Tampere University

ANIL ENGEZ

Stakeholder Contributions to Innovation Development

Studies in the Circular Economy and Sustainability Fields

Tampere University Dissertations 936

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ACADEMIC DISSERTATION
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PREFACE

The doctoral journey has been one of the longest and the most challenging experiences of my life with a lot of ups and downs that evoke intense emotions. When I first arrived in Finland seven years ago for my master's studies in industrial engineering and management, I would not have thought that pursuing a doctoral degree and becoming a scholar was going to be one of my career alternatives. What led me to this path is the lovely people and great colleagues around me whom I shared my time with during the period of writing my master's thesis. I am glad that I took this path to explore stakeholder contributions to innovations, which opened up many opportunities and helped me evolve and grow personally and professionally along the way. Finalizing this journey and marking the end of the doctoral work would not have been possible without the help, support, and encouragement of many people and I would like to thank each one of them.

First, I want to thank my supervisor Professor Leena Aarikka-Stenroos for giving me the opportunity to work on this project and for providing guidance throughout the work, when writing the manuscripts, writing the response letters, and completing the thesis. It's been almost six years since we met, and I am grateful for all the support you have provided during these years. Your support helped me push to the final stage in the studies and finalize the work despite the struggles, so big thanks for this. No matter how busy you are, thank you for sparing time to discuss and guide the work. I would also like to thank Dr. Ulla Saari for supporting me as my second supervisor who joined in the second half of my doctoral studies and for the motivational chats we had at the monthly meetings. Thank you for sharing your experiences.

During my doctoral research work, I received financial support from various organizations. Without their support, conducting this work would not have been possible. I am especially grateful to Jenny and Antti Wihuri Foundation for the research grant they provided over the years that enabled me to work on such a long project. In addition, I would like to thank Strategic Research Council of the Academy of Finland for providing funding through the CICAT2025 and UPCE research programs. I also want to thank Tampere University Doctoral School for funding the final stages of my doctoral work and Erasmus+ for funding my research visits.

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Special thanks go to the inspiring and expert co-authors I worked with: Professor Seppo Leminen, Associate Professor Paul H. Driessen, Associate Professor Marika Kokko, and Dr. Valtteri Ranta. Conducting research and writing research papers with you have been a privilege and I am grateful for your support and contribution you provided in the papers.

I want to thank all my friends for their company that enabled a work-life balance during the hectic times of writing the thesis. Playing drums and guitar, cooking meals, having board game nights, going to movies, taking walks, going to gym, cycling with friends all helped me take my mind away from the everyday stresses.

I would like to thank my parents and my sister for their constant support and encouragement throughout my life and studies. Thank you for being always available to have a chat when I am overloaded with work and need to relax when the times are hard. Finally, Fanni, thank you for being my safe haven. We went through both good times and hard times during this journey. I am grateful and happy to have you in my life that made it easier to endure the pains and tough moments. Thank you for your kindness, being there for me and sharing this journey with me.

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Anil Engez

ABSTRACT

The sustainability and circular economy (CE) concepts have gained global attention in innovation development circles due to the growing need for the responsible use of resources in production and consumption processes. These concepts highlight the urgency of the transition to resilient societies and environmentally friendly practices, which require the involvement and intervention of various stakeholders to enable sustainability and maximum efficiency in resource utilization. Many organizations around the world develop innovations and engage in open-innovation practices to accelerate the sustainability transition that pushes for changes in the organization of societal, political, and economic activities. Through innovations, the developments in the four pillars of sustainability (human, social, economic, and environmental) can be realized, and sustainable development goals (SDGs) can be achieved.

While the open-innovation concepts have explored how to organize for innovation, the activities of various stakeholders that contribute to sustainable development need more research. This would improve our understanding of how stakeholders can contribute to the development of regions, innovations, and economic activity, while placing SDGs at the top of their agendas. The objective of this dissertation is to identify stakeholders and activities that contribute to innovation development and sustainability. The research aims to improve our understanding of the innovation activities of different stakeholders and the methods and concepts that are applied to enable innovation development. Such an understanding would help organizations better organize their innovation activities, introduce new ways and ideas to develop innovations, and find a common interest with their stakeholders in the pursuit of becoming more sustainable.

The research features three single-case studies and two multiple-case studies employing an exploratory and qualitative approach. The data used in the studies were semi-structured interviews, journal articles, books, the webpages of relevant organizations, news articles, and teaching experiences.

The research results are presented based on five publications comprising two journal articles and three book chapters. The first two publications focus on the urban living lab concept for innovation development and urban sustainability, the

third publication explores different types of CE innovations and their sustainability benefits, the fourth publication elaborates on the stakeholders and their activities in the commercialization and market creation of a radical innovation, and the fifth publication discusses stakeholders in entrepreneurship education for sustainability.

This dissertation contributes to the understanding of stakeholder activities for sustainability in different innovation and open-innovation contexts. Furthermore, the research specifically contributes to the living lab studies and CE ecosystems and innovation literature alongside commercialization and market-creation studies. This dissertation brings living labs and CE ecosystems literature together, and market creation and commercialization literature together separately under the main innovation literature. It showcases how sustainability agency is distributed among various types of actors in the ecosystem and thus presents practical advice for practitioners, such as municipality officials, companies that develop sustainable innovations, and researchers who study innovation ecosystems. The practical contributions lie in understanding the role of the stakeholders in the innovation ecosystem and organizing the stakeholders for innovations to emerge.

CONTENTS

ORIGINAL PUBLICATIONS

Publication I — Engez, A., Leminen, S., & Aarikka-Stenroos, L. (2021). Urban living lab as a circular economy ecosystem: Advancing environmental sustainability through economic value, material, and knowledge flows. *Sustainability*, *13*(5), 2811. https://doi.org/10.3390/su13052811

Publication II — Engez, A., Driessen, P. H., Aarikka-Stenroos, L., & Kokko, M. (2021). Distributed agency in living labs for sustainability transitions. In S. Teerikangas, T. Onkila, K. Koistinen, & M. Mäkelä (Eds.), *Research handbook of sustainability agency* (pp. 293–306). Edward Elgar. https://doi.org/10.4337/9781789906035.00026

Publication III — Engez, A., Ranta, V., & Aarikka-Stenroos, L. (2021). How innovations catalyze the circular economy: Building a map of circular economy innovation types from a multiple-case study. In S. Jakobsen, T. Lauvås, F. Quatraro, E. Rasmussen, & M. Steinmo (Eds.), *Research handbook of innovation for a circular economy* (pp. 195–209). Edward Elgar.

Publication IV — Engez, A., & Aarikka-Stenroos, L. (2023). Stakeholder contributions to commercialization and market creation of a radical innovation: Bridging the micro and macro level. *Journal of Business and Industrial Marketing, 38*(13), 31–44. https://doi.org/10.1108/JBIM-03-2022-0136

Publication V — Aarikka-Stenroos, L., Engez, A., Harala, L., Henttonen, K., Lehtimäki, H., & Malve-Ahlroth, S. (2022). Bringing environmental sustainability and the circular economy into entrepreneurship education with stakeholders: Four case methods from hackathons to role model cases. In K. Wigger, L. Aaboen, D. H. Haneberg, S. Jakobsen, & T. Lauvås (Eds.), *Reframing the case method in entrepreneurship education: Cases from the Nordic countries* (pp. 40–52). Edward Elgar. https://doi.org/10.4337/9781800881150.00012

AUTHOR'S ROLE IN THE PUBLICATIONS

Publication I Conceptualization of the study was done jointly by A. E., S. L., and L. A-S. A. E. primarily wrote the draft, conducted the literature review, collected and analyzed the data, and wrote the findings, with guidance from the co-authors. A. E. presented an earlier version of the study at the 31st ISPIM Conference (The 31st ISPIM Conference: Innovating in Times of Crisis, Virtual Event, 7–10 June 2020), after which A. E. further developed the manuscript with guidance from the co-authors. The article was peer reviewed prior to journal publication, and based on the feedback, edits were made by A. E. in collaboration with the co-authors, especially to the conclusion, which included the theoretical contributions and practical implications.

Publication II Conceptualization of the study was done by A. E. together with P. H. D. and L. A-S. A. E. primarily wrote the draft, conducted the literature review with P. H. D., collected and analyzed the data, and wrote the findings with guidance from the co-authors. A. E. presented an earlier version of the study at the 41st R&D Management Conference (The 41st R&D Management Conference, École Polytechnique, Paris, France, 17–21 June 2019), after which A. E. further developed the manuscript with guidance from the co-authors. The conceptual framework was developed by A. E. and L. A-S. M. K. verified the results of the study and contributed to the results. Based on the feedback from the review process, the final version was shaped by A. E. in collaboration with the co-authors.

Publication III Conceptualization of the study was done jointly by A. E., V. R., and L. A-S based on the original draft written by V. R. A. E. primarily wrote the draft, conducted the literature review, collected and analyzed the data with V. R., and wrote the findings with guidance from the co-authors. A. E. attended a seminar that was organized by the book editors and presented the study. Based on the verbal feedback received in the seminar, and then the later written feedback, the manuscript was edited by A. E. with guidance from the co-authors. The tree diagram and the table for circular economy innovation types were created by A. E. in collaboration with the co-authors.

Publication IV	Conceptualization of the study was done jointly by A. E. and L. A-S. A. E. primarily wrote the draft, conducted the literature review, collected and analyzed the data, and wrote the findings with guidance from L. A-S. L. A-S. presented an earlier version of the study at the 20th ANZMAC Conference (The 20th Australia and New Zealand Marketing Academy Conference, The University of Adelaide, Australia, 3–5 December 2018), after which A. E. further developed the manuscript. The article was first submitted to a special issue in the *Journal of Business and Industrial Marketing* and was rejected. Later, the critical feedback from the reviewers was taken into account, and the manuscript was edited further by A. E. in collaboration with L. A-S. The article was submitted again to the general issue in the *Journal of Business and Industrial Marketing*, and edited further by A. E based on the reviewers' feedback.
Publication V	Conceptualization of the study was primarily done by L. A-S in collaboration with A. E., L. H., K. H., H. L., and S. M-A. All the authors contributed to ideating regarding the selection of the case methods involved in the study. A. E. contributed to the results section by identifying the stakeholders, writing the hackathon method with S. M-A., and the real-life business challenge case method. A. E. contributed to the creation of the final comparison table regarding the hackathon method and the real-life business challenge case method. A. E. also provided feedback throughout the writing process, along with the co-authors. The manuscript received feedback from the editors of the book during the review process, and based on the feedback, the final version was shaped by all the authors. A. E. was responsible for editing the parts that concerned the hackathon method and the real-life business challenge case method.

1 INTRODUCTION

1.1 Background, motivation, and research gaps

Sustainable and circular innovations are necessary to address the environmental and social challenges that we face today (Cainelli et al., 2020). This includes issues such as climate change, deforestation, and inequality (Markard et al., 2012). Sustainability refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs. It involves considering environmental, social, and economic factors in decision-making to ensure long-term well-being (Farla et al., 2012). By involving stakeholders in the sustainable innovation process, we can ensure that the solutions developed are both effective and reflective of the needs and concerns of those who will be impacted by them. Stakeholder engagement can help build support for sustainable innovation initiatives (Chiappetta Jabbour et al., 2020). When stakeholders are involved in the development and implementation of sustainable solutions, they are more likely to be invested in their success. This can help create a sense of ownership and accountability, which can be crucial for driving the necessary changes and ensuring that sustainable innovations are implemented and sustained over the long term (Markard et al., 2012). Involving stakeholders in the innovation process can help generate new ideas and insights. By bringing together diverse perspectives and experiences, we can unlock knowledge that can be used to develop more effective and sustainable solutions. This would foster a culture of innovation and collaboration, which is essential for driving progress and creating a more sustainable future (Brownlee et al., 2017).

Innovation is defined as improvements in existing processes, services, or products, and it takes place regardless of the type of organization (profit or non-profit) (Rogers et al., 2014). Sustainable and circular innovations are the backbone of the technological advancements that make our lives easier. Innovation involves development, improvement, and change following idea generation in an organization (O'Sullivan & Dooley, 2008). Innovations can be applied to anything to improve it so that it meets the needs of people who are its users. Often, contrarily, this need is discovered by the innovators and not by the users; therefore, innovators need to be thinkers and anticipators who foresee what users will need. For innovations to be sustainable, the change and improvements need to be continual, as many innovations become obsolete at some point (Kline, 2009).

The open-innovation concept emphasizes the impact of knowledge sharing and value co-creation (Chesbrough & Bogers, 2014; Dahlander & Gann, 2010; Huizingh, 2011). Living labs have emerged as a growing concept in open innovation to engage stakeholders in generating solutions for various challenges, especially as users test, validate, and prototype such solutions (Almirall & Wareham, 2011; Bergvall-Kareborn & Stahlbrost, 2009; Leminen et al., 2012). The urban living lab (ULL) concept further investigates how cities can be sustainable by developing new collaboration methods and innovations that tackle growing issues, such as global warming, climate change, over-population, sustainable transportation, fossil fuel use, and greenhouse gas emissions (Bulkeley et al., 2016; Evans & Karvonen, 2010; Juujärvi & Pesso, 2013; Voytenko et al., 2016). To solve these issues, effective collaboration among various stakeholders, technological innovations, and a more circular economy (CE) are needed to shift to more sustainable consumption and production habits (Markard et al., 2012). Circular economy as a regenerative and resilient economic model adopts reduce, reuse, and recycle principles, which helps the transition to more environmentally friendly practices in the business models of companies (Bocken et al., 2016; Bocken & Ritala, 2020) and in municipalities (Evans & Karvonen, 2014; Kronsell & Mukhtar-Landgren, 2018), and the stakeholders are one of the most important influencers in this transition (Geissdoerfer et al., 2017; Ghisellini et al., 2016). Therefore, in this thesis, stakeholders and their contributions are studied to advance the knowledge of collaboration and co-creation methods in the transition from a linear to a more circular economy.

The current literature focuses on co-creation with a few types of stakeholders, and there is a research gap regarding the types of the stakeholders and their influence on the innovation process (Kazadi et al., 2016). Ideas for innovation can be nurtured through the involvement of various stakeholders and can be developed in different places and settings. During the innovation process, firms rely on external stakeholders for knowledge and value co-creation, which provides a competitive advantage for firms (Kazadi et al., 2016). Complex knowledge is required for innovation, which can be fulfilled by stakeholders. On the other hand, involving multiple stakeholders comes with challenges, such as conflicts over goals and interests, or communication issues (Driessen & Hillebrand, 2013; Waligo et al., 2014). Despite these challenges, the stakeholders of an organization are valuable resources who help the organization grow.

The research gaps center around understanding the complete spectrum of stakeholders that can actively contribute to sustainable innovation development. While many studies have identified key stakeholders such as businesses, government bodies, academia, and the general public (Ayuso et al., 2011; De Faria et al., 2010), there may be lesser-known actors, whose influence and contributions are not yet fully comprehended. Identifying these overlooked stakeholders and examining their roles in the innovation process is essential for a holistic understanding of the dynamics involved in sustainable innovation.

Living labs are one of the most prominent ways for stakeholders to contribute to the sustainable innovation development. The current living lab research lacks a CE approach that focuses on the reduction, reuse, and recycling aspects of resources, and there are few studies on the matter (Cuomo et al., 2020; Florez Ayala et al., 2022; Särkilahti et al., 2022; Voytenko et al., 2016). Thus far, living labs research has focused on experimental governance (Bulkeley et al., 2016; Kronsell & Mukhtar-Landgren, 2018), characteristics and outcomes (Veeckman et al., 2013), co-creation dynamics (Puerari et al., 2018), actor roles (Juujärvi & Pesso, 2013; Nyström et al., 2014), network structure (Leminen et al., 2012, 2016), and user roles (Leminen et al., 2015; Menny et al., 2018). More research is needed to understand the impact of the CE approach in living labs on sustainability transitions, and how such transitions take place with the inclusion of impactful stakeholders and innovation activities (Leminen & Westerlund, 2019).

Stakeholders can contribute to the sustainable development of innovations. Collaboration among stakeholders is needed for sustainable development, and important decisions associated with environmentally sustainable products or services cannot be made only by company managers (Hall & Vredenburg, 2003). The discussions in the stakeholder literature have been on stakeholder pressures or managing stakeholder expectations about controversial issues (Goodman et al., 2017), and they have not explicitly elaborated on the contributions of different types of stakeholders and their activities to the innovation development process (Grama-Vigouroux et al., 2020). Inherently, there can be conflicts when a multitude of stakeholders are involved in the decision-making process, but this aspect is not the focus of the concept of stakeholder engagement. The process of stakeholder engagement is expected to be collaborative and beneficial for all the parties involved, and organizations need to improve their skills and resources to make it happen.

Stakeholder engagement research has emphasized multi-stakeholder initiatives, partnerships, and platforms (Goodman et al., 2017), and innovation research has suggested that stepping into external partner networks can provide value to organizations (Kazadi et al., 2016). From the sustainability impact standpoint, the varying roles/activities/responsibilities that stakeholders have influence the transformation to a sustainability-focused society. In this context, consumers and citizens are among the most important stakeholders in sustainability transitions. The stakeholders, their contributions, and innovation outcomes in terms of CE are not adequately known in the context of innovation development and the thesis research aims to close this research gap (Lee et al., 2012). On top of the living lab context, societally important and relevant innovations require stakeholder involvement, and this thesis unveils these stakeholders and their activities to understand how these innovations emerge and progress. Research often stops short of thoroughly examining the outcomes of innovations, particularly in terms of their sustainability and circular economy impact (de Jesus & Mendonça, 2018; Prieto-Sandoval et al., 2018). To address this research gap, it is essential to rigorously evaluate how sustainable innovations translate into tangible benefits for the environment, resource efficiency, and societal well-being.

1.2 Research objective and questions

The objective of this research is to provide an understanding of different stakeholder types and contributions, and how they influence and shape the development process of innovations and sustainability. Table 1 provides an overview of the research questions, gaps, objectives, and publications addressing the research questions.

Table 1. Research questions, gaps, objectives, and publications.

Research question	Research gap	Objective	Publications
RQ1: What kind of stakeholders can contribute to sustainable innovation development in living labs and ecosystems?	Stakeholder types in sustainable innovation development (Ayuso et al., 2011; De Faria et al., 2010; Grama-Vigouroux et al., 2020)	To identify the stakeholders that are contributing to sustainable innovation development in living labs and ecosystems	I, II

RQ2: What kinds of contributions do stakeholders make to sustainable innovation development?	The ways through which different stakeholders can contribute to sustainable innovation development (Goodman et al., 2017; Lee et al., 2012; Leminen & Westerlund, 2019)	To identify and explore the stakeholder contributions and concepts that help an innovation emerge and develop	I, II, IV, V
RQ3: What are the outcomes of innovations in terms of sustainability and the circular economy?	Sustainability and circular economy implications and benefits of the various innovation types (de Jesus & Mendonça, 2018; Hellström, 2007; Prieto-Sandoval et al., 2018; Rennings, 2000)	To identify the outcomes for sustainability and the circular economy that the innovations lead to	I, II, III, IV, V

First, sustainable innovation development involves a wide range of stakeholders, including government agencies, businesses, civil society organizations, academic institutions, and individuals (Ayuso et al., 2011; Hörisch et al., 2014). Each of these stakeholders has a unique role to play in promoting sustainable innovation and can contribute in different ways. Stakeholders are important for sustainable innovation development because they can help ensure that a new product or technology is designed and implemented in a way that is sustainable and beneficial to the community (Grama-Vigouroux et al., 2020). By involving stakeholders in the innovation process, companies can gain valuable insights into and perspectives on the potential impact of their innovation on different groups of people, the environment, and the economy (Freeman et al., 2017). This can help companies identify potential risks and opportunities associated with their innovation and make informed decisions about how to move forward in a way that is socially and environmentally responsible (Garvare & Johansson, 2010). Additionally, involving stakeholders in the innovation process can help build trust and support for the innovation, which can be crucial for its long-term success (Noland & Phillips, 2010; Savage et al., 2010). Currently, we do not know which stakeholders appear as especially relevant and influential in the context of sustainable innovation development in living labs and ecosystems. The first research question of the thesis is as follows:

RQ1: What kind of stakeholders can contribute to sustainable innovation development?

The second research question focuses on the activities and contributions of stakeholders in sustainable innovation development. Stakeholder activities can take place on various platforms and in various settings, such as living labs (Leminen et al., 2012; Voytenko et al., 2016), or as part of the commercialization and market-creation process of a company's radical innovation (Aarikka-Stenroos & Lehtimäki, 2014; Slater & Mohr, 2006). The forms of contributions include, for example, sharing knowledge and expertise, co-creation and co-design, partnerships and alliances, crowdsourcing and open innovation, and collaborative decision making (Chesbrough & Bogers, 2014; Frantzeskaki et al., 2014; Poetz & Schreier, 2012). Stakeholder activities for innovation development are important to explore, as they provide access to technological resources and achievements, reduce the time required for innovation development, and provide access to markets through alliances and partnerships (De Faria et al., 2010). Through cooperation, knowledge and know-how can be obtained from other stakeholders engaged in knowledge exchange (Nieto & Santamaría, 2007; Tödtling et al., 2009). The activities can be for research, development, and production; the dissemination of a particular piece of information to the public; conducting risk and safety assessments; conducting experiments; orchestrating a group of actors; or prototyping, using, and testing, to name a few. In other words, stakeholder activities are scientific, technological, organizational, financial, and commercial (OECD/Eurostat, 2005). Currently, we do not understand adequately how such contributions emerge. The second research question of the thesis is as follows:

RQ2: What kinds of contributions do stakeholders make to sustainable innovation development?

The third research question concerns the outcomes of innovations for sustainability and the CE. The question aims to uncover the sustainability benefits of the developed innovations and what kinds of sustainability issues these innovations intend to solve. The CE is driven by innovation, and novel products and processes are needed to enable it (Prieto-Sandoval et al., 2018). These innovations have environmental, social, and economic implications, and they aim to tackle growing issues in the world, such as the energy supply, global warming, climate change, and greenhouse gas emissions (Markard et al., 2012). Understanding the variety of innovations and how they can mitigate the burdening effects of ongoing issues on the environment, societies, and economies would provide insights, ideas, and different ways to generate solutions and applications (Hellström, 2007; Rennings, 2000; Tukker, 2015). Transformations in many domains are needed, including transportation, agriculture, and energy (Markard et al., 2012). Sustainable CE innovations can be a way forward for the necessary sustainability transitions (de Jesus & Mendonça, 2018). The third research question of the thesis asks the following:

RQ3: What are the outcomes of innovations in terms of sustainability and the circular economy?

1.3 Key theories, concepts, and positioning

The key theories and concepts of the multi-actor/stakeholder contributions to innovation that I use in this thesis are stakeholder theory, innovation ecosystems, open innovation, living labs, and distributed agency. They provide a background to enable the contributions of stakeholders in various innovation settings, such as living labs, a radical innovation's commercialization and market-creation process, and an educational setting for fostering innovation development ideas, to be demonstrated. Stakeholder theory is utilized to examine innovation ecosystems and open innovation therein, particularly inside living labs, to understand more about distributed agency regarding CE and sustainability aspects. The key theories and concepts, their definitions, and their relevance in this thesis are listed in Table 2.

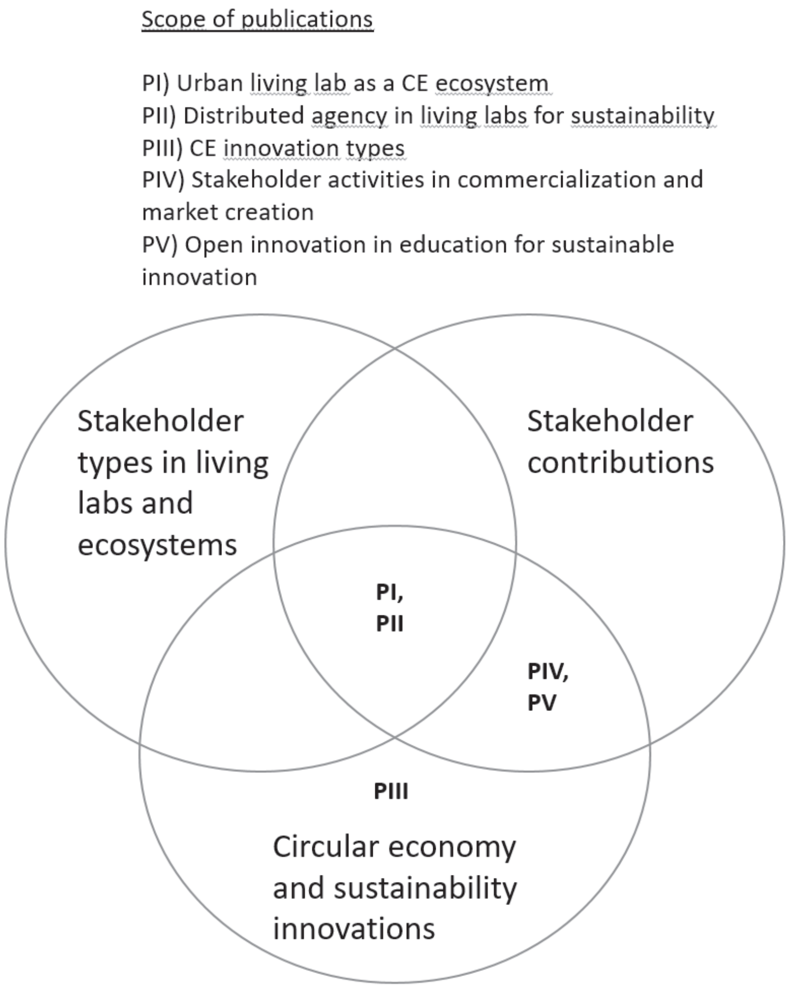
Table 2. Key theories and concepts that are used in the thesis research

Key theories and concepts	Definition	The relevance of the theories and concepts
Stakeholder theory	The theory that defends how groups and individuals have an influence over the success or failure of an organization, and that organizations need to take these stakeholders' interests into account (Freeman et al., 2010; Goodman et al., 2017; Kujala et al., 2019).	Different types of stakeholders have different roles and interests in living labs, ecosystems, and commercialization and market-creation processes in innovation development.
Innovation ecosystem	A network of organizations, people, and activities that are involved in the creation, development, and commercialization of new ideas and technologies (Granstrand & Holgersson, 2020; Valkokari et al., 2017).	Stakeholders, as members of an innovation ecosystem, develop an innovation network, and their actions affect each other and the whole innovation ecosystem.
Open innovation	A distributed innovation process that includes integrating the combination of internal and external ideas and knowledge of an organization to develop new technologies (Chesbrough, 2003; Huizingh, 2011).	Innovations need input from both internal and external stakeholders, which results in quicker development processes and more reliable outcomes.
Living labs	Open-innovation hubs where many types of stakeholders interact with each other to create a solution for a problem, often with the users of the innovation (Bulkeley et al., 2016; Leminen et al., 2012).	Living labs gather various stakeholders together, such as municipalities, companies, research institutes, and users, to develop innovations, and they act as a concept/platform to show their impact.
Distributed agency	Collective action and its effects resulting from the independent actions of multiple individuals in a group with different or similar motivations and interests (Enfield & Kockelman, 2017; Garud & Karnøe, 2003).	Stakeholders' flexibility comes with responsibility and accountability for their actions.

The thesis's research consists of five publications covering the main topic of stakeholder contributions to innovation development for sustainability and the CE.

Publications I and II are at the intersection of the three research gaps, which explore the innovation activities of stakeholders for the CE and sustainability in a ULL ecosystem. Publication IV and V are at the intersection of two research gaps, which explore stakeholder activities when commercializing a radical innovation and creating a market for the emergence of the innovation, and an educational setting for fostering innovation development ideas, both addressing circular economy and sustainability innovations. Publication III responds to the research gap of circular economy and sustainability innovations by exploring various types of CE innovation and their sustainability benefits. The positioning of the publications around the research gaps is illustrated in Figure 1 below.

Figure 1. Positioning of the publications around the research gaps.



1.4 Dissertation structure

This dissertation is structured as follows. The second chapter reviews the literature on multi-actor settings for collaboration for innovation and sustainability research, particularly focusing on the CE and environmental sustainability domains and innovation outcomes and processes. The third chapter presents the research methodology and describes the research design and qualitative research, case study approach, and research context. It further explains the data sources, collection, and analysis, and the assessment of the research. The fourth chapter presents the findings based on the publications. The fifth chapter synthesizes the key findings in light of the research questions, and concludes the dissertation by presenting the theoretical contributions, practical implications, limitations, and future research avenues. Figure 2 illustrates the dissertation's structure.

Figure 2. Dissertation structure.

Introduction	• Background, motivation, and research gaps • Research objective and questions • Key theories, concepts, and positioning • Dissertation structure
Theoretical Background	*Different theoretical lenses for understanding stakeholder contributions to innovation development* • Stakeholder theory, the diversity of stakeholders, and their engagement • Stakeholders in ecosystems (Innovation ecosystems and living labs) • Distributed agency among stakeholders *Sustainability and the circular economy aspects of innovation* • The circular economy and environmental sustainability • Health and social sustainability *The innovation development process and its outcomes* • Diverse innovation types • Innovation activities and diffusion • Organizing for innovation with stakeholders and open innovation projects
Methodology	• Research design and qualitative research • Case study research approach and research context • Data sources and data collection • Data analysis • Assessing the research
Findings	• Urban living labs as circular economy ecosystems • Stakeholder activities in urban living labs for sustainability: Distributed flexibility and accountability • Circular economy innovations: Product, process, service, and business model innovations • Contributions of macro-micro level actors to commercialization and market creation of a radical innovation • Stakeholder contributions through case methods: Entrepreneurship education for sustainability
Discussion and Conclusions	• Synthesis of the key findings • Theoretical contributions • Practical implications • Limitations and future research

2 THEORETICAL BACKGROUND

2.1 Different theoretical lenses for understanding stakeholder contributions to innovation development

As this study focuses on stakeholders' contributions to innovation development, the first section discusses different theoretical lenses to understand diverse stakeholders and their contributive activities and roles in innovation development. The main theoretical approaches are the diversity of stakeholders and their engagement, innovation ecosystems, distributed agency, and living labs as an open-innovation concept to understand the settings, methods, and concepts that help actors contribute to innovation development. These approaches all recognize the importance of collaboration and partnerships in achieving sustainable innovation, and they all involve engaging a wide range of stakeholders in the innovation process.

The stakeholder approach emphasizes the need to involve a wide range of stakeholders in the innovation process, including government agencies, businesses, civil society organizations, academic institutions, and individuals. This approach recognizes that each stakeholder group brings unique perspectives, expertise, and resources to the table, and that their collective efforts are necessary to develop and implement sustainable solutions (Freeman et al., 2010).

Similarly, the innovation ecosystem approach focuses on the importance of collaboration among different actors in a given ecosystem. This approach recognizes that sustainability depends on the interactions and relationships between different elements of an ecosystem, and that innovation and change must be carefully managed to preserve the overall health and resilience of the ecosystem (Adner, 2017).

The living lab approach also emphasizes the importance of collaboration but focuses specifically on the role of users and communities in the innovation process. It is a form of open innovation and in the thesis research it is framed as an innovation ecosystem. This approach involves engaging users and communities in the co-creation, testing, and evaluation of new products and services, with the goal of developing solutions that are both sustainable and meet the needs and preferences of the people who will use them (Leminen et al., 2012).

In the distributed agency approach, each stakeholder has a certain level of autonomy and control over his or her own actions and decisions, but these actions are also influenced and constrained by the actions of other stakeholders within the network. This means that individual stakeholders are not solely responsible for the outcomes of their actions, but rather that the outcomes emerge from the interactions and feedback loops between stakeholders (Enfield & Kockelman, 2017). In the context of innovation development, distributed agency can help us understand how different stakeholders contribute to the innovation process.

Finally, open innovation is a concept that involves leveraging the collective knowledge, expertise, and resources of a wide range of stakeholders to accelerate the innovation process. This approach involves actively seeking out and incorporating external ideas, perspectives, and technologies into the innovation process, with the goal of generating more and better ideas and solutions (Chesbrough, 2003).

