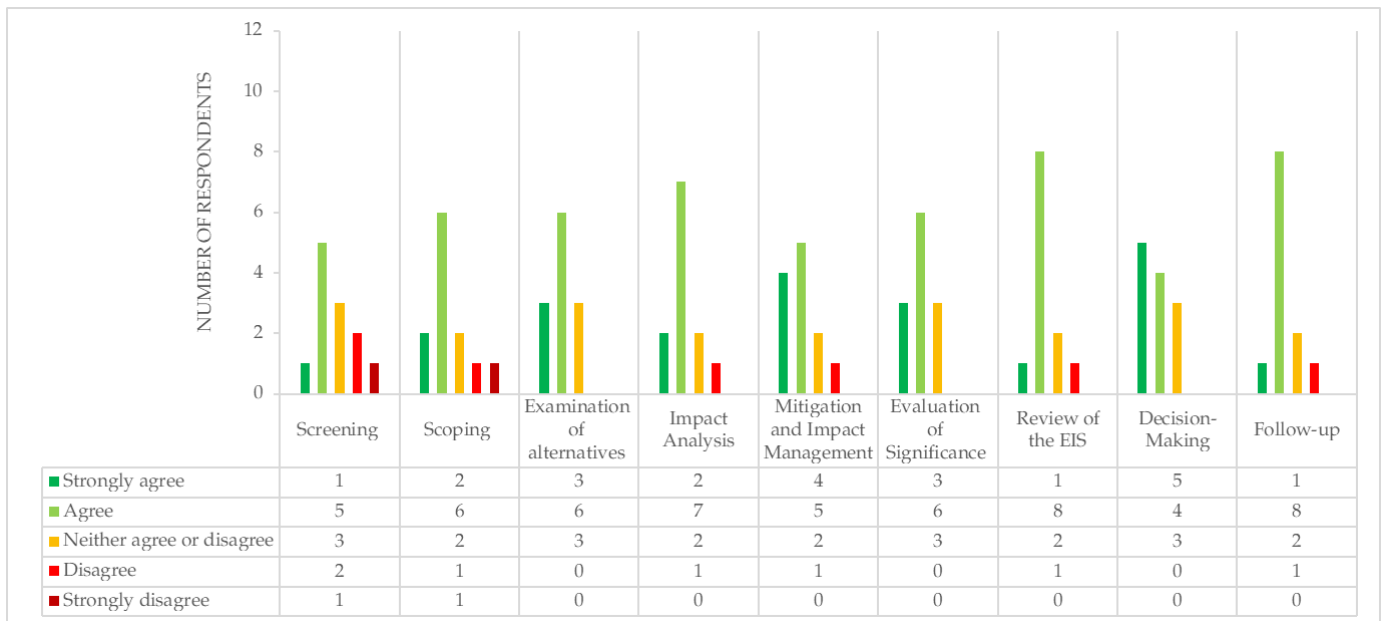


Figure 17– Results for the integration of “Eco-Innovation” into the EIA stages.

The succeeding strategy was the “Governance, Skills and Knowledge”, see Figure 18. In this strategy, no experts selected the “Strongly disagree” alternative for any of the stages.

The “Screening” phase presented mixed opinions, as no experts selected neither the “Strongly agree” and “Strongly disagree” alternatives, however, the options of “Agree” and “Disagree” returned an equal number of responses, with 5 out of 12, posing as the step with the highest feedback regarding the “Disagree” selection.

Additionally, the phases of “Examination of alternatives”, “Impact Analysis” and “Evaluation of Significance” had equivalent reactions for the “Strongly agree” and “Agree” alternatives, with 4 out of 12 for each option.

Nevertheless, the stages of “Mitigation and Impact Management” and “Decision-Making” retrieved the highest number of replies, with 6 out of 12, concerning the “Strongly agree” alternative.

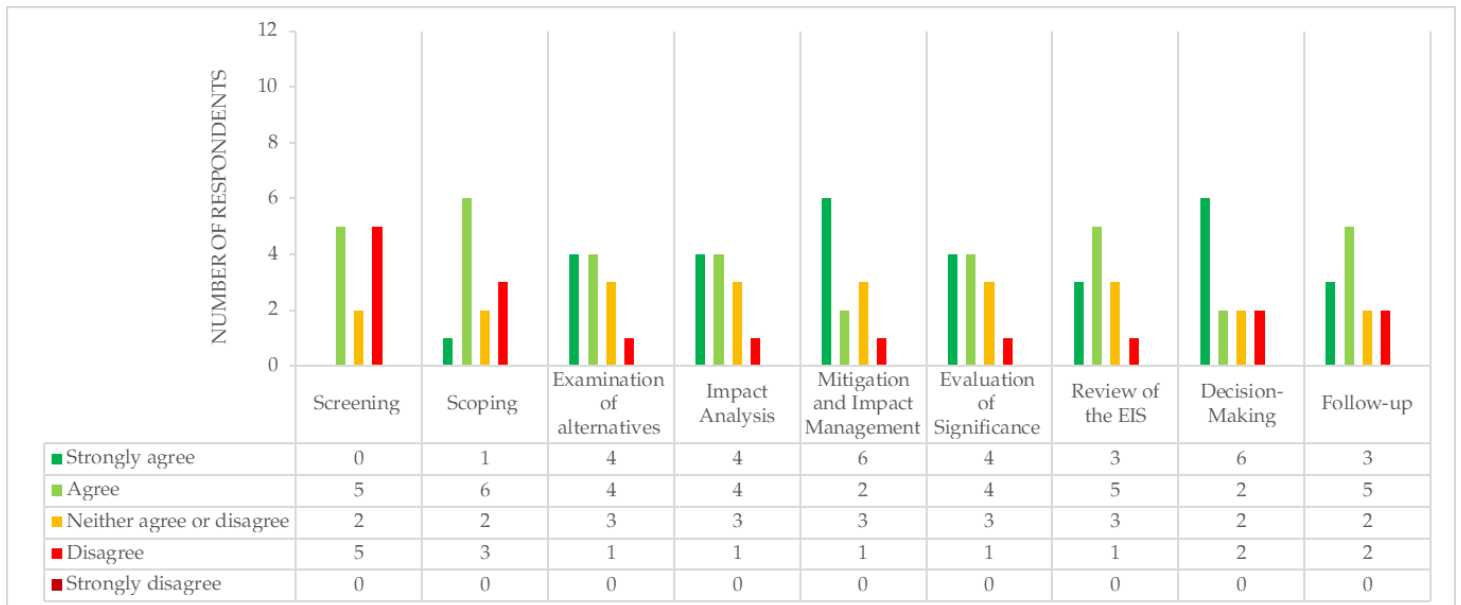


Figure 18– Results for the integration of "Governance, Skills and Knowledge" into the EIA stages.

The seventh strategy regarded "Economic incentives and finances", see Figure 19. The majority of the results were centred in the approving range.

However, the "Screening" stage did not retrieve any "Strongly agree" responses but returned 3 out of 12 replies concerning the "Disagree" alternative, in addition to the "Scoping" phase, where both presented as the steps where most respondents selected this option.

Additionally, the "Screening" stage also had the highest number of "Strongly agree" returned replies, with 2 out of 12, whereas the other steps all retrieved only 1 out of 12 responses for this alternative.

The "Strongly agree" option was highest in the "Decision-Making" phase, with 5 out of 12 responses, and the "Agree" alternative in the "Follow-up" stage, with 6 out of 12 experts marking this option.

The "Examination of alternatives" and "Mitigation and Impact Management" steps returned an equal number of respondents selecting the "Strongly agree" and "Agree" alternatives, with 4 out of 12 reactions for each option.

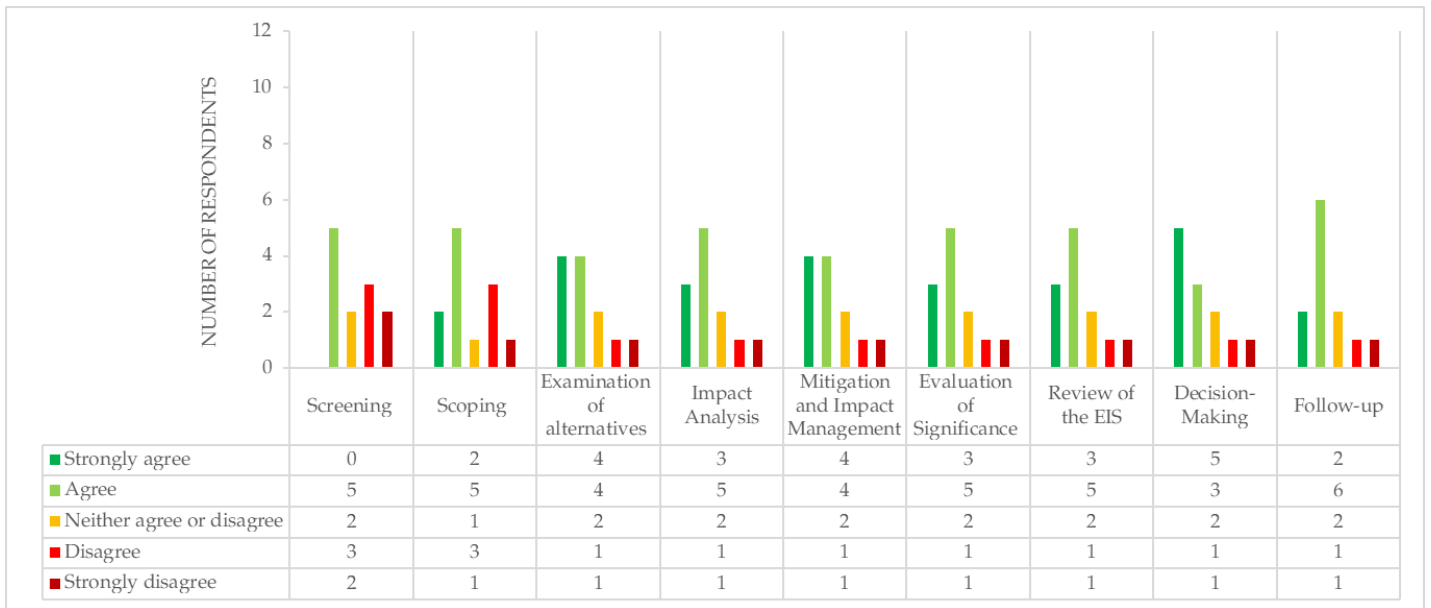


Figure 19– Results for the integration of "Economic incentives and finances" into the EIA stages

The next strategy evaluated concerned the "Reverse Cycles", see Figure 20. In this strategy, the "Agree" alternative was higher than any of the other options at any stage.

Every phase retrieved only 1 response regarding the "Strongly disagree" option. However, the "Disagree" alternative returned a maximum of 3 out of 12 replies, which were situated at the "Screening" step, but the phases of "Examination of alternatives", "Mitigation and Impact Management" and "Evaluation of Significance" had no respondents selecting this alternative.

In the "Scoping" stage, 5 out of 12 experts returned the feedback of "Strongly agree", which presented the highest number of retrieved responses concerning this option. The "Agree" alternative was highest with 6 out of 12 participants marking this option in the stages of "Screening", "Review of the EIS" and "Follow-up".

Additionally, in the "Examination of alternatives" phase, equal feedback was returned regarding the option of "Agree" and "Strongly agree", with 4 out of 12 responses for each alternative.

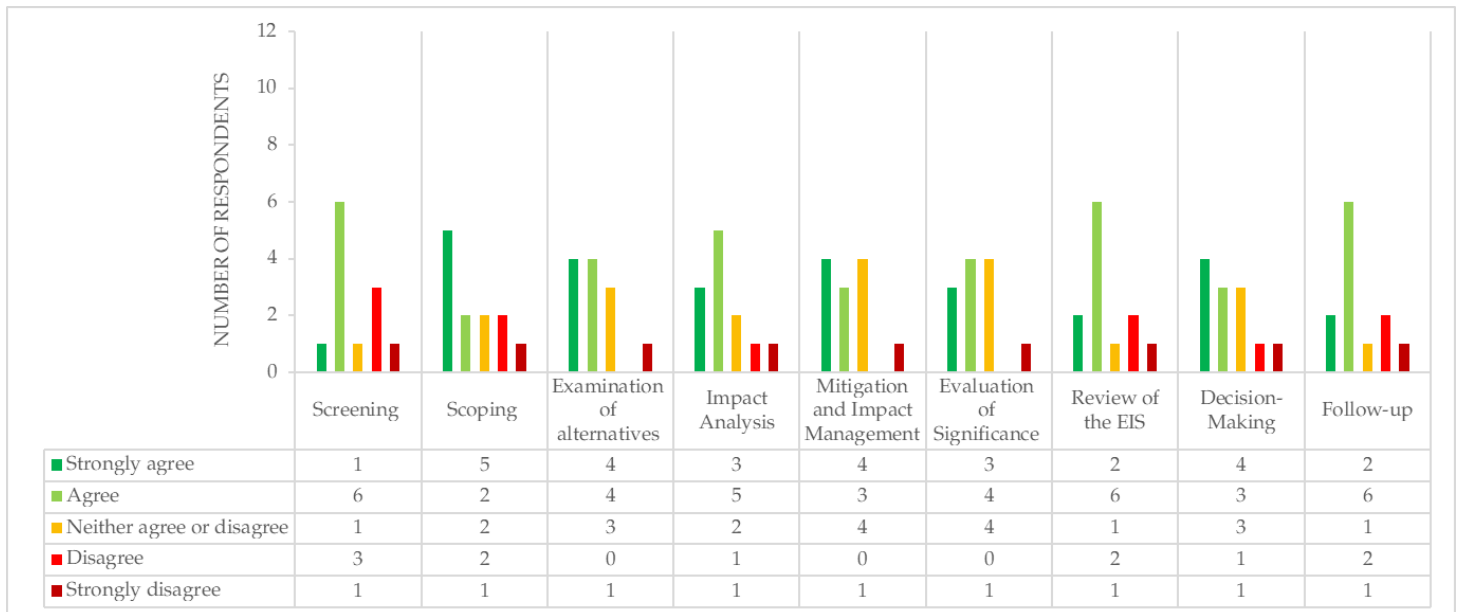


Figure 20– Results for the integration of "Reverse Cycles" into the EIA stages.

