SEI Stockholm Environment Institute

Accelerating the transition to a circular economy through impactful and actionable research

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Contents

Executive summary

In this report, we present the findings of the Circular Economy (CE) Lab project, supported by the Swedish International Development Cooperation Agency (Sida). This project aimed to provide a coherent picture of SEI-wide engagement on CE, identify key outputs from past SEI projects, provide a concrete list of knowledge gaps which future SEI proposals could explore further, and explore how SEI can support future directions for establishing an impactful and actionable CE research agenda.

Our main findings are:

- SEI carried out 57 projects related to CE within the last decade, which mainly address three key areas of expertise: circular bioeconomy, circular solid waste management, and circular water management.
- We identified a broad set of knowledge gaps related to 1) the understanding of the impacts of CE strategies, and the links between the CE and just transition fields; 2) the implementation of CE strategies, such as developing new business models, technological advancements, and including consumer perspectives; and 3) bridging policy gaps to facilitate better financial and regulatory frameworks.
- This has led to future research themes that SEI proposals can explore, such as developing holistic assessment frameworks to appraise CE strategies; tapping into SEI´s expertise on sustainable consumption to better understand the links between CE and behavioral aspects; and analysing supply chains to support private enterprises in developing circular business models.
- Lastly, we suggest that future SEI research on CE should incorporate participatory multi-stakeholder collaborations across sectors, regions, disciplines, and stakeholder groups; engage in capacity building and activities that raise awareness among various stakeholder groups; and provide support to decision-makers to align regulatory and economic incentives to CE goals and targets.

1. Introduction

The circular economy (CE) concept has gained momentum in the last five years among politicians, industry officials and academics, as it offers substantial environmental gains when compared to the current linear economic model, where resources are extracted, used and discarded (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Kirchherr et al., 2017). For example, the non-profit Circle Economy estimates that a circular economy could cut virgin resource use by 28% and reduce global greenhouse gas emissions by 39% (Circle Economy, 2021, p. 8). Furthermore, economic gains include cost savings due to lower resource use, and customer retention (Geissdoerfer et al., 2017).

In recent years, more governments have adopted or developed national roadmaps and strategies towards CE. This is particularly true in Europe, including in Denmark, Finland, France, Netherlands, Portugal, Spain, Sweden and Italy (see European Environment Agency, 2019 for an overview); other regions of the world are also increasingly exploring this concept (such as China and the US) (Ellen MacArthur Foundation, 2018; Metabolic, 2018, 2019). More cities are embarking on CE pathways to reduce the resources they consume and reach their environmental targets (see Petit-Boix & Leipold, 2018; and Vanhuyse et al., 2021 for an overview of cities). The European Union also launched a CE Action plan in 2015 (European Commission, 2015), and reconfirmed CE as a political priority in 2020 as one of the pillars of the EU Green Deal (European Commission, 2020). A growing number of international organizations (such as the Organisation for Economic Co-operation and Development and the World Economic Forum) – as well as foundations and consultancies (such as Circle Economy, the Ellen MacArthur Foundation and Metabolic) – also are focusing on CE. The emergence of CE networks demonstrates the need for facilitating stakeholder collaboration (see, for example, the European Circular Economy Stakeholder Platform, ICLEI and PACE).

The Stockholm Environment Institute's portfolio on CE has grown in recent years, with projects focused on the recovery of organic waste (such as BONUS RETURN, PEGaSus, REVAMP and UrbanCircle), on individual sectors (such as the waste and textile industries), and on cities (such as the Urban Circularity Assessment Framework). This focus links to the SEI 2020-2024 strategy (2019) in all three impact areas: 1) reduced climate risk; 2) sustainable resource use and resilient ecosystems; and 3) improved health and well-being. Given that CE is becoming a political priority, it seems highly relevant to provide informed decision-making and policy support.

1.1 Project objectives

With CE gaining prominence in the policy arena, there is a need to investigate how SEI can accelerate the CE agenda, moving it from a political priority to actionable and impactful research. In this report, we explore how SEI can contribute and further stimulate the discussions around CE, by fulfilling three key objectives:

- First, we provide a coherent picture of SEI-wide engagement on CE by identifying key outputs from past projects.
- Second, we provide a concrete list of knowledge gaps that future SEI proposals could explore further.
- Third and last, we explore how SEI can support the establishment of an impactful and actionable CE research agenda.

To meet the formulated objectives, we dive into SEI's portfolio on CE to gain a better understanding of past projects and their outputs. We then supplement this internal mapping with interviews and workshops with external stakeholders, to understand how they have approached the concept, and the barriers and opportunities they face in their CE-linked work. This also allowed us to map knowledge gaps and stakeholder needs around the current CE agenda and define the research agenda needed for accelerating the CE transition.

The report is structured as follows. Section 2 provides an overview of the CE concept, including a discussion on its promised benefits and implementation challenges. In Section 3, we describe the methodology used for our data collection and analysis. Section 4 contains our findings, followed by a conclusion in Section 5.

2. Definitions of the circular economy

The CE concept has gained increased attention over the last decade, as part of the EU's pillars for a more sustainable society. However, it is not new; for a history of the CE concept, see, for example, Reike et al. (2018) and Winans et al. (2017). Its origins and main principles are linked to systems theory, ecological and environmental economics, and industrial ecology (Ghisellini et al., 2016).

While there is no agreement on the definition of CE, most definitions consider CE as an economic system, including production and consumption systems, aimed at keeping resources in the system for as long as possible. The aim is to reduce the environmental impacts of our current linear economic system of making, taking, and disposing[1]. Some scholars consider CE as a regenerative or restorative system (Ellen MacArthur Foundation, 2015; Geissdoerfer et al., 2017), where the end-of-life concept is substituted with restoration (Kirchherr et al., 2017), through cyclical material flows, renewable energy sources, and energy transfer (Korhonen, Nuur, et al., 2018). CE can be analysed at: the micro-level, focusing on consumers, products, and companies; the meso-level, investigating local ecosystems and eco-industrial business parks; and the macro-level, encompassing cities, regions, nations and the world (Ghisellini et al., 2016; Kirchherr et al., 2017). A systems perspective or a systemic shift is necessary to achieve reductions in environmental impact, as studies have found rebound effects, for instance, in the sharing economy (Chen, 2021). An overview of some of the most prominent conceptualizations is provided in Table 1.