2.1.1 Stakeholder theory, the diversity of stakeholders, and their engagement

According to stakeholder theory, stakeholders are defined as "groups and individuals who have a stake in the success or failure of an organization" (Freeman et al., 2010). Primary and secondary stakeholders in an organization are important factors that influence the sustainable development of innovations, regions, urban areas, companies, and business practices. Stakeholders take different roles in the transformation to a sustainability-focused society (Hines & Marin, 2004). Stakeholders interact with each other for collaborative research, development, and innovation activities in various places and spaces, including hackathons, living labs, and innovation hubs. Organizations might also use crowdsourcing to obtain new ideas and solutions (Poetz & Schreier, 2012). Stakeholders and innovation are reported to be the main factors in sustainable development for the future (Goodman et al., 2017). The stakeholder engagement notion emphasizes that the interactions involve the recognition and respect of a common humanity and that the actions of one stakeholder may affect others (Noland & Phillips, 2010). Stakeholder engagement also affects social and environmental sustainability and innovation development (Freeman et al., 2017). The elements of stakeholder engagement are (1) agreeing on mutual objectives, (2) building trust, and (3) promoting stakeholder responsibility in collaboration with other stakeholders (Brownlee et al., 2017).

Stakeholder theory influences many different fields in an organization, including strategic management, finance, marketing, law, healthcare, public policy, and the environment (Freeman et al., 2010). Stakeholder theory shapes, defines, and emphasizes two important areas: business ethics and corporate social responsibility (Dmytriyev et al., 2021). It argues that to achieve continuous growth, organizations should consider not only the interests of their shareholders, but also of their stakeholders (Kujala et al., 2019). This view also touches upon the morale and ethics of the management of organizations and relationships (Dmytriyev et al., 2017).

Stakeholder theory was created to solve problems related to understanding how business works, to understanding value creation and trade, and the ethics of capitalism, and is linked to entrepreneurship theory from a managerial standpoint (Freeman et al., 2010). As the world becomes more global and relies more heavily on the dominance of information technology, understanding business and relationships is becoming more complex in this turbulent environment. Increased awareness of the impacts of business on society calls for new management mindsets and models that are open, transparent, and responsible. Issues such as corporate social responsibility, corporate legitimacy, and the theory of the firm are addressed using stakeholder theory (Kujala et al., 2019).

What makes businesses successful depends on many factors, including having products and services that customers want, cooperating with suppliers for the progression of operations, having inspired employees who have the passion to move the company forward, and having supportive communities, which are all in the interests of corporations (Freeman et al., 2010; Miles, 2017; Mitchell et al., 1997). Therefore, as a result of managing these stakeholders, corporations can maximize their profits (Mitchell et al., 1997). Stakeholder theory sees profit maximization as an outcome of good stakeholder management and that profitable firms have value and purposes beyond profit maximization (Kujala et al., 2019). Table 3 lists the different views held by stakeholder theory researchers on value creation.

Table 3. Different views on stakeholder theory.

Author	View on Stakeholder Theory
Friedman (1970)	Maximizing profits and shareholder value through satisfying stakeholder interests (market-based approach)
Jensen (2002)	Enlightened value maximization explained by the tradeoff between choosing maximizing profits or market share, and changes in the total long-term market value of the firm (agency theory approach)
Porter (1980)	Value creation through competitive advantage enabled by value-chain actors (strategic management approach)

Stakeholder theory puts the emphasis on creating value for stakeholders. The relationships that an organization has with its stakeholders have an influence on the organization and the stakeholders together. These stakeholders include, but are not limited to, financiers, employees, customers, suppliers, and the local community (Freeman et al., 2010). Managing and shaping the relationships among these stakeholders constitute stakeholder management theory.

Financiers include owners, stockholders, banks, and so on that have a financial stake in the business. They expect a financial gain or return on their investment in the long or short run, depending on their interests. Employees are the running engines of companies. In return for their work, they get wages and security. Customers and suppliers exchange resources, which are money, products, and services. The local community expresses its wishes and concerns to the companies, and the companies in return provide economic and social contributions to the community. Companies are obliged to listen to their communities to operate ethically and transparently.

Stakeholder theory and engagement are widely discussed in the management literature. The aim is to support project management, manufacturing management, process improvement, problem solving, decision making, and information systems management (Freeman et al., 2010). The stakeholder audit concept is used to determine the factors that the organization's performance impacts (Roberts & King, 1989). To measure organizational effectiveness, the stakeholder approach is used to integrate goal- and resource-based approaches (Daft & Marcic, 2001). Stakeholder identification and assumption surfacing are used in the development of a group-decision support system (Nunamaker et al., 1988).

Stakeholder management and project management are closely intertwined. The stakeholder approach to project management has been widely discussed in the project management literature, especially when evaluating and selecting projects in an international context (Oral et al., 2001). The connection between environmental and social sustainability and corporate social responsibility is strong (Uribe et al., 2018). The influence of multiple stakeholder values on project management was brought up by McManus (2002). Stakeholder impact analyses are used in construction project management (Olander, 2007). Moreover, it has been found that there is a correlation between effective stakeholder management and project management success (Achterkamp & Vos, 2008). These studies emphasize that project success highly depends on the management of its stakeholders, who could be anyone that affects the project outcome or is affected by the project to any extent and to any degree.

When managing stakeholders and their interests, three attributes are highlighted for prioritization: legitimacy, urgency, and power. In order for a stakeholder to be taken seriously by the managers of a company, the stakeholder should have a legitimate claim, the request or the need for action should be urgent, and the stakeholder should have the power to influence the organization's activities (Mitchell et al., 1997).

Stakeholder theory has been suggested as a theoretical lens for examining sustainability-oriented innovation (Goodman et al., 2017). Terms such as open innovation, user innovation, and co-creation emphasize the importance of stakeholders in terms of the social and environmental impact of innovations. Since innovating for sustainable development is more complex compared with the regular innovation process, the stakeholders it involves are more ambiguous and wide ranging (Driessen & Hillebrand, 2013; Goodman et al., 2017). Stakeholders' impact on sustainability means that organizations should not only meet the needs of their stakeholders, but should also perform actions in a way that does not harm the environment and that should ensure sustainability on a global scale (Garvare & Johansson, 2010). Therefore, organizational sustainability can be achieved only if it leads to global sustainability concerning nature and future generations.

Engagement with different stakeholders is framed as an organizational capability for promoting sustainable innovation within firms (Ayuso et al., 2011). Through sustainable innovation, companies can achieve sustainable development, which requires new approaches to innovation (Senge & Carstedt, 2001). One of the benefits of stakeholder engagement is that companies can anticipate changes in the business environment quicker, and they can respond accordingly due to knowledge acquisition from various types of stakeholders. For sustainable innovation orientation, three key elements of organizational capability are highlighted: internal stakeholder engagement, external stakeholder engagement, and knowledge management (Ayuso et al., 2011).

In social, environmental, and sustainability management research, stakeholder theory is the most frequently used approach (Hörisch et al., 2014). In an attempt to list the similarities between sustainability management and integrative stakeholder theory, the following aspects are highlighted: (1) long-term stakeholder value is more important than short-term shareholder value; (2) ethical issues cannot be separated from business; and (3) prevention is always better than treatment (instead of compensating for and reimbursing irresponsible practices, value creation in a responsible and sustainable manner is emphasized). On the other hand, sustainability management focuses more on the role of nature and ecosystems, and on the sustainable development of markets, the economy, and society (Schaltegger & Wagner, 2011). To link sustainability management and stakeholder theory, sustainability should be one of the priorities and goals in the stakeholders' mindset, and mutual sustainability interests should be created (Hörisch et al., 2014).

2.1.2 Stakeholders in ecosystems

In an ecosystem, the network of stakeholders consists of organizations, individuals, and other entities that interact with each other (Valkokari et al., 2017). Stakeholders who are involved in an ecosystem influence the progress and developments in the ecosystem, and they have different degrees of importance. Both in stakeholder theory and the ecosystem concept, groups of individuals or entities are interconnected and interdependent (Aarikka-Stenroos & Ritala, 2017; Freeman et al., 2017; Valkokari et al., 2017). As an example, a company that operates in a sustainable way that benefits the environment, community, and its employees is likely to have a more positive impact on its ecosystem, which in turn can lead to more engaged stakeholders, and ultimately to a more successful business.

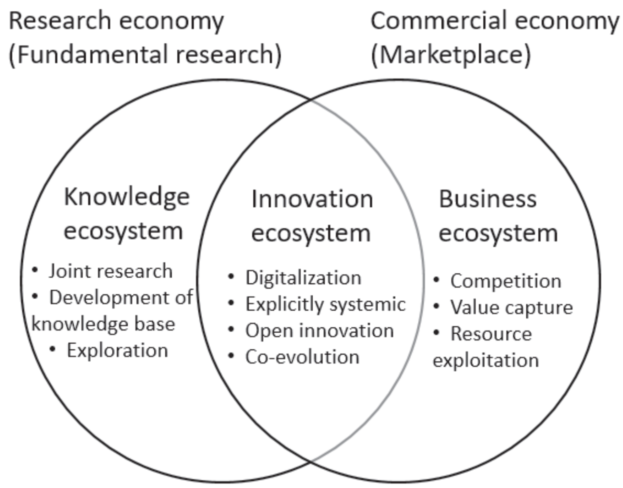
The ecosystem concept is defined as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017). The term "ecosystem" has been widely used in investment and economic development circles, such as in industry, academia, and government. Innovation systems and innovation ecosystems are discussed and compared in the literature, with the addition of "eco" to the terms of national and international innovation systems (Oh et al., 2016). The ecosystem concept stems from the assumption that business environments and ecological systems share similarities, which led to the idea of the ecology of innovations (Aarikka-Stenroos & Ritala, 2017).

2.1.2.1 Innovation ecosystems

An innovation is defined as the creation of new knowledge and inventions, and the successful commercial adoption of those in the markets (Crossan & Apaydin, 2010). There are four innovation ecosystem research challenges that have been brought up (Oh et al., 2016; Ritala & Almpanopoulou, 2017): (1) whether and how innovation ecosystems differ from national and regional innovation systems, (2) similarities and differences between natural and innovation ecosystems, (3) the measurement of innovation ecosystem performance, and (4) distinguishing between the levels in which the term is used.

An innovation ecosystem comprises two distinct economies: the research and commercial economies (Oh et al., 2016). Therefore, innovation ecosystems share the features of both knowledge ecosystems and business ecosystems (Clarysse et al., 2014; Yaghmaie & Vanhaverbeke, 2020), where the innovation is positioned around companies, research institutes, technologies, and platforms for the commercialization of innovations (Aarikka-Stenroos & Ritala, 2017). Innovation ecosystems as a mix of knowledge and business ecosystems is illustrated in Figure 3. The features that distinguish innovation ecosystems from other similar concepts, such as innovation systems, the triple helix, or innovation clusters, are listed as (1) being more explicitly systemic, (2) digitalization, (3) open innovation, (4) placing a greater emphasis on differentiated roles, and (5) placing a greater emphasis on market forces (Oh et al., 2016).

Figure 3. Innovation ecosystems as a mix of knowledge and business ecosystems.



Innovation ecosystems differ from natural ecosystems due to the presence of intention and governance (Papaioannou et al., 2009). It is argued that innovation ecosystems do not evolve like natural ecosystems; instead, they are designed. On the other hand, both innovation ecosystems and natural ecosystems are scalable, which means that they both have the capacity for extension across scales (Willis, 1997). As discussed in the literature, this might be a problem, considering that any networked innovation activity can be labeled as an ecosystem. In light of this, the use of the ecosystem concept is still ambiguous and calls for critical thinking and assessment when using the term. The term should be used especially for systems that focus on innovation activities, involve actor interdependence, and address the co-evolution of actors (Ritala & Almpanopoulou, 2017).

Although some cannot be measured, the success metrics of an ecosystem are reported to be (not limited to) employment rates, wealth, and quality of life, which are affected by effective leadership, the development of people, good connections among actors, and a supportive regulatory environment (Oh et al., 2016). However, measuring the performance or success of any type of multi-actor network is a difficult task due to the potential tensions and contradictions between actor- and system-specific goals (Ritala & Almpanopoulou, 2017).

The term "innovation ecosystem" is mentioned in several contexts in the literature, including corporate innovation ecosystems, regional and national innovation ecosystems, digital innovation ecosystems, city-based innovation ecosystems (innovation districts), high-tech SME-centered ecosystems, and university-based ecosystems. It has been argued that there is a lack of consistency in the use of the term, as in some contexts, the term can be interchangeable (Oh et al., 2016). In response to Oh et al.'s (2016) work, Granstrand and Holgersson (2020) argue that there is a need for the use of the innovation ecosystems concept—and it is different from the innovation systems concept—to emphasize the evolving nature of innovation ecosystems and innovation management (Ritala & Almpanopoulou, 2017).

The focus in innovation systems is largely on policy and institutions, whereas innovation ecosystems focus on business and strategy (Granstrand & Holgersson, 2020). Components and relations play an important role in both innovation systems and innovation ecosystems. In innovation ecosystems, collaboration plays a more prominent role than competition compared to business ecosystems (Granstrand & Holgersson, 2020). In business ecosystems, the focus is on value capture, whereas in innovation ecosystems, the focus shifts to value creation (Gomes et al., 2018). Prefixes such as "multi" and "co" are used widely in innovation ecosystems (Carayannis & Campbell, 2009) to emphasize the diversity, togetherness, interdependence of the actors, and the collaborative nature of the concept.

The networked and systemic nature of innovation, coupled with the increased connectivity of innovation activities, led to the emergence of the innovation ecosystem concept (Ritala & Almpanopoulou, 2017). Although innovation ecosystems are collaborative environments, actors may engage in competitive interactions alongside cooperative interactions, which may change the ecosystem dynamics (Valkokari, 2015). The boundaries of an innovation ecosystem are an important aspect to consider. In biological ecosystems, the boundaries are space and time, and these can be analogously applied to innovation ecosystems (Post et al., 2007; Ritala & Almpanopoulou, 2017). Valkokari (2015) classifies ecosystem boundaries based on geographical scope, temporal scale, permeability (open or closed), and types of flow (knowledge, value, material).

2.1.2.2 Living labs

Living labs are regarded as open-innovation hubs, where many types of stakeholders interact with each other to create a solution to a problem, often with the users of the innovation (Leminen et al., 2012). The emergence of the living lab concept took place in the early 1990s, when students took part in an inner-city neighborhood project to solve complex public sector problems (Bajgier et al., 2008). Living labs employ an open-innovation mindset that enables users, companies, and authorities to work together and generate solutions for various problems. Engaging users in living labs offers not only the advantage of seeing the possible future adoption of solutions in advance that are tested and assessed by users, but also adding users to the process as a source of creation (Almirall & Wareham, 2011). Living labs may lead to new products and services. In the context of cities as living labs, these labs provide a platform to experiment with different solutions and create new economic opportunities (Leminen & Westerlund, 2015).

Various actors and partnerships have helped to initiate living labs throughout the world with different goals and ways of working (Leminen et al., 2012) and they also influence decision-making processes and the progress of innovations. Shifts might be needed in markets, policies, and cultures in order to enable transformations in technologies and infrastructures in urban areas for more sustainable living and for the emergence of eco-friendly processes (Bulkeley et al., 2016; Särkilahti et al., 2017). Almirall and Wareham (2011) discuss the wide diversity of approaches, methodologies, and tools for living labs that were addressed by several scholars. They point out that scholars discuss living labs as an approach to innovation, as an environment, as an organization, and as a network or a system. Moreover, Bulkeley et al. (2016) mention that living labs adopt a learning-by-doing and interventionist approach.

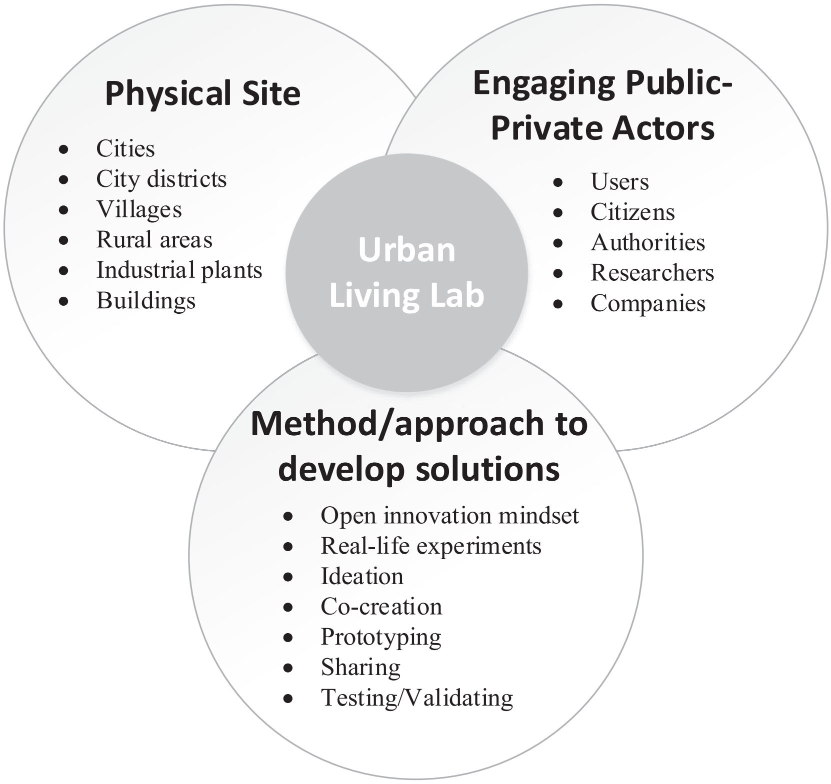
There has been a debate around what makes the living lab concept special compared to other open-innovation approaches, such as hackathons, open sourcing, or crowdsourcing (Westerlund & Leminen, 2011). One of the reasons why they are unique is that they are real-life experiments that result in knowledge creation, which is the reasoning behind the word "living" in the terminology. The other reason is that they are highly visible interventions that make intended transformations possible, which is the reasoning behind the wording "lab" in the concept, as laboratories create enhanced environments where it becomes possible to see things that are not visible elsewhere (Henke & Gieryn, 2008). In a sense, living labs are real-life settings in which results can be achieved quicker than in any other open-innovation approach.

Evans and Karvonen (2010) argue that the living lab term is used by many organizations, such as research organizations, governmental bodies, and companies, to emphasize and promote sustainability in their projects and approaches, although in some cases, the projects hardly relate to the subject (Veeckman et al., 2013). They further argue that living labs are a way to study sustainability and redefine the meaning of experimenting and innovating.

ULLs are sites that are built to create and test solutions through innovations that respond to the issues in an urban area (McCormick & Kiss, 2015). Being located in real places enables ULLs to address urban sustainability challenges at the district level and identify actors who can act upon those challenges. ULLs aim to introduce improvements to urban areas, including smart buildings and sensors, green spaces, more environmental transport and energy options, and sustainable local food production (Voytenko et al., 2016). The focus of ULLs is on the creation of a new learning platform for the governance of urban areas through emerging innovations in order to create urban sustainability (Bulkeley et al., 2016). It is stated in the Joint Programming Initiative (JPI) Urban Europe Program that the role of ULLs is realized through the learning gained from approaches to transition management in terms of policies and planning, which highlights the contribution of ULLs to urban governance (Voytenko et al., 2016).

Evans and Karvonen (2010) discuss the definition of ULLs as functional regions that include cities, villages, rural areas, or industrial plants. According to them, bounding ULLs geographically creates spaces to develop innovations, and there are many types of areas that can be used as living labs, depending on the context, which may include underdeveloped land, a degraded waterway, a smart transportation corridor, or a completely new city or district. In a very similar manner, Voytenko et al. (2016) state that ULLs have been characterized by partnerships and area-based initiatives, and they may be developed in an urban ecosystem, regional forum, cluster, city, district, road, corridor, or a building, thus underlining the geographical embeddedness of living labs. It is also stated that the area and urban configurations where the ULLs are hosted should have a manageable scale. While being located in a geographically bounded area gives living labs the advantage of engaging stakeholders in one place and strengthening cooperative activities, Ballon et al. (2011) point out that they lack economies of scale. The structure of the ULL partnership determines its potential to stimulate broader changes outside of its geographical area (Voytenko et al., 2016). To some extent, living labs have the ability to operate as intermediary spaces in a city or region (While et al., 2010), linking technological features and local solutions for the governance of urban transitions (Hodson & Marvin, 2007). Three main characteristics of an urban living lab are illustrated in Figure 4.

Figure 4. Three main characteristics of an urban living lab.



Voytenko et al. (2016) discuss how some scholars and organizations define living labs as a supportive tool to commercialize the services, products, and technologies that are tested in the pilot projects, and they place more emphasis on this aspect rather than on partnerships. Therefore, it is pointed out that living labs can be considered both as a platform and as an approach to initiate interactions and collaboration among municipalities, citizens, companies, and researchers. Although stakeholder participation has been increasingly highlighted, ULLs should have a clear owner and leader to make it easier to manage the information and resource flows among stakeholders.

ULLs emphasize an experimentation approach to governing cities, as this provides important gains for urban areas (Gibbs & Krueger, 2007). Implementations of experimentation may vary, and the weight of the users' role and their engagement in the living lab are crucial. The benefit of experimentation is that it tests new technologies and policies in real-world settings and can prompt rapid social and technical changes to transform urban governance (Baccarne et al., 2014). Openness between actors when generating new ideas for co-creation is another important element of a living lab (Veeckman et al., 2013). Nieto and Santamaría (2007) argue that co-creation is a way to exploit the knowledge from different sources that create value, and they describe innovations as collaborative development among multiple actors. In order to keep the participants involved and engaged in the activities, knowing what drives their interests to participate and contribute to the activities is also of importance (Ståhlbröst & Bergvall-Kåreborn, 2011). In terms of the duration and scale of living labs, they can vary from short- to long-term initiatives, and the innovation type determines the number of users who would need to participate in the project or research activity (Veeckman et al., 2013). The users involved can have the role of informant, tester, contributor, or co-creator (Leminen et al., 2015).

Living labs can help organizations rapidly develop, commercialize, and upscale an innovation and make it ready for the global market (Leminen et al., 2012). For instance, the effectiveness of the living lab approach has been proven by Procter and Gamble, which applied this approach and included various stakeholders in their research and innovation activities, resulting in substantial benefits to the company in a short time without any increase in their research and development (R&D) expenditure (Kusiak, 2007). Hodson and Marvin (2007) state that climate change issues were one of the factors that triggered local policymakers to take action to adopt ULLs as a new way of governance for urban sustainability.

2.1.3 Distributed agency among stakeholders

Distributed agency is defined as collective action and its effects that result from the independent actions of multiple stakeholders in a group with different or similar motivations and interests (Enfield & Kockelman, 2017; Garud & Karnøe, 2003). Similarly, the stakeholder approach emphasizes that organizations need to consider their stakeholders' interests when making decisions, and that stakeholders influence the outcomes of organizations' actions (Mitchell et al., 1997). Both approaches point to the importance of a single stakeholder in a given ecosystem affecting a specific outcome. The main theory behind distributed agency is that the capacity to act and make decisions is affected by the interactions and relationships between multiple stakeholders, including people, technology, and institutions (Garud & Karnøe, 2003). Over time, these interactions between and actions of stakeholders create a path that leads to a steady accumulation of practices, rules, and knowledge that shapes stakeholders in different domains, such as regulation, design, or production

(Garud & Karnøe, 2003). Distributed agency is most fruitful when it generates benefits for all the stakeholders and society in general (Garud & Karnøe, 2003). The distributed agency concept comprises distributed flexibility and distributed accountability elements (Enfield & Kockelman, 2017). The article explains how David J. Miller showed a level of flexibility and accountability when he burned his draft card as a symbolic anti-war act regarding the US government's army call up for the Vietnam War.

The concept of flexibility is analyzed in terms of the potency and impact of two elements that determine the outcome of various traits. The flexibility element consists of having a degree of flexibility in and accountability for meaningful behaviors by agents. Agents have flexibility over meaningful behavior through control, and they determine the specific time and place of the behavior, compose or design the behavior as a means to a particular end, or anticipate how others could view and react to the behavior (Enfield & Kockelman, 2017). Controlling consists of the act that initiates the whole process of events that lead to the aftermath. Composing consists of planning and executing possible outcomes that would arise, what the act stands for, and the motive behind the act. Subprehending refers to anticipating the interpretants of the behavior (Enfield & Kockelman, 2017).

The accountability aspect concerns the responsibility for and ownership of individual actions and behaviors, and the evaluation of the outcomes of the behavior. Distributed accountability refers to the fact that the actors are subject to evaluation. The concept of accountability is analyzed in terms of three elements: public evaluation, the entitlement to carry out the behavior, and the obligation to carry out the behavior (Enfield & Kockelman, 2017). Public evaluations of the behavior can be executed by many people, which could be in the form of praise, blame, or other such reactions. Agents may design their behavior purposefully to state their reasons for action, which makes them entitled to publicize their reasons for action. Furthermore, the agents may be obligated to perform some actions, as they may be expected to carry out a certain behavior as a means to initiate a movement for the betterment of a bigger group or, for instance, for motivating others, or out of a moral obligation (Enfield & Kockelman, 2017).

2.2 The innovation development process and its outcomes

This section explores the diverse innovation types, innovation activities done by stakeholders and diffusion, and organizing for innovation and open-innovation projects to explain the overall innovation development process. Innovation outcomes are the result of the innovation process, which involves the collaboration and participation of various stakeholders within an innovation ecosystem (Granstrand & Holgersson, 2020). An innovation ecosystem is made up of the people, organizations, and institutions involved in the creation, development, and implementation of new ideas (Suominen et al., 2019). This can include researchers, entrepreneurs, investors, regulators, and other stakeholders who all play a role in supporting the innovation process and influencing its outcome.

2.2.1 Diverse innovation types

Innovation is a broad concept; consequently, researchers have suggested diverse innovation typologies. For instance, Garcia and Calantone (2002) classify innovations as incremental and radical based on their technological novelty and their capability of changing the market structure. Radical innovations are novelties that dramatically change consumer behavior, habits, and market structures, and they introduce something that is novel and unique with completely new product features. With radical innovations, consumers realize and recognize a new need and demand, which leads to the creation of new markets, industries, and firms (Garcia & Calantone, 2002). Incremental innovations progress gradually and typically involve an improvement to an existing product line, technology, or service in an existing market. Companies tend to push for incremental innovations more commonly than radical innovations due to the lower risk and less difficulty that incremental innovations carry because of the lower newness and higher familiarity (Atuahene-Gima, 1995; Garcia & Calantone, 2002; Hellström, 2007).

Another innovation classification approach by Crossan and Apaydin (2010) identifies the forms of innovation as product, process, service, and business model innovations. This typology separates the form of innovation more distinctively by identifying product and service innovations as novel offerings available to and thus visible to the customer; business model innovations as novel and more sustainable ways of interaction with the customer and as novel and more sustainable ways of value creation, delivery, and capture for the customer; and process innovations as new or improved ways of producing or managing products and services (see Table 4).

Table 4. Diverse innovation types (Crossan & Apaydin, 2010; Geissdoerfer et al., 2020; Henard & Szymanski, 2001; Kindström & Kowalkowski, 2014; Maine et al., 2012; Wang & Ahmed, 2004).

Innovation Type	Definition
Product	An assembled product that is sold to a customer once manufactured, which evokes the perceived newness, novelty, originality, uniqueness, and usefulness of the innovation (Henard & Szymanski, 2001).
Process	Implementation of new production methods, new management approaches, and new technology that can be used to improve production and management processes (Wang & Ahmed, 2004)—that is, referring to processes that enable value creation that are internal to the firm (Crossan & Apaydin, 2010) and commercializable to other firms (Maine et al., 2012).
Service	Development of new service offerings and concepts, while intertwining the tangible (e.g. product forms) and intangible (e.g. processes, knowledge) aspects of an innovation (Kindström & Kowalkowski, 2014) with the aid of information technologies.
Business Model	Conceptualization and implementation of business models as a novel way of creating/capturing value, which comprises the creation of start-ups, diversification into business models, the acquisition of business models, or the transformation of a business model into a circular one (Geissdoerfer et al., 2020).

The literature has acknowledged that a sustainability transition leading to resource efficiency enabled by the CE can be realized through innovation, and both the sustainability and innovation management streams have increasingly investigated eco-innovations (Hellström, 2007; Rennings, 2000). Within the innovation literature, the sustainability stream has particularly addressed the necessity of institutional support and a change in social arrangements for eco-innovations to advance (Freeman, 1996). The innovation management stream has focused particularly on the changes in technological, social, and institutional innovations, and the specific role of regulatory instruments for sustainable innovation development (Rennings, 2000).

2.2.2 Innovation activities and diffusion

The innovation process includes four main stages: ideation, development, commercialization, and post-launch (Hoyer et al., 2010). As various stakeholders are involved in the innovation development process, the activities that stakeholders perform in different innovation process stages, innovation dynamics, and how innovations diffuse in markets are explained. According to Cooper and Kleinschmidt (1991), the process starts with the determination of the resources needed to launch an innovation. Once the resources are defined, management allocates them for different activities. Generating as many ideas as possible and refining and choosing them at the beginning of an innovation process is essential. The next phase of the process is the development phase, which includes developing the operational and technological aspects of an innovation and analyzing the financials and markets. When the basic product features are developed and tested in the market, the product evaluation phase takes place. This is the last phase before the validation of the product. Testing and validation evaluate a product's readiness for the market (Mankins, 2009). The last decision for managers before the product is launched in the market is made at this point. After the launch of the product, a post-launch evaluation takes place, where the analysis of the whole process is carried out (Cooper & Kleinschmidt, 1991). When the dominant design of a new technology starts to take shape, we see a rapid increase in performance (Vargo et al., 2020). This is the point where other players in the industry start to use all their resources to develop the dominant design; hence, product performance increases (Anderson & Tushman, 2018). The product performance increase and maturity can be explained by the S-curve, which depicts the natural growth and discontinuity of technologies (Christensen, 1992).

Customer needs must be fulfilled to obtain the benefits of a new product launch. In different phases of innovation development, the ideas and feedback from users should be collected, as they will be the ones who will use and benefit from the innovation (Cooper & Kleinschmidt, 1991). Rogers et al. (2014) used innovation-diffusion models to forecast the demand for an innovation and to capture its lifecycle dynamics. The level of diffusion increases as the population starts to understand the benefits of the innovation in order to utilize it effectively. The diffusion level is measured by the percentage of the population using the innovation. When the innovation comes to the marketplace, the number of users gradually increases (Rogers et al., 2014). According to Moore (1991), the key point here is to cross the chasm area, which is between the early adopters and the early majority. This area represents the break point for companies to enter the mass market with their innovations. If a company can diffuse its innovation further away from the chasm area, it should direct its focus to improving the marketing and pricing of the innovation rather than its technological features (Moore, 1991). From that point onwards, the innovation can be self-sustaining.

In the first periods of the innovation, users are often uncertain about its effects. Starting from a certain point, the market begins to pick up pace. However, as with discontinuities, every diffusion has a natural limit, which in the end creates a saturated market (Veryzer Jr., 1998).

According to Rogers et al. (2014), the speed of the diffusion rate is positively influenced by the relative advantage, compatibility, trialability, and observability of the new technology, while complexity negatively influences the diffusion rate. If the new technology is better than the existing technology in terms of solving problems, then the diffusion rate moves faster, which is called a relative advantage. Compatibility describes how, when a new technology emerges, consumers do not have to change their current habits around using the product. Moreover, complexity highlights the difficulty in understanding the benefits of the innovation. Trialability explains the possibility of trying the new technology at minimum cost. Observability means that the visibility of a product's benefits should be considered (Rogers et al., 2014). In addition to Rogers's work, it is argued that greater innovation radicality ("the extent to which the innovator's new product departs from prior new products in an industry") (Lee et al., 2003, p.756) results in a higher extent and speed of diffusion, and that a greater scope of innovation ("the number of customers, markets, and competitors a new product innovation is targeting") (Lee et al., 2003, p.757) leads to a faster diffusion speed (Lee et al., 2003).

When determining the speed of a diffusion process in a social system, interpersonal communications, mass media, and nonverbal observations play an important role (Mahajan et al., 2000). There are eight applications to show the diffusion models for strategic new product decisions. Forecasting and sampling are the applications that are used in the pre-launch and launch stages. Sampling is used to convince customers to try a new product. However, it is costly to offer free products. There are two types of sampling: neutral and target sampling (Jain et al., 1995). The difference between the two is the target customer segments to which the product samples are offered. In target sampling, the focus is on opinion leaders and innovators, whereas in neutral sampling, the focus is not on that. For post-launch strategic decisions, there are six applications: the timing of successive generations of a product, the determination of the impact of capacity decisions on innovation diffusion, an estimation of pirated sales, an estimation of lost sales and market expansion due to patent infringements, the determination of the market value of a business due to anticipated market penetration, and an assessment of market saturation and expansion opportunities for retailers (Mahajan et al., 2000).