The last strategy, “Enablers and favourable conditions”, see Figure 21, was the one with the least retrieved responses regarding the “Strongly agree” alternative, with the stages of “Screening” and “Review of the EIS” returning no feedback for this option.

However, this evidence was compensated with the number of experts selecting the “Agree” alternative, with the stages of “Review of the EIS” and “Follow-up” exceeding the others, with 7 out of 12 responses for this option.

Every stage retrieved at least 1 reaction of “Neither agree nor disagree” but returned a maximum of 2 respondents selecting this alternative.

Regarding the “Disagree” option, the phases of “Screening” and “Scoping” presented the highest results, with 3 out of 12 responses. For the “Strongly disagree” alternative, the majority of the steps only returned 1 out of 12 replies for this option, except the stages of “Screening” and “Review of the EIS”, where 2 participants Strongly disagreed with the incorporation of this strategy into those phases.

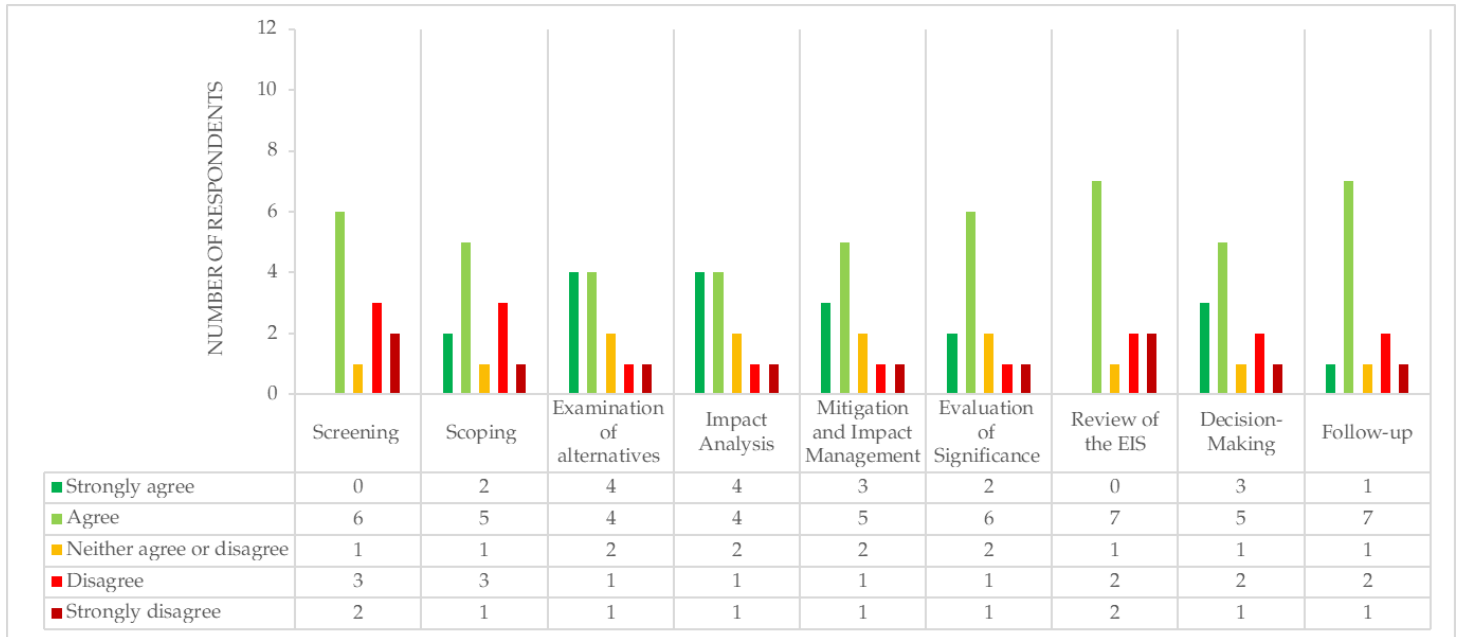


Figure 21– Results for the integration of "Enablers and favourable conditions" into the EIA stages.

## 4.2.5. CE proposals and their integration into the EIA process

### 4.2.5.1. Pathways to integrate CE into the EIA stages

This next subsection is intended to understand experts' opinions on the proposals developed to integrate circularity topics into the different EIA stages. As several suggestions were projected it was crucial to understand how suitable, viable and accepted they would be by individuals with experience and knowledge in the field.

The first proposal made was for the "Screening" stage, see Figure 22, where it was suggested to broaden the project's scale through the application of systems thinking, and whenever possible connect the proposals with other business/sector/projects.

To this recommendation, the majority of the responses were situated at the consenting range, with 4 experts strongly agreeing with this proposal, 5 participants who agreed, 1 who marked the "Neither agree nor disagree" alternative and 2 surveyees that marked the "Disagree" option.

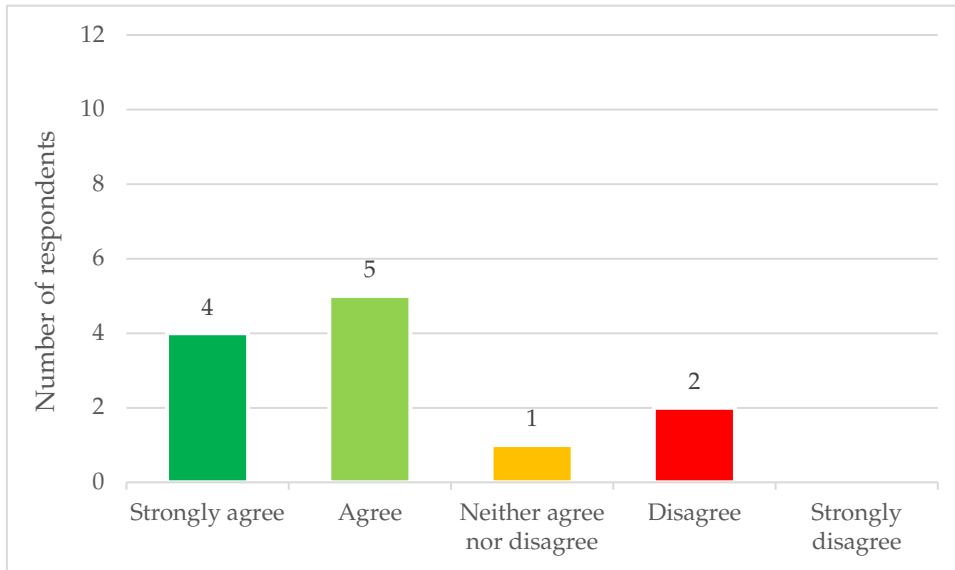


Figure 22– Results for the proposal regarding the Screening stage.

Subsequently, it was proposed to connect several CE strategies and principles to the different impacts of a proposal, with the intention to create an indicators list, see Figure 23, that would allow evaluating the project's performance through a circularity perspective. Analysing the results, 6 surveyees strongly agreed and 3 others agreed this would be a possible pathway to integrate CE topics into the “Scoping” stage. However, 2 of the participants selected the indifferent option, while only 1 disagreed with the suggestion made.

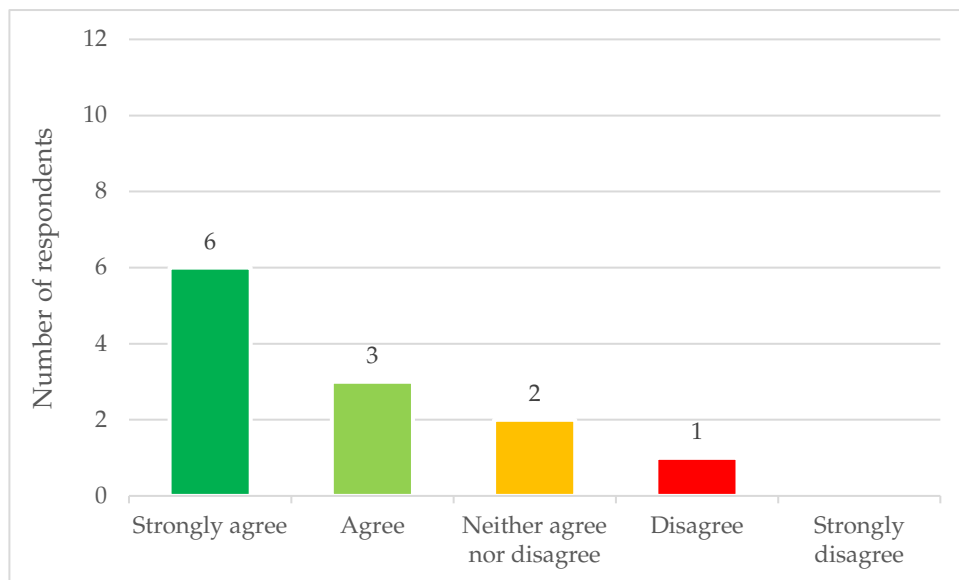


Figure 23 – Results for the proposal regarding the Scoping stage.

At the “Examination of alternatives stage”, see Figure 24, when inquired about evaluating the different alternatives according to their performance and excellence on the CE strategies, principles and indicators, that were identified as suitable in the previous stage, 6 experts pronounced they strongly agreed, and 4 they agreed, with 1 participant returning the “Neither agree nor disagree” option and another 1 who strongly disagreed from the proposal.

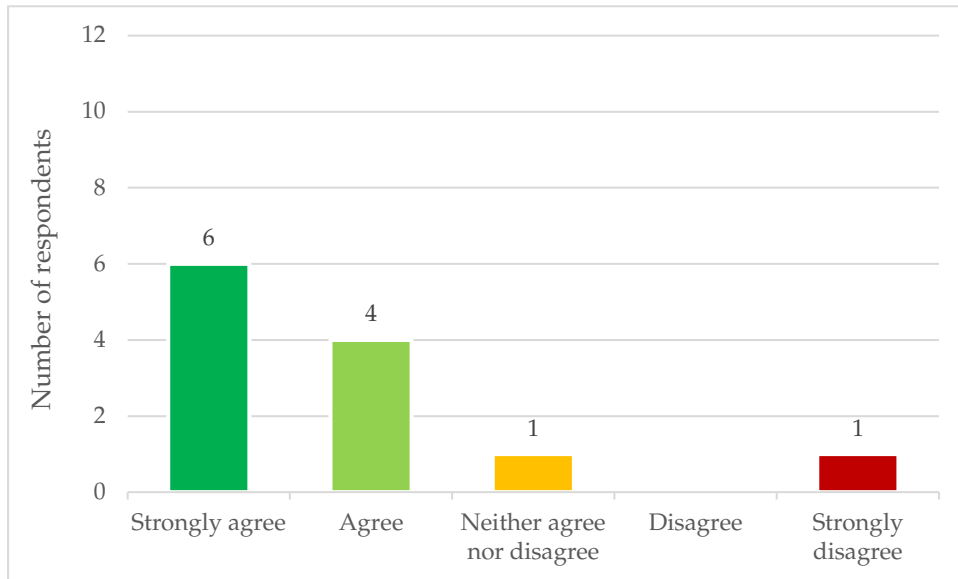


Figure 24 – Results for the proposal regarding the Examination of alternatives stage.

The next proposal was regarding the “Impact Analysis” stage, see Figure 25, where applying CE principles, strategies and indicators would increase the project’s effectiveness, as this approach avoids the loss of natural capital. The results show that the majority of the experts inquired strongly agreed (5 out of 12) and 4 others agreed with the suggestion made, while 2 testees neither agree nor disagree and 1 participant strongly disagreed with the proposal.