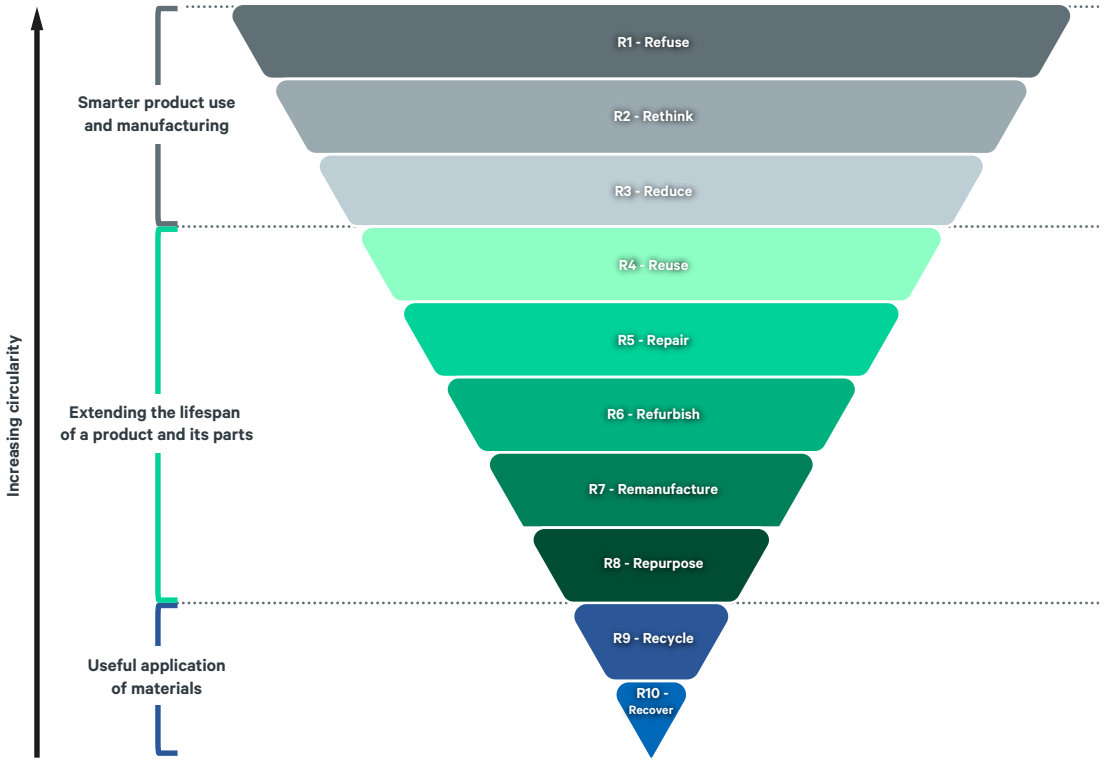
Table 1. Some of the most prominent CE conceptualizations

Author	CE definition
Ellen MacArthur Foundation (2015)	An industrial system that is restorative or regenerative by intention and design. There are three main principles of CE: preserve and enhance natural capital, optimize resource yields, and foster system effectiveness by revealing and designing out negative externalities.
Geissdoerfer et al. (2017, p. 759)	"A regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling."
Kirchherr et al. (2017, p. 229)	"[A]n 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."
Korhonen, Honkasalo, et al. (2018, p. 39)	"Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical material flows, renewable energy sources, and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development."

1 For some conceptualizations of the CE, please see Geissdoerfer et al. (2017), Ghisellini et al. (2016), Homrich et al. (2018), and Kirchherr et al. (2017).

CE is often linked with the terms “slow, narrow and close loops” (Bocken et al., 2019) and “reducing, recovering and recycling”, or R Strategies; the number of suggested R Strategies varies significantly in recent conceptualizations. Figure 1 demonstrates the 10 circular R Strategies suggested by Potting et al. (2017), ranked by environmental benefits. Refusing consumption has the largest potential. The figure also includes the principles attributed to each strategy; the first three R Strategies are linked to the smarter use of products and manufacturing; R4 through R8 focus on extending the lifespan of products and their parts; and the last two strategies, R9 and R10, refer to the useful application of materials.

Figure 1. Circularity strategies within the 10R framework.



Source: Adapted from Kirchherr et al. (2017) and Potting et al. (2017).

CE comes with the promise of tackling environmental challenges alongside economic uncertainties (Murray et al., 2017). Research suggests that its benefits include economic growth, the creation of jobs, the reduction of virgin resource use from unsustainable production and consumption processes, and, ultimately, a contribution to overall wellbeing (Ghisellini et al., 2016; MacArthur, 2013). Wijkman and Skånberg (2017), for example, report substantial job opportunities in a CE. CE could also have direct positive impacts to a diverse set of Sustainable Development Goals (SDGs), such as SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life below Water) and SDG 15 (Life on Land) (Schröder, 2020; Suárez-Eiroa et al., 2019). In this context, more governments are seeking to implement CE solutions as an essential tool to achieve sustainable development and reduce climate risk, as the CE presents a systematic and holistic approach to tackle cross-cutting issues.

Despite being mainstreamed as a sustainability notion (D’Amato et al., 2017), CE’s links to sustainable development are not yet clearly defined nor measurable (Geissdoerfer et al., 2017).

Even though recent studies stress the creation of new jobs, they do not specify the types of jobs that would be created or their net contribution to overall wellbeing or other social impacts linked to the CE (Padilla-Rivera et al., 2020; Schröder, 2020). Some scholars criticize the concept for not questioning the dominant paradigm of economic growth (D'Amato et al., 2017). Furthermore, it is challenging to assess the actual environmental impacts of CE initiatives, due to conceptual and methodological limitations. For instance, the system boundaries of CE activities are difficult to identify, as the physical flows of energy and materials reach across organizational, administrational and geographical boundaries. Additionally, recycling activities have their limits: they require energy and generate wastes or produce side products, making a complete recovery of materials impossible. Beyond the technical challenges, CE also requires socio-cultural shifts, such as changing the current global consumer culture (Giampietro & Funtowicz, 2020; Korhonen, Honkasalo, et al., 2018). So far, the understanding of the concept varies across actors, presenting another major obstacle to its successful implementation (Kirchherr et al., 2017).