For an individual, the awareness, persuasion, decision making, implementation, confirmation, and replacement phases need to be gone through to fully adopt the innovation (Mahajan et al., 2000). The first phase emphasizes being aware of the innovation so that the individual is able to spread the knowledge. The next phase is the persuasion phase, which explains the marketing to consumers to persuade them to buy or use it. In the decision-making phase, the consumer makes a decision about buying the product or declining the product. The implementation phase explains the use of the processes. The confirmation phase evaluates how the use of the innovation fulfills the consumer's needs. In the replacement phase, using the innovation comes to an end by discarding it.

2.2.3 Organizing for innovation with stakeholders and open-innovation projects

In innovation management and organization, there are different concepts and forms of cooperating that are utilized, such as hackathons, innovation hubs and spaces, open-innovation projects, living labs, and fab labs (Westerlund & Leminen, 2011). Open innovation is defined as a distributed innovation process that includes integrating the combination of internal and external ideas and knowledge of an organization to develop new technologies (Chesbrough, 2003). The open-innovation concept was in use even before the open-innovation term became popular, in the form of absorptive capacity or using the input of outsiders to improve internal innovation processes (Huizingh, 2011). For organizations, some of the goals in engaging in open-innovation relationships are value creation and capture through the accelerated co-development of sustainable innovations, reduced R&D costs, and accessing new and valuable knowledge that cannot be obtained alone (Chesbrough et al., 2014). Open-innovation practices can take place among innovation and R&D networks, and innovation ecosystems. Even though knowledge sharing in the open-innovation process has benefits, the process needs to be managed carefully so that agreement can be reached on what knowledge should be shared in order to prevent the risk of a leakage of knowledge that is not intended for sharing (Ritala & Stefan, 2021). This aspect brings up the issue of the confidentiality and secrecy of the knowledge that firms possess and the type and context of the information with which firms can contribute to the open-innovation process.

The internal use of external knowledge is called inbound open innovation, whereas the external exploitation of internal knowledge is called outbound open innovation (Dahlander & Gann, 2010). It is stated that inbound is more commonly used than outbound open innovation, which implies that companies do not adequately capture the benefits of their internal knowledge by licensing out their technologies and making a profit (Chesbrough & Crowther, 2006). According to Dahlander and Gann (2010), firms use formal and informal methods to capture value from innovations and protect their intellectual property. Formal methods include patents, trademarks, and copyright protection, while informal methods include lead times, first-mover advantages, and lock-ins. Identifying the innovation-related knowledge (exploration), integrating the knowledge internally (integration), balancing incentives, and using multiple channels to capture value (exploitation) make up the knowledge integration process for open innovations (Wallin & von Krogh, 2010).

Based on user feedback and involvement, open-innovation projects have the flexibility to adjust the goals of innovation development without the need to set pre-defined goals. Integrating users as co-developers in R&D projects reduces the risk of the failure of the products/applications and ensures the fit of the solutions. User participants in open-innovation projects do not usually expect any monetary returns because their main motive for participation is their contribution to the project (Westerlund & Leminen, 2011). In open-innovation projects, as the projects progress, the need for resources might change over time, unlike in conventional projects.

In order to achieve sustainability in many domains, scholars have highlighted the importance of projects and project management (Rammel & Van Den Bergh, 2003). Sustainable development concerns economic, environmental, and social development goals, and projects act as vehicles to pursue these goals (Keeys & Huemann, 2017). Projects as a means to gather relevant stakeholders together to realize SDGs can be on a project, corporate, ecosystem, or sustainable development agenda level. For instance, many ULL projects focus on urban sustainability and achieving low-carbon targets. ULLs, through the associated sustainability projects, highlight the impact of technologies and services, how to achieve social inclusion, smart city transformations, sustainable mobility and transportation, and new forms of urban governance (Voytenko et al., 2016). Projects integrate adaptive learning with planning, develop a common vision and approach, have transformation potential with goal-driven processes, and bring together identity, means, and networks to collaborate and co-create for sustainable development (Keeys &

Huemann, 2017). Transparency and the accommodation of stakeholder norms and practices, and determining key areas of engagement to maintain project boundaries support value co-creation in projects.

2.3 Sustainability and the circular economy aspects of innovation

Sustainability and the CE are increasingly important in the field of innovation. This is because they provide a framework for developing new products, services, and business models that support the transition to a more sustainable and resilient economy (Hysa et al., 2020; Markard et al., 2012). By focusing on reducing waste and maximizing the use of resources, sustainability and the CE can help to drive innovation in a number of ways. The principles of the CE can inspire new ideas for closed-loop manufacturing processes, the shared use of assets, and the use of renewable energy (Geissdoerfer et al., 2017; Tukker, 2015). These ideas can provide a platform for innovation as they challenge traditional linear economic models and encourage the development of new technologies and business models (Ferasso et al., 2020; Lüdeke-Freund et al., 2019; Ranta et al., 2018). In addition, the focus on sustainability can also drive innovation by providing a new set of challenges and opportunities (de Jesus & Mendonça, 2018). As the world faces increasing environmental and social challenges, such as climate change, the loss of biodiversity, and inequality (United Nations, 2022), there is a growing need for innovative solutions that address these issues. By focusing on sustainability, innovators can develop new products, services, and technologies that support the transition to a more sustainable future (Markard et al., 2012).

2.3.1 Environmental sustainability and the circular economy

Environmental sustainability has been a growing research topic in recent years due to the deteriorating impacts of climate change and the depletion of natural resources, which has prompted firms to look for innovations for sustainability (Dangelico, 2015; Olah et al., 2020). Recent research has identified that sustainable businesses can deliver improved financial performance and competitive advantage through more effective resource use due to the scarcity of resources (Ghisetti & Rennings, 2014). In the field of sustainability, the CE notion, in particular, has gained global interest regarding resource efficiency, the conservation of natural resources, and increasing carbon neutrality (Markard et al., 2012). In the CE, the value of materials and products already in circulation is maintained in order to reduce the need for virgin natural resources. This requires suppliers to implement changes in their current business or introduce entirely new business (Prieto-Sandoval et al., 2018). The CE requires material circulation and a reduction in wasted materials through reusing, reducing, and recycling, and it is innovation-driven by nature. To capture competitive advantage while being sustainable, many technology developers are putting effort into innovations that enable resource efficiency and the CE. In other words, to be more sustainable, suppliers need to innovate (Mariadoss et al., 2011).

The idea of the CE started with the fact that a resource should not be wasted and should be circulated with the highest utilization rate and with as little waste as possible (Stahel, 2016). Resources such as raw materials and energy are used to produce a product, and once it is produced, it is beneficial for the environment to keep the product in use for as long as possible. If the product comes to its end of life, the materials that make up the product can be recycled or reused, or the whole product can be remanufactured by replacing the old parts with new components (Geissdoerfer et al., 2017). In fact, the products and side streams have the potential to be recycled and utilized to make new products. Therefore, a shift to a CE approach with appropriate manufacturing designs and proper systems is needed. To leverage the transition toward a CE, different stakeholders must work together to create a CE ecosystem. This shift in attention toward business model innovation is a key leverage for circular technology adoption (Geissdoerfer et al., 2020; Rashid et al., 2013). Additionally, the study by Ghisellini et al. (2016) also points out that the transition toward a CE requires the involvement of all actors in society and these actors' capacity to link and create suitable collaboration and exchange patterns.

In order to explore the definitions of two similar terms—reuse and recycle—which are often confused as being the same thing, detailed explanations will be given next. The term "reuse" emphasizes the highest level of conservation of the already consumed energy and raw materials that would be required to produce a new product. Reuse is associated with the slowing resource-loop strategy by applying long-lasting designs, and designing for durability and the ease of maintenance and repair to keep the product in use for as long as possible (Bocken et al., 2016). Recycle is associated with the closing resource-loop strategy by designing the product for technological and biological cycles, and designing for disassembly and reassembly. Recycle and reuse emphasize the value and preservation of the already consumed energy and resources that were used to produce the product; nevertheless, recycling is considered to be the least sustainable solution compared to reduction and reuse in terms of resource efficiency and profitability (Stahel, 2013). In conclusion, the CE implies an increase in the efficiency of resource use with a special focus on urban and industrial waste, the adoption of cleaner production patterns at the company level, an increase in the producers' and consumers' responsibility and awareness, the use of renewable technologies and materials (wherever possible), and the adoption of suitable, clear, and stable policies and tools (Ghisellini et al., 2016). In order to make these achievements possible and to create awareness, the living lab approach can be applied to utilize the users' perspective and to engage public and private actors in collaboration and knowledge sharing (Leminen et al., 2012).

In a study that discussed the benefits that nutrient recycling would provide (Marttinen et al., 2017), it was found that the total amount of recyclable phosphorus in Finland would easily cover the amount of phosphorus needed for all of Finland's annual plant production, which highlights the capability of domestic phosphorus production and the potential of eliminating dependency on phosphorus imports. In many highly populated countries, there are no phosphorus reserves, and the current supply of phosphorus in the world is diminishing. Many countries are solely dependent on imported phosphorus for plant production. It is estimated by the European Sustainable Phosphorus Platform (ESPC) that replacing the imported phosphorus with recycled nutrients would create 66,000 new jobs (Aho et al., 2015). Such examples point out that in order to supply food to people in the future, every means of nutrient recycling is important. Mineral fertilizers are currently being sold at affordable prices, but their price might eventually increase in 50 or 100 years due to the lack of supply. In this case, nutrient recovery from different sources will offer substantial benefits, and the subject is also part of the EU's CE goals (Marttinen et al., 2017).

2.3.2 Health and social sustainability

The circular economy, which is rooted in environmental sustainability, has a direct and indirect impact on health and social sustainability. The reduced environmental impact, efficient resource use, and sustainable practices of the circular economy contribute to improved health outcomes, economic opportunities, and social equity, thus establishing a significant link between these dimensions of sustainability (Markard et al., 2012). In addition to the CE and environmental sustainability, healthcare and social sustainability are important pillars of sustainable development along with economic and human dimensions. SDGs can be achieved by providing products and services for the people (social), planet (environmental), partnerships and prosperity (economic), and by adopting sustainable practices in everyday living habits, which relate to many sustainability-related issues, such as poverty reduction, increased prosperity, inclusion, and equality (United Nations, 2022). In order to achieve the SDGs, Sachs et al. (2019) list six areas that need transformation in countries throughout the world for the progression toward a global sustainable society: (1) education, gender, and inequality; (2) health, well-being, and demography; (3) energy decarbonization and sustainable industry; (4) sustainable food, land, water, and oceans; (5) sustainable cities and communities; and (6) a digital revolution for sustainable development. Among the dimensions of sustainable development, social sustainability deals with having a sense of community, safety, health, and place attachment (Eizenberg & Jabareen, 2017). From a company point of view, social sustainability relates to the positive and negative business impacts on its stakeholders, as relationships and engagement with stakeholders are crucial for businesses to grow and prosper.

The health aspect of social sustainability affects everyone around the world. An individual's health and well-being are affected by one's social, mental, economic, cultural, and physical environment and condition, and food and eating habits are among the most impactful variables in this equation (World Health Organization, 2003). Healthy eating (including appropriate proportions of vegetable, fruit, and wholegrain intake) has an impact on energy levels, sleeping patterns, and one's overall health condition, and it alleviates the risk factors for physical health problems, such as cardiovascular disease and diabetes. Cardiovascular disease was one of the main causes of death in the world, and a healthy diet and regular exercise can prevent it (Willett, 1994).

Healthcare innovations involve diverse stakeholders who must be engaged in order to earn the trust of consumers and other related market actors (Jirotka et al., 2005; Puhakka et al., 2019). A healthy food innovation, such as functional food, which is at the intersection of food and a strongly regulated health and medicine sector, can be studied to analyze its commercialization and market creation. Functional food has been defined as any modified food or food ingredient that may provide a health benefit and reduce the risk of a disease beyond the traditional nutrients it contains (Bloch & Thomson, 1995). With regard to the market-creation aspect of functional foods, several factors have led to increasing demand and market formation (Heasman & Mellentin, 2001). These factors are the unhealthy dietary habits of the aging population, which results in early deaths associated with coronary heart disease, increased awareness of the nutritional benefits of certain types of foods, consumers' willingness to try new foods, increased healthcare costs, the healthy shift in the dietary guidelines of countries, government initiatives, such as setting up special study groups to study the occurrence of cardiovascular disease, and establishing an assessment and approval system for the verification of the health claims of functional foods (Heasman & Mellentin, 2001). The market category of functional foods started to exist after regulators' approval for the distribution of products that have health claims. Therefore, regulators acted as gatekeepers, allowing society to start accepting the novelty.

3 METHODOLOGY

3.1 Research design and qualitative research

The thesis's research adopts an exploratory qualitative research approach due to the "who" and "what kind of" types of research questions that are suitable for exploratory research (Patton, 2015). It focuses on stakeholder collaboration and contributions to innovations, particularly CE innovations. In order to study this phenomenon, two studies (Publications I and II) analyze the living lab concept, one study (Publication III) analyzes CE innovations, one study (Publication IV) analyzes the stakeholder activities that contribute to commercialization and market creation, and one study (Publication V) analyzes the methods in entrepreneurship education that focus on the CE and environmental sustainability.

The qualitative case study approach is used in the thesis research for several reasons. This approach is well-suited for investigating the complex and dynamic relationships between stakeholders and their contributions to innovation in the circular economy and sustainability fields. Circular economy and sustainability initiatives involve a multitude of stakeholders, including businesses, government agencies, non-governmental organizations, and consumers. A qualitative case study approach allows for an in-depth exploration of the intricate interactions, perspectives, and contributions of various stakeholders within specific contexts (Bryman, 2015). The circular economy and sustainability fields are context-dependent and can vary significantly across industries, regions, and organizations. Qualitative case studies enable researchers to understand the unique contextual factors that influence stakeholder contributions and innovation in specific cases (Eisenhardt & Graebner, 2007). The innovation development process is often iterative and involves a series of interconnected activities. Qualitative case studies are well-suited to capture the dynamic and evolving nature of innovation in sustainability and circular economy contexts, allowing researchers to study the entire innovation lifecycle (Yin, 2009). Given the practical implications of sustainability and circular economy initiatives, qualitative case studies provide valuable insights that inform policy, industry practices, and sustainability strategies by showcasing real-world examples of stakeholder-driven innovation (Stake, 1995).

The research topic is timely and contemporary, as the CE has gained global interest in recent years, aiming for the mitigation of the negative environmental impacts caused by linear consumption and production patterns, climate change, global warming, the depletion of raw materials and resources, and other sustainability-related issues (Geissdoerfer et al., 2017; Ghisellini et al., 2016). The need for developing innovations in the CE for the reduction, reuse, and recycling of materials calls for collaboration between different types of actors, and living labs are one of the prominent methods of collaboration, bringing users, authorities, companies, and research organizations together.

Although there are studies on stakeholder impacts on innovation development, the CE aspect is missing (Corsaro et al., 2012; Nieto & Santamaría, 2007). The thesis's research is qualitative and exploratory due to the lack of knowledge on stakeholder contributions to innovation development in a CE, while considering, in particular, living labs alongside the market-creation and commercialization phenomena. A qualitative exploratory research design is suitable for understanding phenomena in real-life contexts, with the aim of providing new and holistic knowledge (Yin, 2009). The methodologies of the original publications are listed in Table 5 below.

Table 5. Methodologies of the original publications.

	Publication I	Publication II	Publication III	Publication IV	Publication V
Research design	Qualitative exploratory single-case study	Qualitative instrumental single-case study	Qualitative exploratory multiple-case study	Qualitative exploratory single-case study	Qualitative instrumental multiple-case study
Form of logical reasoning	Abductive	Abductive	Abductive	Abductive	Deductive
Unit and level of analysis	Design, implementation, and evaluation phases of the projects along with the actors and activities in these phases	Individual and collaborative actions for sustainability and nutrient recycling projects	Four innovation types (product, service, process, business model)	Commercialization and market-creation activities of various stakeholders	Four case-method experiences. Target group, learning goals, content, key stakeholders, innovations, organizing, intensity, and length of methods
Data	Multiple sources, semi-structured interviews (9), longitudinal observation, the websites of the companies and the municipality that provide information about the ongoing research	Multiple sources, semi-structured interviews (9), longitudinal observation, the websites of the companies and the municipality that provide information	27 selected cases from a compilation by the Finnish Innovation Fund (SITRA)	Multiple sources, semi-structured interviews (10), news articles (> 100), innovator firm's website, publicly accessible documents, journal	Individual teaching experiences from educational acts and courses

	projects (4) in the district, and the project reports	about the ongoing research projects (5) in the district, and the project reports		articles (> 50), websites of relevant organizations (> 10)	
Data analysis	Thematic analysis. Identification of the design, implementation, and evaluation phases of the projects, the driving actors in each phase, their activity sets, and the types of flows	Thematic analysis. Analyzing stakeholder activities in the living lab setting	Content analysis. Analyzing the main innovation types, three sub-types, innovation examples per sub-type, the company that developed the innovation, the main sustainability issue addressed by the innovation, and the pursued benefit/value	Thematic analysis. Identifying the events, decisions, activities, opportunities, and challenges in the market-creation and commercialization process	Comparison of the four case methods

All research has epistemological (positivism, interpretivism, etc.) and ontological (objectivism, constructivism, subjectivism) perspectives. This research adopts subjectivism ontologically as the philosophy of science and employs an interpretivist epistemology (Creswell & Creswell, 2017). The interpretivist approach argues that the researcher is embedded in the research, is part of the research, and cannot be removed from the research; therefore, it has the implication that the research results are the outcome of the researcher's interpretation of the data, knowledge, and truth (Gray, 2013). Subjectivism argues that reality exists based on our awareness of it, and it varies from person to person; that is, it is a first-person perspective (Hofweber, 2020).

3.2 Case study research approach and research context

The thesis's research consists of three single-case studies and two multiple-case studies. The research employs a case study approach predominantly because case studies provide contextual, in-depth knowledge about specific real-life phenomena for theory building (Eisenhardt & Graebner, 2007; Toomer et al., 1993). Therefore, applying case studies to understand how stakeholders contribute to innovation development in the CE is suitable for the thesis's research. Case studies facilitate a holistic understanding of complex phenomena that are not easily separated from their contexts (Eisenhardt, 1989; Yin, 2009).

In Publications I and II, several research projects are included in the case for analysis, and they are examined under the single case of the Hiedanranta ULL. The single cases of Hiedanranta ULL are chosen for these studies, as single cases allow in-depth and detailed examinations of stakeholders and their activities. Studying a single ULL provides more detailed examples and allows a researcher to study in-depth the stakeholders that are located in one single living lab. In Publication III, the novel offerings of 27 companies are analyzed as a multiple-case study, categorized under four innovation types reflecting their contribution to the CE. Multiple case study is chosen for this study to involve multiple type of innovations from different companies. In Publication IV, the single case is the market creation and commercialization of a radical innovation, and the stakeholder activities are analyzed, as the single case study method is a way to show the various points of view of each stakeholder, their impacts, and how they influence the whole process of a single large company. In Publication V, four methods in entrepreneurship education that focus on the CE and environmental sustainability are analyzed and compared with each other. The multiple case study is chosen for this study to include various experiences from different universities and researchers. The multiple case study provides the opportunity to compare each of the four methods in entrepreneurship and thus provides a better understanding of different teaching experiences.

The research contexts of the studies in the thesis differ slightly from each other. Publications I and II focus on the Hiedanranta ULL as a single-case study, Publication III focuses on the offerings from 27 companies in Finland that contribute to the CE, Publication IV focuses on the stakeholder activities in the market creation and commercialization of Raisio's Benecol product, and Publication V focuses on different case methods that are used in entrepreneurship education for sustainability and the CE. The common theme among these studies is the stakeholder contributions to innovation development and how the stakeholders collaborate to innovate. This theme is especially dominant in Publications I, II, IV, and V, and Publication III elaborates on the different innovation types in the CE.

Publications I and II examine the same case: the Hiedanranta ULL. ULLs engage municipalities, research organizations, companies, and residents to generate and implement ideas for urban development. In Publication I, it is argued that a sustainable ULL consists of three types of CE ecosystems, namely economic value flow-, material flow-, and knowledge flow-based ecosystems. This study analyzes four sustainability projects in the Hiedanranta ULL and the activity sets of stakeholders in the projects to map the CE ecosystem types. Publication II features the Hiedanranta ULL, focusing on distributed agency among living lab actors. Individual and collaborative actions for sustainability were identified through the analysis of five projects. The projects that are presented in Publication I and Publication II aim to improve environmental sustainability in the area, particularly promoting nutrient recycling.

In Publication III, innovations in the CE in Finland are examined. Forerunners and suppliers with innovative offerings were selected from a compilation of data from SITRA (Finnish Innovation Fund). From the compilation data, the most promising companies were selected based on their offering's pursued benefit/value for sustainability. Case selections were made using the theoretical sampling method (Patton, 1990), covering the four innovation types (product, process, service, business model). The offerings introduce new usages of recycled materials, new services for lengthening product lifecycles, novel and more sustainable production processes, and new business models for reusing and sharing products.

In Publication IV, the market creation and commercialization of Raisio's Benecol product are analyzed, and the stakeholders involved in these processes, along with their activities, are examined. We have chosen and studied a radical innovation case, following the theoretical sampling procedure (Patton, 1990), by analyzing a functional food innovation: a novel product category between food and medicine. The innovation in question is a vegetable fat spread that lowers cholesterol with its unique ingredient, a plant stanol ester, which aims to prevent cardiovascular disease, and is therefore categorized as a functional food in the markets. We framed the commercialization activities at the micro level and the market-creation activities at the macro level, as the stakeholder contributions to commercialization activities are mainly supported (and initiated) by the focal company whose innovation is commercialized, while contributions to market-creation activities take place at the macro level and market structure level.

In Publication V, four case methods (solving real-life business challenge cases, role-model cases, the hackathon method, and adult education through experimental learning) are examined. The methods help entrepreneurship education students understand the impact of businesses and their products and services on environmental sustainability. The methods allow various stakeholders to benefit from the collaboration in different ways, as the methods differ in terms of their target group, key stakeholders, intensity, and length.

3.3 Data sources and data collection

In Publications I, II, and IV, I used semi-structured interviews as the primary data source, consisting of key questions that help define the areas to be explored (Gill et al., 2008). All the interviews were conducted face to face, except for two interviews that were conducted online. Even though online interviews do not provide the opportunity for interaction at a physical location, they are advantageous in situations where the interviewer and interviewee are located in different regions or countries (Flick, 2009). In addition to the interviews as the primary data source, for Publications I and II, audio recordings from a seminar were utilized in which the developments, projects, and sustainability aims of the city district were explained by the head of the city district development program.

In Publications I and II, the secondary data consisted of the webpages of the projects accessed on the municipality's website. The municipality's website lists the ongoing projects in the district, and detailed information about the projects can be found. When selecting the projects for the case studies, the emphasis was on nutrient recycling projects due to their substantial potential to improve environmental sustainability. Therefore, although there are many other urban development projects in the area, the impact of these projects has been excluded from the studies. A thematic analysis was employed.

In Publication III, I used compilation data from the Finnish Innovation Fund (SITRA), which is a national leader and independent expert organization promoting awareness of the CE and the technology industries of Finland. The compilation data were used to sample 27 forerunners and suppliers with innovative offerings. A content analysis was employed.

In Publication IV, extensive secondary data were used to complement the primary data. The secondary data consisted of news articles gathered using the LexisNexis news search engine, and the websites of Benecol in different regions, the Ministry of Agriculture and Forestry of Finland, the Finnish Food Authority, the European Food Safety Authority, and related industry associations, such as the European Atherosclerosis Society. The news articles were categorized based on the information type and the geographical location where the news article was published. A thematic analysis was employed in the study.

In Publication V, the data were based on our teaching experiences from educational acts and courses at two Finnish universities (Tampere University and its technical campus, and the University of Eastern Finland) and one university of applied sciences (Turku University of Applied Sciences). Each teaching experience in the publication is described by a different author, and some authors are involved in more than one teaching experience.

3.4 Data analysis

Thematic analysis and content analysis were employed in the thesis's research. A thematic analysis is a way to identify patterns, and to analyze and interpret them from qualitative data. It is usually applied to interviews and transcripts, and follows a six-step process: data familiarization, code generation, theme generation, reviewing themes, defining and naming themes, and writing the results (Braun & Clarke, 2006). On the other hand, in a content analysis, the researcher can analyze the meanings of the content, such as texts or visuals (Bryman & Bell, 2011). Both thematic analysis and content analysis methods involve coding and interpreting the data. Qualitative methods are used in the thesis's research due to the exploratory nature of the research that cannot be easily quantified or measured (Creswell & Creswell, 2017).

In Publication I, the thematic analysis was carried out in four stages. In the first open coding stage, the ULL projects that focused on environmental sustainability and the informants from the projects to be interviewed were identified. In the second focused coding stage, project phases (design, implementation, and evaluation), the ecosystems in which the projects were involved, and the actors involved in the project phases were identified. In the third focused coding stage, the activity sets and types of flows in the design, implementation, and evaluation phases of the projects were identified. In the fourth stage, the codes were theorized by synthesizing the first three stages: the contribution of the projects to urban development and environmental sustainability was uncovered, and the actors, flows, and outcomes in ULL ecosystems were revealed. As a result, the ecosystems in ULLs were conceptualized.

In Publication II, the same dataset of interviews as in Publication I was used for the thematic analysis. In the first stage, actors, actor types, the projects in which the actors were involved, and the roles of the actors in the projects were identified. In the second stage, the distributed flexibility of actors was identified under three main actor categories: public sector and government actors, market actors, and research institutes. In the third stage, the distributed accountability of the actors was identified. In the final stage, as a result of the synthesis of the previous stages, individual and mutual acts of living lab actors were depicted, and distributed agency in living labs was conceptualized.

In Publication III, compilation data from SITRA were used for the content analysis. We applied an analysis framework that differentiates between four types of organizational innovation: product, process, service, and business model innovations (Crossan & Apaydin, 2010). After setting up the analysis framework, the compilation data allowed us to further divide each innovation type into three sub-types, resulting in 12 sub-types in total. Following this process, we identified the most promising offerings from the compilation data for each innovation sub-type to include them in our analysis. Each innovation sub-type consisted of one to four offering examples. In total, 27 offering examples were included in the analysis. Along with the offering examples, we listed the company names, and identified the sustainability issues addressed by the offering, and the pursued benefit/value of the innovation offering. As a consequence of the synthesis, the study conceptualized the CE innovation types in the form of a tree diagram.

In Publication IV, a radical innovation's commercialization activities by the innovator company and the market-creation activities of the involved stakeholders were analyzed through interviews and extensive secondary data. This case applied a historical analysis that allows for the examination of large-scale phenomena, such as market creation. A thematic content analysis was employed, and the focus was on identifying the events, decisions, activities, opportunities, and challenges in the market-creation and commercialization process from the primary data. A timeline of the important events in Benecol's commercialization and market creation was created to point out the milestones in the process. Secondary data, particularly news articles in the fields of science and medicine, regulation, markets, and society in Benecol's and Raisio's history, enabled the analysis of critical stakeholders. Based on the analysis and data triangulation from the combination of primary and secondary data, the final model was created depicting the multi-directional interlinkages of stakeholders in the commercialization and market creation of innovations.

In Publication V, the analysis was undertaken by comparing the four case methods. Individual teaching experiences from educational acts and courses were used as data sources. In the analysis chart, the following aspects of each case method were listed for comparison: target group, learning goals, content, key stakeholders, organizing, time frame, intensity, length of methods, and educators' reflections on challenges and opportunities. Following the analysis, the most optimal usage of each case method for integrating sustainability and the CE and entrepreneurship was proposed.

3.5 Assessing the research

This section examines, in particular, the validity (internal and external) and reliability of the research presented in this thesis by focusing on the trustworthiness of the research (Eriksson & Kovalainen, 2008).

Internal validity refers to the degree to which the findings of a study can be attributed to the specific cause-and-effect relationships being examined rather than to other factors (Leung, 2015). In this thesis's research, stakeholder contributions are examined to demonstrate their impacts on innovation development and sustainability. The internal validity of the thesis's research is enhanced using multiple sources of data and the triangulation of data (using multiple methods to collect data) (Miles & Huberman, 1994) in Publications I, II, and IV, which increases the credibility and confirmability of the research (Guba & Lincoln, 1989). The accuracy of the data is strengthened through literature reviews and quotations from the semi-structured interviews with experts, and is checked with the co-authors of the publications. The information on the sustainability projects in the Hiedanranta area concerning Publications I and II was gathered from the municipality's website, and for Publication III, the Finnish Innovation Fund's (SITRA) database was used, which are both credible sources of information. In Publication V, internal validity is enhanced by using data from individual teaching experiences that involved multiple co-authors. The conceptualizations in the studies were done together with the co-authors, who are knowledgeable in their fields. Feedback from peer researchers was sought to ensure the quality and reliability of the studies prior to publication.

External validity refers to the extent to which the results of a study can be generalized to other populations, settings, or time periods (Yin, 2009). It is important to consider external validity when interpreting the results of a study because it determines the extent to which the findings can be applied beyond the specific context in which the study was conducted. Results from Publications I and II can be applied to other ULLs in Finland and in other countries, as well as to the results from Publication III and Publication V. The results of Publication IV may not yield similar results in other countries or regions, as the study involved functional food industry actors in Finland, and there are different regulations applied for a health-sensitive product category in different geographical areas. The external validity of the thesis's research was increased by linking the studies to earlier research in similar fields, providing detailed descriptions of the study context and participants, using rich and descriptive data, and by building conceptual frameworks that enhance transferability.

Reliability refers to the consistency and reproducibility of the results of a study (Maxwell, 2013; Morse, 2015). A study is considered to be reliable if it produces similar results each time it is repeated, or if different researchers using the same methods arrive at similar conclusions (Leung, 2015). The reliability of the thesis's research was enhanced through the use of rigorous and systematic single- and multiple-case studies, literature reviews, and semi-structured interviews with experts, as well as through the use of thorough and detailed documentation for the research process (Eisenhardt & Graebner, 2007). The reliability of the thesis's research was enhanced and interview bias was reduced by seeking confirmation of the research findings from the study participants in Publications I, II, and IV in which interviews were conducted. In Publications I and II, selecting projects that focused particularly on increasing environmental sustainability in the city district might have caused a bias regarding positioning the district as a sustainable ULL and a CE ecosystem, as there were also other types of active projects in the area. Despite this, the municipality's efforts were apparent in terms of the city district producing more resources than it consumes and implementing solutions that promote circularity and sustainability in the long term.

Internal and external validity help to ensure that the findings of a study accurately reflect the specific research questions being addressed, while reliability helps to ensure that the results are consistent and reproducible (Miles & Huberman, 1994).

4 FINDINGS

Next, the findings are explained through the thesis author's five publications. Publications I and II analyze the stakeholder activities in living labs for innovation, Publication III analyzes CE innovations, Publication IV analyzes the stakeholder activities that contribute to the commercialization and market creation of a radical innovation, and Publication V analyzes the methods in entrepreneurship education that focus on the CE and environmental sustainability.