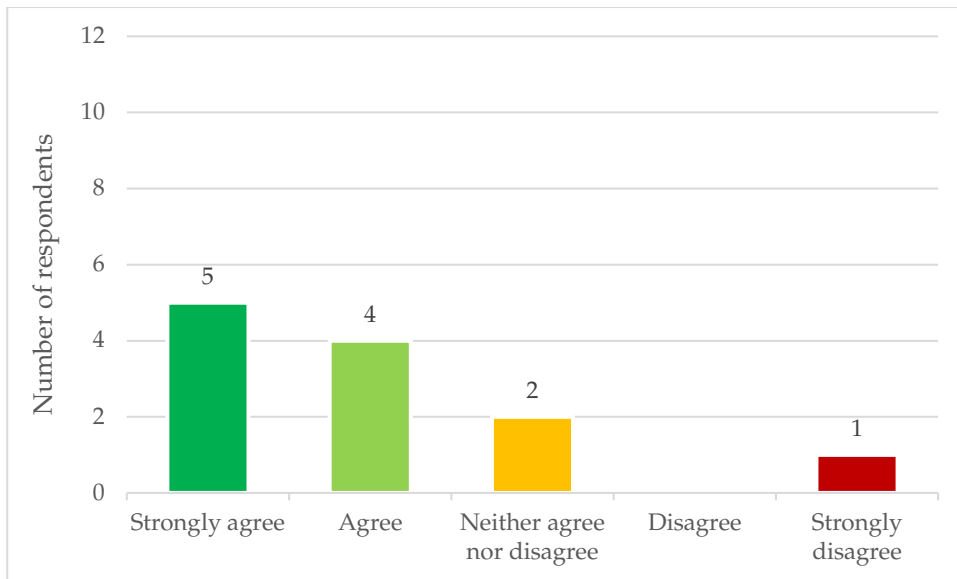


Figure 25 – Results for the proposal regarding the Impact Analysis stage.

For the “Mitigation and Impact Management” stage, see Figure 26, the recommendation made was to leave “end-of-pipe” measures and attempt to avoid impacts as upstream as possible with the assistance of CE approaches. For this proposal, no experts disagreed with the suggestion made, although 3 participants did not provide their judgement, as they selected the “Neither agree nor disagree” option. Nevertheless, 5 surveyees strongly agreed and the other 4 agreed with the recommendation made.

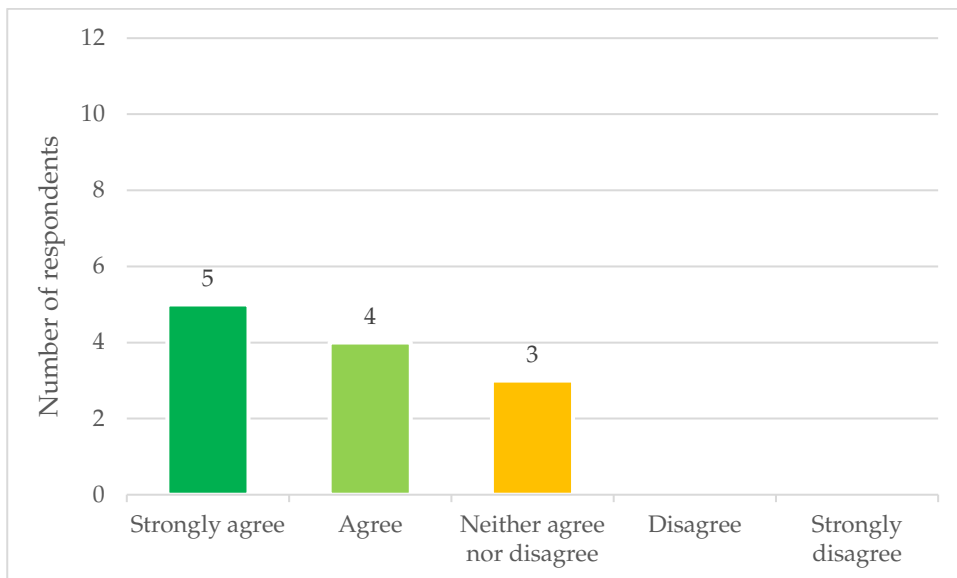


Figure 26 –Results for the proposal regarding the Mitigation and Impact Management stage.

The sixth proposal made was regarding the “Review of the EIS” stage, see Figure 27, whereupon reviewing the report, the CE principles and strategies that were identified as suitable in the first steps of the process should be verified whether they have been met and clearly documented. Stating this, 5 experts strongly agreed, and 4 others agreed with this statement, while 2 participants selected they neither agreed nor disagreed with this suggestion and only 1 respondent marked they disagreed with the recommendation.

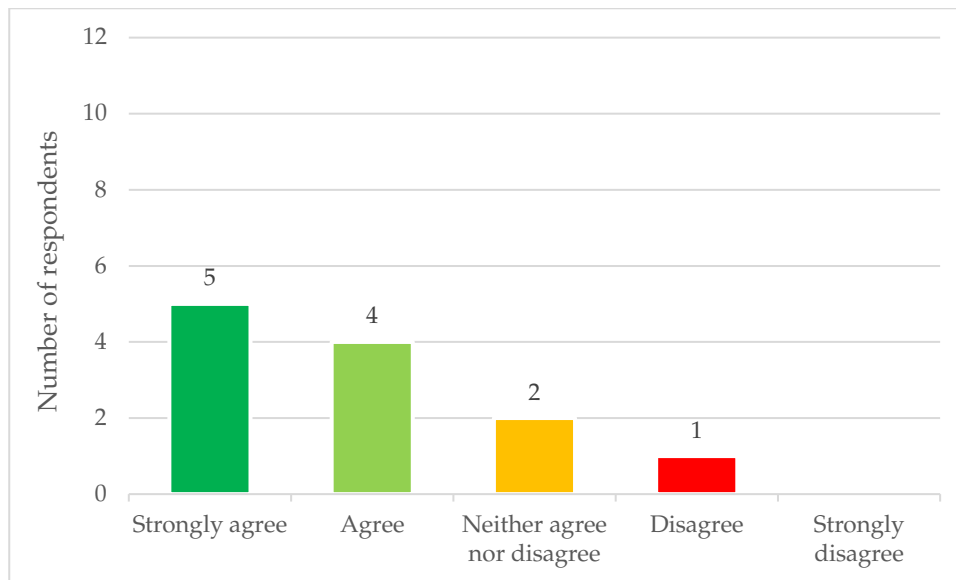


Figure 27 – Results for the proposal regarding the Review of the EIS stage.

This next suggestion concerned the “Decision-Making” stage, see Figure 28, and aimed to evaluate how the CE methodologies and approaches were applied and met, as they should be weighed in the approval or rejection of the proposal. With so, no participants disagreed with this recommendation, and only 1 respondent selected the “Neither agree nor disagree” option. The approving range overshadowed the findings, as 6 experts strongly agreed, and 5 others agreed with the proposal made.

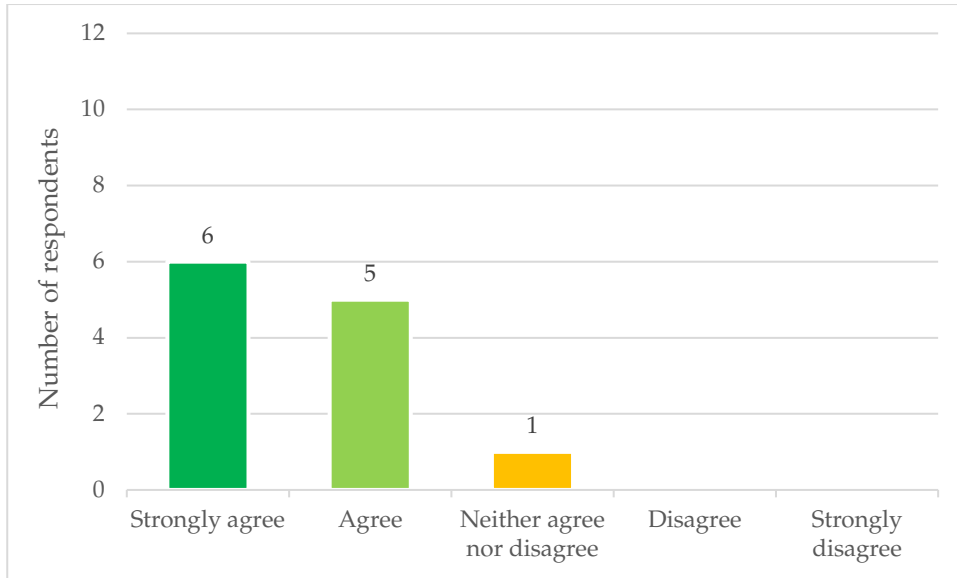


Figure 28 – Results for the proposal regarding the Decision-Making stage.

The last suggestion made regarding the integration of circularity topics into the EIA stages, related to the “Follow-up” phase, see Figure 29, as it aims to apply CE assessments and methods to document and evaluate the progress and performance of a project, identify different connections between impacts and dimensions, so that measures could be proposed effectively, thus increasing the effectiveness of the proposal, as well as to robust the knowledge for future EIA’s success. The results show that although 1 participant disagreed with the suggestion, and another selected the “Neither agree nor disagree” alternative. The majority of the findings are situated in the approving range, as 7 experts agreed and the other 3 strongly agreed that this would be a possible and suitable path to integrate CE and EIA, in this stage.

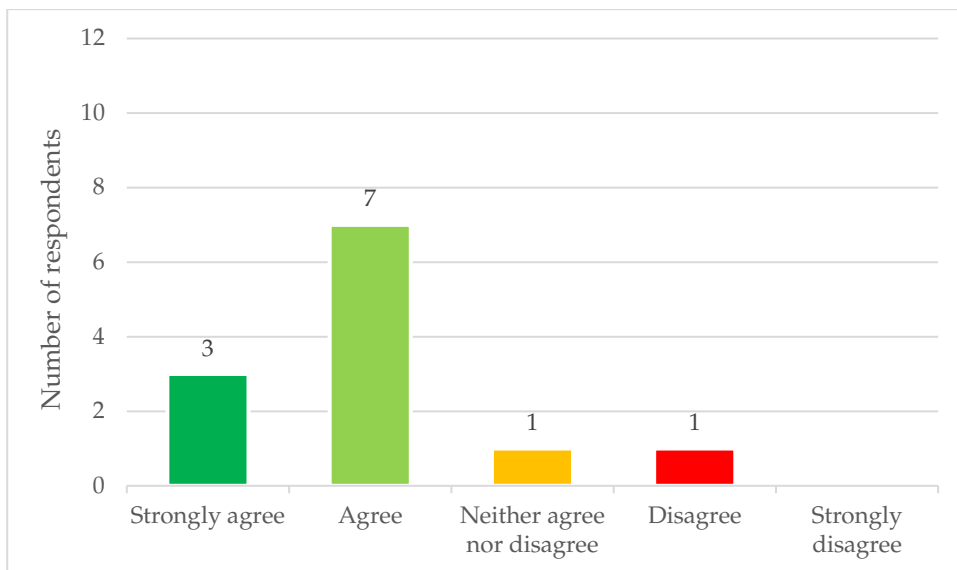


Figure 29 – Results for the proposal regarding the Follow-up stage.

At the end of this subsection, two additional information commentary questions were available and optional to respond to. The first regarded the “Evaluation of Significance” stage, as no proposals were recommended for this step, and the second concerned any additional suggestions of pathways to integrate CE into the EIA stages.

The first question retrieved five commentaries in total, see Table 4.4, however, three of them were returned responses of “Sorry”, “Nil”, and “I do not”. The other two feedbacks mentioned that a review and incorporation of policies related to CE could be performed but integrating these dimensions could be extremely complex due to a variety of elements involved in these fields.

Table 4.4 – Citations of the respondents regarding CE integration into the Evaluation of Significance stage

#	Citation
R2	<i>“Sorry”</i>
R3	<i>“The circular economy in any one city or region is very complex, involving many actors and flows of many types of materials. It is not surprising that aligning this myriad of CE opportunities, relationships, and impacts with elements of EIA can be problematic”</i>
R4	<i>“Nil”</i>
R8	<i>“Review and integration of policies related to CE”</i>
R10	<i>“I do not”</i>

The second question returned 6 comments in total, see Table 4.5, however, three of them were responses of “Nil”, “No”, and “I do not”. The other 3 suggestions comprehended mixed opinions on this matter, as they varied from CE not being a subject that EIA should address, to EIA guidelines requiring revision to include CE principles and strategies, and to state that although EIA should consider CE, this latter one has several issues related with the quantity and reliability of data, which could influence the process.