Based on the most recent attempts to conceptualize the CE, we established the following definition of CE to provide a holistic picture and guide our analysis: *"A regenerative system with circular material and energy flows, both in production and consumption systems, which mimics nature and preserves resources through different circularity strategies (10R framework), ranked by their environmental benefit (with refusing consumption as the highest priority); hence, a system that reduces environmental impacts and aims for lasting positive social impacts while creating economic benefits"*.

3. Materials and methods

To fulfil the outlined objectives, we used a mixed methods approach, with participatory elements, to create an innovative space for accelerating the CE agenda at SEI. Our focus was on identifying competitive advantages at SEI, creating opportunities for new ideas, and strengthening partnerships, rather than providing a comprehensive picture of the current state of CE research.

First, we mapped out SEI's CE-related projects over the last 10 years, in order to gain an understanding of trends, skills, and internal gaps. We then surveyed the SEI employees engaged in these projects to understand their expertise, and mapped associated topics, tools and partners. Next, we conducted interviews with external stakeholders to gain an improved understanding of research gaps and future research opportunities for SEI. Lastly, we held workshops with both external partners and SEI colleagues from various centres to provide a creative space for discussion, build new partnerships, and validate previous findings. The findings were triangulated across different methods. Each step is further outlined below, and Annex 1 contains details of our data collection.

3.1 Mapping of CE projects at SEI

Building on systematic review principles, we carried out a search of SEI's project database in September and October 2021. Table 2 shows our criteria.

To ensure that all projects were captured, the directors of centres that might not use the PMEC system were contacted to submit a list of projects. Complementary information was retrieved from SEI's internal and public web pages.

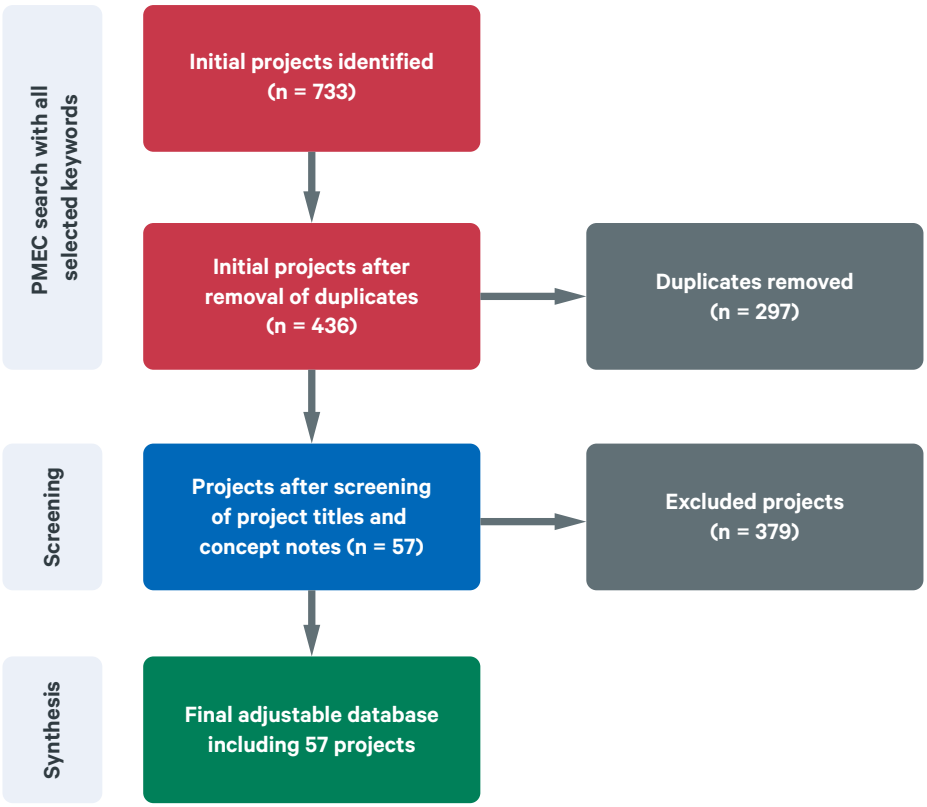
Figure 2 shows the flow chart of our screening process. The keyword search yielded 733 results. Following the removal of duplicates (297), the titles and project concept notes of the remaining 436 projects were screened to assess their relevance to CE based on the definition

Table 2. Search criteria

Details	Description
Database	PMEC (Planning, Monitoring, Evaluation, and Communication) system, an internal database that comprises all proposals and projects SEI has or is working on
Time period	January 2010 – September 2021
Search terms	Circular, circle, natural capital, natural resource, closed loop, material, material flows, manufacturing, by-product, production, distribution, consumption, rethink, reduce, reuse, repair, refurbish, repurpose, recycle, recover, end-of-life, waste, waste management, renewable energy, life-cycle
Type of project	Ongoing or complete projects only. Proposals were excluded.

outlined in Section 2. All co-authors screened a set of projects. The team discussed projects where there was uncertainty. For quality assurance, one co-author verified the coding of half the projects. Overall, 379 projects were removed in this phase, resulting in 57 included projects.

Figure 2. PRISMA flow diagram illustrating the projects included or excluded at each stage of the screening process



Our coding framework for the 57 projects included:

- General project information: project number, key topics, project start and end date, regions and countries covered, project status, tool development, project lead, and leading centre.
- Consortium: external partners were identified and categorized.
- Funding: overall budget and funding sources. Funding sources were categorized into internal, academia, private, public, international, and other.
- Level of CE: micro-level (consumers, products, companies); meso-level (local ecosystems, such as eco-industrial parks); and macro-level (cities, nations, regions, global).
- R-strategies: 10R framework (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover).
- Sectors: these were considered according to the NACE classification for sectors.

The data was analysed in Microsoft Excel. The quantitative data was summarized and visualized in different types of graphs.