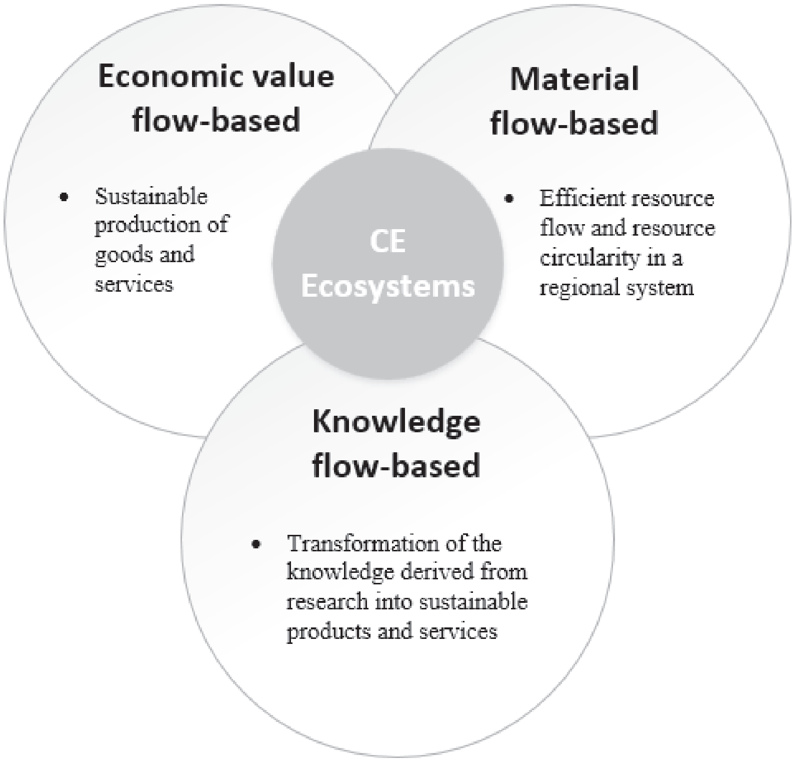
4.1 Urban living labs as circular economy ecosystems involving stakeholders contributing to innovation: Economic value flow-, material flow-, and knowledge flow-based ecosystems

In Publication I, CE ecosystems in a ULL were analyzed and positioned as economic value flow-, material flow-, and knowledge flow-based ecosystems where different projects took place. The activities of the City of Tampere, various research organizations, companies, and users were analyzed through projects in the Hiedanranta ULL setting. The actor activities in the projects were analyzed across three phases, namely, the design, implementation, and evaluation phases. The article emphasizes the environmental sustainability aspect of the living lab collaboration method and promotes and favors actor activities that are beneficial to the environment.

Ecosystems and living labs share similar characteristics, such as distinctive coordination mechanisms, shared goals, system-level outcomes, and network conceptualizations (Thomas & Autio, 2020). CE ecosystems are settings where actors collaborate for the circulation of resources, which employ the reduce, reuse, and recycle principles. This section elaborates on the flow types in a ULL that contributed to the CE.

As Hiedanranta is a work-in-progress city district in Tampere, the City of Tampere (municipality) is the main coordinator of the ULL, where it is active in engaging companies, users, and research organizations for economic value flow, material flow, and knowledge flow. These flows ensure that resources circulate in a closed-loop system for the sustainability of the ULL. The main goal of the Hiedanranta living lab is to produce more resources than it consumes; thus, flows have an important role in making that goal possible. The goals of circular economy ecosystems are illustrated in Figure 5.

Figure 5. Goals of circular economy ecosystems.



Economic value flow is explained through a project on developing a partnership model in which companies aimed to take an active role in redesigning urban areas, mainly via the utilization of waste and side streams. Partnerships were sought for premises and services for the CE, material circulation, urban food production, and the improvement of blue-green infrastructure in the district. Through these focus areas, the municipality's aim is to reduce waste and increase resource efficiency in industrial procurement and applications. The main actors for economic value flow were identified as the European Union, the municipality, and the companies. The design phase of the project in which the municipality was the leading actor included creating visibility for the project, encouraging stakeholder interaction through different media, identifying specific themes for the pilots, evaluating the economic and environmental viability of the pilots, looking for companies and research institutions to participate in the pilots, and cooperation and the co-design of project activities with the city stakeholders. The implementation phase in which the municipality and the expert consulting firm were the leading actors included initiating a tendering process to invite suppliers to conduct the pilot projects, the deployment of pilot projects in Hiedanranta, designing how the city could create market demand for products and services in line with CE principles, promoting an organizational-level approach in the city's procurement methods to create a sustainable operating model, and structuring and creating the partnership and leadership models. The final evaluation phase in which the municipality was the leading actor included the evaluation of the pilots and their business viability, scaling up the results to the city level, and exporting the partnership model to other cities as a concept.

Material flow is explained through the projects on nutrient recycling, and it took place mainly through companies providing equipment, and research organizations providing know-how. The goal of material flow is to recycle nutrients that are generated within cities to enhance environmental sustainability. This is primarily planned to be implemented by utilizing alternative sanitation systems, such as dry and vacuum toilets to capture the nutrients and recycle them. The main actors for material flow were identified as the municipality, the Ministry of the Environment, research institutes and universities, farmers, residents, and equipment suppliers. The design phase of the projects in which the municipality and the Ministry of the Environment were the leading actors included creating visibility for the project through information platforms, conducting surveys to determine residents' opinions on utilizing alternative toilet solutions for urban nutrient cycles, and installing dry and vacuum toilet systems in Hiedanranta to be tested. The implementation phase in which the municipality, research institutes, equipment supplier, farmers, and residents were the leading actors included conducting urine and black water treatment experiments using advanced methods, monitoring the quality of crops that were grown using urine fertilizers, carrying out environmental impact and lifecycle assessments, and assessing the system's capacity for handling the processing of huge amounts of nutrient fractions. The final evaluation phase in which the municipality and a research institute were the leading actors included creating an operating model for resource and energy-efficient management and utilization of nutrient-containing wastewater fractions in cities and changing attitudes toward the use of urine fertilizers.

Knowledge flow concerns all actors, as they all need to provide feedback and exchange information among users, companies, research organizations, and the municipality. In the article, the context for knowledge flow was a project on developing nature-based solutions. In the project, feedback from all actors was needed, especially from residents/users. The developed nature-based solutions worked as parks and recreational areas for the residents; therefore, their involvement was important in the project. The main actors for material flow were identified as the European Union, the municipality, companies, research institute, residents, and material suppliers. The design phase of the project in which the municipality and the European Union were the leading actors included organizing design thinking workshops, organizing workshops with students and teachers, developing ideas for nature-based solutions, raising awareness of nature-based solutions, and identifying the needs of the different stakeholders involved. The implementation phase in which the expert consulting firm, the municipality, a research institute, a material supplier company, and residents were the leading actors included engaging people to co-create multi-functional nature-based solutions that work as parks and recreational areas for residents, developing the monitoring and impact aspects of nature-based solutions, and developing business models around the nature-based solutions. The final evaluation phase in which the municipality was the leading actor included monitoring water, biodiversity, health, and well-being, and integrating the project results into long-term municipal processes. Flows among ecosystem actors are depicted in Figure 6.

Figure 6. Flows among ecosystem actors.

Publication I positioned ULLs as a CE ecosystem (Aarikka-Stenroos et al., 2021), and thus connected the ecosystem literature (Adner, 2017; Valkokari, 2015) with the ULL literature (Bulkeley et al., 2016; McCormick & Kiss, 2015; Voytenko et al., 2016) with the aim of achieving the development of a sustainable city district. It revealed economic value flows, knowledge flows, and material flows in ULLs through activities that contribute to environmental sustainability and improve the understanding of CE ecosystems. The study shows how actors undertake different roles in different ecosystems based on the ecosystem's goal. Projects that have the same theme initiated in ULLs create an ecosystem in which the actors work toward the goal of the ecosystem.

4.2 Stakeholder activities in urban living labs for sustainability: Distributed flexibility and accountability as distributed agency

In Publication II, stakeholder activities in ULLs for sustainability were analyzed through the distributed flexibility and accountability lenses, which make up the distributed agency phenomenon. The distributed agency concept was used in Publication II to highlight the shared goal of actors that work toward improving environmental sustainability, even though their individual actions and motivations might be different from each other. Publication II employed the ULL concept as the theoretical backdrop to explicate the activities and distributed agency. The context of the research was projects in a work-in-progress city district (Hiedanranta) that is promoted as a smart and sustainable future neighborhood, positioned as a ULL (see Table 6).

The distributed flexibility element concerns the actors' independence to fulfill their own role, while the distributed accountability element concerns the responsibility that the actors have regarding sustainable development. Sustainability agency in the ULL is distributed among public sector and government actors, companies, research institutes, and users. The public sector and government actors' aim is to develop a more sustainable region, the companies' aim is to develop commercially viable sustainable solutions, the research institutes' aim is to produce and provide contemporary knowledge on sustainable technologies, and the users' aim is to provide information about local requirements and give feedback. Just as these actors have individual acts, they also have mutual acts with each other. These acts were identified as ideating and brainstorming to develop solutions; testing, designing, and developing solutions; collaborating and developing nascent competitive sustainable solutions; implementing solutions to improve sustainability of the focal region; and disseminating new knowledge to improve sustainability in the focal region.

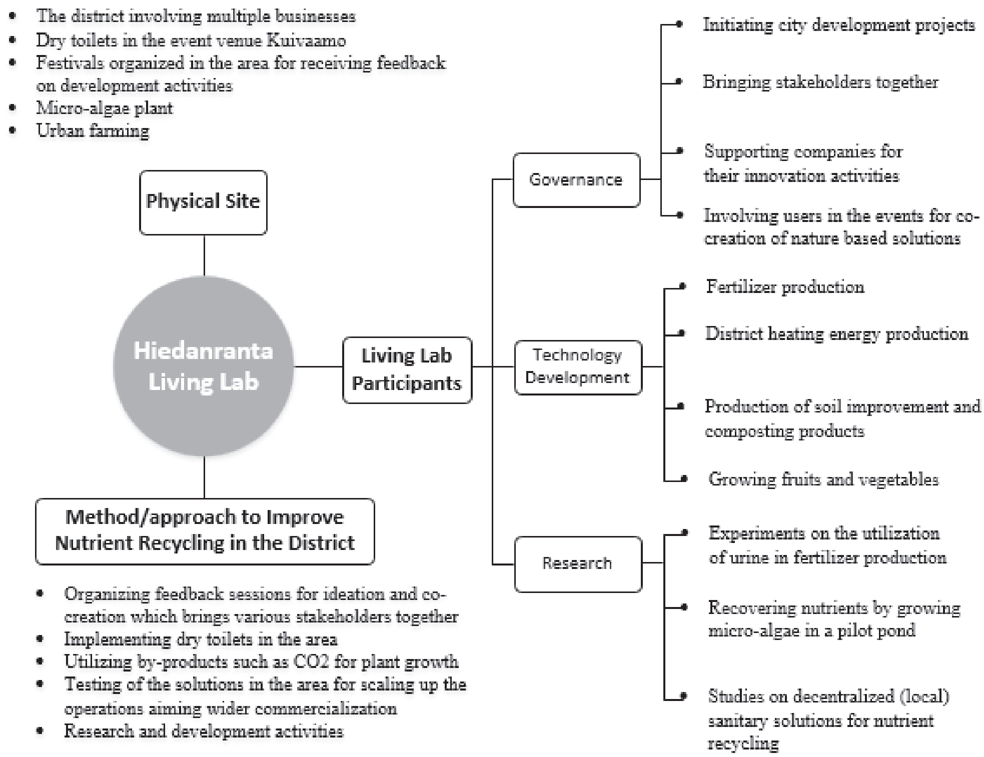
Table 6. Sustainability projects in Hiedanranta.

Project	Shared Sustainability Goal	Involved Actors	Actor Types	Distributed Agency Among Actors
NutriCity	Reducing the amount of nutrient leakage into the Baltic Sea by recycling nutrients, such as phosphorus and nitrogen, through decentralized sanitary solutions.	Ministry of the Environment, City of Tampere, Tampere University, Finnish Environment Institute (SYKE), Users (Residents), Global Dry Toilet Association of Finland	Ministry, Municipality, Research Institute, User, Association	Ministry of the Environment: Providing funding and guidelines for the projects City of Tampere: Providing facilities to enable experimentation and providing expertise and resources for project management Tampere University, Finnish Environment Institute (SYKE), Technical Research Centre of Finland (VTT): Conducting research and experiments Users (Residents): Participating in the testing and providing feedback for the usage phase of the solutions Global Dry Toilet Association of Finland: Promoting ecological sanitation and communicating the benefits of nutrient cycles Vanajavesi Center: Creating an active network of actors for the improvement of lakes and rivers Biochar company: Producing the biochar material and the district heating Vertical farming company: Participating in the experiments by testing the urine fertilizers
UNaLab	Stormwater management systems, e.g., biofilters in Hiedanranta are developed to treat nutrient-rich seepage waters from the old landfill.	City of Tampere, Engineering Consulting Company, Biochar Company, Technical Research Centre of Finland (VTT)	Municipality, Company, Research Institute	
Leväsieppari	Nutrient removal in different wastewaters using algae.	Ministry of the Environment, Tampere University, Finnish Environment Institute (SYKE), Vanajavesi Center	Ministry, Research Institute	
Hierakka	The collected and processed urine was tested as fertilizer in agricultural fields. The project encourages the adoption of urine fertilizers in large-scale applications.	Global Dry Toilet Association of Finland, Tampere University, Users (Residents), Vertical Farming Company, Dry Toilet Company	Association, Research Institute, User, Company	

Kivireki	Involving people in community gardening to make urban agriculture widespread and contributing to energy-efficient food production.	Global Dry Toilet Association of Finland, Tampere University, Users (Residents), Restaurants	Association, Research Institute, User, Company	Dry toilet company: Providing the equipment for the collection of urine

While these actors had the flexibility to participate in different projects, the areas that they were accountable for were governance, technology development, and research. The actors participated in single or multiple projects depending on the requirements of the project and how they could contribute. The projects analyzed in the ULL focused heavily on nutrient recycling in the area, as nutrient recycling is one of the main targets of the European Union and the Ministry of the Environment in Finland to enhance the environment and water bodies. Characteristics of Hiedanranta Urban Living Lab and the distributed agency among actors are illustrated in Figure 7.

Figure 7. Characteristics of Hiedanranta Urban Living Lab and the distributed agency among actors.



Actors in a living lab perform tasks, such as designing and operating advanced technologies, applying energy-efficient production methods that adopt less water use, which results in more crops than in conventional and traditional business models, piloting growing grains and cereals in indoor environments, conducting research on recycling nutrients in the area, educating the community about preserving the environment and about the importance of sustainable consumption, helping municipalities with risk management decisions, doing research for the creation of the best possible business ecosystem, and lastly, organizing seminars to raise awareness and initiating and supporting collaboration between different actors in the field.

Publication II contributes to the sustainability transitions literature (Bulkeley et al., 2016; Florez Ayala et al., 2022; Markard et al., 2012) by examining a ULL as a platform to explicate distributed agency, and thus it connects three research streams together. It shows how actors work independently for their own goals but, at the same time, through their individual acts, they also serve a bigger purpose of advancing environmental sustainability in the city district. This distributed accountability keeps the actors motivated and dedicated to realizing their goals for the development of the city district and the environment.

4.3 Circular economy innovations: Product, process, service, and business model innovations

In Publication III, product, process, service, and business model innovations in a CE were analyzed. Our analysis of 27 innovative offerings by forerunner firms in the Finnish CE ecosystem uncovered the diverse innovation types (product, service, process, business model) and the value they provide in the field of sustainability.

The identified product innovations in the CE can be divided into three categories: 1) products/materials that are suitable to be returned to circulation by either recycling or as refurbished products, 2) substitute products that are inherently more sustainable than their traditional alternatives, and 3) durable products with a long lifespan. Compared to product innovations, the identified service innovations were a more heterogeneous category, with more variation in service-related novelties enabling sustainability. The service innovations were also divided into three categories: 1) platforms or online marketplaces that allow customers to connect to others to improve sharing or the second-hand use of products; 2) transferring knowledge and expertise for the customers' benefit in the form of monitoring, optimization, consultancy, and design services; and 3) loop-closing (recycling) services. When it comes to process innovations, we identified three categories: 1) technological innovation that enables a certain type of waste or used product to be processed in a new, much more efficient way; 2) material efficiency improvements to increase the utilization rate; and 3) take-back processes for products that are no longer in use (reverse logistics). For the business model innovations, our analysis revealed four broad categories into which the cases could be divided: 1) a diversification of the business model into a two-sided business model where on one side the firm sells recycled materials or products made from recycled materials, and on the other side it provides waste management services to acquire the required raw materials; 2) providing products in the form of services, which involves transferring the ownership of the product from the customer to the firm, while replacing the one-time product purchase for the customer with continuous service fees during the use of the product (product service systems); and 3) implementation of deposit systems where customers are financially rewarded for returning their used products.

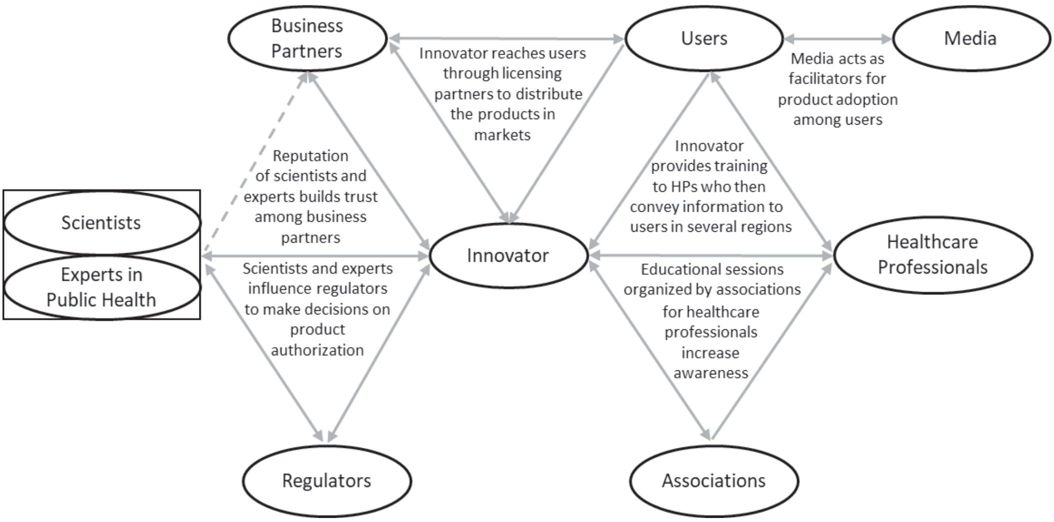
Publication III contributes to the CE innovation literature (de Jesus & Mendonça, 2018; Hysa et al., 2020; Suchek et al., 2021) by categorizing four different innovation types: product, process, service, and business model innovations. It provides examples of the innovative companies in Finland and their offerings to demonstrate the diversity of innovations and their impact on sustainability and the CE.

4.4 Stakeholder activities in the commercialization and market creation of a radical innovation: Contributions of macro- and micro-level actors

In Publication IV, stakeholder activities for commercialization and market creation of a functional food product positioned as a radical innovation were examined. The activities of nine major stakeholders in the commercialization and market-creation process were analyzed. The macro-level stakeholders were listed as regulatory authorities, scientists, experts in public health as opinion leaders, and the media, while the micro-level stakeholders were complementary business partners in the value chain, an innovator firm, users, healthcare professionals, and associations. The distinction between the macro and micro levels comes from the fact that the macro level concerns the market-creation aspect and the stakeholders at this level have the ability to broadly influence market structures and public opinion, whereas micro-level stakeholders particularly contribute to the company's commercialization efforts.

The interactions among stakeholders and their contributions are illustrated in Figure 8. The dashed line represents interlinkages due to the indirect influence of scientists and public health experts on business partners (scientists' reputation and ability to validate the impacts of the innovation contributed to business partners' business development efforts), straight lines represent interlinkages due to direct influences, and arrows represent the flow of information.

Figure 8. Main stakeholders and the interactions/interlinkages of their contributions.



The findings of the study indicate that the actors contributed: 1) directly to the commercialization efforts (e.g., an innovator firm initiating the innovation process by discovering or inventing and by managing the innovation network; healthcare professionals and associations recommending product use in different countries for the well-being of people; users giving feedback on products' strengths and weaknesses and carrying out word-of-mouth marketing; and business partners providing the local user base for the innovation in the market, distributing products, and making them available for users); 2) directly to market creation (e.g., scientists and experts in public health creating awareness, influencing business partners, users, regulators, and building a trust network; the media acting as a facilitator for product adoption and awareness creation; and regulators providing guidance on product authorization procedures, and conducting and evaluating risk assessments to ensure product safety) that make the markets more favorable to the commercialization activities by the innovator company; 3) to the intersection of the market-creation and commercialization activities (e.g., scientists' studies and experiments to reveal the positive health effects of the innovation proved to the regulators that the product was safe to use and had health benefits, and thus enabled the product to enter the markets as a macro-level contribution, and, at the same time, the successful studies proved to business partners that the product had potential to be diffused in their local markets, which supports both the innovator's and its business partners' commercialization efforts at the micro and meso levels).

Publication IV contributes to radical innovation commercialization and market-creation research (Aarikka-Stenroos & Lehtimäki, 2014; Möller, 2010; Storbacka & Nenonen, 2011). It shows how a novel product category of functional foods changes the market structures and shows the stakeholder activities that are needed for the commercialization of a functional food in global markets. It also reveals the relationship between market creation and the commercialization of radical innovations. Elaborating on the activities of different types of stakeholders makes it possible to understand the interactions between the actors in the commercialization and market-creation processes over the long term.

4.5 Stakeholder contributions to innovations through case methods: Entrepreneurship education for sustainability

In Publication V, different case methods in entrepreneurship education were examined while keeping environmental sustainability and the CE at the top of the agenda, including support from different types of stakeholders. Integrating the sustainability aspect into entrepreneurship education is of high importance, as it is an ongoing and growing issue worldwide. To slow down resource overuse, overconsumption, and unnecessary and unsustainable economic activity, new and innovative products, services, processes, and business models are needed. Therefore, the case methods applied in this study in cooperation with companies present useful challenges as case examples for entrepreneurs and students pursuing sustainability in their prospective businesses. The study also explains the necessary stakeholders who need to collaborate for environmentally sustainable entrepreneurship.

The identified methods were listed as (1) solving real-life business challenge cases by sustainable start-ups and companies; (2) role-model cases by involving successful sustainable start-ups and entrepreneurs; (3) the hackathon method, allowing students to solve the sustainability challenges of companies; and (4) embedded cases and adult education through experimental learning. The study compares the four methods across multiple aspects, such as their target group, learning goal, key stakeholders, key tasks per actor, intensity and duration, and educators' reflections.

Solving real-life business challenge cases of sustainable start-ups and companies provided an opportunity for students to form groups, engage in teamwork, experience complicated sustainability challenges that the companies were facing, and get feedback from various stakeholders, including the company representatives and educators. Role-model cases involving successful sustainable start-ups and entrepreneurs gave students the opportunity to listen to the experiences and stories of successful entrepreneurs and learn from their career paths about growth and sustainability. The hackathon method, which allows students to solve the sustainability challenges of companies, is a short-term method (24 hours to 48 hours) compared to the other two methods. However, it is more intense, and this provided student groups with practice at working around the clock and constantly seeking feedback from their peers, innovation advisors, and educators. The embedded cases and adult education through the experimental learning method are for more experienced postgraduates and executives. The cases employing this method featured analyses of implementing sustainability and CE in the companies that the students were part of.

Publication V contributes by elaborating on different case methods involving various stakeholders to enhance environmental sustainability through entrepreneurs, educators, business activities, and innovations (Kirchherr & Piscicelli, 2019; Kopnina, 2019). The comparison of four case methods provides an understanding of the advantages and disadvantages of the methods and helps educators in choosing the most appropriate method based on their needs when teaching entrepreneurship education. The study also elaborates on the stakeholder activities needed for implementing the methods, such as event preparation, organizing, providing feedback, and interacting with students.

5 DISCUSSION AND CONCLUSIONS

5.1 Synthesis of the key findings

The goal of this thesis was to identify stakeholders and their activities that contribute to innovation development and sustainability. To accomplish this goal, three research questions were generated within different theoretical lenses to understand multiple actors contributing to innovation, sustainability, the CE, and innovation outcomes and processes. This chapter explains how the publications address the three research questions. While Publication V talks about the front-end of sustainable/CE ecosystem innovation and helps gain certain different stakeholders' viewpoints, Publication IV discusses the commercialization and market creation stage and was able to notice contributions at the macro-level. Publication I-II unveils the organizational stakeholder contributions and elaborate on the later innovation stages once an innovation is already on the market. Publication III identified the product, process, service, and business model innovations in the circular economy in the Finnish context, which reduce excess resource use and increase sharing practices, thus accelerating the transition from a linear to a circular economy. Table 7 points out the research questions, findings, and key contributions.

Table 7. Research questions, findings, and key contributions.

Research question	Findings	Key contribution
RQ1: What kind of stakeholders can contribute to sustainable innovation development in living labs and ecosystems?	• Publications I and II revealed the stakeholders in an urban living lab ecosystem through projects	This work demonstrates that stakeholders have an important role in sustainable innovation development and stakeholder theory can be applied not only in public and private organizations, but also in framed concepts, such as living labs and ecosystems (Freeman et al., 2017; Leminen et al.,

		2012; Valkokari et al., 2017).
RQ2: What kinds of contributions do stakeholders make to sustainable innovation development?	• Publications I and II identified the governance, technology development, and research contributions of municipality, companies, and research organizations in an urban living lab ecosystem through projects. Urban living lab accelerated the development process of an urban area with its innovative companies involved. • Publication IV uncovered the macro-level market-creation and micro-level commercialization activities of stakeholders of a radical innovation • Publication V explores stakeholder contributions through four case methods from the educator, student, and company viewpoints	This work builds an understanding that stakeholders contribute to sustainable innovation development through different activities and projects in circular economy ecosystems such as living labs, in commercialization and market-creation processes, and in educational settings where case methods are employed (Aarikka-Stenroos & Ritala, 2017; Kirchherr & Piscicelli, 2019; Möller, 2010; Kopnina, 2019).
RQ3: What are the outcomes of innovations in terms of sustainability and the circular economy?	• Publications I and II identified the economic value, material, and knowledge flows that improve environmental sustainability and the current state of the natural ecosystem through nutrient recycling • Publication III identified the product, process, service, and business model innovations in the circular economy in the Finnish context, which reduce excess resource use and increase sharing practices, thus accelerating the transition from a linear to a circular economy • Publication IV involves a cholesterol lowering margarine	This work builds an understanding that more sustainability innovations are needed to tackle the growing sustainability issues, such as climate change, loss of biodiversity, global warming, deforestation, and pollution, through relevant products, services, processes, and business models (de Jesus & Mendonça, 2018; Hysa et al., 2020; Suchek et al., 2021).

	that is proven to reduce the risk of getting cardiovascular diseases • Publication V identified the educational methods that allow the integration of environmental sustainability into innovations	

The first and second research questions focused on the relevant stakeholders that contribute to innovation development to identify the stakeholder types in living labs and ecosystems and stakeholders' contributions to innovations. Publications I and II respond to the first and second research questions from different perspectives, which deal with ULLs, distributed flexibility and accountability, the commercialization and market creation of a radical innovation, and entrepreneurship education for sustainability. Based on the findings from Publications I and II, ULLs are a form of collaboration platforms that classify the participating stakeholders as municipalities, companies, research organizations, and users, and that emphasize the 4P concept of public–private–people partnerships (Leminen et al., 2012). In this regard, the general categorization of stakeholders in ULLs falls under the 4P concept. In ULLs, stakeholder types are theoretically limited to four main categories, and in other innovation platforms, the main categories might differ. In living labs, different roles are assigned to four main categories of stakeholders (Leminen et al., 2012): enabler (cities/municipalities), utilizer (companies), provider (developer organizations/universities), and user (users). Although the roles are pre-defined, they might change over time depending on the innovation network's needs and goals.

Apart from the single roles that were defined, in the literature, municipalities are also assigned promoter, partner, regulator, catalyst, and provider roles (Kronsell & Mukhtar-Landgren, 2018; Leminen et al., 2017; Zvolska et al., 2019). Furthermore, the provider role expands into investor and host roles, and the enabler role is further analyzed through matchmaker, partner, and communicator roles. The different role dimensions show and explicate the activities of the municipalities within different roles. Since different studies assign the same role (partner) to municipalities as a separate role dimension and as a characteristic of the enabler role, the conceptualizations may create confusion and complications. Complications also emerge in the overlapping provider roles of municipalities and research organizations. However, the role assignments are useful in order to understand the types of activities that municipalities engage in. Municipalities, as the initiators of ULLs, test experimental governance through citizen engagement. As the municipalities adopt the living lab approach, residents have a chance to influence decisions that are made with the consideration of the environment.

In the early stages of the innovation in urban living labs, municipalities play a major and dominant role in advancing the innovation forward and gather the relevant stakeholders together. The municipality acted as the initiator of the projects that led to the emergence of innovative solutions. Users as early stage actors are more of a voluntary actor in the innovation process as they don't get any monetary rewards or gains in the short-term. However, in the long run, their feedback and ideas might provide benefit to their well-being once these ideas are implemented and the results are seen in the future. Companies and research organizations are mid/late stage actors that contribute with their expertise and knowledge once the plans are set by municipalities in the urban living labs.

Publications I and II revealed that projects have an important role in ULLs to create an agenda for activities and to assign tasks to actors that take part in a ULL (Voytenko et al., 2016). In other words, projects guide and shape the goals, activities, and purpose of a ULL (Schuurman, 2015). Therefore, projects act as a form of collaboration. In ULLs, the actors engage in activities that contribute to economic value flow, material flow, and knowledge flow that contribute to the CE (Engez et al., 2021; Robaeyst et al., 2021). Some of these activities include creating visibility for the project through a blog page, web pages, newsletters and social media; encouraging stakeholder interaction through different media; designing how city can create a market demand for products and services in line with circular economy principles; carrying out environmental impact and lifecycle assessments; and evaluation of the pilots and their business viability. Publication II explains the importance of responsible innovation through distributed flexibility and accountability frameworks (Enfield & Kockelman, 2017). The actors engage in activities that serve their own goals, but they also contribute collectively to different dimensions of sustainability. There is no direct link between companies and users in the studied ULL, although other actors in the ULL share mutual acts. However, since the users interact with public authorities and research organizations, they indirectly influence company decisions in the ULL. In the analyzed ULL, companies develop solutions for the sustainability of the region, such as biochar production, growing fruits and vegetables using vertical farming systems, and testing vacuum toilets. It is useful to consult user residents to find out their views on the applicability, usability, and viability of the solutions before launching them (Leminen et al., 2015).

Publication IV discusses different stakeholders and activities that contribute to the commercialization and market creation of a radical innovation from the micro-and macro-level standpoint (Möller, 2010). The macro-level stakeholders are listed as regulatory authorities, scientists, experts as opinion leaders, and the media, while the micro-level stakeholders are complementary business partners, healthcare professionals, and associations. The macro level has a broad influence on issues affecting society, such as regulations, scientific validity, and diffusion. The micro level concerns the focal firm, as the activities are for launching and commercializing its innovation. The stakeholders analyzed in this publication are part of the focal company's innovation network. As the company is in the food industry and its innovation concerns health, the stakeholders that influence the commercialization and market-creation process are relevant to the food industry and healthcare.

Publication V explains the stakeholder contributions to innovations through the case methods in entrepreneurship education integrating sustainability. Alongside educators, researchers, and company managers, students help companies develop their offerings in a collaborative setting. Different case methods highlight the importance of integrating an environmental sustainability mindset when developing innovations (Kirchherr & Piscicelli, 2019; Kopnina, 2019). Although Publication V focuses on the case methods for teaching entrepreneurship, the settings can be regarded as open-innovation platforms as the student groups provide their inputs on company challenges and receive and give feedback. This is especially apparent in the hackathon and real-life business case methods, as they are regarded as open-innovation methods where participants collaborate to generate solutions to various company challenges. Companies can utilize the student input to develop their innovations by, for example, changing a product's design, or getting information about user behavior for a product.

The third research question focused on the outcomes of innovations for sustainability and the CE, which covers all the publications. Publications I, II, and III respond to the third research question, covering CE innovations and the innovations in ULLs for sustainability. Based on Publication III that deals with CE innovations, the innovations are positioned as product, process, service, and business model innovations, and they address the following sustainability issues, which are the outcome of innovations: low nutrient recycling and eutrophication, the low recycling rate of interior materials, high production and consumption of meat, non-renewable plastics, unnecessary consumption, fossil fuels, greenhouse gas emissions, high water consumption in textile fiber production, low circulation of zinc and manganese in soil, low utilization of industrial waste, low packaging recycling, low circulation of reusable consumer goods, food waste, the misuse of batteries, low digitalization in waste management operations, early replacement of spare parts, excess heat recovery and recycling, and textile waste. This thesis sheds light on the four types of product, process, service and business model CE innovations and out of the four CE innovation types, in the literature the attention has been mostly on business model innovations (Bocken et al., 2016; Suchek et al., 2021) due to the broader audience they can reach, for instance, through product service systems (Tukker, 2015) in which product ownership is transferred from the customer to the firm. Product service systems enable the sharing of products among multiple users and maximum utilization of the produced products, as the downtimes are reduced due to sharing. The on-demand services enable value creation with fewer products produced for the users, which contributes to environmental sustainability due to reduced raw material and resource consumption. Therefore, product lifecycle management has an important role in product service systems, as a single unit of a product is used by many users more frequently, which causes more frequent maintenance needs and replacements. Product service systems adopt the reduce and reuse principles of the CE.