Table 4.5 – Citations of the respondents regarding CE integration into the EIA stages

#	Citation
R3	<i>“EIA incorporates assessment protocols that may be much more development than measurements of the potential or impacts of the circular economy (CE). My recent work in the CE highlighted an array of problems with data related to material consumption and waste flows. The lack of reliable data on what has happened makes modelling to identify what might happen doubly problematic. So, CE considerations should be included EIA, but methods to reflect the current lack of good data”</i>
R4	<i>“Nil”</i>
R5	<i>“CE is generally not a matter that project EA should be expected to address”</i>
R7	<i>“EIA guidelines at all stages of assessment should be reviewed to address various principles and strategies of CE”</i>

R8	"No"
R10	"I do not"

#### 4.2.5.2. Overcoming EIA barriers through CE integration

Similarly, to the previous subsection, this one aimed to evaluate experts' opinions on the proposals suggested to overcome some of the EIA barriers through the incorporation of circularity topics.

The first recommendation made concerned the practitioner's subjectivity and interpretation, see Figure 30, as a possible pathway to reduce this constraint was by deepening and strengthening the expert's knowledge on CE, so they may apply it to projects correctly and effectively. To this statement, the results show an equal number of responses for the "Strongly agree" and "Agree" alternatives, with 4 out of 12, in addition to 3 participants selecting the indifferent option and 1 testee who disagreed with the proposal.

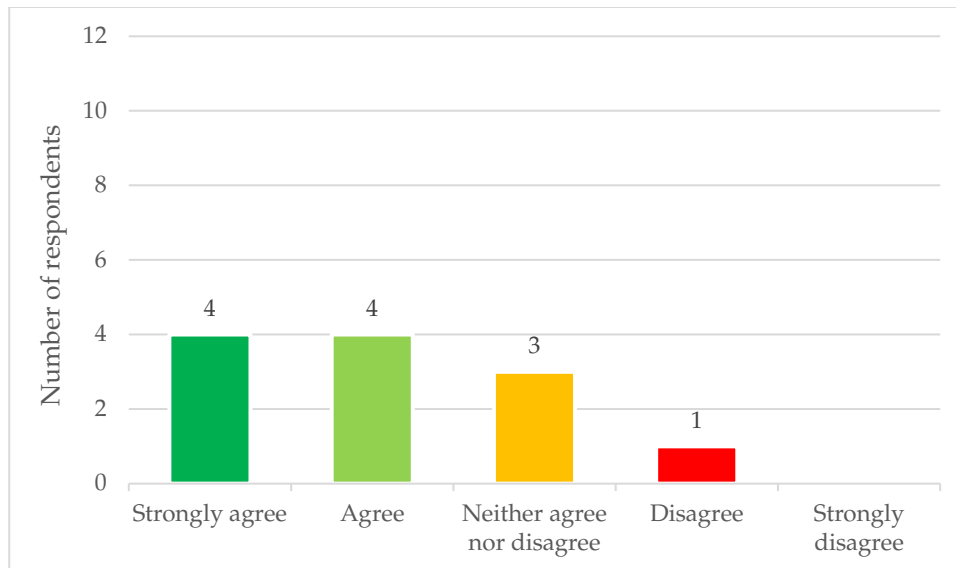


Figure 30 – Results for the proposal regarding the EIA barrier of practitioner's subjectivity and interpretation.

Regarding constraints over screening thresholds and criteria, see Figure 31, defining circularity criteria for different sectors or areas, to build a CE checklist and frameworks, could be a way to decrease this issue. Although no experts strongly disagreed with the proposal, 1 surveyee disagreed and another 1 returned they neither agree nor disagree. Nevertheless, 6 respondents agreed and the other 4 strongly agreed this could be a pathway that would allow overcoming this barrier.

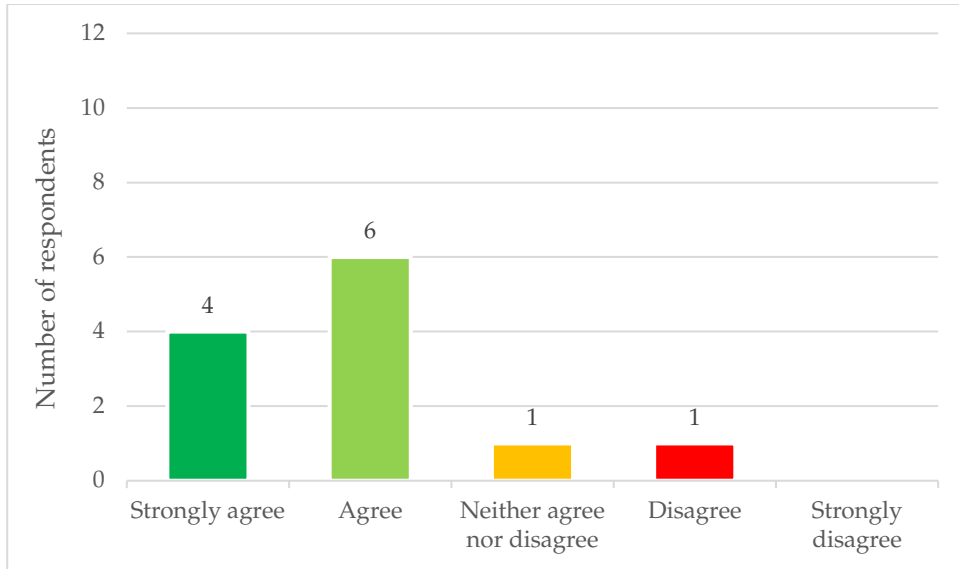


Figure 31 – Results for the proposal regarding the EIA barrier of constraints over screening thresholds and criteria.

By applying the CE methodology to assess and evaluate the performance and progress of projects, see Figure 32, could reduce the constraint of lack of tailored methods. Like so, 7 experts agreed and other 3 agreed with this proposal, while 1 participant neither agreed nor disagreed and only 1 disagreed with the suggestion.

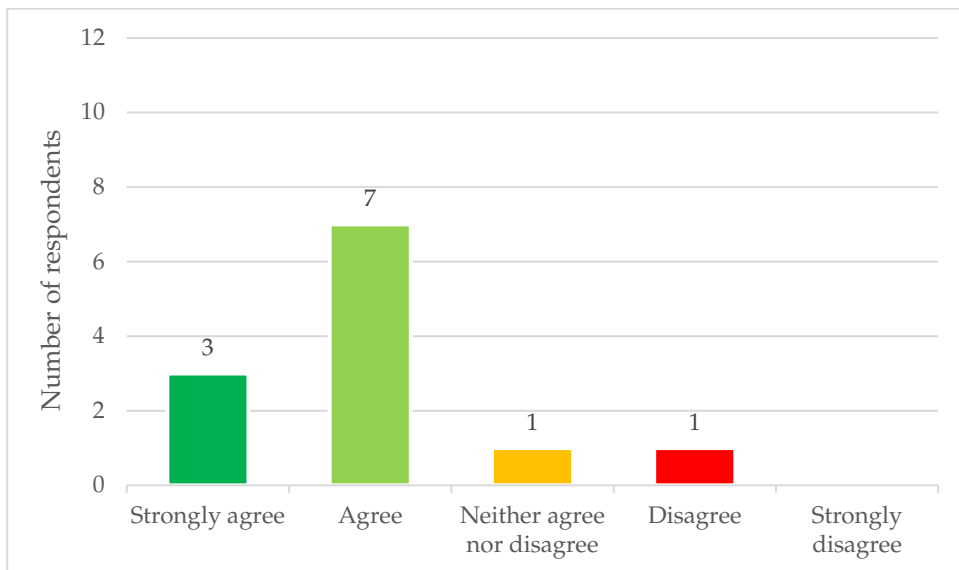


Figure 32 – Results for the proposal regarding the EIA barrier of lack of tailored methods.

Expert judgement is a crucial part of the EIA process, and several uncertainties may arise from this barrier, see Figure 33. Through the application of CE methods and techniques that ensure economic, environmental, and social values, this may be a path to guarantee the project's integrity, decreasing the dependence level in expert judgment. The results for this suggestion show that 1 respondent strongly disagreed and other 2 neither agreed nor disagreed. However, 5 experts strongly agreed and 4 others agreed with this proposal.

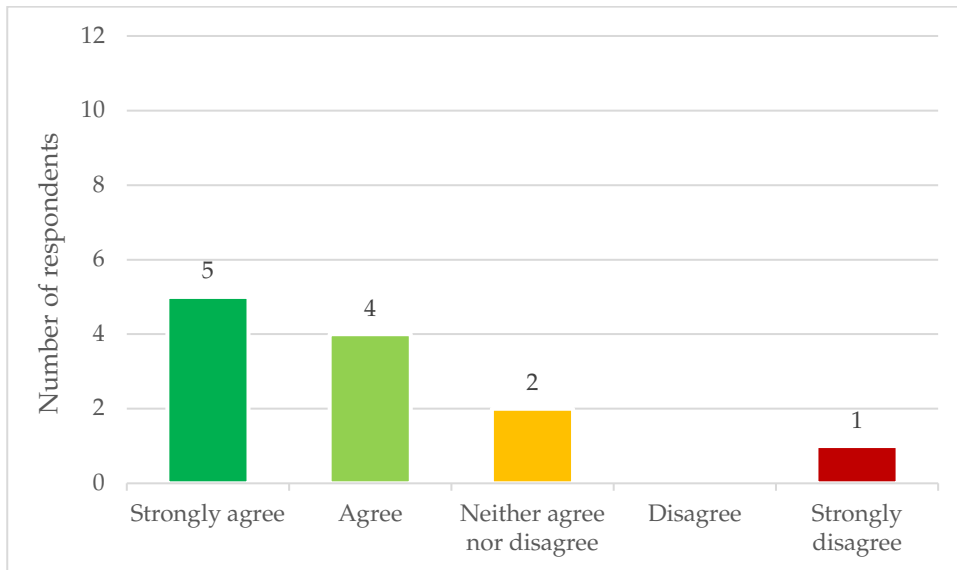


Figure 33 – Results for the proposal regarding the EIA barrier of expert judgement.

The next proposal, see Figure 34, was to encourage the development of CE guidelines and manuals, that comprehended a variety of circular techniques, intending to decrease the barrier of lack of guidelines and manuals, defining lines on when, how, and where to apply them and evaluate them. The findings for this suggestion are fairly similar to the previous one, as the only difference concerned the level of disagreement in the reply of 1 respondent.

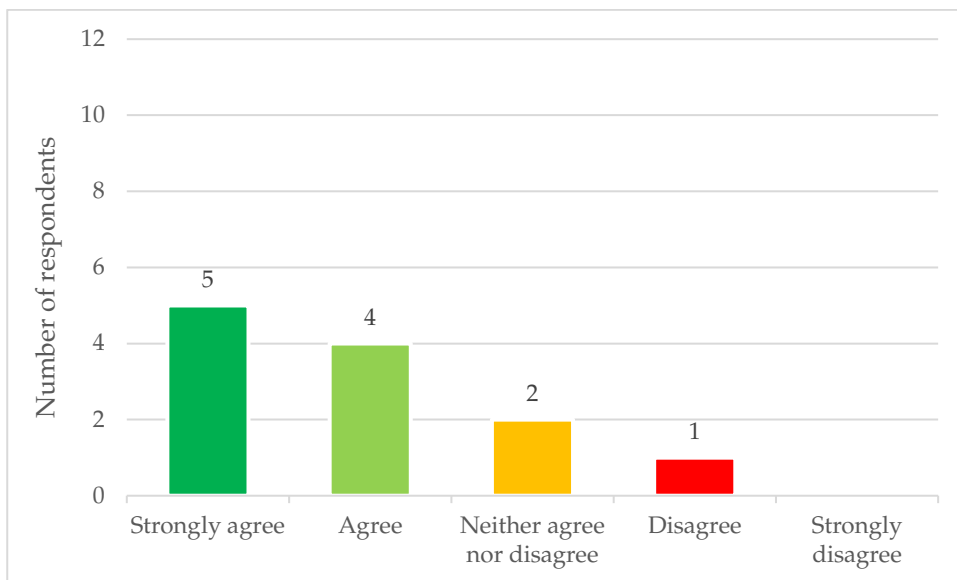


Figure 34 – Results for the proposal regarding the EIA barrier of lack of guidelines and manuals.

Resources are an inherent part of every project or proposal, however, constraints over their quantity or allocation may emerge, see Figure 35. With so, employing circularity methodologies and techniques that allow identifying the critical areas or stages, provides the opportunity to apply resources where they are needed, thus, increasing the effectiveness of their

allocation. The results show that 9 experts agreed with the proposal and other 2 strongly agreed, whereas only 1 participant disagreed with the suggestion.