3.2 Survey and key stakeholder interviews

We collected qualitative data through a survey with SEI employees and key stakeholder interviews.

A short survey was shared with all SEI employees in August and September 2021. In total, 25 people replied to the survey. The survey included 14 questions, covering the following topics: 1) background and link to CE, 2) personal understanding of CE, 3) barriers and opportunities of a CE transition, and 4) outlook and collaboration. The results were presented at the SEI Science Forum 2021.

Key stakeholder interviews were organized in October and November 2021. We carried out an initial stakeholder mapping with the project advisory board. In total, we interviewed 15 key stakeholders with diverse expertise and knowledge, and who represented a vast range of geographical locations, sectors and organizations. We used a semi-structured approach. Some interviews were carried out over video conferences using Microsoft Teams, whereas others were done over email due to time limitations. Detailed notes were taken during the interviews. The interview consisted of open-ended questions linked to CE perceptions, opportunities, barriers, current knowledge gaps and future perspectives. In addition, the *Urban Circularity Assessment Framework (UCAF)* project (Vinnova, grant number: 2019-03237) also carried out interviews to understand the perceptions of CE, perceived barriers and opportunities among different stakeholder groups. We included four of these interviews – which were held with researchers from private enterprises and research institutes – as they included additional questions on CE knowledge gaps and how to close them. We coded the notes from the interviews, noting down themes as they emerged. We then synthesized the results.

3.3 Workshops

We conducted two virtual workshops with SEI colleagues and external partners: one in September 2021 and one in December 2021. We took a participatory approach, using virtual tools such as Miro and Mentimeter to stimulate the discussion across stakeholder groups, as well as sectoral and organizational borders.

Our first workshop was held during the SEI Science Forum in September 2021, with almost 30 SEI participants. In this workshop, we presented and validated our initial findings from the mapping exercise on CE-linked SEI projects and the SEI internal survey (see Sections 3.1 and 3.2). We used the findings to stimulate a debate on the topic among SEI colleagues, and with the help of an interactive Miro board, we recorded ideas on individual CE perceptions, perceived knowledge gaps in SEI's CE portfolio, and future directions for SEI research.

A second workshop took place in December 2021, in order to validate our overall findings, develop future directions for upcoming CE-related SEI proposals (based on the identified stakeholder needs), and stimulate new collaborations in this context. A total of 21 participants took part, comprising both SEI and external stakeholders. See Appendix 6.4 for more details.

3.4 Internal advisory board

We continuously engaged, in a collaborative process, with an internal advisory board made up of SEI colleagues across five centres. Two formal advisory board meetings were held, as well as individual consultations with board members to integrate regional experience and expertise. These interactions helped steer the project and stimulate cross-centre collaboration. Some activities included the mapping of external stakeholders in the CE transition, participating in key stakeholder interviews, and validating the findings.

3.5 Analysis and synthesis

As part of our analysis, we synthesized the data derived from the steps outlined in Section 3 to form an integrated understanding of SEI-wide engagement on CE, describe CE-related knowledge gaps identified by external stakeholders, and establish future directions for an impactful and actionable CE research agenda at SEI. We combined data gathered from the internal mapping, survey, key stakeholder interviews, and workshops, and clustered them into emerging themes. The findings reflect the key themes appearing in the dataset.

3.6 Limitations

We want to stress some limitations of the analysis. The project was limited in terms of time, resources, and scope, occurring between September and December 2021. We performed no literature review of ongoing research outside of SEI; consequently, we may not have identified some research gaps and future directions. The internal mapping was limited to the information available in SEI's internal project database, which did not contain the full details of all projects. We also focused solely on funded projects, and excluded both proposals, and events and engagements that were not part of a project. Moreover, the number of key informant interviews was limited, due to time and resource constraints. We identified the key stakeholders based on existing partners and additional snowballing, which might have resulted in a biased sample. No key stakeholders represented Latin America.

4. Findings: common knowledge, research gaps, and ideas for SEI's future CE portfolio

4.1 Existing knowledge on CE at SEI

SEI's portfolio focuses primarily on the bioeconomy, lacking links to more sectors and more R Strategies.

Based on the internal mapping, our analysis shows that SEI's knowledge has been built up across sectors and in several of the R Strategies. Three key clusters emerge from the SEI project portfolio, comprising 79% of the projects (45 of the 57): circular bioeconomy; circular solid waste management; and circular water management. An overview is provided in Table 3. Significant overlaps exist between these clusters.

Table 3. Key clusters emerging from internal mapping of CE projects, topics and expertise

Name	R Strategies	Sector
Circular bioeconomy	Recycling and recovery	Agriculture, energy and waste management
Circular solid waste management	Reducing, recycling and recovery	Solid waste management
Circular water management	Reducing, reusing, recycling and recovery	Agriculture, water and sanitation, and waste management

The first, and biggest, cluster includes 22 projects linked to *circular bioeconomy*[2]. Key concepts and themes include bioenergy, biofuels and biomass. Three key sectors are in focus, namely agriculture, energy and waste management. The projects look at recycling and recovery loops, mostly seeking to cascade the use of biomass.

The second cluster included 15 projects that focused on *circular solid waste management*. This was expected, given the integral role of waste elimination in CE. The projects foremost addressed the following three R Strategies: reducing, recycling and recovery. Furthermore, waste management was approached at different levels of analysis, including products, cities, nations and regions.

The third and last cluster included 8 projects that investigated *circular water management*. Most projects focused on alternative nutrient-recovery systems, transforming human waste into valuable products like biomass and fertilizers. The projects engaged in the sanitation-energy-agriculture nexus by considering four R Strategies, namely reducing, reusing, recycling and recovery. These strategies were studied at both a micro- and macro-level.