In Publications I and II, the innovations developed by companies and researchers in the ULL address nutrient recycling and include soil improvement products, such as biochar, hydroponic systems for growing food without the need for soil use, and vacuum toilets to capture nitrogen and phosphorus for fertilizer use. The need for innovations for a sustainable future is highly important, as some of the innovations solve more urgent problems, such as food waste, energy production with non-renewable sources, greenhouse gas emissions, and low recycling and reuse rates, whereas some have value potential in the long term, such as vacuum toilets. Overall, the outcome is that the developed innovations aim to reduce, optimize, process, and utilize waste when it is generated, and improve processes for a cleaner environment (Hysa et al., 2020; Suchek et al., 2021). Living labs and the projects involved act as innovation platforms to cooperate and co-create innovations.

Overall, Publications I, II, III, and V are focused on the concept of the circular economy and its relationship with sustainability. These articles explore how innovations and entrepreneurship can contribute to environmental sustainability through circular economy practices. Publications I and II include living labs and sustainability transitions. These publications involve the study of living labs as platforms for testing and implementing sustainability initiatives and innovations. Distributed agency, as mentioned in Publication II, refer to the shared responsibility among various actors in these living labs to drive sustainability transitions. Publications III and IV are related to the role of innovation in the context of the circular economy and sustainability. They explore how different types of innovations contribute to circular economy practices and how various stakeholders participate in the commercialization and market creation of these innovations. Publication V focuses on entrepreneurship education and its connection to environmental sustainability and the circular economy. It discusses how entrepreneurship education can involve stakeholders through methods like hackathons and case studies to promote sustainable business practices.

The synthesis of the five articles highlights that the enhanced picture of the research phenomenon of the dissertation is an interdisciplinary study that investigates the interplay between circular economy practices, sustainability, innovation, entrepreneurship, and the active involvement of stakeholders. The dissertation seeks to understand how these elements are interconnected and how they can collectively contribute to a more sustainable and circular economy. Stakeholders can contribute to the innovation by being part of an urban/living lab that facilitates idea creation or within a company to develop a solution to an untapped problem area or to an existing problem.

5.2 Theoretical contributions

The thesis's research employed different perspectives and theoretically contributed to different fields, including ULLs, CE innovations, CE ecosystems, stakeholder theory, and commercialization and market-creation activities, with stakeholders in focus. By doing so, it fulfilled the research objective, which was to provide an understanding of stakeholder types and activities and how they influence and shape innovation development processes.

The research contributes to the ULL discussion by framing a ULL as a CE ecosystem (Aarikka-Stenroos et al., 2021), highlighting the shared properties of ecosystems and ULLs with sustainability in focus (Voytenko et al., 2016). The ecosystem approach emphasizes how actors are interconnected, and how the action of an actor affects the other actors in the ecosystem, leading to a system-level outcome (Valkokari et al., 2017). The findings contribute by pointing out that a ULL comprises multiple ecosystems in which different projects take place. The projects aim at economic value flows, material flows, and knowledge flows, which determine the type of ecosystem. In other words, the study argues that projects under the same theme make the corresponding ecosystem emerge in the living lab. Ecosystems and living labs share similar characteristics, where multiple stakeholders are engaged. This positioning provides improved ULL visibility in terms of circularity practices and encourages living lab actors to engage in circular activities. For the CE to be realized in resource-intensive industries and societies, an ecosystem approach is necessary for understanding the implications of linear and circular economies, and for acting together for a sustainable future (Parida et al., 2019). In this context, the study shows that ULLs are visible platforms where new technologies and solutions for circularity and sustainability can be tested with an ecosystem approach, engaging multiple stakeholders orchestrated by the municipality.

The research also contributes to the discussion of distributed agency within the ULL and sustainability transition literature (Bulkeley et al., 2016; Enfield & Kockelman, 2017; Farla et al., 2012; Garud & Karnøe, 2003; Markard et al., 2012). For sustainability transitions to be apparent, the research argues that sustainability agency is distributed among multiple actors. The study shows which actors are involved and take an active role in different projects aiming at sustainability, and shows how actors contribute to the projects by demonstrating their role, thus extending the discussion on actor roles in ULLs (Juujärvi & Pesso, 2013). The framework of individual and mutual acts of living lab actors contributes to the distributed flexibility and distributed accountability concepts, and demonstrates how actors fulfill their individual goals while working toward a shared goal.

The research contributes to the innovation literature, particularly to the areas of eco-innovation and sustainable innovation (de Jesus & Mendonça, 2018; Hellström, 2007; Hysa et al., 2020; Rennings, 2000; Suchek et al., 2021), by uncovering the main innovation types in the CE. Building on the typology of innovation forms by Crossan and Apaydin (2010), the research provides examples of sustainable innovations that foster a more circular economy, and further categorizes them into their corresponding innovation type. Therefore, the research introduces a new typology for CE innovations that can be developed to increase raw material availability, energy savings, product/material utilization rates over its lifecycle, and reduce the carbon emissions that are harmful to the environment. Apart from the innovation types in the CE, the research elaborates on various sustainability issues that the innovations can tackle (Markard et al., 2012). The innovations' pursued benefits and value are also uncovered. Therefore, the research creates an awareness of the realization of existing sustainability issues and how they can be alleviated by innovative solutions.

The research contributes to the market creation and commercialization of radical innovations literature by identifying the stakeholders around an innovator firm and their activities. It does so by distinguishing between the macro- and micro-level stakeholders that have primarily influenced market-creation and commercialization activities, respectively (Aarikka-Stenroos & Lehtimäki, 2014; Möller, 2010; Storbacka

& Nenonen, 2011). The innovator firm gains a sustainable competitive advantage by actively engaging and orchestrating stakeholders, such as experts and scientists, effectively, which contributes to the resource-based view (Barney, 1991). The study also contributes to the discussion on functional foods and the stakeholders that influence the market-creation and commercialization strategies of companies that develop functional foods (Matthyssens et al., 2008). It showcases the importance of working with regulatory authorities and following product category guidelines for launching a new product in new markets, especially in a lesser known category, such as functional foods (Bech-Larsen & Scholderer, 2007; Mark-Herbert, 2004; Siró et al., 2008).

The research also contributes to the open innovation in education discussion (Howells et al., 2012; Laine et al., 2015) by illustrating the four case methods that are used in education to develop sustainable solutions in collaboration with student groups and companies. It showcases how stakeholders, such as students, company representatives, and educators, can work together in a university environment as part of university courses to share knowledge on being an entrepreneur with environmental sustainability values, and thus contribute to education for the CE discussion (Kirchherr & Piscicelli, 2019; Kopnina, 2019). By participating in university courses as case providers, companies can seek feedback on their products or services, get new ideas, and develop sustainable innovations with student groups facilitated by educators. The methods provide mutual benefits for both students and companies, as the students get to know the practices and solutions of sustainable companies, while the companies can utilize the student input in an open-innovation setting.

As the final contribution, the research contributes to the stakeholder theory literature in general (Freeman et al., 2010; Mitchell et al., 1997) by demonstrating that stakeholders have an important role and are crucial to consider not only in public and private organizations but also in framed concepts, such as living labs and ecosystems. The CE requires stakeholders from different fields to work together and interact with each other to develop novel innovations for sustainability transitions to be realized (Farla et al., 2012). The research emphasizes that the interests of each stakeholder group should be assessed, and strategies should be formed carefully for novel innovations to find their way into markets Once a clear understanding of each stakeholder group's interests is reached, developing tailored strategies for each group comes next. These strategies should address their specific needs and concerns while aligning with the overall goals of the innovation. For instance, when launching a product innovation in another country, regulators play an important role and product launch guidelines and procedures should be followed to choose the right product category to avoid delays in product launch. It's important to ensure that innovation complies with all relevant regulations and standards. Government agencies and industry watchdogs can be important stakeholders, and non-compliance can lead to legal and reputational issues. When considering urban living labs, user ideas should be consulted and this strategy should be applied to all living labs to develop and gather solutions with user stakeholders. After the innovation is launched, it's important to gather feedback from stakeholders to assess its impact and effectiveness. Using this feedback to refine the strategies and make necessary improvements would result in better outcomes.

5.3 Practical implications

With the current global energy crisis, the application of CE and renewable energy solutions has started to gain more attention throughout the world, and the adoption of sustainable production and consumption methods, along with clean energy applications, has become inevitable as a way to meet energy and resource demands. In this current situation, alternative resources to oil and gas, such as solar power, hydrogen, and wind power, have become significant energy supplies due to oil and gas shortages. Such ongoing issues around the world emphasize the importance of sustainable innovations and solutions, which require collaboration among different types of stakeholders, such as regulators/policymakers, research institutes, companies, and users. The findings of the thesis's research have implications for practitioners who take part in innovation development activities for sustainability, such as city governance officials within municipalities, company managers, and researchers who develop solutions in collaboration with companies, municipalities, and users.

First, the living lab concept is a useful method for bringing together different types of actors to develop solutions for urban sustainability issues. The findings in Publications I and II suggest that involving four types of actors, namely municipalities, companies, researchers, and users, in a living lab approach for developing urban areas provides effective flows of materials, knowledge, and economic value. In light of this, municipality officials who govern city development projects can consider involving these actors to generate the most useful solutions for residents with the residents in the ecosystem.

Second, the projects in the living labs for sustainable urban development can be chosen and executed carefully for the benefit of residents, who are the users of the innovations. The researchers in the projects who conduct experiments can ideate with user residents and get their feedback to verify the viability and applicability of the solutions. The projects provide the living labs with their purpose and enable the living lab actors to work toward the goals of the projects.

Third, the open-innovation concept is useful for educators to organize a setting where students and companies can come together to develop ideas and solutions for many sustainability challenges. For company managers, it is a fruitful avenue to get ideas from student groups to develop and improve products and services that contribute to the CE and environmental sustainability. Educators can use the identified case methods in Publication V to integrate sustainability and the CE into entrepreneurship education.

Fourth, company managers can engage the right types of stakeholders for commercializing their products to create new markets with new product categories, such as functional foods. Depending on the type of product, managers can interact with certain types of stakeholders, such as scientists or expert opinion leaders, to guide and influence regulators and business partners in the value chain. This might require repetitive experiments and trials to prove the product's credibility for it to be approved in different global markets. In this effort, regulators can guide the innovator companies in entering new markets, or the innovator companies can seek guidance from regulators. Utilizing the right stakeholders is important, as they have different capabilities when attempting to commercialize an innovation and create a market. Support from these diverse stakeholders is crucial, as each engaged stakeholder has a different role that helps an innovation to be commercialized. Understanding the distinction and relation between innovation commercialization and market creation would provide insights for managers when choosing their stakeholders to perform these activities.

Fifth, the innovation management should evolve in a way that the user perspective should be one of the top priorities of municipalities and companies and citizens/users should be involved early in the innovation development phase. In urban living labs, municipalities should facilitate cooperation between companies that are located close to each other, which enables the material sharing and using company resources. For instance, in the studied Hiedanranta living lab, two companies got involved in doing business together in the form of exchanging materials and byproducts. Carbon dioxide that is generated in the production facility was used for the plant growth in the plant production facility. The heat that is generated in the biochar production facility is used and forwarded as district heating, which is an example how municipalities can utilize urban living lab companies. Such living labs also create opportunities for local small businesses to experiment with new products and services and enables them to start a business with guidance and counselling from the municipality.

Innovation management should prioritize sustainability and resilience. For the value creation in circular economy, urban living labs should focus on developing solutions that address environmental concerns, energy efficiency, and climate change mitigation, contributing to more sustainable and resilient urban environments. The evolution of innovation management also requires adaptation of policies and regulations. Governments and municipalities should create an enabling environment that supports experimentation and the deployment of innovative solutions within cities. Once successful innovations are developed within urban living labs, there should be a strategy for scaling and implementing them across the city or in other urban areas. Effective innovation management should involve public awareness and engagement to gain support for innovative projects. In that sense, urban living labs can serve as a means to engage citizens and ensure their input in the innovation process. They offer a framework for evolving innovation management in the context of urban development. They encourage open collaboration, user-centered design, data-driven decision making, experimentation, and sustainability while involving a diverse set of stakeholders. To foster innovation effectively, it's essential to embrace these principles and adapt to the evolving needs of urban environments and their inhabitants.

5.4 Limitations and future research

The thesis's research explored multiple settings and concepts for innovation development and the ways in which different stakeholders collaborate, while having some limitations, especially geographically, considering that the research context was only in one geographical area, Finland. What works for a group of actors in a Finnish ecosystem might not work in another ecosystem in Finland, in another country or on another continent due to different values, habits, systems, opinions, worldviews, and mentalities. Therefore, further research could investigate how actors work together for innovation development and sustainability in a different country in a similar single-case setting, such as a living lab. In addition to investigating the living lab approach in a different country, further research could investigate multiple firms and the relevant actors around these focal firms to explore the impact of their networks on the commercialization and market creation of their innovations. CE ecosystem actors' joint/separate innovation activities can be explored further from the strategic decision-making, environmental uncertainty, and power dynamics aspects.

Using projects that focus on environmental sustainability as the unit of analysis in living labs has some clear limitations. The chosen projects that were analyzed specifically focused on increasing environmental sustainability in the living lab, although there were many other projects in the living lab that were not as sustainability-focused as the selected projects. Thus, to the readers, the living lab may be seen as a setting that focuses solely on environmental sustainability. Future research could involve projects that do not entirely focus on environmental sustainability but also on social, human, and economic sustainability to provide a holistic overview of the living lab.

Using the organizational innovation types (Crossan & Apaydin, 2010) for the selected CE innovations in Finland is a useful way to categorize different types of innovations to understand their development process and impact. Further research could involve innovations in contexts other than Finland to expand the geographical reach of the CE to see the environmental impacts of innovations that are developed worldwide.

In the thesis's research, the activities of the stakeholders of a single company in the functional food industry in Finland were analyzed in the context of commercialization and market creation, which has some limitations in terms of the generalizability of the study to other than the food and healthcare contexts where health is a concern. Moreover, the stakeholder types and the significance of the key stakeholders might differ in other industries when commercializing a radical innovation. Further research could approach the phenomenon by employing a multiple-case study and including companies in other countries in the same industry and in different industries to test how geographical and industrial differences affect stakeholder interactions and the commercialization and market-creation outcomes.

Further research can focus on identifying best practices and strategies for scaling up successful urban living lab projects and replicating them in different urban settings. Understanding how to transfer successful solutions to other cities and regions is crucial for broader impact. Research can assess the long-term impact of Hiedanranta urban living lab on urban development, sustainability, quality of life, and economic growth in the future when there is new residents of the new city district. Investigation of the governance models and policy frameworks that support the establishment and operation of urban living labs can be studied further. This includes research on legal, regulatory, and institutional aspects that facilitate innovation in urban settings. Another important point is to examine ways to enhance citizen participation, engagement, and co-creation in urban living labs regarding tools, methods, and platforms that facilitate meaningful involvement.

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PUBLICATION I

Urban living lab as a circular economy ecosystem: Advancing environmental sustainability through economic value, material, and knowledge flows

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Urban Living Lab as a Circular Economy Ecosystem: Advancing Environmental Sustainability through Economic Value, Material, and Knowledge Flows

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Abstract: Environmental sustainability is an increasingly relevant aspect of urban living labs. The objective of this study is to examine an urban living lab through ecosystem approach lenses and reveal the actor activities and diverse flows between them, enabling sustainable urban development. The study examines an urban area through four living lab projects in the Hiedanranta district in Tampere in Finland. We apply a qualitative research design strategy including semi-structured interviews reinforced with the project reports and websites. The collaboration and co-creation nature of living labs resembles an ecosystem structure, as both include diverse complementary actors and have distinctive coordination mechanisms, shared goals, and system-level outcomes. Building on the ecosystem analogy and circular economy ecosystem typology, our study examines living labs as ecosystems, enabling the economic value flow, material flow, and knowledge flow and pursuing the shared goal of improved environmental sustainability. The findings of the study demonstrate how the different ecosystem types manifest in urban living labs, and the actors, flows, and outcomes in these ecosystems. The study concludes that urban sustainability-oriented living labs comprise all main types of circular economy ecosystems. The dominant type of the activities (biased to economic value, material, or knowledge) determines the ecosystem type in an urban living lab, highlighting a key topic for future research: The contribution of collaborative projects to environmental sustainability in urban living labs realized through diverse ecosystem types.

Keywords: living lab; urban living lab; circular economy; sustainability; ecosystem; resource efficiency; nutrient recycling

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1. Introduction

The interest in and significance of environmental sustainability has been growing globally due to the increased awareness of the effects of climate change on natural habitats [1]. Such global developments draw attention to the need for more resource-efficient and regenerative systems, which can be experimented with and tested in a living lab environment [2,3].

Living labs are one of the most recent forms of open innovation networks, providing multiple research opportunities [4,5]. Living labs scrutinize multiple disciplines and concepts such as the transition to low-carbon economies, experimental governance, and new approaches to sustainable development [6,7]. A living lab emphasizes the roles of user involvement, prototyping, testing, and validating in the creation of new technologies, services, products, or systems in real-life settings [8]. Living labs adopt an experimentation approach and involve public–private–people partnerships in the co-creation process [9].

Living labs are distinguished from other open-innovation approaches by allowing users to improve the technologies that are being co-created and tested with other stakeholders in real-life environments [10]. A living lab consists of a physical region or virtual realities where the actual collaboration among stakeholders takes place [4].

This paper particularly examines urban living labs for environmental sustainability and circular economy. An urban living lab is a living lab formed in an urban area [2], including different stakeholders such as companies, researchers, authorities, users, and residents who develop solutions for existing problems in an urban area. The use of the living lab concept for the development of urban areas enables rapid social, technical, and economic transformation [6]. In the context of urban living labs, city districts that are under development are seen as innovation spaces where new applications are tested on a large scale [11]. Urban living labs are increasingly applied for environmental sustainability and circular economy, and they aim to regenerate neighborhoods, support circular companies, enable tenders for circular experimentation, and allow decentralized waste recovery systems to be tested [12]. Acknowledging [13,14], we define circular economy as a restorative and generative economic system, which aims to maintain the value of products, materials, and resources by reducing, reusing, recycling, and recovering materials in production/distribution and consumption processes. As the term sustainability includes the pillars of economic, environmental, and social development and refers to maintaining performances of these three pillars over time, circular economy concept contributes to sustainability with an emphasis on the economic and environmental benefits [15].

In this paper, we argue that an urban living lab for environmental sustainability and circular economy can be considered as a multi-actor ecosystem: The ecosystem conceptualization has been applied increasingly during the last decade [16] to refer to diverse complex multi-actor settings. An ecosystem conceptualization can be considered both as a theoretical concept (e.g., business ecosystem; innovation ecosystem) and more loosely, as a metaphor referring to a broad system of multiple actors. The collaboration and co-creation processes in living labs resemble the ecosystems, as both have distinctive coordination mechanisms, shared goals, system-level outcomes, and network conceptualizations [17]. Acknowledging Aarikka-Stenroos et al. [18] and Thomas and Autio [17], this study applies the ecosystem concept, referring to a heterogeneous community, a system of actors that are hierarchically independent and have diverse roles and a system-level goal or outcome. In this paper, we examine sustainable urban living labs as particular circular economy ecosystems [18]. Such ecosystems focus on resource circularity, circular economy knowledge, or circular economy business and business models as their shared goal and system-level outcome. The value network of an urban living lab ecosystem generates value through dynamic exchanges between various stakeholders, and these exchanges can be mapped as different value flows [19,20].

The extant urban living lab literature focuses on the sustainable urban living lab projects [2], the networked nature of living labs [21], the governance of the urban sustainability transitions [22], and the diversity of living labs and their actors [10,11]. However, studies on urban living labs as ecosystems focusing on environmental sustainability are nascent. Therefore, the objective of this study is to analyze ecosystem types in an urban living lab and their actors, flows, and outcomes regarding environmental sustainability. Our research questions are twofold:

- What are the circular economy ecosystem types in urban living labs?
- What are the actors, flows, and outcomes in urban living labs as urban circular economy ecosystems, contributing to environmental sustainability?

In this study, we generate a new understanding on urban living labs as we study how they function as a circular economy ecosystem: Collaborations in urban living labs, often actualized via projects, create an ecosystem in which the actors work towards the particular goal of the ecosystem (such as material flow). Actors' collaborations in a particular project often concern the same topic (such as nutrient recycling). Thus, an urban living lab contains several parallel ecosystems, in which multiple projects take place. In the identified urban living lab ecosystems, the dominant type of the project activities determines the ecosystem type that a project belongs to. The project activities include knowledge flows, material flows, and economic value flows, which result in the description of the corresponding ecosystem type in the urban living lab. We integrate the ecosystem approach into sustainability and circularity [18], as our study complements this conceptual discussion by providing an empirical in-depth analysis of circular economy ecosystems actualized in living lab settings. Our study showcases how diverse actors from companies, the city, universities, and users/residents and flows in sustainable urban living labs constitute circular economy ecosystems.

This paper is structured as follows. Following this introduction, we discuss the actors in urban living labs and the circular economy ecosystems to elaborate on the current understanding. In the third section, we present the research design of the study. In the fourth section, we present the circular economy ecosystem types in the Hiedanranta urban living lab and the results of the study. The fifth section concludes the paper and synthesizes the results, which includes the theoretical contribution, practical implications, and the limitations and future research topics respectively.

2. Urban Living Labs for Environmental Sustainability and Circular Economy

2.1. Actors and Activities in Urban Living Labs

Urban living labs comprise various actors that take part in the practice-based innovation activities in an urban area, tackling varying urban challenges. These actors are categorized mainly as municipalities, companies, research institutes, and residents [11]. Another approach to classifying the living lab actors points out the actors' roles and goals of participating in the living lab and uses the following categorizations, respectively: Enablers, utilizers, providers, and users, which is in line with the action-based role theory [9,10]. Action-based role theory explains the actor roles through their actions: An actor takes a role to achieve a specific goal. The roles act as a means to organize innovation in networks, and to assess the resource and partner selection when conducting the tasks that are associated with the roles [10]. Therefore, to some extent, the roles describe the contribution and commitment of the actors to specific goals in the urban living lab.

The enabling characteristics of municipalities indicate the supportive nature of the public sector actors and their role in creating a vision and spreading and communicating the vision to other actors in the urban living lab. This "enables" the emergence of innovations for urban challenges. The companies in urban living labs improve their knowledge capital through collaborations while continuing the development of their business operations in the area, which demonstrates the utilization of collaborations for the company's benefit. Therefore, one of the motives for a company to participate in an urban living lab is to gain a competitive advantage through information retrieval from other actors, especially users [9]. The research institutes and universities bring up the methods, tools, expertise, and additional resources that they offer for the development. The long-term research projects conducted in the urban living labs make it possible to generate reliable knowledge. Lastly, residents, as the essential actors of the urban living labs, use and test the solutions that are developed and provide their feedback for further improvements [11,23]. Although each actor type is introduced with specific roles, these roles might change over time as they are context-specific and depend on the innovation network's needs and goals [10,24].

2.1.1. Municipalities

Cities are innovation spaces and areas for urban living labs where various opportunities can emerge that accelerate sustainability and environmental transitions [25]. The experiments that take place in cities can be scaled up to generate broad systemic change [26], and municipalities, as enablers, are the prominent actors in the local sustainability governance [22]. Municipalities adopt the experimental governance approach in urban living labs, which emphasizes knowledge generation and innovation development through open and engaged learning [6]. Municipalities are embedded in local networks, partnerships, and collaborations, and seek the expertise of public and private actors to implement local policies [27].

2.1.2. Residents

As one of the crucial actors of open-innovation in urban contexts, residents as users have the potential to influence the decision making in urban governance and positively affect the urban development and their living environments [28]. Residents play a direct role in designing and developing innovations to address sustainability challenges [22]. Including residents already in the early design stage of the urban living labs helps identify the user needs that would shape the development process [29]. In some cases, the residents in urban living labs are not necessarily involved as users. The solutions that are developed might not have a use for a resident, but instead may serve the resident, as in the case of nature-based solutions that are developed to manage the stormwater for flood prevention [30].

2.1.3. Companies

Companies in an urban living lab drive the transition to a low-carbon economy and sustainable living by engaging in the development of innovative solutions [6]. Some of the solutions that enable sustainable living include renewable energy production; urban farming; the utilization of nutrient, energy, and material flows; and the utilization of side streams from the production activities. By undertaking these tasks, companies tackle various urban issues such as poor air and water quality or waste disposal problems. The primary goals of companies in urban living labs include economic performance improvements while reducing the environmental impact of their operations [6]. Developing and testing products and services with other actors are the additional motives for companies to take part in urban living labs. While performing these activities, companies utilize the user data that are easily accessible due to the open-innovation approach that the urban living labs adopt, which provides open and engaged learning [24]. Companies seek agile actions and rapid results in living labs to apply strategies according to their business goals. Although urban living labs mainly serve the objectives of municipalities, it is still beneficial for companies to participate in an urban living lab, in terms of making use of the information and knowledge created in a collaborative setting [9,24]. Moreover, tackling urban challenges with proven innovative products and services might be of use in the value proposition for business prospects.

2.1.4. Research Organizations

Urban living labs provide the opportunity for cross-disciplinary research, which enhance ties between the creators and users of the generated knowledge [6]. Urban living labs act as a basis for theory development, knowledge creation, and the discovery of new teaching and research methods, which can be argued to be the roles of the research organizations in urban living labs [9]. Research organizations are responsible for generating objective knowledge of scientific practice in urban living labs to influence policies. The outcome of the research activities might have the potential to influence urban development policies in areas of sustainable infrastructure design or material procurement strategies [25]. The researchers may act as consultants when opinions are needed on technical decisions such as the selection of monitoring equipment and its location [6]. Commercialization of the solutions as a result of the research projects can be sought to upscale the impact. However, the local knowledge production does not always find its way to creating a widespread impact, as there might be misalignment between scientists and policymakers due to the organizational differences [6,31]. One of the reasons for the misalignment is the lack of an established standard and protocol for data storage and incorporation of this data into decision-making processes. This holds important implications as science and policy are interconnected in urban sustainability [6].

2.2. Circular Economy Ecosystems in Urban Living Labs

In this paper, we examine urban living labs as circular economy ecosystems. Three flow types in circular economy ecosystems are identified, namely ecosystems that address economic value flow, material flow, and knowledge flow [18]. In this paper, we will examine how they are present in urban living labs. First, economic value flow-based ecosystems focus on the sustainable production of goods and services. This type of ecosystem typically consists of a central hub actor that coordinates other actors for the system-level outcome of a sustainable value proposition; in other words, here the ecosystem actors contribute to creating business and flow of money from diverse resources. Next, material flow-based ecosystems describe efficient resource flow and resource circularity in a regional system, in which recycling and reuse are the fundamental actions [32]. In this type of ecosystem, administrative actors and physical infrastructure play an important role. Material flow-based ecosystems enable the local resource flow through industrial or public-private collaborations; in brief, the actors can for example enable recycling of an important resource. Last, knowledge flow-based ecosystems reveal the transformation of the knowledge derived from research into sustainable products and services through the open processes of R&D and innovation [33]. Here the actors jointly develop new knowledge on diverse circulating resources.

One archetype of circular economy ecosystem, namely urban circular economy ecosystems (such as urban living labs), supports urban amenities, promotes societal activities, develops and improves infrastructure, and produces goods and services [18]. The actors in such ecosystems take part in various projects that are in line with the goal of the ecosystem (to enable material flow, knowledge flow, or monetary/economic value flow). The projects in the ecosystems act as a vehicle for actors to pursue sustainable urban development [34]. Policy, governance, culture, and individual and collective behavior are the driving factors for determining the adoption levels of sustainability in urban ecosystems [35]. Figure 1 below illustrates how the projects and ecosystems are positioned in an urban living lab. An urban living lab consists of three types of ecosystem, and in each ecosystem, there are multiple ongoing projects.

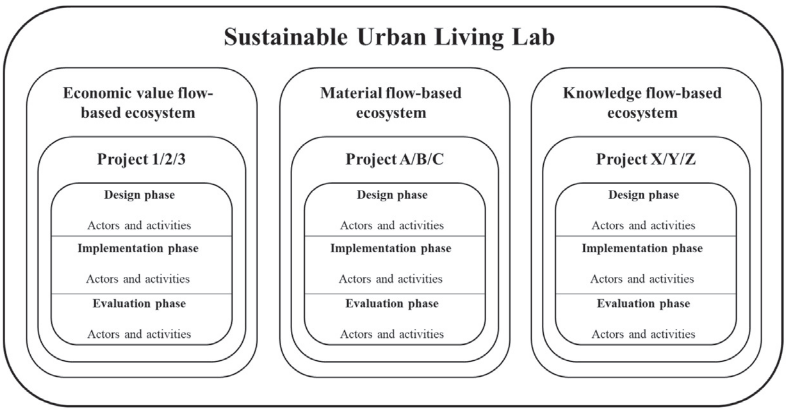

Figure 1. Sustainability-oriented urban living lab for improving economic value, material, and knowledge flows through projects.

3. Research Design

This study is a qualitative and explorative single case study in a developing city district, namely Hiedanranta urban living lab in Tampere, Finland. Hiedanranta is a work-in-progress lakeside urban district where 25,000 residents are expected to reside in the upcoming years. Along with its new residents, 10,000 new jobs will be created as part of the development activities in the area. The objective of the municipality is to build a smart and sustainable future city district in Hiedanranta that produces more resources than it consumes. Some of the development activities in Hiedanranta include utilizing smart technology in the infrastructure, planning of the transportation solutions, construction of the new residential buildings with the aim of improving the services and everyday life of residents. The city district experiments with circular economy by having a biochar production plant, vertical farming facility, dry toilets in the event venue, and an algae growing plant in the area. The urban area includes various research projects, business activities, and citizen participation in the development of the district. Thus, this purposefully selected area provides a strategic case to study sustainable urban living lab, its diverse actors, flows, and goals related to improving sustainability and circularity.

The case study is carried out in the period of January 2019–December 2020. It contains four projects (KIEPPI, NutriCity, Hierakka, and UNaLab) occurring in Hiedanranta district, which engage diverse actors to collaborate for circularity. The unit of analysis is the design, implementation, and evaluation phases of the projects along with the actors and activities in these phases. The projects concern specific sustainability and circularity related themes and goals (such as improving nutrient recycling) that require actors to collaborate for the economic value flow, material flow, or knowledge flow. We selected the projects based on their high impact on environmental sustainability. The case study is constructed based on extensive data from multiple sources, including nine semi-structured interviews conducted by the author, longitudinal observation, the websites of the companies and the municipality that provide information about the ongoing research projects in the district, and the project reports. We recorded and transcribed the interviews. We conducted interviews with the managers of the urban living lab firms, city development project managers from the municipality, and researchers who are involved in the projects that take place in the urban living lab. The key informants are selected based on their key responsibilities in the selected projects, companies, and the municipality, having an impact on the sustainable development of Hiedanranta. The details of the interviews are listed in Table 1 below.

Table 1. Interviews.

Actor Type	Role	Theme	Date	Duration
Municipality/Researcher	Project Manager (Urban planning/Nutrient recycling)	Ongoing nutrient recycling projects in the city associated with the development of the region	21 March 2019	45 min
Municipality	Project Manager (Urban planning)	Stakeholder engagement in the city development	12 April 2019	52 min
Municipality	Project Manager (Urban planning)	Ongoing development on the partnership model for sustainable neighborhoods	2 April 2020	64 min
Researcher	Project Manager (Nutrient recycling)	Research on dry toilets and utilization of nutrients from urine	27 March 2019	55 min
Researcher	Project Manager (Nutrient recycling)	Research in microalgae plant and using nutrients for microalgae growth	4 April 2019	25 min
Company	General Manager	Nutrient recycling activities in the vertical farming facility in the area	2 April 2019	53 min
Company	General Manager	Information about the biochar company and its operations	17 May 2018	44 min
Company	General Manager	Information about the dry toilet company and its operations	23 May 2018	23 min
Association	Project Manager	Benefits of dry toilets for nutrient recycling and required policy and infrastructure changes for their adoption	10 April 2019	60 min

At the analysis stage, the design, implementation, and evaluation phases of the projects, the driving actors in each phase, their activity sets, and the type of flows were identified. Data analysis phases are listed in Table 2 in more detail.