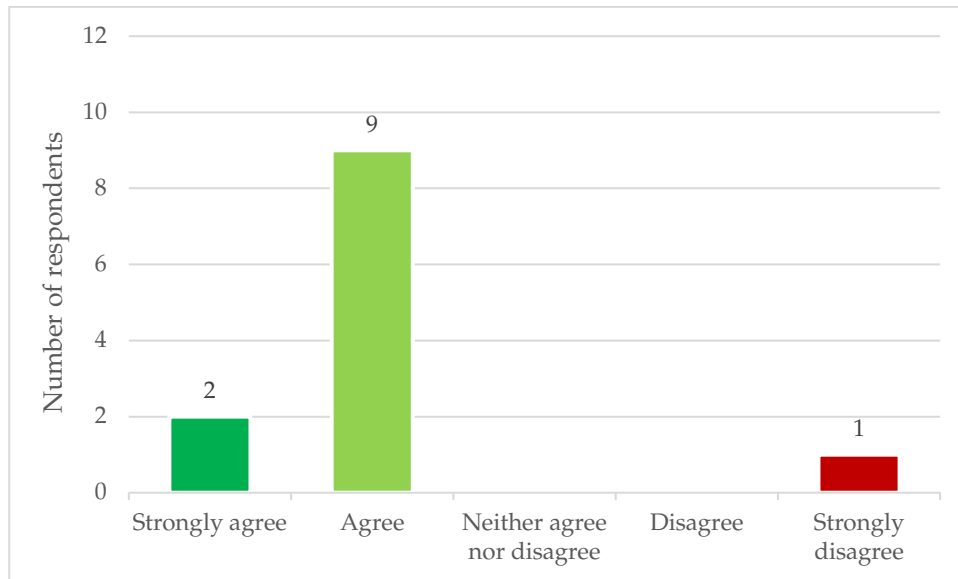


Figure 35 – Results for the proposal regarding the EIA barrier of difficult resource allocation.

When performing an EIA, the majority of impacts are identified at the beginning of the process, which occasionally may be too premature to predict some of the long-term effects, presenting a constraint to the success of the project, see Figure 36. System thinking is a perspective that allows the practitioner to understand a variety of connections between dimensions or topics, which could facilitate this long-term prediction. For this proposal, 6 respondents agreed and other 3 strongly agreed with the suggestion, whereas 2 participants neither agreed nor disagreed and only 1 disagreed.

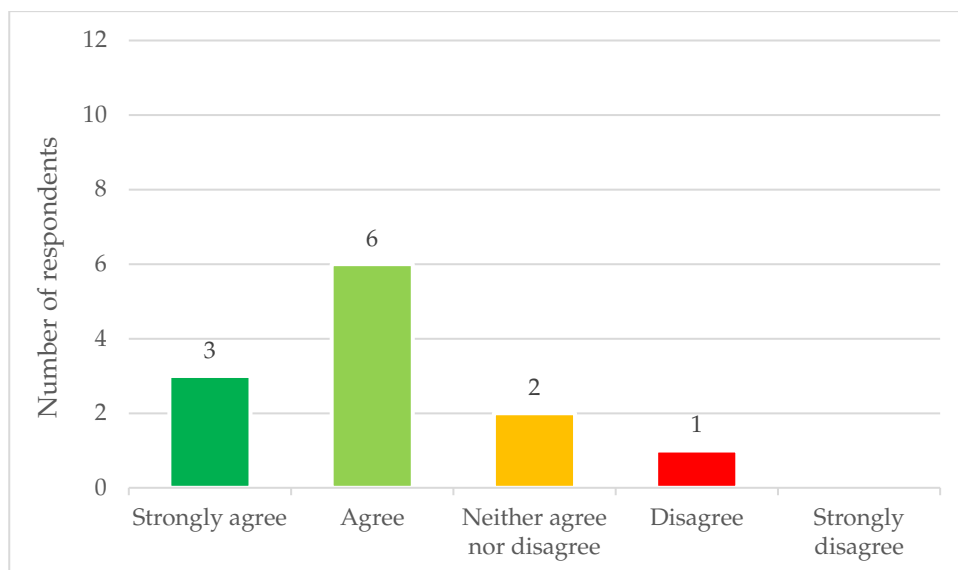


Figure 36 – Results for the proposal regarding the EIA barrier of lack of monitoring data and time frame could be too early to predict long-term effects.

Weak institutional frameworks and legal instruments have been appointed as a constraint to the success and effectiveness of the EIA process, see Figure 37. With so, the suggestion proposed was to include a section for EIAs into CE regulations and instruments that are being developed and institutionalized, taking the process stages and barriers into account, facilitating and encouraging the harmonization and integration of these dimensions. The results show from the 12 respondents who completed the survey, 8 of them agreed with the proposal, while 3 neither agreed nor disagreed and only 1 selected the “Strongly disagree” option.

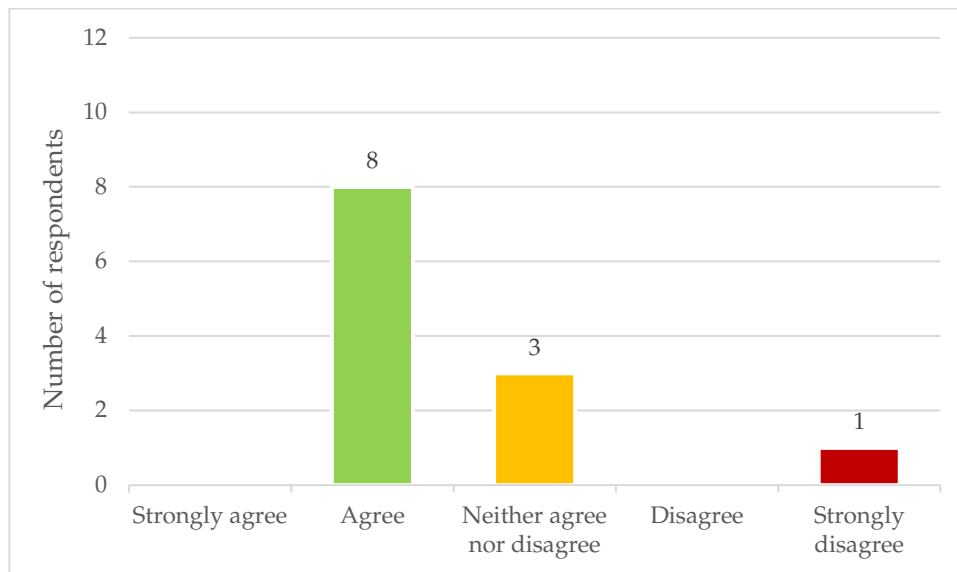


Figure 37 – Results for the proposal regarding the EIA barrier of weak institutional frameworks and legal instruments.

The last proposal developed, see Figure 38, for this subsection regarded the level of uncertainty about legal regulations and guidelines, where a revision of the current ones should be performed or new ones should be developed and circularity topics should be encompassed, with specific orientation on where and how to apply them and evaluate them, to decrease the uncertainty. With so, 10 experts agreed, and another strongly agreed with the recommendation proposed, while only 1 participant disagreed with the suggestion.

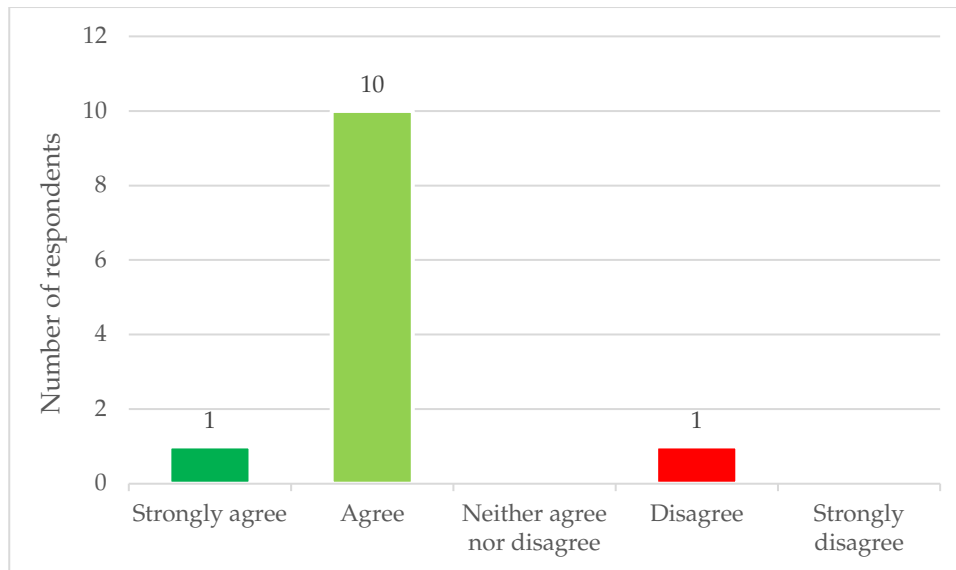


Figure 38 – Results for the proposal regarding the EIA barrier of uncertainty about legal regulations and guidelines.

Similarly to the previous subsection, optional and additional commentary questions were provided at the end to the barriers where no proposals were developed, and one question for any suggestions the respondents might propose to overcome EIA issues through CE integration.

There were seven constraints where no recommendations were provided, respectively, “Time frames and lack of resources”, “Lack of communication/cooperation between actors”, “Roles and responsibilities”, “Review body dependent on the project’s proponent”, “Lack of political will and stakeholder engagement”, “Bureaucratic intervention” and “Lack of transparency and openness of information to the public”. The retrieved comments are displayed in Annex C, however, several responses of “Sorry”, “Nil”, “No” and “I do not” were returned, but have been excluded from the table, as they do not carry any judgement or suggestion and for visualization purposes.

### 4.3. Analysis of the policy documents reviewed

In this section, the aim was to understand if the CE regulations and legal requirements that have been institutionalized embody or consider the EIA dimension or procedures. To accomplish so, the European and Chinese policy documents have been reviewed, through a content analysis, as these two contexts have been the most predominant regarding the implementation of CE.

The table below, see Table 4.6, is an overview of the documents analysed, where a small description of their content is comprehended, as well as the digital platform that they have been gathered from.

The majority of the regulations and legal requirements evaluated did not refer to nor comprehend the EIA procedures. However, in three documents there is a short mention of this topic.

In the Chinese context, only in "The Circular Economy Promotion Law of the People's Republic of China" (National People's Congress, 2008), is stated that all eco-industrial parks, before construction, expansion or modification, have to be subjected to an EIA.

Regarding the European context, the "Guidance Document on Best Practices in the Extractive Waste Management Plans" (European Commission, 2019), mentions that in the elaboration of extractive waste management plans, the risks concerning mining and waste management have to be incorporated. However, in order to obtain a mining license, an EIA is required to obtain such permission. With so, the risks of mining and waste management have already been identified and evaluated, in the environmental assessment necessary to acquire the mining license.

Additionally, the revised legislative framework on waste (European Parliament and the Council of the European Union, 2018), refers that the conditions of a production unit, its immediate environment and the likely effects of the operation have to be subject to an EIA, for new operators that are applying for organic production, and are able to produce more than 20 tonnes of aquaculture per year.

Table 4.6 – Overview of the policy documents reviewed

Context	Policy Document	Description	Available at
European	“Closing the Loop – An EU Action Plan for the Circular Economy” (2015)	This plan defines 54 actions, comprehending the entire life cycle, from production to waste management, including the market for secondary raw materials. These measures aim to stimulate the European transition towards CE, boost competitiveness, foster sustainable economic growth and generate new jobs.	<a href="https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=CELEX:52015DC0614">https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=CELEX:52015DC0614</a>
	Eco-Design Working Plan (2016-2019)	Presents the ongoing work and upcoming reviews of existing product-specific measures, identifies additional groups of products to be further examined, and detail how eco-design will contribute to the circular economy objectives.	<a href="https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=CELEX%3A52016DC0773">https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=CELEX%3A52016DC0773</a>
	Monitoring Framework for the Circular Economy (2018)	Presents a monitoring framework composed of a set of strategic, significant indicators which capture the key aspects of the circular economy.	<a href="https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?qid=1516265440535&amp;uri=COM:2018:29:FIN">https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?qid=1516265440535&amp;uri=COM:2018:29:FIN</a>
	Report on Critical Raw Materials for the Circular Economy (2018)	Supports the implementation of the renewed EU Industrial Policy Strategy, aiming to ensure a coherent and effective approach, provides key data sources, promotes best practices and identifies possible future actions	<a href="https://op.europa.eu/en/publication-detail/-/publication/d1be1b43-e18f-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-80004733">https://op.europa.eu/en/publication-detail/-/publication/d1be1b43-e18f-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-80004733</a>
	Commission Communication on the Plastics Strategy (2018)	This document presents the key commitments for action at the EU level regarding the Plastics Strategy.	<a href="https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?qid=1516265440535&amp;uri=COM:2018:28:FIN">https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?qid=1516265440535&amp;uri=COM:2018:28:FIN</a>
European	Staff Working Document on the Plastics Strategy (2018)	Outlines the opportunities and challenges on plastics and goes into the envisaged measures to tackle environmental leakage, the economics of recycling and explores the international dimension.	<a href="https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=SWD%3A2018%3A16%3AFIN">https://eur-lex.europa.eu/legal-con-tent/EN/TXT/?uri=SWD%3A2018%3A16%3AFIN</a>
	Staff Working Document on the implementation of the Cir-	Identifies the pertinent issues at the interface between chemical, products and waste legislation, largely supported by the responses from the interested parties to the targeted consultation and proposes options on the way forward.	<a href="https://eur-lex.europa.eu/legal-con-tent/en/TXT/?uri=CELEX:52018SC0020">https://eur-lex.europa.eu/legal-con-tent/en/TXT/?uri=CELEX:52018SC0020</a>