2 "The circular bioeconomy focuses on the sustainable, resource-efficient valorization of biomass in integrated, multi-output production chains (e.g. biorefineries) while also making use of residues and wastes and optimizing the value of biomass over time via cascading. Such an optimization can focus on economic, environmental or social aspects and ideally considers all three pillars of sustainability. The cascading steps aim at retaining the resource quality by adhering to the bio-based value pyramid and the waste hierarchy where possible and adequate." (Stegmann et al., 2020, p. 5)

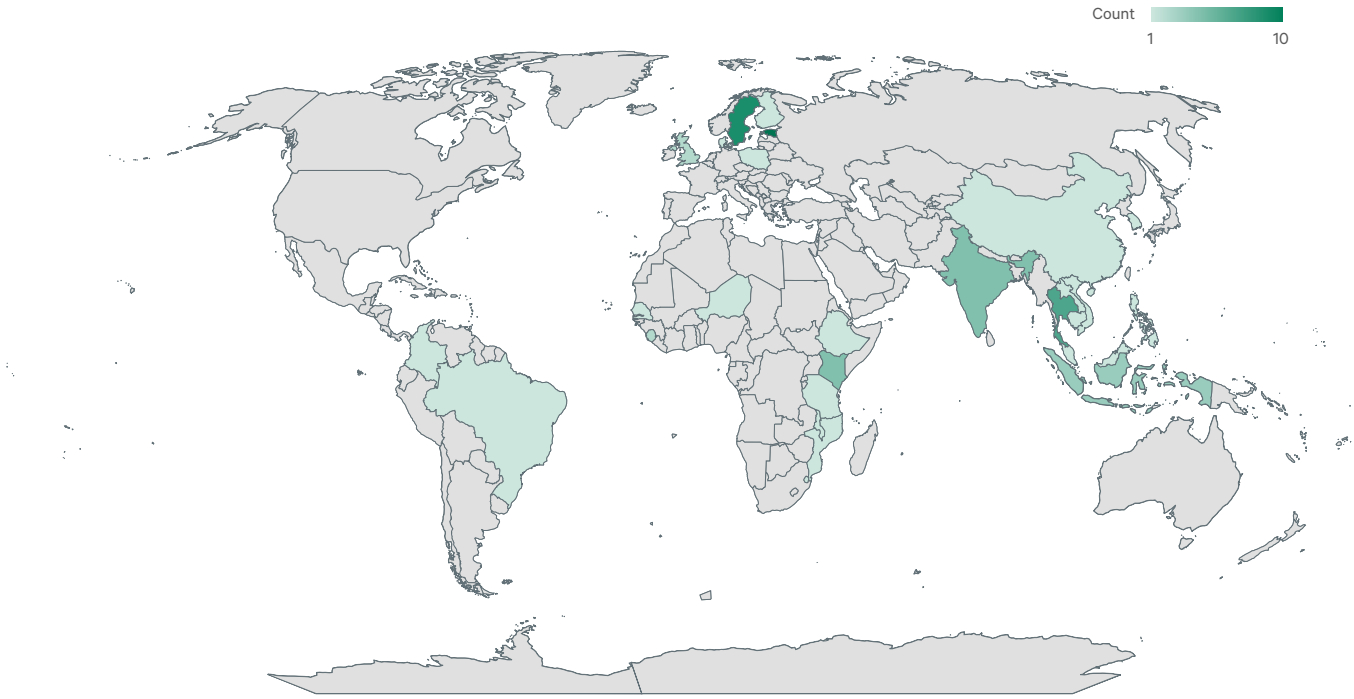
Most SEI projects focus on the useful application of materials, but do not link to higher priority strategies.

The SEI project portfolio focuses mostly on lower priority strategies, with most projects addressing reusing, recycling and recovery. Some projects promote the reduction of material usage through sharing or multi-functionality. No projects address the top R Strategies refuse and rethink, indicating that links to higher priority strategies are missing.

Most SEI projects focus on Europe and Asia.

The SEI project portfolio shows regional diversity, demonstrating diverse geographical expertise (Figure 3). However, most projects (29) have a European focus, either focusing on Estonia or Sweden. Some projects are situated in Asia (13) and Africa (12). Only two projects take place in Latin America. No projects take place in North America. Some projects used a global perspective, thus exploring concepts beyond specific contexts.

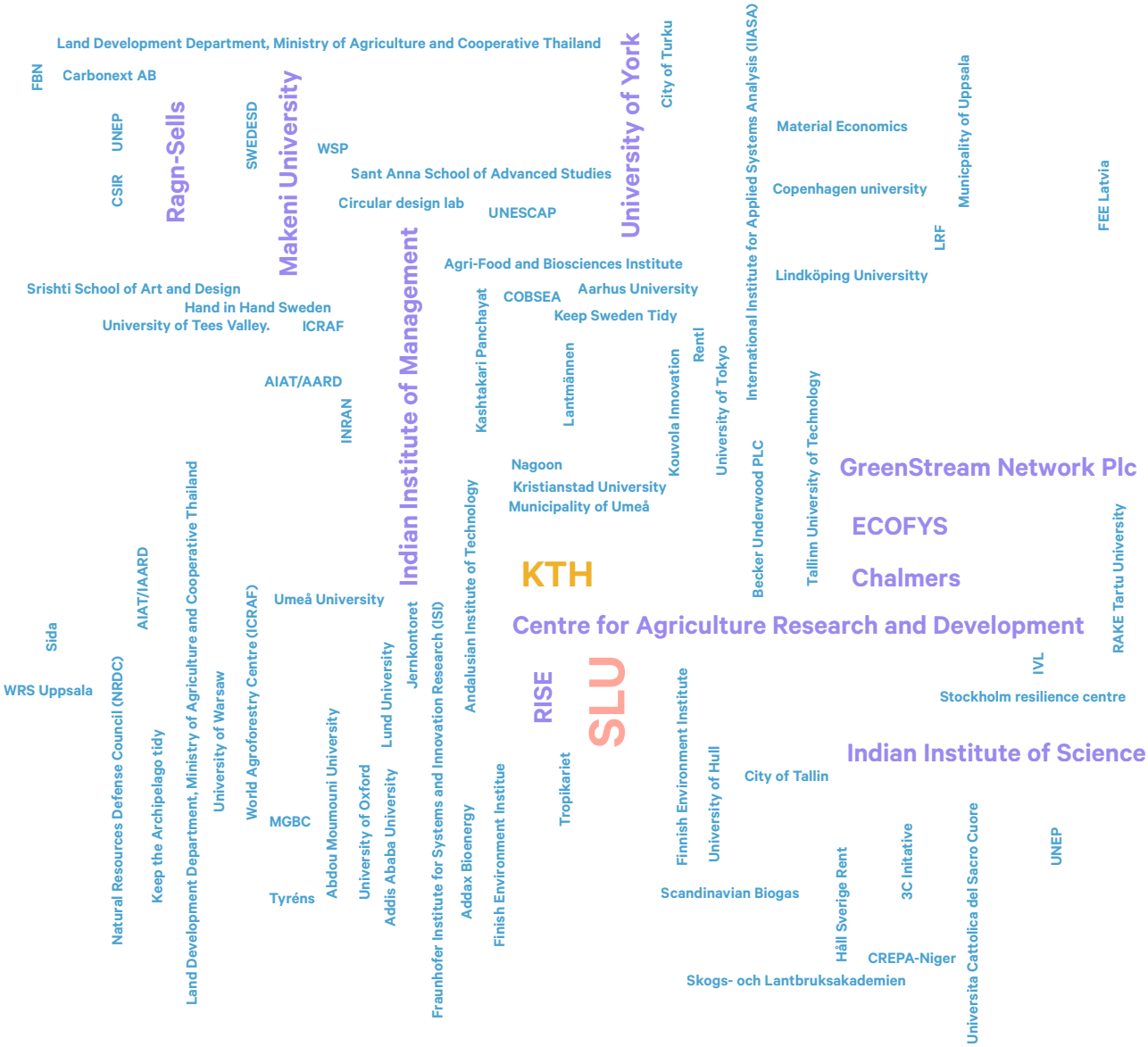
Figure 3. World map with countries covered in projects