Table 2. Data analysis process.

Data Analysis Phases	Task	Outcome
1. Open coding	• Dataset organization • Identifying the urban living lab projects that focus on environmental sustainability • Identifying the informants from the projects to be interviewed	Overview of urban living lab projects and the informants that are associated with the projects [10,36]
2. Focused coding #1	• Identifying the project phases • Identifying the ecosystems that the projects are involved in • Identifying the involved actors in the project phases	Overview of project phases, the involved actors in each phase, and the urban living lab ecosystems [18]
3. Focused coding #2	• Identifying the activity sets and the type of flows in the design, implementation, and evaluation phases of the projects	Overview of the activity sets and the type of flow that a specific activity belongs to
4. Theorizing the codes	• Synthesizing phases 1 to 3: analyzing the contribution of the projects to the urban development and environmental sustainability • Describing the actors, flows, and outcomes in urban living lab ecosystems	Conceptualization of the ecosystems in urban living labs and their comparison with the literature

4. Ecosystem Types and Flows in Hiedanranta Urban Living Lab and Its Projects

4.1. Economic Value Flow and Related Ecosystem in Urban Living Labs: Project on Developing a Partnership Model for Environmentally Sustainable Neighborhoods

We analyzed an economic value flow and related ecosystem in an urban living lab by examining the Kestävien Kaupunginosien Kumppanuusmalli (KIEPPI) project that aims to create a partnership model for sustainable neighborhoods in the three cities in Finland. Hiedanranta district in the city of Tampere is one of the focus areas in the project where the urban areas are increasingly redesigned according to sustainability and circular economy principles. Tampere municipality coordinated the project and the European Union funded it. The funding mechanism and the partnership model support the creation of carbon-neutral technologies, services, or innovations in cooperation with companies, research organizations, and municipalities. Apart from the solutions related to the utilization of waste and side streams, the municipality as the driving actor of the project seeks solutions for four identified themes: Premises and services for the circular economy, material circulation, urban food production, and the improvement of blue-green infrastructure in the city district to improve the wellbeing of future residents. In our analysis, we focus on the project activities that deal with the Hiedanranta development.

The municipality's inclusive efforts are in line with the experimental governance approach that the urban living labs adopt, as the municipality encourages action through partnerships and facilitates stakeholders to collaborate. According to the project manager, the municipality has never taken such a role in the development of a certain urban area before, which is Hiedanranta area in this case. The city currently faces many new challenges relating to urban planning, co-creation, and cooperation models for the Hiedanranta development. The municipality allocates resources to the sustainable development of Hiedanranta and maintains resources for this specific purpose. In order to accelerate the development and to make it more structured, the municipality has launched a company that works independently and manages the urban planning and construction of the infrastructure and park areas in Hiedanranta. The development company is solely responsible for the development of Hiedanranta. Therefore, the innovation activities in the Hiedanranta development depend highly on the external actors, and the city acts as a bureaucratic actor rather than an innovative actor. The project manager highlights that the external actors mainly consist of companies and research institutes, and that the citizen involvement in this project is minimal. The project focuses on reducing waste and increasing resource efficiency in industrial procurement and applications where the citizens do not have a major impact.

The municipality offers the Hiedanranta area to companies and research organizations to perform their activities and introduce novel ideas and solutions that would develop Hiedanranta as a self-sufficient city district. The anticipated involvement level is highest for the companies and lowest for the residents. It is underlined by the project manager that incentives, such as different types of subsidies or lower rents offered to companies and research organizations, might be needed to attract them to take part in Hiedanranta. In the case of infrastructure procurement, the municipality has a huge role in creating sustainable business opportunities, as it is one of the biggest buyers of infrastructure materials. If the municipality starts demanding more sustainable infrastructure services, the whole industry would have to change, which would enable a shift from linear business models to circular business models. Eventually, this might also lead to the emergence of companies that value the use of recycled or reused materials.

In the design phase of the project, the municipality identified three development themes. The City of Tampere partners with an expert consulting firm to develop the partnership model and to identify the methods that will be used to attract companies and research organizations to the area. The expert consulting firm has complete control over designing the partnership model. Once the model is created, three partner cities of the project will jointly utilize the model. Recently, the municipality initiated a tendering process to invite suppliers or contractors to conduct the pilot projects. The tender aims to attract startups since the budget for pilots is relatively low for large companies. However, larger companies might still have an interest in the pilots due to the anticipated growth in the city district area. The city uses the tendering process as a means to test out the companies' motivation to cooperate with the city and participate in the partnership model. One downside of the tendering process is that it only allows the companies that are based in Finland to submit an offer, which restricts the participation of interested innovators from other countries that might be capable of accomplishing the goal of the development of Hiedanranta. However, the project manager highlights that the main goal is the creation of the partnership model and discovery of the innovations and technologies rather than pilots per se. In the evaluation phase of the project, scaling up the results to the city level and exporting the partnership model to other cities as a concept will be pursued. Figure 2 below illustrates the project phases, driving actors, activity sets, and the activity flow types.

The goal of the project is not the pilots but the creation of the partnership model as it also shows in the budget. Pilots are there to test out the partnership model and to test out the businesses' cooperation with the city. Also, to discover what kind of innovations and technologies the companies already have at hand (Project manager of KIEPPI Tampere).

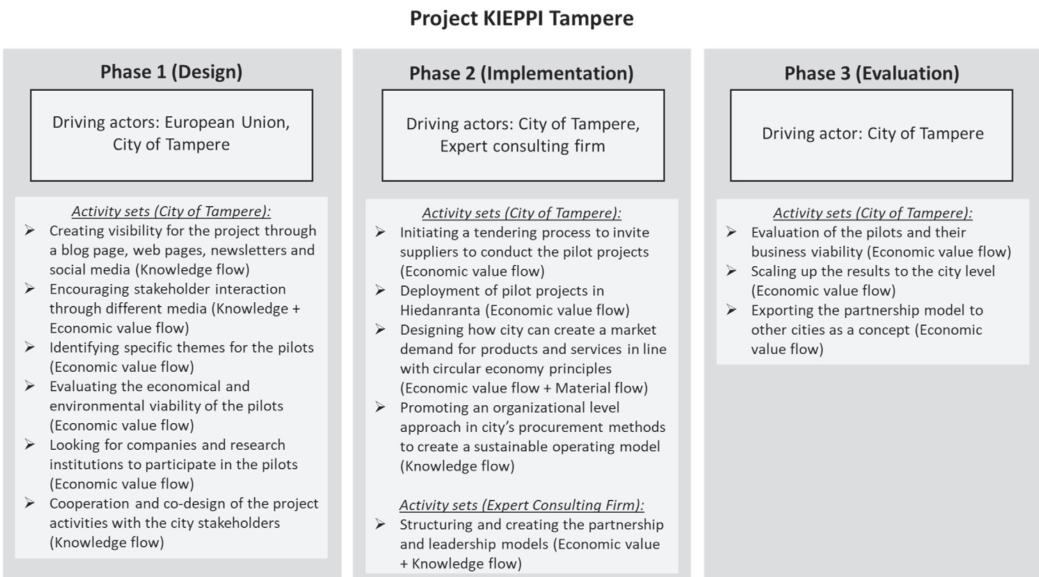

Figure 2. Driving actors and activity sets in Project Kestävien Kaupunginosien Kumppanuusmalli (KIEPPI) Tampere.

4.2. Material Flow and Related Ecosystem in Urban Living Labs: Projects on Nutrient Recycling in Hiedanranta Urban Living Lab

Next, we analyze the material flow and related ecosystems in an urban living lab by focusing on the relevant material flows, namely nutrients. The Hiedanranta district aims to be a carbon-neutral and sustainable urban area where nutrient recycling is crucial. In line with this goal, several projects have been initiated in the area in cooperation with research organizations and companies, which are discussed next. The projects have a top-down approach as there is a push from the European Union and the Ministry of the Environment in Finland to enhance nutrient recycling for the improvement of the environment and water bodies.

NutriCity project aims to reduce the amount of nutrient leakage into the Baltic Sea by recycling human waste nutrients through alternative sanitation solutions such as dry and vacuum toilet systems. The Ministry of the Environment of Finland funded the project, and the City of Tampere implemented it together with Tampere University of Applied Sciences (TAMK) and The Finnish Environment Institute (SYKE). The goal of the project is to recover nutrients such as phosphorus and nitrogen from the human waste fractions through dehydration and produce fertilizers. Based on the results of the NutriCity project, an operating model for resource and energy-efficient management and utilization of nutrients containing wastewater fractions in cities will be created. The project manager of NutriCity represents the municipality and university and has a dual role in the project as she is part of both organizations, therefore bringing the technical knowledge into the municipality. According to the project manager, in Tampere, there is a strong cluster of research in the use of alternative sanitation systems such as dry and vacuum toilets. The same actors from the cluster are usually involved in the projects associated with nutrient recycling. The project manager points out that although there is pressure from authorities to recycle nutrients for more sustainable food production, major players in the food industry in Finland are unwilling to use grains that are produced with fertilizers made from wastewater sludge due to the risks of contaminants. Therefore, in practice, the low acceptance of the fertilizers made from recycled nutrients is a bottleneck in their market creation. This brings up the question of whether authorities, companies, and researchers should come up with new strategies and solutions that would make such products accepted while ensuring that there are no risks to health and the environment. In all the nutrient recycling projects, the municipality offers the event venue Kuivaamo to be used for research purposes. The dry toilet systems in the event venue that were implemented by the dry toilet company make it possible to collect urine for conducting studies on its properties and suitability for use as fertilizers. The dry toilet company acts as an equipment supplier in the area. In the project, residents have both the roles of informant and tester, as they can test the dry toilets located in Hiedanranta and provide their feedback through an online survey that seeks resident opinions on utilizing alternative toilet solutions for urban nutrient cycles.

There is a top-down pressure from the European Union and the Ministry of Environment of Finland to enhance nutrient recycling, and there's also funding for that from those resources. Cities are consumption hubs, there are lots of nutrients concentrated here (Project manager of NutriCity).

Another nutrient recycling project, Hierakka (Promoting nutrient cycle and participatory communication in Hiedanranta), was a one year-project that started in 2017 and ended in 2018. The Ministry of the Environment of Finland funded the project and the City of Tampere implemented it together with Tampere University of Applied Sciences. The study determined the properties of separately collected urine, such as nutrient and harmful metal concentrations, drug and contaminant residues, and microbiological quality. The study also investigated the possible effects of urine fertilizers on the soil's physical properties such as acidity and organic matter content. The results of the study acted as a means to convince authorities, the food industry, and farmers of the functionality of urine as a fertilizer and to change the attitude towards the use of urine fertilizers. The project focused on similar issues as the NutriCity project and used the same resources such as dry toilets in Hiedanranta and the funding source. The urine collected from the Hiedanranta dry toilets was tested as fertilizer in agricultural fields and in the vertical farming company located in Hiedanranta. The company offered its premises to the researchers for testing the effectiveness of the urine fertilizers on crops. In the project, local farmers had the tester role who tested urine fertilizers and saw their positive effect after harvesting in the late phase of the growing season. Figure 3 below illustrates the project phases, driving actors, activity sets, and the activity flow types.

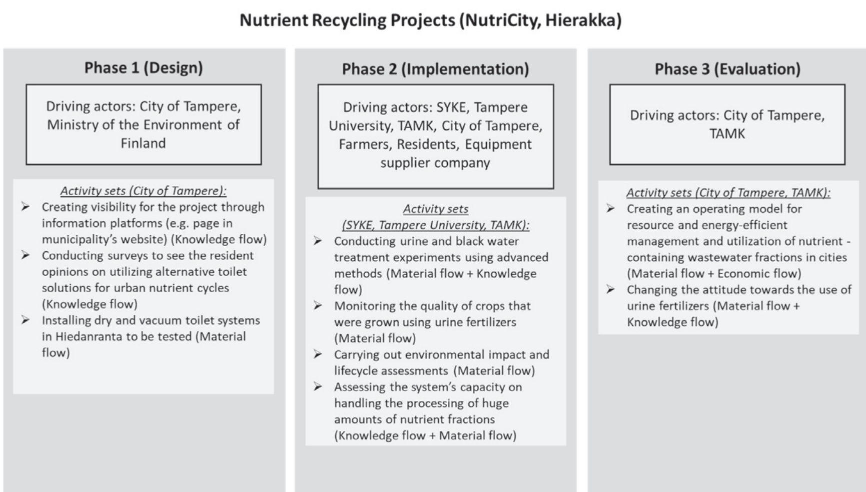

Figure 3. Driving actors and activity sets in nutrient recycling projects.

In some very populous countries, there are no phosphorous reserves. These countries are solely dependent on imported phosphorous. So, to feed people in the future, every means of recycling is important, if we think of it in a broader manner. In the urine separation and in these methods of nutrient recovery from different media, we are not talking about today's situation, but we consider how things will be in 50 years or 100 years. That's where I think it's a necessity, to recover all the sources possible (Project manager of Hierakka).

4.3. Knowledge Flow and Related Ecosystem in Urban Living Labs: Project on Developing Nature-Based Solutions

Last, we analyze a knowledge flow and related ecosystem in an urban living lab setting by outlining the collaborative setting for knowledge creation, particularly in nature-based solutions. Climate change induces the need for such solutions in urban areas as it will affect the Nordics by bringing more rain. Since the greenfield lands in cities are diminishing due to the newly built roads and houses because of densifying population, there is a risk of a reduction in the water infiltration capacity and loss of biodiversity. These issues emphasize the importance of nature-based solutions in urban areas. UNaLab is a European Union-funded project that aims to implement nature-based solutions to tackle climate- and water-related challenges in the urban areas of three frontrunner cities: Tampere, Eindhoven, and Genoa. Tampere, as one of the frontrunner cities in the project, has two locations for the implementation of the pilots, which are the city districts of Hiedanranta and Vuores. The objectives of the project are to develop the monitoring and impact of nature-based solutions, to develop business models around the nature-based solutions, and to engage people to co-create multi-functional nature-based solutions that work as parks and recreational areas for the residents. In our analysis, we will investigate the pilots in these two city districts where UnaLab Tampere deals with the water issues as part of the nature-based solutions.

The project has the same manager as the NutriCity project, who represents the City of Tampere in the activities and events organized by the UNaLab consortium. The consortium consists of 28 partners from 10 cities, including municipalities, research organizations, and businesses. One of the solutions implemented in the Hiedanranta area is the biofilter for the contaminated waters caused by the nearby old pulp landfill. The system has been designed together with experts and the residents of the surrounding areas. The biochar company in Hiedanranta acted as a material provider by supplying the biochar to be used as biofilter. The projects in Vuores work as a benchmark for the Hiedanranta development. In the other city district, Vuores central, a hybrid stormwater management system (medium-sized retention pond) was built to retain and purify the stormwater. Automatic measurements monitor water quality and flow throughout the year. The residents acted as an informant, tester, and designer in the project and shared their need for easy accessibility to forests and walking paths. The residents also took part in the design workshops and contributed to the ideation process together with the city officials. The project used innovation vouchers to build a horse paddock and community gardens in apartment buildings to attract more people to develop solutions together with the city. Figure 4 below illustrates the project phases, driving actors, activity sets, and the activity flow types.

We have a stormwater sewage network that is leading directly from the streets to lakes without treatment. And there is flooding in few spots of the city. And now the new thinking is that we should increase green areas instead of leading all the waters to the pipes, we should increase the multifunctional blue-green infrastructure in the city, like parks where there are streams that can hold the stormwater. The co-creation in living labs has to be well thought in terms of what is the contribution of citizens, how do we take people to co-create these things with us, and how the co-creation can be honest and fruitful (Project manager of UNaLab Tampere).

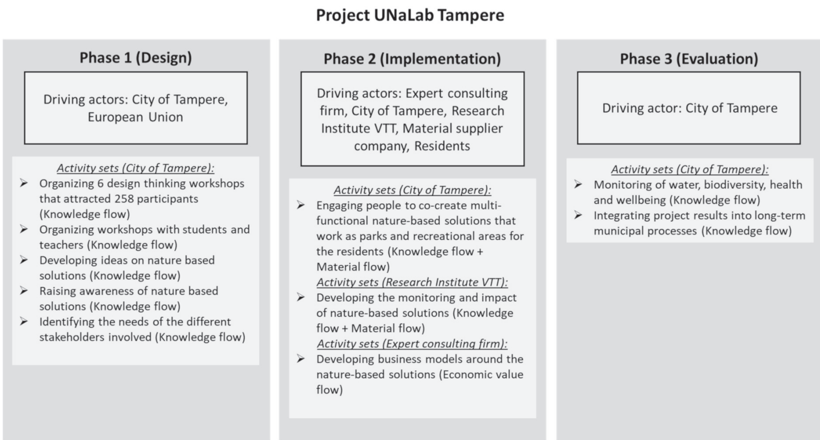

Figure 4. Driving actors and activity sets in Project UNaLab Tampere.

4.4. Summing Up and Discussing the Results

Our case study analyzed sustainable urban living labs as circular economy ecosystems and examined relevant ecosystem actors and their activities around the flows of materials, knowledge and economic value, and outcomes of these ecosystems regarding environmental sustainability. Our analysis leads to multiple key findings.

First, our study shows how the sustainable urban living labs promote knowledge, material, and economic value flows between actors and how they advance sustainable practices in the city district. Our case study in Hiedanranta showcases how economic value, material flow, and knowledge flow-based ecosystems occur in an urban living lab for sustainability. The economic value flow-based ecosystem includes companies that perform carbon-neutral business activities, which results in sustainable products. The municipality provides resources for companies that have material circulation and sharing practices for waste utilization. Therefore, in economic value-flow based ecosystems in urban living labs, the municipality seemed to act as a coordinator to bring together the companies that promote the economic-value flow.

Material-flow based ecosystems inherently recover nutrients from biowaste or household waste fractions that have the potential to be utilized as fertilizers. The material-flow aspect emphasizes the circulation of the materials that can be recycled, such as the cycle of the household waste being converted to fertilizers. In this type of ecosystem, research institutes and universities facilitated the experiments for circulating the materials.

The knowledge flow-based ecosystem develops nature-based solutions with the inclusion of residents and preserves nature by purifying the stormwater that might otherwise contaminate the water bodies, thus contributing to the environmental sustainability of the urban area while benefiting from resident participation and feedback. The knowledge flows among the residents, researchers, and the municipality to develop the stormwater management systems through participant feedback. In all three ecosystems, the municipality promotes the sustainability mentality in all activities. Table 3 lists the actors, flows, and outcomes in ecosystems in the Hiedanranta urban living lab.

Table 3. The actors, flows, and outcomes in ecosystems in Hiedanranta urban living lab.

	Economic Value Flow-Based Ecosystem (Example: KIEPPI)	Material Flow-Based Ecosystem (Example: Nutrient Recycling Projects)	Knowledge Flow-Based Ecosystem (Example: UnaLab)
Actors	- European Union - Municipality - Companies - Consulting firm	- Municipality - Ministry of the Environment - Research institutes and universities - Farmers - Residents - Equipment suppliers	- European Union - Municipality - Companies - Consulting firm - Research institute - Residents - Material suppliers
Flows	- Designing how city can create a market demand for products and services in line with circular economy principles - Identifying specific themes for the pilots - Initiating a tendering process to invite suppliers to conduct the pilot projects - Evaluating the economic and environmental viability of the pilots - Cooperation and co-design of the project activities with the city stakeholders	- Regulators supervise the legislation, for example in this case for fertilizer use - Municipality enables and allows implementing the novel technological solutions, e.g., the facility use for the dry toilets - The company, such as equipment provider, supplies technological solutions; in this case e.g., dry toilets for the collection of urine and service provider processes the waste - Actors together enable and ensure the recycling of critical resources: Urine sample to be converted to fertilizer is taken from the residents through dry toilets located in the event venue Kuivaamo - Actors together improve the methods and processes available. Treatment and management of urine using various methods to reduce its volume while increasing its concentration - Researchers together with farmers and companies run tests on the properties of urine and evaluate its suitability of use as fertilizer	- Municipality and residents share information on the preferences, needs, and problems of everyday life - Research institute, consulting firm, and the municipality develop the plan for the implementation of nature-based solutions in urban areas - Material suppliers provide required materials to be used in stormwater management systems - Research institute monitors the water quality and flow - Municipality and residents monitor the impact of nature-based solutions through workshops
Outcomes	Improving the economic value and business from the location-specific resource in a sustainable way, e.g., creating a partnership model for sustainable neighborhoods	Improving circularity of important resources in the location, e.g., recycling nutrients from wastewater and residential waste	Creating and disseminating new knowledge and solutions for sustainable environment, e.g., developing nature-based solutions such as stormwater management systems
Ecosystem goals	Sustainable production and flow of economic value	Efficient resource flow and resource circularity in a regional system	Transformation of the knowledge derived from research into sustainable products and services

Second, the number of research projects, the number of active companies in the living lab, their size and scope, and the municipality's open mindset to try novel applications in the city district play a major role when determining the impact and level of contribution of a certain actor type to the development and sustainability of an urban living lab.

Third, in urban living lab ecosystems realized through projects, the driving actors may change in the project development phases depending on the required tasks and the competence and expertise level of the set of actors. When reflecting on the ecosystem approach, the finding underlines that actors setting and actors' role in urban living lab ecosystems are rather dynamic. In all the projects examined in the study, the municipality facilitates the development by engaging other actors such as technical experts, companies, residents, and researchers. This indicates a strong involvement of the municipality in the local sustainability governance: thus, it holds a strong role in the ecosystems for circularity in local environments. As our case demonstrated, Hiedanranta urban living lab and involved actors pursue similar objectives as other European urban living labs [12], which are regenerating neighborhoods, supporting circular companies, enabling tenders for circular experimentation, and allowing decentralized waste recovery systems to be tested.

5. Conclusions

5.1. Theoretical Contributions and Practical Implications

Our key results stemming from the empirical in-depth case study on sustainable urban living labs as circular economy ecosystems generated multiple contributions. First, this study contributes to the urban living lab literature by discussing and analyzing the urban living labs as diverse ecosystem structures in the development of a sustainable city district. It showcases how living lab contributors as ecosystem actors collaborate around diverse flows of economic value, knowledge, and material resources, sharing the system-level goals, and thereby aiming to improve environmental sustainability as a collective action. Their diverse activities and activity sets demonstrate how they have complementary and dynamic roles in reaching such a shared goal. To put this differently, this study generated a new understanding of how urban living labs function as a circular economy ecosystem.

Our study reveals that urban living lab projects under the same theme (such as nutrient recycling) create an ecosystem in which the actors work towards the particular goal of the ecosystem (such as material flow) that is aligned with its theme. Thus, an urban living lab contains several ecosystems in which multiple projects take place to serve the goal of that particular ecosystem. Thus, our study extends the literature of living labs that have discussed ecosystems [37] as well as their knowledge, competencies, and materials within boundaries of living labs [38], but as far as we know, has not yet documented the multiplicity of ecosystems actively and simultaneously, or their flows in a single living lab(s).

Secondly, this study continues the emerging analysis of diverse multi-actor collaborations for circular economy and sustainability [18]. This empirical case study depicted and validated how the three major ecosystem types (ecosystems for economic value, knowledge, and material flow) may occur in urban living labs, often in parallel. Living labs have suggested generating and enhancing diverse outcomes [38]. Given that different ecosystem types and flows exist simultaneously, a living lab possesses and fosters diverse types of outcomes in each ecosystem.

Our third contribution is that our results build a bridge between living lab and ecosystem approaches. Both concepts include and engage multiple, diverse, complementary actors working towards a shared goal. Thus, we argue that living labs serve as platforms that nurture and foster the emergence and development of multi-actor ecosystems, engage diverse stakeholders and actors into collaboration, and thereby, bring together diverse needs of and contributions by different stakeholders. Our empirical study allows us to propose that sustainable urban living labs as platforms enable collaborations around flows and tie together the diverse actors and their interlinked actions towards their own and system level, shared goals. As suggested by [25], this study seeks further conceptualizations of the essence of living labs by implementing ecosystem and related flows as novel theoretical lenses.

Further, we identified that same actors act simultaneously in different ecosystems (e.g., companies can contribute not only to the flow of economic value but also to material and knowledge flow). Such findings expand the findings by [10], who suggested that stakeholders may have multiple roles in living labs. This study suggests that living labs and particularly living lab platforms make the diversity of ecosystems visible. They foster collaboration in and between ecosystems. Therefore, urban living labs for sustainability are a fruitful context for researchers examining material, knowledge, and economic value ecosystems that exist in parallel.

This study also develops several practical implications. First, we believe that our study can guide urban living labs development in practice as it demonstrates how ecosystem approach provides new lenses to consider collaborations, actor diversity as well as individual and system level goals, and thereby provides also new aspects to living lab management. Therefore, we encourage experts developing sustainable living labs to consider these aspects (e.g., displayed in Table 3), when initiating and managing collaborations for sustainable urban living labs. Second, to achieve favorable results in city development projects, the dwellers of a city district who practice sustainable living, businesses that contribute to circular economy, research organizations, and municipalities as governing bodies are suggested to collaborate and cooperate. As the initiator of the urban living lab, municipalities are encouraged to attract businesses and create new jobs based on the ideology of the circular economy. Third, the needs of the inhabitants of the district should be considered while testing and co-creating with them, and the sustainability aspect should be emphasized. For a city district that is planned to be carbon-neutral, it is crucial to note that in the process of urban growth, the flow of materials should circulate as closed and resource-efficient as possible. Fourth, a living lab platform provides the opportunity for small-scale testing of the circulating resources (such as nutrient recycling in this case) with the cooperation of municipalities, researchers, users, and companies. In order to increase the sustainability of a living lab, pilots can be run where one company's side stream can be the raw material and resource of another.

5.2. Limitations and Future Research Topics

This study focused on one urban living lab in a Nordic country, including multiple parallel projects, revealing the diversity of ecosystems in an urban living lab. As our focus of analysis was limited to durations of such projects in a single living lab, a more longitudinal analysis may widen our understanding of analyzing urban living labs. Acknowledging that living lab literature is scarce in longitudinal analysis of living labs [24], we suggest that further research could longitudinally analyze living labs crossing ecosystems. Our study suggests a diversity of flows in ecosystems as a glue that couples living labs and their underlying ecosystems. Further analysis of the roles for the development of living lab in ecosystems or the roles for the development of ecosystems in living lab would shed light on their concepts. Third, technological advance drives and limits the development of sustainable circular processes in urban living labs; thereby, future studies could focus even more on the role(s) of stakeholders to overcome such limits of circular process development. Finally, our study suggests further studies and conceptualizations of the identified flows in urban living labs and particularly of how such flows support innovation activities and/or outcomes of living labs and their ecosystems.

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Institutional Review Board Statement: Ethical review and approval were waived for this study, due to the fact that the study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Publicly available datasets were analyzed in this study. This data can be found here: [https://www.tampere.fi/en/housing-and-environment/city-planning/development-programs/hiedanranta/innovative-hiedanranta.html]. The interview data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

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II

Distributed agency in living labs for sustainability transitions

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19. Distributed agency in living labs for sustainability transitions

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INTRODUCTION

The notion of sustainability is closely related to the impact of the production/consumption habits on the environment and ecosystems, and highlights the urgency for the efficient use of raw materials and conservation of nature (Markard et al. 2012). Consequently, sustainability is one of the main principles of the circular economy that aims to convert the linear take, make, dispose models into more circular ones, with the goal of maximizing the utilization of resources (Geissdoerfer et al. 2017).

There is an urgent need for more sustainable living and urban governance as natural resources are gradually being depleted and are deteriorating as a result of linear production/consumption patterns, which threatens our well-being (Bifulco et al. 2016; Liedtke et al. 2012; Voytenko et al. 2016). One of the reasons for the deterioration of natural resources is the insufficient recycling of the nutrients contained in municipal wastewaters and in organic side streams such as biowaste or manure from domestic animals (Malila et al. 2019). Globally, sustainability challenges in many domains are increasing (Geissdoerfer et al. 2017). On the other hand, the shift to the use of renewable energy from fossil fuels has already begun in all parts of the world, aiming for decarbonization, and many sustainability projects have been set up as a response to accelerate the sustainability transition. This brings up the issue of how several actors work together towards environmental sustainability goals. Sustainability transitions involve a broad range of actors who work towards a shared goal in a coordinated way (Markard et al. 2012), thus most sustainability transitions rely on some form of distributed agency.

Agency is defined as "the relation between a person and a course of action and its effects" (Enfield and Kockelman 2017, p. 7). Distributed agency represents the actions of a group or multiple people as an interactive emergence (Garud and Karnøe 2005; Enfield and Kockelman 2017). The concept of distributed agency fundamentally adopts a broad perspective on sustainability transitions and emphasizes that, although some actors work independently from each other with different motivations and interests, their actions result in a shared benefit to all and to society (Garud and Karnøe 2005).

Living labs are one of the ways to support the sustainability transition by employing an experimental approach to testing different solutions for various urban challenges (Voytenko et al. 2016). Living labs can be considered as (i) a research methodology, where a user-centric approach is taken for evaluating complex solutions, or (ii) physical sites, e.g. households, cities, villages, rural areas or industrial sites, where innovative approaches are tested. In both cases the solutions and approaches are tested in real-life contexts (Dell'Era and Landoni

2014). In this chapter, the focus is on a physical living lab located in a city district, i.e. an urban living lab.

The urban living lab concept emphasizes the involvement of authorities, companies, researchers and users who test new products, services, processes and systems which can strengthen the sustainable urbanization efforts in specific areas within cities while taking into account the environmental issues and lifestyles (Bulkeley et al. 2016). By bringing public and private actors together in an urban living lab, the stakeholders of a project can experiment with mechanisms of the distributed agency. Proactive networking among the actors is a key success factor in an urban living lab, which is due to the need to utilize stakeholders for knowledge and resource sharing and awareness creation (Aarikka-Stenroos et al. 2014). An urban living lab can lead to a new way of urban planning through the implementation of novel processes (Engez et al. 2021). Urban areas being built from scratch present opportunities to apply innovative infrastructure, to test and validate solutions, to conduct longitudinal research studies, and to co-create innovations while engaging various stakeholders (Juujärvi and Pesso 2013).

Previous research has acknowledged the contribution of particular actors and activities to sustainability transition (Bifulco et al. 2016; Bulkeley et al. 2016; Koistinen et al. 2020), and our study elaborates the relevance of distributed agency in living labs in terms of the joint efforts of actors on maximization of resource utilization in urban management. Our approach draws attention to the impact of the involved stakeholders on shifting the mindsets towards inclusivity, empowering, experimentation and transparency for increased sustainability. This chapter seeks answers to two questions: first, we explore how the sustainability agency is formed and distributed through a living lab setting; second, we seek answers to how the distributed agency improves sustainability in cities. To support the discussion, we use an example case of distributed agency in a work-in-progress city district that is promoted as a smart and sustainable future neighborhood, positioned as an urban living lab. The activities of various living lab actors on sustainable city development, urban governance, nutrient recycling, and energy production were examined to study the concept of distributed agency at the city district level.

This chapter is structured as follows: following this introduction, the concept of distributed agency, living labs in sustainable city development, and characteristics and building blocks of urban living labs are discussed to build the theoretical background of the study. In the fourth section, the research methodology is presented. In the fifth section, activities of the living lab actors that improve the sustainability in the district are discussed through the lens of distributed agency. The final section concludes the chapter and presents theoretical contribution, practical implications and the opportunities for future research.