	cular Economy Package: Options to address the interface between chemical, product and waste legislation (2018)		
	Revised Legislative Framework on Waste (L 150, 14 June 2018) (2018)	Entails the different revisions made on the regulations and directives concerning the waste dimension.	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2018:150:TOC">https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2018:150:TOC</a>
	Report on the implementation of the Circular Economy Action Plan (2019)	This report presents the main results of implementing the action plan. It also sketches out future challenges to shaping the EU economy and continuing to create a competitive advantage, paving the way towards a climate-neutral economy.	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1551871195772&amp;uri=CELEX:52019DC0190">https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1551871195772&amp;uri=CELEX:52019DC0190</a>
	Guidance and promotion of Best Practices in the Mining Waste Management Plans (2019)	Study to support the identification of such best practices that contribute to a Circular Economy in EWMPs. This document is the first deliverable of this study, the guidance document focusing on: The prevention or reduction of extractive waste production and its harmfulness; The recovery of extractive waste employing recycling, reusing or reclaiming such waste.	<a href="https://ec.europa.eu/environment/pdf/waste/mining/guidance_extractive_waste.pdf">https://ec.europa.eu/environment/pdf/waste/mining/guidance_extractive_waste.pdf</a>
	Accelerating the transition to a Circular Economy – Improving Access to Finance for Circular Economy Projects (2019)	This paper presents the summary of the discussions in the expert group and proposes three sets of recommendations that, if implemented, should together provide a framework that significantly improves access to finance for circular economy projects.	<a href="https://ec.europa.eu/info/publications/accelerating-transition-circular-economy_en">https://ec.europa.eu/info/publications/accelerating-transition-circular-economy_en</a>
European	Revised Fertilizers Regulation (EU) 2019/1009 (2019)	Lays down the rules on the making available on the market of EU fertilizers products.	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1009">https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1009</a>

	Directive (EU) 2019/904 on single-use plastics	This Directive promotes circular approaches that give priority to sustainable and non-toxic re-usable products and re-use systems rather than to single-use products, aiming first and foremost to reduce the quantity of waste generated.	<a href="https://eur-lex.europa.eu/eli/dir/2019/904/oj">https://eur-lex.europa.eu/eli/dir/2019/904/oj</a>
	The European Green Deal (2019)	Presents a new growth strategy that intends to transform the EU into a fair and prosperous society, with a resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts.	<a href="https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691">https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691</a>
	A New CE Action Plan for a cleaner and more competitive Europe (2020)	The plan presents a set of interrelated initiatives to establish a strong and coherent product policy framework that will make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place.	<a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&amp;uri=COM:2020:98:FIN">https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&amp;uri=COM:2020:98:FIN</a>
Chinese	The Circular Economy Promotion Law of the People's Republic of China (2008)	The Law is formulated to facilitate a circular economy, raise resources utilization rates, protect and improve the environment and realize sustained development.	<a href="https://ppp.worldbank.org/public-private-partnership/library/china-circular-economy-promotion-law">https://ppp.worldbank.org/public-private-partnership/library/china-circular-economy-promotion-law</a>
	The 12 <sup>th</sup> Five-Year Plan (2011-2015)	Provides the overall objectives and goals related to rebalancing the economy, ameliorating social inequality and protecting the environment.	<a href="https://www.greengrowthknowledge.org/national-documents/12th-five-year-plan-economic-and-social-development-peoples-republic-china">https://www.greengrowthknowledge.org/national-documents/12th-five-year-plan-economic-and-social-development-peoples-republic-china</a>
	The 13 <sup>th</sup> Five-Year Plan (2016-2020)	The 13 <sup>th</sup> Five-Year Plan sets forth China's strategic intentions and defines its major objectives, tasks, and measures for economic and social development.	<a href="https://www.greengrowthknowledge.org/national-documents/13th-five-year-plan-economic-and-social-development-peoples-republic-china">https://www.greengrowthknowledge.org/national-documents/13th-five-year-plan-economic-and-social-development-peoples-republic-china</a>
	The 14 <sup>th</sup> Five-Year Plan (2021-2025)	Clarifies the Chinese national strategic intentions, makes clear the focus of government work, and guide and standardize the behaviour of market entities.	<a href="https://cset.georgetown.edu/wp-content/uploads/t0284_14th_Five_Year_Plan_EN.pdf">https://cset.georgetown.edu/wp-content/uploads/t0284_14th_Five_Year_Plan_EN.pdf</a>

#### 4.4. Triangulation and integration of research results and findings

The questionnaire results have been triangulated with "The Circular Economy and Impact Assessment - A primer", by Fothergill & Murphy (2020) and with the policy documents mentioned in Table 4.6.

The results of the survey show the majority of the experts inquired are familiar with the circularity notion. However, a significant number of respondents selected the "Neither agree nor disagree" alternative, when queried about their level of acquaintance with the CE concept.

These findings may indicate that the surveyees may not feel confident in their understanding of the CE topic, as not knowing the depth of the questions on the matter, may have pulled them away from the "Agree" and "Strongly disagree" alternatives. Another possibility could be the level of indifference and interest regarding this field, as the respondents may have not been aware of the opportunity and benefits of harmonising these dimensions.

The responses retrieved are in line with the survey conducted by Fothergill & Murphy (2020) where a significant proportion of practitioners stated they were familiar with the CE concept, as a fair percentage feels confident in describing this concept and its importance to colleagues and clients. However, they are less confident on how to incorporate CE in practice. Additionally, the level of interest among IA professionals on the circular economy appears to be "some" to "moderate".

Nevertheless, contemplating the feedback returned on the question about the relevancy of a framework integrating the CE and EIA fields, it appears to be a significant level of acceptance and interest regarding the development of such a model.

The circular economy concept has been acknowledged as a path to achieve sustainable development, coordinating, and comprehending the three pillars of sustainability, the economic, environmental and social dimensions (Kirchherr et al., 2017; Smol et al., 2017; Yuan et al., 2008).

One of the purposes of this notion is promoting and ensuring environmental protection, which has been stated in several policy documents such as "The European Green Deal" (European Commission, 2019), "The Circular Economy Promotion Law of the People's Republic of China"(National People's Congress, 2008), and the "China's 14th Five-Year Plan" for 2021-2025 (National People's Congress, 2021).

In concordance with this goal, stands one of the objectives of the EIA process, where this procedure also encourages and contributes to sustainable development (Cashmore, 2004; Cashmore et al., 2004; Sadler, 1996), in addition to enhancing and safeguarding environmental protection (Cilliers et al., 2020; Jay et al., 2007; Loomis & Dziedzic, 2018; Roos et al., 2020).

Stating this, the objectives of both these fields seem to align with one another, as suggested by Fothergill & Murphy (2020), and also stressed by a respondent of the survey, see Table 4.3.

Also conforming with this statement are the results of the integration of the CE principles and strategies into the EIA process, as the consenting responses, which stand as the selection of the "Agree" and "Strongly agree" alternatives, always surpassed the disapproving feedback.

Although variations were identified between different principles and strategies regarding their incorporation into the different stages, as not all principles and strategies are viable or useful to be implemented at every step of the process, requiring a certain level of judgement on where, how, and why to apply them, in order to benefit from the use of circularity.

However, the principles of "Increased share of renewable and recyclable resources and energy" and "Reduced emissions" presented as the ones with the highest number of "Agree" and "Strongly agree" retrieved responses, while the principle of "Keeping the value of products, components and materials" reported the higher number of disagreeable replies.

Regarding the strategies, the ones with the highest number of agreeable responses were the "Repair, refurbish and re-manufacture" and the "Eco-Innovation". The strategies "New business models" and "Enablers and favourable conditions" retrieved the highest number of "Disagree" and "Strongly disagree" responses. However, the "Enablers and favourable conditions" also presented a significantly high number of consenting replies.

Concerning the practices suggested to incorporate CE into the EIA stages, the proposal of "Broaden the project's scale and connect proposals with other businesses/ sectors" displayed the highest number of disagreeable responses, while the proposal of "Evaluate how the CE approaches were used and met, weighing them in the proposal's approval or rejection" exhibited the highest number of agreeable reactions.

Considering the circular practices proposed to overcome some of the EIA barriers, all of the proposals returned the same number of disagreeable responses. However, the proposals of "Use CE methods to pinpoint critical areas/stages, in order to increase the efficiency of the resource allocation" and "Develop legal guidelines with CE topics, specifying how/where to apply and evaluate them" demonstrated the higher number of "Agree" and "Strongly agree" selected replies.

Nonetheless, the findings demonstrate that these values and actions may be considered appropriate ideals and practices to be harmonized into the EIA process.

Additionally, reinforcing this point, Fothergill & Murphy (2020), state that the set of abilities and qualifications required to be an effective IA professional coordinates with the principles and values that CE comprehends.

However, the majority of CE policy documents reviewed do not embody the EIA field, except the "The Circular Economy Promotion Law of the People's Republic of China" (National People's Congress, 2008), where it is mentioned that eco-industrial parks are required to be subject of EIA, before construction, expansion, or modification.

In the European context, a "Guidance Document on Best Practices in the Extractive Waste Management Plans" (European Commission, 2019), which is under the Final Circular Economy Package, mentions that for the development of these plans, the mining and waste management risks should be incorporated in these documents, however, they have already been identified and assessed in the required EIA to obtain the mining license.

Additionally, the revised legislative framework on waste, (European Parliament and the Council of the European Union, 2018), states that an environmental assessment is required for any new operators applying for organic production and producing more than 20 tonnes of aquaculture per year to ascertain the conditions of the production unit, its immediate environment and likely effects of the operation. The content of such analysis should comply with Annex IV of the Directive 2011/92/EU.

As so, the circular economy policy documents that are or have been institutionalized do not address circularity aspects related to the EIA process. As stressed by Yijun & Ying (2011), and also by a questionnaire respondent, see Table 4.5, subjects regarding CE should be incorporated in the development and revision process of the EIA guidelines.

Regarding the different pathways proposed to integrate CE into the EIA stages and to overcome several barriers, the reactions to the suggestions made were significantly approving, as the response feedback was majorly established in the consenting range.

As stated by Morgan (2012), the stages of Screening, Scoping and Impact Analysis stand as some of the steps where practitioners identify the majority of practice problems. Since the CE goals appear to align with the EIA purposes, the incorporation of these fields presents an opportunity to update and enhance a variety of EIA practices and procedures, by applying new and improved methods, based on the circularity notion, thus, exhibiting the potential to suppress or overcome some of these barriers.

Additionally, the proposals were intended to increase the best practice and performance in a diversity of areas, using the circular approach as a technique to increase the effectiveness and success of the process.

Recommendations such as broadening the project's scale, applying systems thinking, connecting project's to other businesses/sectors, application of methodologies to pinpoint critical areas, develop manuals and guidelines that harmonize CE and EIA are practices that have been reinforced by several authors such as Bice (2020), Fothergill & Murphy (2020) and Yijun & Ying (2011). The responses of the questionnaire conducted regarding these suggestions were mostly positive, however, due to the low response rate, a further and deeper study on the expert's opinions would be required to assess and strengthen the validity of these proposals.

As one of the respondents stressed, see Table 4.5, there are some issues concerning the availability and reliability of CE data. Policy documents such as "A new Circular Economy Action Plan for a Cleaner and More Competitive Europe" (European Commission, 2020) and the "China's 14th Five-Year Plan" for 2021-2025 (National People's Congress, 2021), state the development of circularity indicators for a diversity of areas. In addition, the Chinese National Development and Reform Commission (NDRC) has proposed, in 2007, a list of CE indicators for the macro and meso-level, where some of them may be applied at the project level, in order to combat the metric scarcity in the CE field (Geng et al., 2012).

As the acceptance of the application of the CE concepts continues to increase, new and enhanced metrics and methodologies will be conceptualized and improved. As so, IA professionals should be aware of the development of such techniques, as well as their suitability and viability of implementation into the EIA process.

Additionally, it is important to stress and reinforce that in the development of CE assessment methods, manuals, guidelines, institutional and legal regulations, the EIA field should be considered.

Further adding, the circular economy impacts in the environment, economy, and society, as well as the contribution of this concept to sustainable development, are still being deliberated and examined. Although CE procedures do not categorically mean or lead to a more sustainable development (Blum et al., 2020), this notion has a strong potential to drive society towards such a path (Velenturf & Purnell, 2021).

With this research being on the first approaches connecting these two fields, the intention was not to transpire that linking CE and EIA would automatically drive society to sustainability. However, as both these subjects share some of the same values, goals and ideals, their integration and harmonization may catalyse each other's developments, allowing them to benefit from one another, being a forward step into a sustainable direction.