SEI's partnerships are mostly with academia.

Cross-sectoral partnerships are essential to accelerate CE. SEI mainly collaborates with academia, though it has established some collaborations with non-academic actors such as governments and industry (Figure 4). We identified 83 external partners involved in the 57 projects; 11 of these were involved in more than one project.

Figure 4. Word cloud of partner organizations



4.2 Knowledge gaps related to CE

Drawing from findings collected from both internal and external stakeholders through interviews, a survey, and workshops, we identified three key knowledge gaps that relate to 1) the understanding of the impacts of CE, including how it links with the concept of a just transition and leaving no one behind; 2) CE implementation and the creation of a market, including technological advancements, business models and consumer perspectives; 3) translating science to policy, by filling in gaps in legislation, regulation, and procurement and finance.

Table 4. Overview of knowledge gaps

Knowledge gap	Examples of gaps
CE impacts	Understanding complex and interlinked impacts of CE strategies to push for systems change, tools and methods for impact assessments, and improved data availability. • *Environmental*: Lifecycle thinking in different contexts; material flows, including global flows; impacts of recycling processes • *Economic*: Mapping economic returns and share of investments to communities and public services; contributions to GDP through local circular activities • *Social*: Understanding social consequences of CE strategies, such as changing ownership structures and an informal waste sector • *Context:* Understanding the transitions process and CE trade-offs in different settings, including in the Global South; uncovering interdependencies in global supply and value chains; linking with other themes and events, such as resilience, adaptation, global pandemics, and resource security
Just transition	• Linking CE to the just transition field; identifying advantaged and disadvantaged groups • Addressing inequalities emerging from resource conflicts and conflicting interests • Focusing on inclusiveness and equity, including gender roles, human rights, and the role of marginalized groups • Power dynamics and decision-making in supply chains and financial systems (such as global waste trade and interdependencies)
Business models	• Market feasibility and profitability studies to ensure the profitable investments and financing of CE approaches • Viability of new business models, and feasibility in different sectors and locations • Role of entrepreneurship and small and medium-sized enterprises to accelerate the transition • Capacities to implement CE strategies, and collaborate with a wide range of stakeholders
Consumer perspective	• Exploring the inherent CE practices among communities and how they can be scaled up • Understanding consumer habits, choices and impacts, and how to achieve behavioural change • Accessibility and affordability of more sustainable products (linking it with the concept of equity) • Linking with higher R Strategies, including the goals of refusing and reducing consumption (R1-2)
Technology	• New technology improving energy efficiency and waste recovery • Chemical and mechanical recycling processes, including feasibility studies for commercial use • Innovation on how to integrate CE into value chains • Assessment on technology readiness level
Policy support	• Bridging the science policy gap • Waste regulations (such as end-of-life handling of different products); national laws, such as those related to the textile industry; how to disincentivize the use of virgin raw materials • Potential of sustainable procurement • Economic and financial incentives, market instruments

One of the main knowledge gaps emerging across sectors, stakeholder groups, and regions is a lack of understanding of **CE impacts**; this is linked to a need for more methods and tools to assess the impacts of CE strategies. Further research is needed on how existing methods and tools – such as life-cycle assessments, cost-benefit analyses, and material flow analyses – can be applied and adapted to different CE contexts. Based on our internal mapping, 18% of SEI projects developed a tool. Generally, a broad set of stakeholders have emphasized the need to understand the applications and impacts of the CE, not just on the environment and economy, but also on social and socio-economic issues. Supporting this monitoring and evaluation of CE strategies in different areas is an essential requirement to steer systems change. Life cycle thinking approaches were suggested in the context of **environmental** assessments. For CE strategies in cities, stakeholders highlighted the need for a better understanding of material flows, such as urban metabolism studies. Such material flow analyses are also required on a global level. Our analysis also found a need to map CE's much-promised **economic** benefits for different stakeholders, as well as identify the share of investments into local communities and public services. Regarding **social** impacts, analyses should address overall societal consequences; for example, whenever the creation of new jobs is stressed, their quality needs to be assessed.

Stakeholders also emphasized the need to understand changing ownership structures connected to sharing initiatives, as well as the impacts of waste management initiatives on workers in the sector's informal economy.

There is also a knowledge gap regarding **just transitions**. While this field seems more addressed in other economic transformation processes, such as for fossil-fuel-free or carbon-neutral economies, it has not been sufficiently linked to the CE debate. How to address inequalities emerging from scarce resources and conflicts of interest needs to be further studied. We must address which groups might be advantaged or disadvantaged through the CE transition, with research on gender inequalities, the role of marginalized groups, and human right issues. Another topic that warrants investigation is how power dynamics and decision-making processes in supply chains and financial flows hinder or enable CE.