DISTRIBUTED AGENCY

The concept of agency involves two key elements: flexibility and accountability (Enfield and Kockelman 2017). Flexibility refers to the freedom to display certain behavior. The behavior could be taking a decision, performing an activity or responding to another actor. Flexibility implies that an actor has a certain level of control over the behavior (Enfield and Kockelman 2017). Accountability refers to the evaluation of the outcomes of the behavior. This evaluation could be executed by the actor itself or by external actors. Through accountability, actors are held responsible for their behavior. In the context of sustainability, the evaluation would refer to the degree to which sustainable goals have been met. However, actors could also hold goals they want to achieve for themselves. Distributed agency refers to the phenomenon where multiple actors – with their own goals and while keeping their independence – work collectively towards a common goal (Sprong et al. 2021). "With distributed agency, multiple people act as one" (Enfield and Kockelman 2017, p. 9). Technology entrepreneurship is such a joint process (Garud and Karnøe 2003): agency in an entrepreneurial or innovative context is often distributed. The concept of distributed agency implies that flexibility and accountability are shared. Therefore, the key elements of distributed agency are distributed flexibility and distributed accountability.

Distributed flexibility means that all actors remain independent, fulfill their own role, using the resources they have at hand. *Distributed accountability* means that all actors are collectively subject to evaluation. The behavior is seen to be that of the group and succeeding or failing to achieve the common objective is evaluated on that level. This is very much the case in the context of sustainability, which is typically evaluated on a systems level. Distributed flexibility and distributed accountability require some level of improvisation, bricolage, and effectuation (Garud and Karnøe 2003).

URBAN LIVING LABS AS DRIVERS OF SUSTAINABILITY TRANSITION

The living lab approach is presented as a research methodology for identifying and testing the real-life solutions that are driven by the users and developed through public–private partnerships (Niitamo et al. 2006). Living labs fundamentally have three main characteristics that build up their foundation. First, living labs take place in a forum, a physical location or collaborative virtual networks (Niitamo et al. 2006). Second, they involve real-life experiments, interactions, co-creation, prototyping, testing, and validation while engaging diverse actors such as users, citizens, researchers, companies, and authorities employing an open-innovation mindset (Bergvall-Kareborn and Stahlbrost 2009; von Hippel 2005). Third, they aim to improve or develop a solution, innovation, product, service, technology, infrastructure, or system that would lead to social, economic, and/or environmental value creation (Leminen et al. 2012). The stakeholder engagement aspect of living labs emphasizes the collaborative atmosphere that brings science, policy, business, and civil society together (Edwards-Schachter et al. 2012). Therefore, a living lab approach considers the agency as the complementing actions of the living lab actors that can drive a transformation of socio-technical systems such as energy supply, water supply, or transportation (Markard et al. 2012). Although such transformation typically evolves over long timespans, living labs can be considered as new platforms for distributed agency where socio-technical transitions are accelerated due to the involvement of the stakeholder network in the experiments and co-creation.

As a method of urban governance, local governments have been encouraging partnerships among public organizations, government, and industry in their approaches to address urban challenges (Couch et al. 2003). Living labs are a form of basic coordination, where a set of actors is not governed by control or rewards, but by a minimal level of governance instead (Manser et al. 2016). The governance arrangements in living labs vary and are reported to be "more contingent than controlled" (Bulkeley et al. 2018). The multiple actors in living labs come from different organizations and, thus, they cannot be directly managed but rather motivated by the coordinator of the living lab (Leminen and Westerlund 2012). The public–private–people partnerships (4P concept) among stakeholders are brought up to be the building blocks of the living labs that are composed of heterogeneous actors who get involved in co-creation, exploration, experimentation, and evaluation activities (Westerlund and Leminen 2011). Apart from the roles of the other type of actors, users have a distinct and important role in living labs, which makes the approach more experimental (Leminen et al. 2012).

The application of living labs in urban areas aiming for sustainability has been studied by several scholars. In these studies, the urban living lab (ULL) term has been used and it has been discovered that, with the implementation of the living lab approach in urban areas, rapid social, technological, and economic transformation can be achieved (Voytenko et al. 2016). ULLs focus on issues of planning, governance, infrastructure, resilience, consumption, behaviors, and lifestyles (Voytenko et al. 2016), and they work as a platform for different kinds of interventions, trials, and demonstrations in a city area that brings together various actors, which would contribute to the development of the region (Bulkeley et al. 2016). The developments accomplished in living labs can be scaled up through wider adoption by stakeholder involvement and can eventually become a widespread application or even a radical innovation through the measures taken by policy makers (Geels 2002; Ingstrup et al. 2020).

METHODOLOGY: RESEARCH DESIGN, CASE AND DATA

We explore the concept of distributed agency in an ULL case from Finland. Our case focuses on a living lab that aims to contribute to the development of a work-in-progress city district, Hiedanranta, which involves research projects, business activities, and citizen participation to create and develop the district while employing the principles of sustainability (Ingstrup et al. 2020). The projects and business activities started in the area with the objective of building a smart and sustainable future city district that produces more resources than it consumes. Hiedanranta living lab, which is located in the city of Tampere is chosen as the case study, as it provides a distinctive base to study distributed agency through public–private–people partnerships (4P concept) and includes a multiple stakeholder setting comprising a governmental body, associations, private firms, residents, and research institutes. Hiedanranta living lab enables testing of different solutions, applications, and infrastructures, as the district is in the creation phase of becoming a proper livable city district. Hiedanranta living lab employs an experimentation approach in urban settings through stakeholders who pursue a sustainable city district.

We use the Hiedanranta living lab as an instrumental case study (Mills et al. 2010), as the ULL acts as a basis from which to advance the understanding of the distributed agency concept. The case relies on qualitative research design and multi-sourcing strategy in data gathering. We have captured the case and examined distributed agency among the actors of the Hiedanranta living lab through interviews with key stakeholders, observation, and broad secondary data. As the case includes individual and collaborative actions for sustainability, our methods enabled investigating those individual actors and their involvement. The case encompasses businesses by including three companies (focusing on biochar production, vertical farming, and production of dry toilets) established within the living lab. The case also comprises five sustainability projects in Hiedanranta (see Table 19.1): the projects were

Table 19.1 Selected sustainability projects in Hiedanranta and related stakeholders

Project	Scope	Stakeholders
1. NutriCity	Reducing the amount of nutrient leakage into the Baltic Sea by recycling nutrients such as phosphorus and nitrogen through decentralized sanitary solutions.	Ministry of the Environment, City of Tampere, Tampere University of Applied Sciences (TAMK), Finnish Environment Institute (SYKE), residents, Global Dry Toilet Association of Finland, dry toilet company
2. UNaLab	Developing stormwater management systems such as biofilters to treat nutrient-rich seepage waters from the old landfill in Hiedanranta. Tampere is one of the three pioneer cities of UNaLab (Urban Nature Labs), along with Eindhoven and Genoa.	European Union, City of Tampere, Technical Research Centre of Finland (VTT), residents, Biochar company
3. Leväsieppari	Recovery and recycling of nutrients in wastewater, using algae. The aim is to reduce water pollution and to utilize algae-bound nutrients.	Ministry of the Environment, Tampere University, Finnish Environment Institute (SYKE), Häme University of Applied Sciences (HAMK), University of Helsinki, Vanajavesi Center
4. Hierakka	Convincing authorities, the food industry and farmers of the functionality of urine as a fertilizer and changing the attitude towards the use of urine fertilizers.	Ministry of the Environment, City of Tampere, Tampere University of Applied Sciences (TAMK), residents, Global Dry Toilet Association of Finland, dry toilet company
5. Kivireki	Exploring the potential of professional urban farming, finding solutions to promote local nutrient cycles in cities (e.g. through biowaste, separately collected urine) and examining the associated threats of processing nutrients.	European Union, City of Tampere, Tampere University of Applied Sciences (TAMK), residents, Global Dry Toilet Association of Finland, vertical farming company

chosen based on their potential to improve environmental sustainability, and particularly nutrient recycling in the region, which are the ultimate mutual goals of the involved actors.

In the study, the primary data source is qualitative interviews which were conducted with managers of the three living lab firms, two city development project managers from the municipality, one project manager from an association, and with two researchers who study nutrient recycling technologies. In total, eight people were interviewed in semi-structured form and all the interviews were recorded and transcribed with the interviewees' consent. The gathered data from the living lab firms is used to analyze their operations associated with the district development activities in Hiedanranta, and knowledge and material sharing practices among them. The data from the researchers and association is used to analyze the approaches that are mainly used for the recovery and utilization of nutrients. Lastly, the data from the municipality is used to analyze the urban governance and stakeholder engagement approaches that support the emergence of collaborative innovation in cities.

The analysis is done by assessing the stakeholder activities in the living lab setting, particularly related to nutrient recycling activities, and by comparing the interviews with each other and with news articles to verify the consistency of the information. Therefore, triangulation was employed for the cross-verification of the data and for capturing different dimensions of the phenomenon. In our analysis, we focus on the nutrient recycling projects in the Hiedanranta living lab due to their substantial potential to increase the environmental sustainability; thus, the impact of other types of projects in Hiedanranta has been excluded in this study. The transcribed interviews were thoroughly read, and important statements were highlighted to point out valuable information. After the theoretical framework of the study was created, the activities, interactions, and approaches of living lab actors were identified. Distributed agency is studied by using two elements to realize the impact of actors on sustainability: distributed flexibility and distributed accountability. We use the distributed flexibility element to analyze the aspects and acts of actors that enable or hinder the collaborations in the living lab. Distributed flexibility shows that all actors display behavior that fits with their resources and roles. The second element, distributed accountability, is used to demonstrate how the individual goals are attained and how the mutual goal of sustainability is achieved at the city district level. From our analysis, a conceptual framework was developed to depict the key components of the distributed agency in the sustainable ULLs.

DISTRIBUTED AGENCY AMONG LIVING LAB ACTORS

In the selected sustainability projects in Hiedanranta living lab, we analyze the two key elements of distributed agency, which are distributed flexibility and distributed accountability. In the next three subsections, we discuss three groups of actors (public sector and government actors, market actors, and research institutes) and explain how they are flexible in their activities and have freedom to perform activities according to their own goals and interests. In the fourth subsection, we discuss the distributed accountability in relation to particular sustainability goals. In the last subsection, we summarize the distributed agency in Hiedanranta living lab. The actors, actor types, projects they are involved in, and their roles are listed in Table 19.2 to demonstrate the distributed flexibility.

Distributed Flexibility of Public Sector and Government Actors

The Hiedanranta living lab offers the public sector and government actors a platform to fulfill their own roles, based on their own goals. The Hiedanranta living lab was created by the municipality of Tampere. Changing the way cities use resources, preventing the overuse of natural resources, and creating a neighborhood that produces more resources than it consumes are the visions of resource efficient Hiedanranta. These visions were of utmost importance when creating the plan of the Hiedanranta area and when searching for local businesses in 2015 for the development of the city district. The municipality contributes to the governance of Hiedanranta by initiating and enabling development projects, discussing the development projects in the board meetings of the city to cooperate with decision makers, bringing stakeholders together, supporting the companies for their innovation activities, and involving users and citizens in the events for the co-creation of sustainable solutions. According to the director of the Hiedanranta development project, it is beneficial to create demonstration areas for the public and for decision makers to demonstrate how the development projects are progressing.

When developing Hiedanranta to accommodate 25,000 new inhabitants in the upcoming years, meeting with people and getting their ideas to test the viability of the solutions provide useful insights for the city developers. In order to increase the citizen involvement in the development of Hiedanranta, organizing events such as festivals, theater shows, or concerts proved to be more effective than city planning meetings for receiving feedback from residents. The advantage of organizing such events is to reach people that cannot be reached by organizing city planning meetings. Apart from the citizen involvement in the development of Hiedanranta, the municipality provided buildings for low prices to small businesses such as

Table 19.2 Distributed flexibility in five sustainability projects in Hiedanranta

Actors	Actor type	Project(s)	Role
Ministry of the Environment	Public sector and government	1, 3, 4	Providing funding and guidelines for the projects
European Union	Public sector and government	2, 5	Providing funding and guidelines for the projects
City of Tampere	Public sector and government	1, 2, 4, 5	Providing facilities to enable experimentation and/or providing expertise and resources on project management
Tampere University	Research institute	3	Conducting research and experiments
Tampere University of Applied Sciences (TAMK)	Research institute	1, 4, 5	Conducting research and experiments
Finnish Environment Institute (SYKE)	Research institute	1, 3	Conducting research and experiments
Technical Research Centre of Finland (VTT)	Research institute	2	Conducting research and experiments
Häme University of Applied Sciences (HAMK)	Research institute	3	Conducting research and experiments
University of Helsinki	Research institute	3	Conducting research and experiments
Vanajavesi Center	Foundation	3	Creating an active network of actors for the improvement of lakes and rivers
Residents	User	1, 2, 4, 5	Participating in the testing and providing feedback for the usage phase of the solutions
Global Dry Toilet Association of Finland	Industry association	1, 4, 5	Promoting ecological sanitation and communicating benefits of nutrient cycles
Biochar company	Company	2	Producing biochar material and district heating
Vertical farming company	Company	5	Participating in the experiments by testing the urine fertilizers
Dry toilet company	Company	1, 4	Providing the equipment for the collection of urine

artisans who are currently running their operations in Hiedanranta, which is an example of how a city can support the transformation of the district into an active and productive area.

Many interesting and important projects in Finland have received funding from the Ministry of the Environment of Finland, which has been one of the active actors that promote the conservation of nature by initiating nutrient recycling projects to improve the ecological status of the Archipelago Sea and reduce eutrophication. The projects they funded in Hiedanranta tackle the issues of environmental pollution, depletion of natural resources, wastewater and sludge treatment, and the threat of rising fertilizer prices in the future.

Distributed Flexibility of Market Actors

In this study, the market actors refer to the companies that have active operations in Hiedanranta living lab and the residents of the city who participate in the development activities in the area. In the living lab, the companies proceed towards their own goals that coincide with the goals of Hiedanranta. The residents contribute to the development of the area by participating in the projects and sharing their requests about their future living environments with city officials.

One of the companies operating in the area has been active in producing biochar using a pyrolysis process, which takes place through the burning of the woodchips in an oxygen-free environment under high temperatures (~ 600°C) in order to provide the highest carbon content possible. Due to the high temperatures generated, the pyrolysis process produces syngas and pyrolysis oil, which are used to provide heating energy in the area. The produced biochar can be used as a growth medium in agriculture to grow organic foods, as it enhances plant growth and crop yield by storing nutrients.

An example where the biochar products are used include the UNaLab project, where stormwater management systems are developed to biofiltrate the nutrient-rich leachate from an old pulp mill landfill to prevent it from flowing into the lakes in the area. In the project, biochar along with peat and clay are used for the treatment of water that comes out from a contaminated land. The residents act as informant, tester, and designer in the project.

Due to the harsh winter conditions in Nordic environments for growing food, and due to the unavailability of the land area for growing sustainable food in cities, indoor hydroponics can be considered as a method for crop production. The vertical farming company located in Hiedanranta is specialized in producing strawberries and takes part in sharing and recycling practices in the area, such as using fertilizers made from urine for plant growth, in collaboration with the researchers. The company uses the biochar as a growth medium in its hydroponic systems. It also utilizes the CO_2 that is generated in the biochar production facility. The CO_2 is transferred through a piping system that was built between two facilities and it is used in the plant growth. The facility uses software that optimizes over 20 parameters for smart resource consumption in order to eliminate waste. The software also creates and utilizes plant growth pattern data that is available to all the farmers worldwide and shares the best practices. In addition to these applications, future plans include processing of local biowaste in a biogas plant in the area and using the nutrient-rich byproduct (sludge) as a fertilizer for plants in the farming facility. The solutions are implemented to create a zero-waste community.

For the proper collection of toilet waste for its further utilization as a fertilizer product, a company takes part in providing the equipment, such as source-separating dry toilets, in the premises in the Hiedanranta area. The pilot of the dry toilets has been designed and implemented in the event venue Kuivaamo, which is currently the largest facility in the area that organizes events for up to 1000 people. The residents act as temporary inhabitants of the area by attending events that take place in the event venue Kuivaamo. The dry toilet waste that is collected in the venue is later composted. The produced compost contains mainly phosphorus and nitrogen, which has been tested and approved for fertilizer use by Finnish authorities. It has been tested in the vertical farming facility in Hiedanranta and in other agricultural fields.

Distributed Flexibility of Research Institutes

The living lab environment provides a platform and more room for experimentation for researchers to develop breakthrough innovations. It also makes it easier to cooperate with other types of actor due to the open-innovation principle of living labs, which enables the development to progress faster. In Hiedanranta living lab, research has been done on the utilization of urine (collected from source-separating dry toilets) in fertilizer production, recovering nutrients from urine by growing micro-algae in a pilot pond, energy efficient food production by encouraging community gardening, and on decentralized (local) sanitary solutions aiming at nutrient recycling.

The NutriCity project emphasizes the improvement of centralized wastewater treatment systems with decentralized local solutions e.g. to collect the urine directly from source-separating dry toilets. As part of the Hierakka and Kivireki projects, researchers encourage the adoption of urine fertilizers in large-scale applications. In the projects, local farmers who tested urine fertilizers were able to see their positive effects. The data generated in the studies was a means to promote the reuse of nutrients and urine fertilizers, encouraging farmers, authorities and policy makers to take action towards making this a widespread practice. However, the required infrastructure for the collection and transportation of urine needs more development and push from the regulators. In this sense, living labs can act as test beds for developing the infrastructure and testing new applications.

In the first demonstration of the micro-algae cultivation plant in Hiedanranta, researchers from Tampere University studied the growth of algae and their capability to capture nutrients from source-separated urine. In addition to fertilizers, some examples of commercially viable end products of micro-algae cultivation may include health food supplements, pigments used as fish feed, cosmetic products, and omega-3 fatty acids. The organic materials that micro-algae contain can be used for biodiesel production, even though this is not the first commercial application to consider due to the current affordable gasoline prices and the high costs of micro-algae cultivation.

Distributed Accountability

All the actors identified in Table 19.2 have individual goals. For instance, companies want to develop sales, local government wants to develop the district, and research institutes want to develop state-of-the-art knowledge and technologies. However, sustainability goals are often the same both for the living lab as a whole and for the individual actors: to make cities and communities sustainable, to build resilient infrastructure to foster innovation, and to preserve aquatic ecosystems. Accountability concerns the actions of the public sector and government actors, market actors, and research institutes, which is linked to three main activities: governance, technology development and implementation, and research, respectively. We see these activities as the essentials of the sustainability transition that requires effective governance approaches in urban management, timely technology development to respond to the needs, and progress in research to discover new methods, technologies, and approaches to coping with urban challenges. The governance in Hiedanranta living lab is not strictly controlled at present and includes, for example, gathering actors interested in sustainability in one place, encouraging collaboration between the actors, and enabling market development and piloting of technologies. However, in the future the governance should become stricter, when, for example, certain technologies are chosen to be used in the city district based on the current pilots and activities.

Collaboration in Hiedanranta can be seen in a few cases, where the actors are accountable towards each other. For example, heating energy produced in the biochar facility is used to heat the event center Kuivaamo and other buildings in Hiedanranta. The biochar is used as biofiltration material in stormwater management systems in the area and as a growth medium for plants that are grown in the vertical farming facility. The source-separating toilets in Kuivaamo provide the urine to be studied in the research projects that could not be executed if this type of waste stream was not available. To achieve sustainability in nutrient recycling in Hiedanranta, the City of Tampere operates dry and vacuum toilets, and needs researchers and companies to treat the waste and to find future solutions for the city district. The research units and companies have a unique opportunity to study nutrient recovery from this kind of material, since there is no other place in Finland that would offer these waste streams with such big quantities. The results show, in Hiedanranta living lab, how each actor has the flexibility to fulfill its own role, yet still can be held accountable for sustainability goals.

Summary of the Distributed Agency in Hiedanranta Living Lab

The analysis of the activities in Hiedanranta has demonstrated that in the living lab environment, the sustainability agency is distributed among citizens, businesses, researchers, and the municipality for the transformation of the city district into a sustainable setting. The actors have a shared motivation for using the resources in the city district in the most efficient way, which has led to the alignment of goals and initiation of various projects with a sustainability mindset (Ingstrup et al. 2020). Hiedanranta living lab hosts nutrient recycling experiments and facilitates cooperation among businesses and research organizations to share knowledge and expertise. Getting feedback for potential improvements from all the stakeholders such as residents, experts in city planning, architecture, building, and maintenance is inevitable, as Hiedanranta living lab employs an open-innovation mentality and provides an opportunity for ideation and sharing.

CONCLUSIONS

Distributed agency improves sustainability in cities by enabling different individuals and organizations to work towards a collective goal. To achieve the collective goal of increasing sustainability in the city district, particular activities need to be performed, which include optimization of resource use for the mitigation of carbon emissions, increasing the utilization of waste and side streams in business operations, improving the daily lives of residents through integration of sustainable solutions, performing sustainable business operations, and conducting research and development activities for the exploration of sustainable innovations and solutions to respond to urban challenges. In this context, living labs not only provide the physical location for facilities that enable co-creation activities, but also provide the mentality of open-innovation and stakeholder engagement for those who are part of the living labs, which boosts value maximizing closed loop collaborations.

We argue that individuals have flexibility to perform certain actions and behaviors according to their own agenda. Eventually, what matters for the sustainability transition will be the contribution of these individuals to the areas of governance, technology development, and research, which they will be accountable for. To get the full benefit of the distributed agency, the results of the governance, technology development, and research activities should be evaluated collectively to see if the whole system has succeeded and if the goals are met.

While ULLs are located, for example, in a certain city district or village, the results of the living lab approach can often be transcribed into similar locations where new urban areas are being built. It's worthwhile mentioning that not all the actors (especially governmental actors) might be open to the experimentation approach that urban living labs adopt to transform an urban area. However, in the Hiedanranta living lab, the municipality supports the urban development by being an active promoter of the experimentation approach that has been sought to change the overall landscape of the innovation activities in the city.

Theoretical Contribution

Our study shows that living labs create a context for distributed agency, as they combine shared flexibility and shared accountability, and that this enables actors to jointly pursue sustainability. In other words, living labs are a way to organize for distributed agency, which can help achieving sustainability goals. This study provides a hands-on approach to urban development and urban living lab literature (Voytenko et al. 2016) by examining the aspects and actions that enable collaborations in living labs. It introduces a new smart city district as an enabler-driven living lab to the researchers who are interested in developing the knowledge in this area (Leminen et al. 2012). It introduces ways to utilize the resources in a work-in-progress city district that aims to apply sustainable urban management methods contributing to a circular economy (Bulkeley et al., 2016). It clarifies how the sustainability agency is distributed among public sector and government actors, technology companies, academic researchers, and residents. The individual and mutual acts of these actors are displayed in the conceptual framework (Figure 19.1) of distributed agency in sustainable living labs.

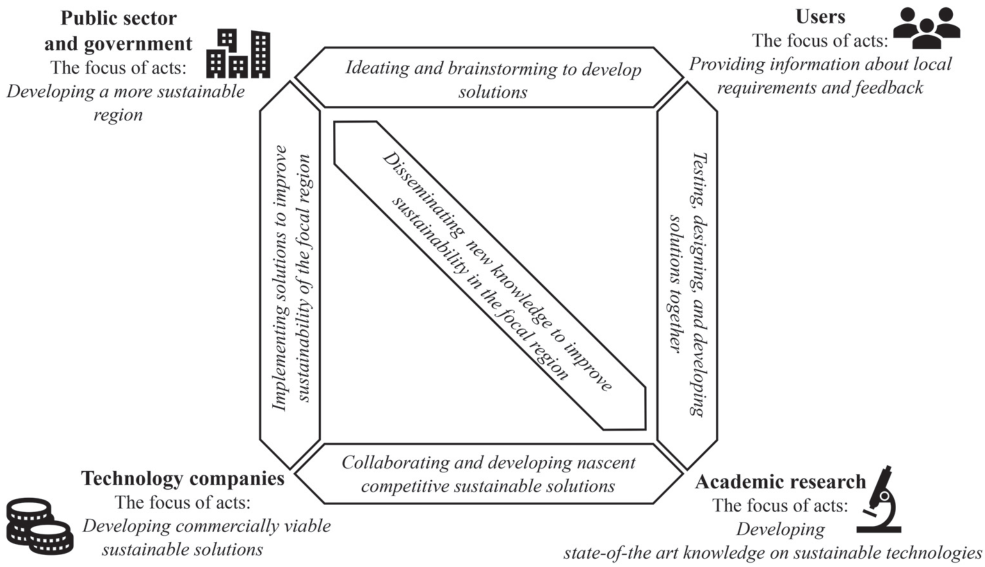

Figure 19.1 Individual and mutual acts of living lab actors

Practical Implications

Our chapter on distributed agency in sustainable living labs suggests practical implications on how to manage collaborations between diverse actors towards a mutual goal of sustainability. In the big picture, our study shows how a living lab approach can be beneficial for the involved actors (see Figure 19.1), as the municipalities can benefit from supporting small and medium-sized enterprises and researchers that are involved in living labs regarding the sustainable development of a city district. Our study uncovers the positive impact of distributed agency by demonstrating the collaboration between different types of actor, which results in collective learning and reaching the mutual goal. Furthermore, our conceptual model shows synergies between involved actors and these can be used as motivational drivers when engaging other actors to include in collaborations. However, we believe that distributed accountability also highlights a relevant pragmatic issue: all actors need to be aware of other actors' success points, otherwise the mutual goal cannot be reached.

Future Research

Our study builds avenues for future research themes and related research questions, which are suggested next.

Actor diversity in collaborations, distributed agency and multi-actor settings

What are the positive and negative sides of the actor diversity when pursuing sustainability? How to steer collaborations? What kind of boundary objects or collaboration methods can be used in generating a better understanding among diverse actors to facilitate distributed flexibility and distributed accountability?

Sustainable (urban) living labs and their diversity

What are the differences between small- and large-scale living labs with regard to collaborations? Further examination of actor perspectives on sustainability would improve the understanding on how the sustainability agency is distributed. Including the residents in the study and employing a survey methodology might provide useful insights on user perspectives on the feasibility and acceptability of new solutions, such as the adoption of decentralized sanitary solutions for nutrient recycling vs. less sensitive sustainable solutions such as shared vehicles in urban settings.

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PUBLICATION
III

How innovations catalyze the circular economy: building a map of circular economy innovation types from a multiple-case study

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17. How innovations catalyse the circular economy: building a map of circular economy innovation types from a multiple-case study[1]

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INTRODUCTION

In the field of environmental sustainability, the circular economy (CE) has attracted global interest concerning resource efficiency, conservation of natural resources, and increasing carbon neutrality (Ghisellini et al. 2016). The CE has been identified as a concrete means of implementing sustainability into business (Ghisellini et al. 2016) and is strongly driven by innovation, as it requires firms to introduce novel products and processes that adhere to CE principles (Prieto-Sandoval et al. 2018). In the CE, the value of materials and products is maintained to reduce demand for virgin natural resources (Geissdoerfer et al. 2018). Thus, it may require companies to adapt or replace their current business models (Prieto-Sandoval et al. 2018) and innovate in diverse ways (Mariadoss et al. 2011) to generate innovation that catalyses the CE.

Environmentally sustainable innovations have been framed as eco-innovations (De Jesus and Mendonça 2018; Hellström 2007; Prieto-Sandoval et al. 2018; Rennings 2000) and product and CE business model innovations (Bocken et al. 2016; den Hollander et al. 2017; Vasiljevic-Shikaleska et al. 2017). Eco-innovations are socio-technical solutions that preserve resources by allowing for the recovery of resources and mitigate environmental degradation (De Jesus and Mendonça 2018). Thus, they provide a foundation for CE innovations. Studies have highlighted the potential of eco-innovations to contribute to environmental sustainability but have under-explored the related aspects of innovation management. The consequent research gap regards the innovation types that enable the CE and the sustainability issues that those innovations aim to solve. To address this gap, the present chapter examines the diversity of CE innovations through innovation management lenses to illuminate the innovation needs of firms, which range from technology to business development for sustainability and the CE. To this end, it maps CE innovation types and their characteristics to uncover innovation diversity in the CE in theory and to guide managers and practitioners in their innovation efforts to develop sustainable solutions. The study considers three research questions (RQs):

RQ1: What are the CE innovation types from the technology and innovation management perspective?

RQ2: Which sustainability issues are addressed by the CE innovations?

RQ3: Which benefits do CE innovations pursue?

We apply an analysis framework that differentiates between four organizational innovation types: product, process, service, and business model innovations (Crossan and Apaydin

2010). We further divide each innovation type into three sub-types based on our analysis. Following this categorization, we provide examples for each sub-type with references to CE innovations developed by various companies. Our study not only introduces a new, nuanced, and explicit categorization of CE innovations with comprehensive sub-types but also explores the pursued sustainability implications and the pursued benefits of the various types. While similar studies have been limited to the descriptive and explorative level and focused on the product design and business model strategies (Bocken et al. 2016; den Hollander et al. 2017; Vasiljevic-Shikaleska et al. 2017), this research extends the CE innovation categorization approach by presenting the process and service innovation categories along with the relational aspect of CE innovations and sustainability issues. Consequently, the study connects the CE with technology and innovation management research streams.

This chapter is structured as follows. After the introduction, the second section discusses the innovation types in the CE to explain the theoretical background of the study. The third section then presents the research design. Subsequently, the fourth section examines product, process, service, and business model innovations and their sub-types through company offerings. The final section concludes the chapter and specifies the theoretical contribution, practical implications, and future research avenues.

INNOVATION IN CE: INNOVATION TYPES

The CE is a restorative and generative economic system that aims to maintain the value of products, materials, and resources by reducing, reusing, recycling, and recovering materials in production/distribution and consumption processes (Kirchherr et al. 2017; Ranta et al. 2018). In CE, innovations are developed to slow and close resource loops (Bocken et al. 2016). Slowing resource loops refers to the process of decreasing the rate of material flows from production to recycling. It can be achieved by extending a product's lifespan through the use of durable materials and a design that is repairable, reusable, upgradable, and suitable for disassembly and reassembly (Bocken et al. 2016; Stahel 2016). Meanwhile, closing resource loops refers to a recycling process that utilizes materials from products that are no longer usable. Therefore, it seeks to close the loop between post-use waste and production (Stahel 2016). These two approaches are dominant in CE innovation literature. To expand this view and ground CE innovations in innovation management literature, we review the innovation types of product, process, service, and business model innovations (Crossan and Apaydin 2010) within their CE context.

Product Innovations

Product innovation is realized as an assembled product that is sold to a customer once it is manufactured and which evokes perceived newness, novelty, originality, uniqueness, and usefulness of the innovation (Henard and Szymanski 2001). When developing product innovations for the CE, it is important to apply sustainability principles at an early stage in the product design process. These principles include designing for a technological cycle (emphasizing the cycle of the products of service), a biological cycle (using materials that can biodegrade through e.g. composting), disassembly and reassembly, product-life extension, and long-lasting products (Bocken et al. 2016; Vasiljevic-Shikaleska et al. 2017). Another approach to classify CE product innovations considers the integrity and recycling aspects in the product design (den Hollander et al. 2017). Designing for integrity focuses on preventing obsolescence at the product/component level, while designing for recycling applies such focus at the material level.

Process Innovations

Process innovation refers to the implementation of "new production methods, new management approaches, and new technology that can be used to improve production and management processes" (Wang and Ahmed 2004, p. 305), which describes processes that enable internal value creation for a firm (Crossan and Apaydin 2010). A process innovation may lead to the emergence of new products or enhance an existing product's performance, design, and cost attributes or the materials/components of which it is composed (Maine et al. 2012). Therefore, process innovations are not only internal to one firm but can also be commercialized and transferred to other firms.

Service Innovations

A service is an asset that serves a customer need and provides a benefit to the customer. Thus, it is an inherent value that is transferred from the provider to the recipient (O'Sullivan et al. 2002). Service innovation emphasizes the development of new service offerings and concepts and intertwines tangible (e.g. product forms) and intangible (e.g. processes, knowledge) aspects of an innovation (Kindström and Kowalkowski 2014), in which information technology is influential. As the digital era departs from the goods-dominant logic of value creation, service innovations need to be network-centric, information-centric, and experience-centric to remain competitive in the market (Lusch and Nambisan 2015). This need requires firms to realign their dynamic capabilities of sensing opportunities and threats, seizing opportunities, and reconfiguring their resources (Kindström et al. 2013; Teece 2007). The service-dominant logic dictates that firms must concentrate on actor-to-actor networks, digitize information, and densify and integrate their resources (Lusch and Nambisan 2015). In the CE, services can reduce the overall use of resources by allowing multiple users to share underutilized resources or helping to optimize the use of resources by a single user (Ranta et al. 2020). Furthermore, services contribute to closing loops through recycling (Stahel 2016).