## CONCLUSIONS

This research analysed the connection between Circular Economy (CE) and Environmental Impact Assessment (EIA), with the aim to propose a variety of circularity practices that presented suitable to be incorporated into the EIA process, culminating in a conceptual model that would merge these two fields.

The model displays both CE and EIA dimensions and their focal points, in addition to how they are connected with one another. These two fields are powered by a diversity of actors, who represent the active agents of change, with the ability to execute and transform the processes in these topics and to communicate change across several chains.

In addition, this framework is accompanied by several practice proposals, regarding the steps involved in the EIA procedures, such as connecting CE strategies/principles to the proposal's impacts, creating a CE indicators list, and suggestions to overcome some of the constraints of the EIA process, for example, use CE methods to pinpoint critical areas/stages, in order to increase the efficiency of the resource allocation.

The harmonization of these subjects presents an opportunity with the potential to advance the progress of both CE and EIA. Attempting to evaluate the potential of such opportunity, the conceptual model and proposed practices were evaluated through a questionnaire that intended to probe experts' opinions on the integration of these fields.

Due to the low response rate, the survey sample does not represent the EIA professional's universe, and for that, no great generalizations can be made. Nevertheless, the level of professional experience of the respondents provides a boost of confidence in the results retrieved, and even though the response level was lower than expected, that does not imply the bias of the findings (Rogelberg et al., 2007).

However, despite the low response level, the reactions retrieved were substantially positive, exhibiting the potential of merging these subjects.

By creating a synergic relationship, where they can benefit from one another's strengths, while at the same time cutting back on their constraints, contributes to promoting the transition towards CE and the enhancement of the effectiveness of the EIA (Yijun & Ying, 2011).

The acknowledgement that CE is not a "magic wand" that will drive society unequivocally towards sustainability and resolve all EIA's barriers is assumed, in addition to being an approach that only recently has been put to practice and is still undergoing examination and development.

Nevertheless, it represents a broad and adaptive concept that could be applied at several levels in a diversity of contexts, presenting the opportunity to be suitable and appropriate to be integrated into the EIA procedures.

This research introduces an exploratory study on the subject, intending to delve and collect information on the matter, as this topic represents a distinctive and unexplored theme. With so, this thesis is displayed as one of the first approaches contemplating the incorporation of CE and EIA.

Being a probing and exploratory research implies that there is an extended range for improvement and future developments to be accomplished. Thus, the connection between these two realms should be deepened analysed, reinforcing the common ground they both share.

With so, an extended and ameliorated study on experts' opinions should be performed, with a better representation of the EIA's professional universe, as this point represented our biggest weakness.

Furthermore, an improvement of the proposals conceived, as well as the development of new and improved ones should be accomplished, so that the harmonization of CE and EIA may reach its full potential, and actively contribute to enhancing these fields developments.

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## A. Questionnaire |

**“Development of impact assessment practices to help enable circular economy progress”****Participant information sheet and consent**

This questionnaire is under the scope of the Master Thesis “Development of impact assessment practices to help enable circular economy progress” (working title) being developed by Mariana Rato from the Master Programme in Environmental Engineering (NOVA School of Sciences and Technology, NOVA University of Lisbon, Portugal) and supervised by Tomás B. Ramos (NOVA University of Lisbon, Portugal), Alexandra Polido (University of Aveiro, Portugal) and Hinrika Droege (NOVA University of Lisbon, Portugal). It aims to evaluate the connection between Environmental Impact Assessment (EIA) and CE.

The questionnaire respects the respondents' privacy rules, ensuring the security and confidentiality of the information collected, in strict compliance with the General Regulation on Data Protection (GRDP). The data are the responsibility of the MSc student, Mariana Rato.

The questionnaire is anonymous but there is some personal information collected, specifically, age, gender, level of education, role in EIA, years of experience in EIA, number of EIAs involved and country of activity. This information is necessary to characterize the respondents. The data will be used in an aggregated form, never explicitly identifying the respondents.

The results of the survey will be used to conduct research for a Master's thesis and subsequent publication in a peer-reviewed scientific journal. Best practice indicates that in the case of publication in a peer-reviewed journal, data should be retained for 5 years after publication.

The data will not be shared with other entities or with third countries.

Your participation is voluntary, and you may withdraw from the questionnaire at any time, as well as request the cancellation of the data already provided. For this purpose, you only need to send an email to the responsible for the data (mv.rato@campus.fct.unl.pt).

Access to and processing of the data is authorised only for the MSc student (Mariana Rato) and supervisors, according to the purpose of the project.

All respondents have the right to access their personal data and to receive information about the processing of such data; to rectify inaccuracies about their personal data during the period of the data collection; to delete their personal data; and to lodge a complaint with a Supervisory Authority. These rights can be exercised by emailing the responsible for the data (mv.rato@campus.fct.unl.pt).

This survey is expected to take about **25 to 30 minutes** of your time, by providing your opinion based on your expertise. There are no right or wrong answers.

If you have any questions, please do not hesitate to contact **Mariana Rato** ([mv.rato@campus.fct.unl.pt](mailto:mv.rato@campus.fct.unl.pt)).

**I have understood the aims and purposes of the study and of this questionnaire, as well as of the way how the data collected are processed and I agree to participate in this questionnaire.**

- Yes, I agree
- No, I do not agree

## Welcome!

Thank you for agreeing to participate in this survey on the development of impact assessment practices to help enable circular economy progress. We appreciate your insights.

This survey was developed for researchers, practitioners and decision-makers in the field of impact assessment, specifically Environmental Impact Assessment (EIA).

**You are free to withdraw at any point.**

### 1. Circular Economy Background information

This section consists of questions about Circular Economy (CE) to understand the overall opinions of the respondents on the subject using a scale from **1 (Strongly disagree)** to **5 (Strongly agree)**.

There are no right or wrong answers, so we kindly ask you to answer all questions truthfully.

Assuming the CE concept as:

*“An economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.” (Kirchherr et al., 2017)*

#### 1.1. Please provide your opinion about the following sentences:

	1 Strongly disagree	2	3	4	5 Strongly agree
1.1.1. I am familiarized with the CE concept	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1.1.2. CE is a good approach to assess the impacts of project EIA	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.3. CE is a good approach to mitigate the impacts of project EIA	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.4. I consider relevant a structure/framework that allows me to integrate the CE approaches into the EIA process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1.2 If you answered 1 (Strongly disagree) or 2 (Disagree), in the previous question, please give us a brief explanation of your response.

## 2. CE Principles and their integration in the EIA process

This section aims to understand your opinion about where, in the EIA process, you would integrate different CE principles, using a scale from 1 (Strongly disagree) to 5 (Strongly agree). The principles used to develop this survey were based on “Circular Economy in Europe – Developing the Knowledge Base” (European Environment Agency (EEA), 2016).

Please choose the answer that expresses your thoughts the most accurately.

**2.1. The CE Principle 1: Less Input/use of natural resources** should be integrated into: *This principle implies the minimization and optimization of the exploitation of raw materials while providing more value from fewer materials, by reducing the import dependency on natural resources and by using them efficiently.*

	1 Strongly disagree	2	3	4	5 Strongly agree
2.1.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2.1.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.7. Review of the EIS <sup>2</sup>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.1.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 2.2. The CE Principle 2: Increased share of renewable/recyclable resources and energy should be integrated into:

*This principle refers to the replacement of non-renewable resources for renewable ones, within sustainable levels of supply, replace the share of virgin materials for recycled and recyclable ones, by closing the material loops and sustainably sourcing the raw ones.*

	1 Strongly disagree	2	3	4	5 Strongly agree
2.2.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<sup>2</sup> The Environmental Impact Statement (EIS) was assumed as the report where the impacts of the proposal are clearly and impartially documented, as well as the significance of those impacts, the mitigation measures and the concerns of the public and affected communities by the proposal.

**2.3. The CE Principle 3: Reduced emissions** should be integrated into:

*This principle involves the reduction of emissions within the entire material cycle by sustainable sourcing and decreasing the use of raw materials, as well as decreasing the levels of pollution by using clean material cycles.*

	1 Strongly disagree	2	3	4	5 Strongly agree
2.3.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**2.4. The CE Principle 4: Fewer material losses/residuals** should be integrated into:  
*This principle means keeping the incineration and landfill to a minimum and minimizing the waste build-up and the dissipative losses of valuable resources.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
2.4.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.3. Exami- nation of al- ternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.5. Mitiga- tion of impact and manage- ment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.6. Evalua- tion of signifi- cance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.8. Decision- Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**2.5. The CE Principle 5: Keeping the value of products, components, and materials in the economy should be integrated into:**

*This principle implies the extension of the lifetime of products by keeping them in use and by reusing their components and preserving the value of materials in the economy by high-quality recycling.*

	1 Strongly disagree	2	3	4	5 Strongly agree
2.5.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 3. CE Strategies/Approaches and their integration in the EIA process

This section aims to understand your opinion about where in the EIA process you would integrate different CE strategies, using a scale from 1 (**Strongly disagree**) and 5 (**Strongly agree**). The strategies/approaches used to develop this survey were based on “Circular Economy in Europe – Developing the Knowledge Base”(European Environment Agency (EEA), 2016).

Please choose the answer that expresses your thoughts the most accurately.

#### 3.1. The CE Strategy 1: Eco-Design/Circular Design should be integrated into:

*In this strategy, the products are designed based on sustainable and minimum use of natural resources, facilitating high-quality recycling of the materials at the end of a products life. They are also designed for a longer lifetime, promoting their upgrade, reuse, refurbishment and re-manufacture and by substituting the hazardous substances in their components and processes to enable cleaner material cycles.*

	1 Strongly disagree	2	3	4	5 Strongly agree
3.1.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.1.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.2. The CE Strategy 2: New Business Models** should be integrated into:

*This strategy focuses on offering product services instead of products ownership, collaborative consumption, and industrial symbiosis, where there is a collaboration between companies/sectors thus the waste or by-products of one become materials for another.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
3.2.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.3. Exami- nation of al- ternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.5. Mitiga- tion of impact and manage- ment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.6. Evalua- tion of signifi- cance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.8. Decision- Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.3. The CE strategy 3: Repair, Refurbishment and Re-manufacture** should be integrated into:

*In this strategy, it is given priority to the repair, refurbishment and re-manufacture of products, components, and materials.*

	1 Strongly disagree	2	3	4	5 Strongly agree
3.3.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.4. The CE Strategy 4: Recycling** should be integrated into:

*This strategy directs to high-quality recycling of much waste as possible avoiding down-cycling (converting waste materials/products into new materials or products of less quality), using recycled materials as secondary raw materials, a strong market for secondary raw materials, avoidance of mixing and contaminating materials.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
3.4.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 3.5. The CE Strategy 5: Eco-innovation should be integrated into:

*This strategy refers to facilitating and encouraging technical, social, and organisational innovation.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
3.5.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.3. Exami- nation of al- ternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.5. Mitiga- tion of impact and manage- ment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.6. Evalua- tion of signifi- cance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.8. Decision- Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.6. The CE Strategy 6: Governance, Skills and Knowledge should be integrated into:**

*This strategy refers to raising awareness about changing lifestyles and consumption patterns, participation, stakeholder interaction and experience, data, monitoring, guidelines, and indicators.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
3.6.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.7. The CE Strategy 7: Economic incentives and finances should be integrated into:**

*This strategy focuses on shifting taxes from labour to natural resources and pollution, phasing out environmentally harmful subsidies, internalisation of environmental costs, extended producer responsibility, and enabling finance mechanisms supporting circular economy approaches.*

	1 Strongly disagree	2	3	4	5 Strongly agree
3.7.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.7.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.8. The CE Strategy 8: Reverse Cycles should be integrated into:**

*This strategy implies the skills for cascades and the final return of materials to the soil or back into the industrial production system including the delivery chain logistic, power generation, risk management, warehousing, sorting, molecular biology, and polymer chemistry.*

	1 Strongly dis- agree	2	3	4	5 Strongly agree
3.8.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.3. Exami- nation of al- ternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.5. Mitiga- tion of impact and manage- ment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.6. Evalua- tion of signifi- cance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.8. Decision- Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.8.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.9. The CE Strategy 9: Enablers and favourable conditions should be integrated into:**

*This strategy includes access to financing, supplying a suitable set of international environmental rules, leading by example and driving upscale, collaboration, and rethinking incentives.*

	1 Strongly disagree	2	3	4	5 Strongly agree
3.9.1. Screening	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.2. Scoping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.3. Examination of alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.4. Impact analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.5. Mitigation of impact and management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.6. Evaluation of significance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.7. Review of the EIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.8. Decision-Making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.9.9. Follow-up	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 4. Connecting EIA and CE thinking

This section aims to understand your opinion about possible pathways to CE thinking in the EIA process, using a scale from 1 (**Strongly disagree**) to 5 (**Strongly agree**).

Please choose the answer that expresses your thoughts the most accurately.