Another main gap revolves around the CE business case and new **business models**. The role of entrepreneurship – and particularly of small and medium-sized enterprises – in the acceleration of the CE needs to be investigated and supported through informed policies. Market feasibility studies also are required. Although awareness on the importance of CE is rising among companies, the lack of research on the profitability of CE approaches presents a main obstacle towards implementation. Hence, CE financing strategies, new business models, and viable markets need to be further studied.

A further knowledge gap is around the CE and **consumer perspectives**. Stakeholders stressed that CE strategies need to reach far beyond sole technological innovations and consider the behaviour of consumers. Both consumer habits and motivations are insufficiently understood, as is their role in the transition process. Stakeholders emphasized the need for research on behavioural change, social marketing, and customer preferences. So far, consumers have a limited understanding of post-consumer processes and the impacts of their choices. By exploring this gap further, consumers could be empowered, creating accountability that both supports the CE transition and reaches broader sustainability issues linked to resource conflicts and climate change. At the same time, alternative products need to be more accessible and affordable, since a sustainable lifestyle currently often comes with higher costs and time requirements.

Technology gaps were mentioned a few times in our interviews and workshops, with stakeholders emphasizing not the technology itself but rather the exploration of its integration into existing socio-technical structures. We need to understand the technology user phase, which is linked to consumer behaviour. It remains unclear which consumer shifts, policies for new innovations, and technology implementations are required, necessitating an analysis of the technology readiness level. Stakeholders also mentioned technological obstacles for sectors such as waste management and textile manufacturing, linked to a lack of feasibility studies for recycling processes.

The need for **policy support** was highlighted in our interviews and workshops. Stakeholders stressed a gap in evidence-based policy, due to the lack of practical solutions and policy pathways to support CE implementation, especially from a business perspective. In addition, they pointed to a lack of incentives and an unsupportive regulatory framework as major hindrances in supporting the transition. The waste management and textile industries were among the sectors that stakeholders stressed as needing national laws and thus evidence-based policy support. They also raised the need for research on how regulations can help disincentivize the use of virgin resources. With regards to financial and economic incentives, further studies are also needed on how market instruments can overcome linear business practices and the potential for sustainable procurement.

Our analysis also highlights gaps in addressing issues of **contextuality**. It is essential to study context-specific applications of CE strategies and potential trade-offs. Stakeholders further highlighted the need to move away from the European focus on CE and close existing

knowledge gaps linked to the potential of CE strategies in the Global South, including, for example, understanding the region-specific impacts of global waste trading. Beyond that, we need to study the process of knowledge transfer; various transition processes, including what drives and hinders them; and circular business models. Above all, the ongoing Covid-19 crisis has demonstrated the need to investigate the role of more sustainable and resilient supply chains, and to stimulate further learning effects.

4.3 Suggested future research agenda for CE

We identified future research topics, approaches and methods, based on our analysis of SEI's current CE focus areas, identification of CE knowledge gaps, and findings from key stakeholder interviews. Key future research themes include the holistic assessment of CE strategies, the exploration of links between CE and behavioural change, and the analysis of circular supply chains. To be truly transformative and contribute to the promised benefits for businesses, communities, cities and nations, the CE research agenda requires: 1) multi-stakeholder collaborations, incorporating different viewpoints into the discussion; 2) a transdisciplinary focus and systems thinking, combining environmental and economic assessments with social innovation and value creation; 3) capacity building to increase awareness among various stakeholder groups; and 4) support for decision makers to ensure that CE practices and principles are in line with sustainable development.

Future CE research topics, approaches and methods include:

Improved assessment frameworks for evaluating and measuring impacts on people, society and the environment

Holistic CE assessments need to be developed to assist public authorities, private enterprises and civil society organizations in transitioning to a sustainable and inclusive society. These assessments should be designed to reflect key dimensions of sustainable development, incorporating environmental, economic and social aspects to capture unintended trade-offs and the impacts of CE on people, societies and the environment. We recommend bringing in systems and people perspectives, considering no one should be left behind, and designing economic and regulatory frameworks to support just transition processes. These frameworks should be tested in different contexts and sectors, drawing inspiration from existing methods and tools such as life cycle analysis, urban metabolism studies and transition analysis. Improvements in datasets are required for these assessments to be feasible in practice.

Bridge the gap between sustainable consumption and CE to explore behavioural change

For the **consumers' perspective**, future research should consider bridging the gap between CE and sustainable consumption, including: defining metrics to assess consumer and citizen behaviour; exploring supplier-buyer strings; and understanding what social impacts the CE can yield among citizens and consumers. CE and sustainable consumption are traditionally considered as separate research fields, and their interconnections and overlaps are in general poorly understood. Sustainable consumption could serve as an entry point, given the extensive expertise at SEI around the topic. This could help us gain a better picture of the interlinkages between circularity, individual consumption, and behavioural change, and how they can impact CE and sustainable development. This can shift the CE research agenda towards higher priority strategies, including those of refusing and rethinking, and help markets and policy to align accordingly.

Understand circular supply chains and business models

As for **markets**, future research should contribute to a better understanding of how local businesses connect to the global value chains; explore opportunities for marginalized group and informal workers, identifying opportunities for designing and scaling circular business models; and investigate high-volume mass distribution models and its compatibility with CE. The interconnectivity of global supply chains and policies requires further research. SEI has

considerable expertise in analysing supply chains; this could be adapted and applied to improve the understanding of circular supply value chains, thus enabling the monitoring of opportunities and barriers linked to CE.

Engage in multi-stakeholder collaboration

Our analysis linked various obstacles to the CE transition with a lack of collaborations. Hence, it is recommended to explore participatory **multi-stakeholder collaborations**, reaching beyond governmental silo structures, sectoral borders, disciplinary boundaries and stakeholder groups. Multi-stakeholder collaboration can accelerate the CE transition by encouraging diverse stakeholder groups to develop shared visions and stimulate long-term commitment, ultimately improving innovation potential, efficiency and communication. Key partners include civil society, large businesses, small and medium enterprises, trade associations and knowledge institutes, product designers and researchers, and public-private partnerships. Such partnerships should include collaboration between potential competitors. Collaboration across contexts and regions also can further stimulate two-way learning, in which the Global North can learn from the inherent CE practices that characterizes many low-income countries. SEI can serve as an intermediary, facilitating collaboration across disciplines and sectors while improving knowledge around CE.