**4.1.1** For the EIA stage of **Screening**, a possible pathway to integrate Circular Economy thinking is to broaden the project's scale by applying system thinking, and if possible, connect the proposals with other businesses/sectors

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.2** For the EIA stage of **Scoping**, a possible pathway to integrate Circular Economy Thinking is to connect the CE strategies and principles to the impacts of the proposals, to create a list of CE indicators that are able to evaluate the performance and progress of the project

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.3** For the EIA stage of **Examination of alternatives**, a possible pathway to integrate Circular Economy thinking is to evaluate the alternatives according to their performance on the CE strategies/principles/indicators. Then select the option that meets the objectives (environmentally, economically, and socially)

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.4** For the EIA stage of **Impact Analysis**, a possible pathway to integrate Circular Economy thinking is to increase the project's effectiveness by applying the CE principles, strategies, and indicators. These principles avoid the loss of environmental "critical capital"

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.5** For the EIA stage of **Mitigation and Impact Management**, a possible pathway to integrate Circular Economy thinking is to leave the "end-of-pipe" measures and avoid the impacts as upstream as possible by applying the CE approaches

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.6** For the EIA stage of **Review of the EIS**, a possible pathway to integrate Circular Economy thinking is to check if the principles and strategies identified were met and documented, to ensure the decision-making is well informed.

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.7** For the EIA stage of **Decision-Making**, a possible pathway to integrate Circular Economy thinking is to check if the CE approaches and how they were used weigh in the approval or rejection of the proposal

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.1.8** For the EIA stage of **Follow-up**, a possible pathway to integrate Circular Economy thinking is to use the CE assessments to document and evaluate the progress, as well as different connections noticed to increase the effectiveness of the project and for information for future EIAs

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

#### **4.1.9 Additional information on pathways to integrate CE into the EIA stages**

Despite the extensive literature review done, it was not possible to find specific indications for pathways to integrate CE in one stage. If you have information that would be helpful regarding pathways to integrate Circular Economy in EIA stages "Evaluation of significance", please let us know

#### **4.1.10 Additional Comment**

If you have additional comments regarding the pathways to integrate CE in the EIA stages, please let us know

## 4.2. Overcoming EIA barriers through CE integration

This section aims to understand how integrating CE in EIA could help overcome each barrier, using a scale from **1 (Strongly disagree)** to **5 (Strongly agree)**.

Please choose the answer that expresses your thoughts the most accurately.

**4.2.1** For the EIA barrier of **Practitioners' subjectivity and interpretation**, a possible way to overcome it by integrating Circular Economy in the process is to robust the knowledge on the circular economy approach in order to apply it correctly and effectively in projects

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.2** For the EIA barrier of **Problems with screening thresholds and criteria**, a possible way to overcome it by integrating Circular Economy in the process is to define main circularity criteria for different sectors/areas. Build a CE checklist and reference framework to minimize the subjectivity

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.3** For the EIA barrier of **Lack of tailored methods**, a possible way to overcome it by integrating Circular Economy in the process is to use CE principles, strategies and indicators to evaluate the project's performance and progress

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.4** For the EIA barrier of **Expert judgement**, a possible way to overcome it by integrating Circular Economy in the process is to utilize the CE assessment methods to ensure the project's environmental integrity

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.5** For the EIA barrier of **Lack of guidelines and manuals**, a possible way to overcome it by integrating Circular Economy in the process is to encourage and facilitate the development of CE manuals and guidelines, with strategies and indicators, as well as when/how/where to apply them and evaluate them

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.6** For the EIA barrier of **Difficult resource allocation**, a possible way to overcome it by integrating Circular Economy in the process is to use CE strategies (e.g., LCA) to pinpoint critical areas/stages, in order to increase the efficiency of the resource allocation

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.7** For the EIA barrier of **Lack of monitoring data and time frame could be too early to predict long-term effects**, a possible way to overcome it by integrating Circular Economy in the process is to try to establish/predict some long-term effects by applying system thinking. Encourage and facilitate studies/evaluations to reduce the lack of monitoring data, or try to use strategies/indicators that require less data

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.8** For the EIA barrier of **Weak institutional frameworks and legal instruments**, a possible way to overcome it by integrating Circular Economy in the process is to include a section for EIAs since CE regulations and legal instruments are beginning to be institutionalized

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**4.2.9** For the EIA barrier of **Uncertainty about legal regulations/guidelines**, a possible way to overcome it by integrating Circular Economy in the process is to develop legal guidelines with CE topics, specifying how/where to apply and evaluate them

1 Strongly Disagree	2	3	4	5 Strongly agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

#### **4.5. Additional information on how to overcome EIA barriers by integrating CE**

Unfortunately, we were still not able to find recommendations to overcome seven EIA barriers by integrating CE.

If you have any suggestions on how to overcome the following EIA barriers, please let us know

**4.2.10.1 "Time frames and lack of resources"**

**4.2.10.2 "Lack of communication/cooperation between actors"**

**4.2.10.3 "Roles and Responsibilities"**

**4.2.10.4 “Review body dependent on the projects’ proponent”**

**4.2.10.5 “The lack of political will and stakeholder engagement”**

**4.2.10.6 “The bureaucratic intervention”**

**4.2.10.7 “Lack of transparency and openness of information to the public”**

**4.2.10.8 Additional Comment**

If you have any additional comments on ways to overcome EIA barriers by integrating CE, please let us know (optional)

## **5. Personal Information**

Please provide some information about yourself. This is necessary to understand the background of the respondents

### **5.1 Age**

### **5.2 Gender**

- Male
- Female
- Not listed
- Prefer not to say

### **5.3 Highest level of education**

- Secondary school
- Bachelors’ Degree
- Master’s Degree
- Doctoral Degree

**5.4 How are you currently involved with EIA?**

- Practitioner/Consultant in a privately held company
- Practitioner/Decision supporter in a public authority
- Decision-Makers
- Researcher/Academic
- Other

**5.5 How many years of professional experience with EIAs do you have?**

- < 2
- 2-5
- 5-10
- 10-20
- > 20

**5.6 In how many EIAs have you been involved?**

- None
- 1-10
- 10-20
- 20-30
- > 30

**5.7 Country of activity**

## B. Ethic Statement |

### Project Overview

#### **Title of the project**

“Development of impact assessment practices to help enable circular economy progress” – survey

### Project Details

#### **A brief outline of the project**

With this project, we intend to identify the different practices that can enable CE in the EIA process and develop a conceptual model that integrates different circular economy topics in environmental impact assessment practices. To accomplish this task, we carried out a literary review, based on the scientific articles and grey literature available on these topics. With this, we have developed a conceptual framework. To strengthen our model, we are conducting a participatory exercise, this survey, to improve and tune our work through your opinion and professional experience.

#### **Funding**

This project is not funded

### Participant Details

#### **Potential Participants**

The research population will be active professionals, such as researchers, practitioners, and decision-makers, who are involved in the Environmental Impact Assessment (EIA) process. The research itself, regarding the fielding of the online survey, collecting and analysing the data will take place in Portugal, in the Faculty of Sciences and Technologies of Nova University, in a partnership with the University of Aveiro. However, the research subjects will be professionals across the globe who will access the survey online.

#### **Recruitment Process**

Our research sample will be members of the International Association for Impact Assessment (IAIA), which is an association based in the United States and holds members for more than 120 countries. The survey will be conducted anonymously through an online platform, Lime Survey, and the participants are not required to supply their e-mail.

#### **Consent and Withdrawal**

Participation in this survey is purely voluntary and the consent is accepted from the moment the participants submit their responses. They are also able and free to withdraw from the survey at any time until the submission of the responses at the end of the survey. Not all questions require responses, some of them are optional questions. If they do not wish to respond, all the information they provided previously will be deleted and not used in the research.

## **Participation**

The participants are asked to respond to several questions about their expertise and opinion upon these topics:

1. Background information
2. CE Principles and their integration in the EIA process
3. CE Strategies and their integration in the EIA process
4. Pathways to integrate CE in the EIA stages
5. Overcoming EIA barriers through CE integration
6. Personal information
7. Follow-up study

## **Duration**

This survey will take 25-30 minutes of your time.

## **Remuneration**

The participants will not be remunerated for responding to the survey, their answers are purely voluntary.

## **Data Details**

### **Use of Data**

The data collected in this survey will be used in a chapter of a Master Thesis, from the Faculty of Sciences and Technologies of Nova University in a partnership with the University of Aveiro, Portugal.

### **Confidentiality**

The survey is completely anonymous, and all the information provided will only be managed by the research team. The survey is done using Lime Survey, a secure service, approved by the University of Aveiro. The information will be aggregated in groups, and the participants will not be identified in the research or publication.

### **Data Storage**

All the information collected will obey the Information Security Policy of the University of Aveiro. All the responses will be gathered on GDPR compliant platform, Lime Survey, and stored locally on the Faculty of Sciences and Technologies of Nova University for analysis. After the end of the research, all the data will be deleted.

### **Risks**

The research carries small a risk, despite the information being anonymous there is a chance of discovering sensitive information, since the participants may be identified indirectly. We have minimized this risk by giving them the option not to reveal their gender, by inquiring about their work country instead of residency, and by ensuring that the data collected will only be handled by the research team. The survey is done using Lime Survey, a secure service, approved by the University of Aveiro.

### **Queries and Concerns**

If the participants have any questions or concerns regarding the study, they may contact us at 'Mariana Rato' [mv.rato@campus.fct.unl.pt](mailto:mv.rato@campus.fct.unl.pt)

## C. Table of the citations of the questionnaire respondents

Barrier	#	Citation
<b>Time frames and lack of resources</b>	R3	<i>"Perhaps, one can develop a library of case studies of EIA completed using CE principles and aspirations. That can help practitioners to understand how such assessment is done without excessive trial and error"</i>
	R8	<i>"Being made part of learning curriculum from lower grades to higher university levels"</i>
	R11	<i>"Specify the time and develop guidelines"</i>
	R12	<i>"Frequent feedback to the relevant actors by offering information to fulfil the legal regulation"</i>
<b>Lack of communication/co-operation between actors</b>	R2	<i>"Improve participation"</i>
	R3	<i>"A CE-based discussion among actors can provide tangible outcomes and benefits beyond the results of the particular project being assessed. That is, the CE necessitates a systems view and consideration of a network or web of relationships for consumption and use of materials and energy. Those working relationships should persist beyond the timeline of a particular project being considered for development"</i>
	R8	<i>"Uses of advocacy"</i>
	R11	<i>"Awareness raising"</i>
	R12	<i>"Discussion with all stakeholders to share the information to reduce the gap of interest in the planning processes"</i>
<b>Roles and responsibilities</b>	R8	<i>"Legal framework"</i>
	R11	<i>"Assign CE practitioners as part of the ESIA process"</i>
<b>Review body dependent on the project's proponent</b>	R3	<i>"The CE likely engages an array of participants well beyond stakeholders or proponents of a given project. So, one could imagine a CE advisory body for a region that is independent of a project proponent"</i>
	R8	<i>"Create awareness"</i>
	R11	<i>"Objective reporting"</i>
	R12	<i>"Coordination meeting to mitigate the differences between the proponents and opponents"</i>

<b>Lack of political will and stakeholder engagement</b>	R3	<i>"The CE is a regional phenomenon, rather than a project mainly of benefit to a proponent and their clients. This breadth of appeal can stimulate a larger scope of engagement"</i>
	R8	<i>"Make it have a legal framework"</i>
	R10	<i>"It would be important to study the mechanism to involve communities in the process"</i>
	R11	<i>"Legal framework development"</i>
	R12	<i>"Consensus meeting by the participation of all stakeholders to draw out the desirable outcomes or social deliberation conferences"</i>
<b>Bureaucratic intervention</b>	R8	<i>"Awareness"</i>
	R11	<i>"Reduce the system integration"</i>
	R12	<i>"Public participation processes on the legal background and institution"</i>
<b>Lack of transparency and openness of information to the public</b>	R3	<i>"The CE involves strong market mechanisms, which rely on transparent information about availability and condition of materials. So, CE elements can broaden the availability of information, though perhaps not making all information visible"</i>
	R8	<i>"Awareness"</i>
	R11	<i>"Accountability reporting frameworks"</i>
	R12	<i>"Information disclosure stage to all public before final decision making"</i>
<b>Additional information</b>	R3	<i>"I like the idea of using a broad concept, like CE, that applies to a region as a basis for addressing limitations of a narrower process focused on an individual project"</i>
	R5	<i>"I think you need to talk to actual EA practitioners (like me) to understand what it really means to do project EA and what can reasonably be done to meet our important future needs, but NOT assuming that such objectives can actually automatically be met or met at all in project EA. CE is a noble and well-intentioned objective and project EA may be able to play a role"</i>





2021

Mariana Vieira Rato

DEVELOPMENT OF IMPACT ASSESSMENT PRACTICES TO  
HELP ENABLE CIRCULAR ECONOMY PROGRESS