Foster meaningful engagement through transdisciplinary research

As highlighted, there is a need to generate knowledge and skills beyond that offered under existing structures. **Transdisciplinary research** can help foster meaningful and engaging collaborations across sectors. CE is, at its core, multidisciplinary; future collaborations must reflect this inherent diversity in terms of sectors, stakeholders and disciplines. We need to move beyond waste management and low priority strategies, and approach CE from multiple perspectives that address various R Strategies. Participatory methods are key, as they can strengthen relationships, develop context-tailored knowledge, solve pressing societal issues, and boost scientific progress (Blackstock et al., 2007; Heink et al., 2015). Many suitable methods exist, including games, workshops, role plays, and mapping exercises (Reed et al., 2021). Many SEI colleagues have significant experience using participatory methods, which future studies around CE can utilize.

Invest in raising awareness

Capacity building is needed to fill current information gaps. Awareness needs to be raised among various stakeholder groups, nurturing a shared understanding of CE approaches and applications. Stakeholder platforms, seminars, workshops, and training courses can help raise awareness and facilitate knowledge exchange. Potentially, civil society organizations or education systems can serve as platforms for awareness raising. CE perspectives are currently narrow, excluding the regenerative aspect of CE or stressing only lower ranked R Strategies, according to researchers (Vanhuyse et al., 2021) and our analysis' internal mapping (Section 3). Decision-makers and practitioners need to be supported with capacity-building programmes, addressing these gaps.

Produce solid decision support

Lastly, solid **decision support** is necessary to assist key actors in successfully transitioning to CE. Participatory research can enhance ownership, legitimacy, credibility, and accountability, thus increasing the likelihood that research findings are implemented (Reed et al., 2018). Furthermore, research must be presented in a format that is accessible to decision-makers, civil society organizations, and private enterprises; it should therefore be communicated using simple language, without any professional jargon. To further decision support, researchers could: 1) conduct more studies linked to financing CE strategies, in order to decrease financial risks and make investments more feasible; 2) support policymaking in accelerating CE in different contexts; and 3) develop practical approaches and tools for decision-makers.

5. Conclusion

This report contains an assessment of SEI's current knowledge related to CE, based on a review of SEI's research portfolio, as well as key informant interviews and workshops held between September and December 2021. In total, we identified 57 projects at SEI outlining three main research topics: the bioeconomy, solid waste management, and water management. These projects focused mostly on Europe and Asia, and covered recycling, recovery of resources and, to a lesser extent, reducing consumption. Our interviews and workshops with a total of 18 CE practitioners confirm this narrow CE focus and support a need to approach the CE concept more widely, looking at higher R Strategies – such as rethinking, repurposing and refusing consumption – and linking CE with the concept of sustainable consumption.

Our analysis also highlights the need to incorporate the perspectives of more sectors and stakeholder groups; multiple stakeholders requested holistic tools and methods to assess economic, environmental and social impacts. This links to the limitations of the concept and ensuring its positive contributions to sustainable development (see Section 2). Whether governments are at the start of embarking on a CE trajectory or have already implemented CE policies, they need research to support evidence-based policymaking towards sustainable development. Therefore, we suggest that researchers facilitate collaboration, put theory into practice, and develop a favourable environment for implementing CE strategies. Our findings demonstrate that a future CE agenda needs to disrupt existing structures in the way we produce and consume goods and services, by finding new ways to collaborate, establishing support systems for making informed decisions, developing capacities, and assessing the impacts of CE strategies. The CE calls for a new paradigm, where strategies are embedded in complex and dynamic systems, requiring transdisciplinary research beyond existing sectoral boundaries.

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7. Author contributions

SR – conceptualization, methodology, data curation and analysis, investigation, writing – original draft, project administration, funding acquisition

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FV – conceptualization, methodology, supervision, data curation, writing – original draft, funding acquisition

KM – investigation and data analysis

PJ – investigation and data analysis

JN – investigation

AF – methodology, data curation, funding acquisition

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9. Annex 1: overview of data collection

9.1 Project schedule

Table 5. Project overview

Date	Activity
September	Mapping of projects, people and topics linked to CE at SEI, internal survey
23 September	Science Forum 2021 Workshop – Circular Economy: Going from Political Priority to Research Agenda
29 September	1st Advisory Board Meeting – Project overview
14 October	2nd Advisory Board Meeting – First results and stakeholder mapping
October – November	Key informant interviews across regions (n=15)
November – December	Writing of the report
7 December	Dissemination Workshop
Spring 2022	Publication of CE Lab project report

9.2 Overview of advisory board members

Karin André (SEI HQ), Karina Barquet (SEI HQ), Daniel Ddiba (SEI HQ), Neal Haddaway (SEI HQ), Fedra Vanhuyse (SEI HQ), Kristiina Martin (SEI Tallinn), Harri Moora (SEI Tallinn), Carol Chepkemoi Mungo (SEI Africa), George Kabue Njoroge (SEI Africa).

9.3 Overview of key stakeholder interviews

Key stakeholders worked in Europe (n=7), Asia (n=4) and Africa (n=3). They represented academia (n=5), the public sector (n=1), the private sector (n=3), civil society (n=5), and the United Nations (n=1). The interview partners covered various sectors, including textile, food, construction, energy, waste, and more. Out of the 15 interviews, 12 were conducted virtually via Microsoft Teams video conference, while 3 interview participants sent their answers via email.

9.4 Overview of workshop participants

The dissemination workshop included 21 participants, including:

- 20 SEI colleagues, from SEI HQ (n=10), SEI Africa (n=2), SEI Asia (n=3) and SEI Tallinn (n=2)
- 5 external partners, comprising a private sector representative from Europe (n=1) and non-profit officials from Asia and Africa (n=4)

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