Business Model Innovations

A firm's business model consists of three main elements: the value proposition to customers, value creation and delivery, and value capture (Teece 2010). Business model innovation entails changes in an organization's business model elements, which concern the target segments, the offering, value chain organizations, revenue capture mechanisms, and the value proposition itself. Business model innovation complements the traditional subjects of process, product, and service innovations by devising a novel way of creating, delivering, and capturing value (Foss and Saebi 2016). In the CE, circular business models aim to generate profits from the flow of materials and products over time (Bocken et al. 2016).

RESEARCH DESIGN

Since the current literature on innovations in the field of CE is nascent, we employed an explorative approach to fulfil our objective. Specifically, we conducted a multiple-case study of 27 firms from Finland with 27 innovative offerings that have been introduced to domestic and global markets to catalyse the CE. To sample forerunners and suppliers with innovative offerings, we selected our cases from a compilation by the Finnish Innovation Fund (SITRA), which is a national leader and independent expert organization in promoting awareness of CE and the technology industries of Finland. The offering descriptions include suppliers' explanations of new features of the offering (i.e. innovation reflecting the sustainability transition) and the value that the offering imparts to customers and the provider. Following our strategy for gathering a comprehensive and inclusive data set, the offerings are based on a variety of innovations, including unprecedented usages of recycled materials, new services for lengthening product lifecycles, novel and more sustainable production processes, and new business models for reusing and sharing products. Thus, they cover each of the innovation types identified in the literature.

As our units of analysis, we used the four aforementioned innovation types. The analysis chart lists the following aspects: the main innovation types, three sub-types, innovation examples per sub-type, the company that developed the innovation, the main sustainability issue addressed by the innovation, and the pursued benefit/value. The final framework synthesizes the chart into a conceptual figure that depicts the CE innovations and their sub-types in the form of a tree diagram.

FINDINGS

Our analysis of 27 innovative offerings by forerunner firms in the Finnish CE ecosystem encompasses the four innovation types and their value in terms of sustainability. The analysis informed a map of the main CE innovation types and their sub-types (see Figure 17.1).

The next sections detail our findings per CE innovation type with examples. Table 17.1 contains an overview of the CE innovation types and their corresponding sub-types, example offerings from companies, explanations of the main sustainability issues that the innovations address, and the pursued benefits. A detailed analysis follows.

Product Innovations

Recyclable products that are suitable for return to circulation

As an example of this innovation type, Honkajoki produces fertilizers made from organic waste from local communities and industrial operators. In industrial plants, animal-based waste is converted into raw materials for the energy, cosmetics, fertilizer, and animal feed industries. A second example is the biochar product by Carbons/Carbofex. The pyrolysis process produces biochar along with gas, pyrolysis oil, wood vinegar, and heat. The latter can be distributed in the district heating network. Because of its high water and nutrient absorption capacity, biochar is effective as a biofilter in stormwater management systems and a growing medium in agriculture and for the treatment of seepage water runoff. A third example is Durat's production of recycled interior design materials from plastic waste, which uses recy-

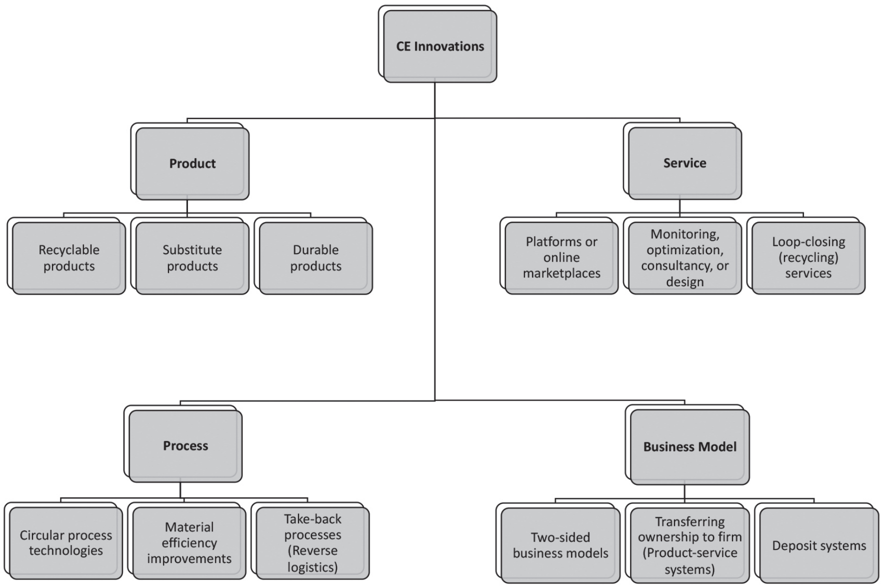

Figure 17.1 *The main CE innovation types and their sub-types*

cled post-industrial plastics to create interior materials, such as kitchen and bathroom sinks and kitchen worktops. Recycling reduces the demand for virgin raw materials.

Substitute products that are more sustainable than their traditional alternatives

Substitute products intend to replace current unsustainable products. An example is Gold & Green's range of plant protein products made from oats and legumes as alternatives to meat-based products. Meat production is inherently unsustainable due to the high greenhouse gas emissions that result from methane production by livestock (Steinfield et al. 2006). Similarly, bio-based renewable materials intend to replace non-renewable materials, such as plastics. One example is Sulapac's development of biodegradable packaging products that use wood- and plant-based binders, such as wood chips and cellulose. The reusability, recyclability, and biodegradability attributes of these renewable materials define them as a sustainable alternative to plastics.

Durable products with a long lifespan

Durable products have a long utilization period. Durable products include high-quality materials and components that last longer without breaking down or becoming worn out, which extends the product's lifespan. An example of this innovation is a laser coating created by Kokkola LCC that increases the durability of metal parts in the metal, energy, and process industries. Durable products require fewer repairs and component replacements over time, which slows resource loops by eliminating new raw material usage. They also enable users to reduce repair and maintenance costs, although their purchase price might exceed that of regular products.

Table 17.1 *Circular economy innovation types*

Innovation type	Sub-type	Example	Company	Sustainability issue addressed	Pursued benefit/value
Product	(1) Recyclable products	Biochar to be used as growing medium and as biofilters	Carbons/Carbofex	Low nutrient recycling and eutrophication	A sustainable improvement for soil quality, acting as a carbon sink
		Fertilizers and raw materials from animal by-products	Honkajoki	Low nutrient recycling and eutrophication	Turning animal-based waste into pure and safe raw materials (e.g. pet foods, biofuels, and pharmaceuticals)
		Solid recyclable surface material containing recycled post-industrial plastics	Durat	Low recycling rate of interior materials (e.g. worktops, sinks)	Durable sustainable products made from recycled plastics
	(2) Substitute products	Plant protein products from oats and legumes	Gold & Green	Meat production and consumption (greenhouse gas emissions)	Replacing meat products that have significant emissions and land footprints with plant-based alternatives
		Biodegradable packaging using wood-based materials as raw materials	Sulapac	Non-renewable plastic materials	Replacing plastic packaging with biodegradable wood-based packaging
	(3) Durable products	Reducing maintenance costs and increasing durability with laser coating	Kokkola LCC	Unnecessary consumption of raw materials	Lengthening component and product lifecycles

Innovation type	Sub-type	Example	Company	Sustainability issue addressed	Pursued benefit/value
Process	(1) Circular process technologies	Vegetable oil refining process to produce renewable diesel fuel	Neste	Fossil fuels (greenhouse gas emissions)	Replacing non-renewable, fossil fuel-based oil products with bio-based renewable alternatives
		Technology for producing textile fibre from cellulose	Spinnova	High water consumption in current textile fibre production	Replacing polluting and water-intensive cotton and synthetic materials production with wood-based textile fibre
		Extraction and purification of used alkaline batteries to make fertilizers	Tracegrow	Low circulation of zinc and manganese in soil	Extracting otherwise wasted valuable materials, producing recycled nutrients
		Process for turning industrial waste into geopolymer-based construction materials	Betolar	Low utilization of industrial waste	Replacing high CO_2 footprint cement-based concrete with environmentally friendly geopolymer concrete using industrial waste as raw material
	(2) Material efficiency improvements	New uses for by-products and use of barley husk for energy production instead of peat	Altia	Low utilization of industrial waste	Reducing industrial waste through improved utilization of by-products
	(3) Take-back processes (Reverse logistics)	Take-back process for cardboard, glass, plastic, and metal packaging	Rinki	Low packaging recycling	Enabling source separation for recyclables, improving recycling rates, and preventing incineration of waste
		Take-back process for reusable delivery packaging for online retailers	RePack	Non-renewable plastic materials	Halting the growth of packaging waste from online sales by providing reusable postal packaging

Innovation type	Sub-type	Example	Company	Sustainability issue addressed	Pursued benefit/value
Service	(1) Platforms or online marketplaces	Online marketplace that convenes the sellers and buyers of used goods	Tori.fi	Low circulation of reusable consumer goods	Providing a convenient marketplace for trading used products
		Online marketplace for surplus food	ResQ Club	Food waste	Ability for grocery stores and restaurants to capture revenue from expiring products, access to discounted products for consumers
	(2) Monitoring, optimization, consultancy, or design	Battery optimization	Bamomas	Misuse of batteries and lack of information on battery usage rates	Lengthening product lifecycles and optimizing value gained from the product by customers
		Waste management optimization	Enevo	Low digitalization in waste management operations	Inefficient logistics causing both unnecessary greenhouse gas emissions and overflow of waste collection containers
		Supply and optimized spreading of nutrients on soil	Soilfood	Low nutrient recycling	Improving soil quality with nutrients made from recycled materials
		Predictive real-time maintenance	Konecranes	Unnecessary maintenance visits and early replacement of spare parts	Lengthening product lifecycles
	(3) Loop-closing (recycling) services	Energy recycling in the form of district heating from excess industrial waste heat	Calefa	Transferring excess heat into air or water instead of recovery and recycling	Improving the energy efficiency of the system, reducing greenhouse gas emissions

Innovation type	Sub-type	Example	Company	Sustainability issue addressed	Pursued benefit/value
Business model	(1) Two-sided business model	Acquiring label waste and turning it into new products for sales	UPM	Low utilization of industrial waste	Turning waste into a product, reducing incineration of waste, and replacing virgin raw materials with recycled ones
		Buy-back of old spare parts to repair and resell them	Ponsse	Low utilization of reusable old spare parts	Lengthening product lifecycles and preventing product components from becoming waste
	(2) Transferring product ownership from customer to the firm (Product-service systems)	Solar power as a service	NAPS	Fossil fuels (greenhouse gas emissions)	Replacing non-renewable, polluting energy sources with clean, renewable alternatives
		Work uniform and textile-leasing model	Lindström	Textile waste	Reducing textile waste and need for new products through reuse and maintenance of products
		Shared mobility on pay-per-minute basis	Voi/Tier	Fossil fuels (greenhouse gas emissions)	Reducing the need for owning own products through a service-based business model
	(3) Deposit systems	Managing and developing beverage package return and deposit systems	Palpa	Low packaging recycling	Ensuring high recycling rates for beverage packaging, incentivizing consumers to return beverage packaging
		Remanufacturing used tractor gearboxes and managing and developing their return and deposit systems	Valtra	Low recycling rate of used tractor gearboxes	Lengthening product lifecycles, providing an affordable, cost-efficient alternative for new products through remanufacturing

Process Innovations

Circular process technologies that enable novel and efficient processing of a certain type of waste or used product

An example in this category is the hydrotreated vegetable oil (HVO) refinery process by which Neste produces diesel fuel. This process employs several forms of waste and residue as raw materials (e.g. used cooking oil, animal fat from food industry waste, and vegetable oil processing waste and residues). Generating diesel from renewable materials results in up to a 90 per cent reduction in greenhouse gas emissions compared to fossil diesel production. Another example is Spinnova's process of producing textile fibre from cellulose. The company partners with a eucalyptus pulp producer, an expert company in cellulose fibre, and several clothing brands. Other examples in this category include Betolar's transformation of industrial waste into geopolymer-based construction materials and Tracegrow's extraction and purification of used alkaline batteries to produce organic fertilizers.

Material efficiency improvements to increase utilization rate

Material efficiency improvement processes aim to maximize the utilization rate of a material by modifying the material or its use process. Because the material can be used for longer periods, the higher utilization rate reduces carbon dioxide emissions and costs by eliminating the need for new raw material production/usage and providing energy savings. An example in this category is the usage of barley husk as the main fuel for steam energy production in Altia's Koskenkorva distillery. The plant uses barley grain to manufacture the spirit and produces starch and animal feed as sidestreams. In this process, carbon dioxide is captured and employed in greenhouse farming, and ashes are given to farmers to use as fertilizer, which results in a material efficiency of 99 per cent.

Take-back processes for products that are no longer in use (reverse logistics)

In this category, firms take back usable materials or parts of a product and return them to the market for reuse, optionally after remanufacturing or recycling them. Producers benefit from this process through profits generated from the reuse, remanufacture, or recycling processes of reclaimed products and materials. An example is the eco take-back point network of Rinki, which has over 1,850 take-back points for cardboard, glass, and metal packaging and over 500 take-back points for plastic packaging. The collected packaging waste materials are processed into raw materials for new products. Another example is RePack's reusable delivery packaging for online retailers. The take-back process starts when end users return empty packages by post for free. They are rewarded for returning the packages, which enables a high return rate. Apart from packaging, batteries, cars, and electronics are other consumer products that are widely considered suitable for take-back processes and further refurbishing or recycling.

Service Innovations

Platforms/online marketplaces on which people can connect and share or sell used products

An example of this innovation is Tori's online platform, which facilitates consumer-to-consumer (C2C) sales and thus slows resource loops by encouraging the reuse of goods. As another example, ResQ Club targets the issue of food waste by offering a location-based online platform on which restaurants and supermarkets can sell their surplus or nearly expired food products at a discount at the end of the day. Once the food products are posted on the platform, end-users can pay the reduced price online and collect the food from the restaurant or supermarket. This service allows restaurants and supermarkets to generate additional revenue from surplus food that would otherwise be wasted. Additionally, it enables customers to save time on cooking and enjoy restaurant-quality food.

Monitoring, optimization, consultancy, or design services

As an example in this category, the company Soilfood, which specializes in nutrient recycling, offers soil improvement services to its clients. The company supplies and spreads recycled nutrients on soil according to the soil properties. By using recycled nutrients as organic fertilizers, farmers can improve crop yields while minimizing fertilizer costs. Another example in this category is Bamomas' extension of the lifespan of industrial batteries through optimization. This service uses sensors for measuring the voltage, current, temperature, and water refill levels of the batteries to pursue more efficient use of batteries through maintenance and the detection of end-of-life batteries for replacement. A third example is Enevo's collection of data from waste management operations for optimization analysis. The company installs sensors inside waste containers to monitor the fullness of the container. This information allows waste collection once a container is completely full, which lowers logistics costs. The sensors are key to monitoring and optimization services, as both cases employ them in providing their services. A fourth example in this category is the predictive real-time maintenance service of Konecranes, which eliminates unnecessary maintenance visits and early replacement of spare parts. The service benefits both suppliers and customers, as both parties can save on time and costs. The services in this category can be diversified by using different types of sensor, such as vision and imaging, temperature, proximity, position, pressure, or humidity sensors.

Loop-closing (recycling) services

As an example in this category, Calefa recycles energy from excess industrial waste heat to convert into district heating. Recycling the waste heat reduces costs and carbon dioxide emissions, as the captured heat can be sold or reused in buildings, and it minimizes the additional heat generation requirement. The company closes the loop by recovering and recycling the excess heat instead of transferring it into the air or water.

Business Model Innovations

Diversification of the business model through a two-sided design

In this category, a single firm provides waste management services to obtain the required raw materials and then produces new products from those materials. For example, the forest industry company UPM offers recycling services for self-adhesive label by-products and then transforms them into magazine paper, paper liner, composite material, or energy. The company maintains a two-sided business model that establishes a waste management service for customers of its label business alongside an entirely new business of producing and selling products that are made from the label waste. As another example in this category, the business model of Ponsse, which specializes in forestry vehicles and machinery, entails buying back its old spare parts to later repair and resell them. This approach increases the utilization rate of reusable old spare parts.

Transferring product ownership from customer to firm (product-service systems)
These innovations replace the one-time product purchase fee for customers with continuous service fees throughout the use of the product. Lindström has adopted this business model in leasing work uniforms and equipment to its clients for a certain period. With this service, companies can avoid spending a large lump sum on work uniforms, and they can focus on their core business activities while the provider company assumes responsibility for clothing maintenance and ensures that the equipment is in good condition and has a long lifespan. Another example is the design, implementation, and maintenance of photovoltaic systems (e.g. solar panels) for clients by NAPS. The company generates revenue by periodically billing its clients, who only pay for the photovoltaic power produced on their roofs. A final example in this category is the rental of electric scooters by Voi/Tier via a mobile application, where users pay on a per-minute basis.

Deposit systems where customers reclaim deposit amount upon returning used products
An example in this category is a bottle return system by Palpa. The broad range of the beverage bottle recycling network in Finland facilitates a beverage container recycling rate of over 90 per cent. When a customer buys a beverage from a supermarket, its price includes a deposit for the bottle, which can be reclaimed by returning the empty bottle to an automated reverse vending machine. The machine transfers the bottle to the respective container for its material (e.g. glass, plastic, or can), which it identifies by scanning the barcode of the bottle. The machine automatically compresses the collected plastic bottles and cans to accommodate more returns and increase the cost efficiency of transportation. Once the materials are transported to the recycling centre, they are further processed into raw materials for new beverage bottles. The recycling of cans is highly sustainable; because of the lightness and durability of aluminium, it consumes only 5 per cent of the energy of the first manufacturing process. Meanwhile, coloured plastic bottle flakes can be repurposed as raw material for the textile industry. The whole process is carried out by the non-profit company Palpa. Cooperation among the manufacturers and importers of beverages, consumers, stores and supermarkets, logistics companies, and operators is vital to realize an efficient recycling process.

Another example is the innovation of Valtra, which specializes in tractor and agricultural machinery manufacturing, in its deposit scheme for used tractor gearboxes. In this model, the company remanufactures used tractor gearboxes, and it manages and develops their return and deposit systems. Remanufactured gearboxes are sold at a price that is 30–40 per cent lower than that of new products. In addition to the purchase price of the remanufactured gearbox, the customer pays for an additional deposit that amounts to approximately 50 per cent of the gearbox price. If the purchased gearbox breaks down after the one-year warranty period, the customer can return it to the company and reclaim the deposit. The company will then take back the broken gearbox, fix it, and remanufacture it for the next customer. Remanufacturing requires nearly 85 per cent less energy than manufacturing a brand new gearbox.

DISCUSSION AND CONCLUSIONS

Studies on sustainability and CE transition have strongly emphasized the role of 'eco-innovations' (De Jesus and Mendonça 2018; Hellström 2007; Rennings 2000). This chapter has employed the term 'CE innovations' to highlight the recirculation of resources in reuse, recycling, and renewal processes to slow and close resource loops (Bocken et al. 2016). The term also stresses the significance of the circularity aspect of the innovations for sustainability. We have divided CE innovations into four types and three sub-types for each for a total of 12 CE innovation sub-types. Our categorization is based on Crossan and Apaydin's (2010) framework of organizational innovation as an outcome and thus connected the CE and technology and innovation management stream, which supports a clearer understanding of the CE for organizations that are at the forefront of advancing the CE (Vasiljevic-Shikaleska et al. 2017). Our analysis reveals four innovation types in the CE (product, process, service, and business model) and provides insight into their benefits and sustainability impacts. The CE innovation types are here considered as categories in a typology (not a taxonomy), in which each type is kind of archetype. Therefore, the types can overlap and interact (e.g. technological process innovation can lead to a business model innovation), and an empirical case can hold characteristics of several CE innovation types.

Theoretical Contributions

The examination of the main CE innovation types in this study contributes to innovation literature in the areas of eco-innovation and sustainable innovation (De Jesus and Mendonça 2018; Hellström 2007; Rennings 2000). To build on the typology of innovation forms by Crossan and Apaydin (2010), the study has cited examples of CE innovations and further categorized them into their corresponding innovation type. Therefore, the study has devised a new typology for CE innovations that can increase raw material availability, energy savings, and product/material utilization rates over the lifecycle as well as reduce carbon emissions. This study has extended beyond the descriptive and explorative level of previous literature (Bocken et al. 2016; den Hollander et al. 2017; Vasiljevic-Shikaleska et al. 2017), to establish a CE innovation categorization that considers the process and service innovation types alongside the relational aspects of the CE innovations and sustainability issues. Thus, it offers a new, nuanced, and explicit categorization of CE innovations and comprehensive sub-types while addressing ongoing global sustainability issues that can be mitigated by innovating within those categories.

Practical Implications

The identified CE innovation types and sub-types can guide managers in (re-)designing their customer value propositions and approaches to creating, delivering, and capturing value in line with sustainable development goals. Sustainable design is essential to improve resource efficiency and reduce the negative environmental impacts of products and services. Companies must transform their linear business models into circular ones to meet the urgent demand for sustainable innovations that can combat the acceleration of global warming. The categorization in this study can act as a guide for emerging innovations to be designed taking into account their environmental impact.

The refined categorization of innovation types reveals innovations that enable the introduction of the CE into a firm's operations. Thus, it provides managers with a clear set of options for use in planning. Managers can also apply the categorization to consider the interplay of different types of innovation; for example, business managers who are designing a business model for a technological innovation that supports efficient reuse of products should be interested in the process and business model innovations that facilitate profitable implementation of the technological innovation. Meanwhile, technology managers should consider the technological CE process capabilities under development within a firm in light of other potentially necessary types of innovation. Our CE innovation categorization clarifies the CE and can inform idea generation at the beginning of the innovation process.

Future Research Avenues

This study has explored innovation examples from numerous companies. Future research could examine the dynamics of the relationship between firms and stakeholders in successful introductions of CE innovations. Such findings could deliver crucial guidance for firms in collaborating with stakeholders and for stakeholders in supporting the introduction of the CE in firms.

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PUBLICATION IV

Stakeholder contributions to commercialization and market creation of a radical innovation: bridging the micro- and macro levels

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Stakeholder contributions to commercialization and market creation of a radical innovation: bridging the micro- and macro levels

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Abstract

Purpose – Successful commercialization is crucial to innovative firms, but further investigation is needed on how diverse stakeholders can contribute to the commercialization of a radical innovation that requires particular market creation support. This paper aims to, therefore, analyze the key stakeholders and their contributive activities in commercialization and market creation, particularly in the case of radical innovations.

Design/methodology/approach – This study relies on qualitative research design including interviews with key stakeholders, such as regulators, scientists, experts, licensing partners, core company representatives and extensive secondary data. This single-case study concerns a functional food product, which is a radical innovation requiring the development of a novel product category positioned between the food and medicine categories in global market settings. Since its market launch in 1995, the involvement of multiple stakeholders was needed for its successful commercialization in over 30 countries.

Findings – Results uncover the contributions of diverse stakeholders to commercialization and market creation, particularly of radical innovation. Stakeholders performed market creation activities such as regulating the marketing and labeling of food products, conducting safety assessments, revealing and validating the positive health effects of the novelty and raising awareness of healthy living and cardiovascular health. The commercialization activities included distributing the products overseas, applying the ingredient to different food products and making the products available for users.

Research limitations/implications – This single-case study provides an overview of the positive stakeholder activities with contributions to market creation and commercialization of functional food innovations. Although the user perspective was not included in the empirical part of this study because of our focus on B2B actors, users of the innovation can contribute to R&D activities to a great extent.

Originality/value – The developed framework of stakeholders' contributive activities in radical innovation commercialization and market creation contributes to literature discussing market creation as well as commercialization within the marketing and innovation management research fields. This work also generates practical advice for managers who commercialize (radical) innovations.

Keywords Market creation, Commercialization, Innovation management, Stakeholders, Functional food, Radical innovation

Paper type Research paper

1. Introduction

The improvements in existing processes, services or products can be regarded as innovation, and it involves development, improvement and change, following the idea generation in an organization (O'Sullivan and Dooley, 2008). Successful commercialization is crucial for all innovative firms to stay in business and be profitable (Aarikka-Stenroos and Sandberg, 2012; Lin *et al.*, 2015; Marx and Hsu, 2015). It often requires involving diverse stakeholders as they can support the innovator firm in taking the innovation to the market (Aarikka-Stenroos *et al.*, 2017; Aarikka-Stenroos *et al.*, 2014; Reypens *et al.*, 2016). Commercialization is considered to be the final innovation activity in the innovation process, defined as the dissemination of the innovation to the market(s) and generating profits because of this dissemination (Costa *et al.*, 2004; Crawford, 2008). Markets are the outcomes of intentional and designed actions for innovations to emerge, which require firms to engage in market-

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shaping activities in their favor (Fehrer *et al.*, 2020; Lipnickas *et al.*, 2020; Nenonen *et al.*, 2019). Multiple studies in the field of industrial, B2B and innovation marketing acknowledge the relevance of stakeholders throughout the innovation process (Aarikka-Stenroos *et al.*, 2014; Canning and Szmigin, 2016; Hao and Feng, 2016; Kazadi *et al.*, 2016; Lievens and Blažević, 2021; Lim *et al.*, 2017; Manser *et al.*, 2016; Reypens *et al.*, 2016). It is emphasized that the collaboration among stakeholders can boost the innovation diffusion, refine the innovation process and contribute to the development and implementation of innovations (Makkonen and Johnston, 2014; Schiavone and Simoni, 2019; Widén *et al.*, 2014). However, there is still a lack of empirical-based understanding of how diverse stakeholders can advance successful commercialization and market creation of radical innovations. To respond to this gap in the literature, the objective of this study is to identify the key stakeholders and their contributive activities for commercialization and market creation of a radical innovation. Our context for radical innovation is the functional food market.

Stakeholders are defined as "groups and individuals who have a stake in the success or failure of an organization" (Freeman *et al.*, 2010). Extant studies on stakeholders' relevant inputs to innovation have acknowledged that these inputs can be studied from the perspective of commercialization of the particular innovation as well as from market creation and development of new business fields perspective (Aarikka-Stenroos and Lehtimäki, 2014; Hietanen and Rokka, 2015; Hillebrand *et al.*, 2015; Manser *et al.*, 2016; Nenonen *et al.*, 2019; O'Connor and Rice, 2013). Particularly in the case of radical innovations, for which markets do not yet exist and market structures and configurations are changing or developing, the line between commercialization and market creation can be thin and blurred (Aarikka-Stenroos and Lehtimäki, 2014; Möller, 2010). Radical innovations are developed with the aim of commercialization, and they are innovations that lead to the transformation of existing markets and creation of new markets (Leifer *et al.*, 2000). We argue that in order for a radical innovation to be commercialized and reach its users, the market actors should be aligned, existing market structures should be modified and a new market should be created. Commercialization is defined as a set of decisions that influence the product's introduction and position in a market (Aarikka-Stenroos and Lehtimäki, 2014; Hultink *et al.*, 1997). Therefore, it is crucial to highlight the market creation aspect: the foundation of market creation lies in the interplay between the actors on the micro–meso levels and the market configuration on the macro–meso levels, which explains how markets are shaped and developed (Peters *et al.*, 2020; Storbacka and Nenonen, 2011; Windahl *et al.*, 2020). Microlevel includes the organizational and individual level and examines the smallest levels of interaction. Mesolevel includes established business fields and networks that determine technological trajectories through the activity patterns of techno-economic and social actors. Macrolevel includes sociopolitical actors such as nation states and political coalitions that influence slowly evolving sociotechnical landscapes (Möller, 2010). The focus of commercialization research is inherently on the micro- and mesolevels, as it examines an innovator company's attempts to take a novelty to the market where stakeholders play an important role (Aarikka-Stenroos *et al.*, 2017; Aarikka-Stenroos *et al.*, 2014; Chiesa and Frattini, 2011; Corsaro *et al.*, 2012; Driessen and Hillebrand, 2013; Nieto and Santamaría, 2007). Market creation research, instead, applies a macro and mesolevels approach as it examines the market as a dynamic evolving structure that is modified when innovator firms introduce novelties in collaboration with stakeholders (Fehrer *et al.*, 2020; Lipnickas *et al.*, 2020; Nenonen *et al.*, 2019). Such dynamics can be seen where a new network of stakeholders such as codevelopment partners, distribution channel agents and ultimate users emerge (O'Connor and Rice, 2013; Sarasvathy and Dew, 2005). From this discussion, the interplay between commercialization and market creation comes into play.

The actors who are already embedded in an existing market structure can support the creation of a new market that is needed for the commercialization of a radical innovation, by companies. To succeed in this, apart from improving innovation's technical performance, the focus should also be on assessing innovation's readiness and match with the market. Support from diverse market actors, that is, stakeholders, such as value chain actors, regulators, experts, researchers and public organizations can help an innovator firm not only in successfully developing an innovation but also in enabling it on the market. For instance, Tesla created a new electric vehicle market by building the product and the required value chain for producing the batteries to run the vehicle, setting up compatible charging stations as well as the self-driving computer control systems. Not only it created a product but also the complementary necessities to create a new market and commercialize this radical innovation, which required the involvement of various types of stakeholders in the value chain. By understanding the full diversity of stakeholders and their contribution potential to commercialization and market creation, an innovator company can engage its stakeholders and align its goals with them. To address this objective, we present the research question of the study:

RQ. How do stakeholders contribute to commercialization and market creation?

To answer this question, we will map both the diverse stakeholders and their contributive activities in the commercialization of the focal innovation at microlevel and related market creation at macrolevel and their interlinkages.

We conduct a qualitative study piecing together the relevant literature on commercialization, market creation and the stakeholder approach and empirical based knowledge from a single-case study including versatile stakeholders (regulators, scientists, experts, business partners, core company representatives) and extensive secondary data. The single-case study concerns a functional food product, which is a radical innovation requiring the development of a novel product category between food and medicine categories in global market settings. Since its market launch in 1995, the involvement of many stakeholders was needed for its successful commercialization in over 30 countries. Single-case studies provide an empirically rich, holistic account of specific phenomena (Yin, 2003), and therefore, they allow researchers to examine stakeholder activities in more depth. The study contributes to the discussion on the stakeholder activities for commercialization and market creation of radical innovations especially from the perspective of the functional food context. The study also contributes to the market creation literature, innovation marketing and commercialization literature and to the stakeholders' contributions to innovation development.

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Functional food is defined to be any modified food or food ingredient that may provide a health benefit and reduce the risk of disease beyond the traditional nutrients it contains (Bloch and Thomson, 1995; Heasman and Mellentin, 2001). Industries such as medical equipment or functional food involve sensitive elements and typically encounter strict regulations because of primary health concerns. This aspect lets us consider a wide spectrum of stakeholders, including regulators and scientists involved in the study, which increases the stakeholder diversity and thus provides different perspectives on commercialization and market creation activities.

This work is structured as follows: following this introduction, relevant literature on commercialization, market creation and the stakeholder approach to innovation are presented in Section 2. In Section 3, the research methodology, the overview of the research context and the radical innovation case are covered. In Section 4, stakeholders in the functional food industry and their activities in commercialization and market creation are presented. In Section 5, the summary of the results are presented. In Section 6, we conclude the paper, discuss our theoretical contributions and managerial implications, and present the limitations and directions for future research.

2. Theoretical background

In this section, we present our theoretical building blocks, starting from commercialization and market creation and their activities and then show how stakeholders are seen to be engaged in such activities, in the light of the extant research knowledge.

2.1 Commercialization of radical innovation driven by a company – microlevel approach

Commercialization involves marketing communications, internal training, global launch and distribution (Chiesa and Frattini, 2011; Guiltinan, 1999; Hultink *et al.*, 1997; Jolly, 1997). O'Connor and Rice (2013) argue that one part of the commercialization process is the creation of a new business, which may include new markets, new revenue models and new partners. Commercialization process of a radical innovation starts with the innovator firm and develops as other actors are involved to shape a new market that is needed for the radical innovation. Regardless of the success potential of the innovation, all companies need support from their industrial and innovation networks to execute an effective commercialization process (Aarikka-Stenroos *et al.*, 2014). As the timing of setting up the relationships is essential in the commercialization process, it is advised that firms start building up relationships in advance, constantly seek feedback, work with partners and share resources (Perks and Moxey, 2011). The key commercialization activities of the innovator firm are listed as:

- planning the timing of the innovation's preannouncement and launch;
- forming long-term partnerships with critical actors in the network to disperse innovation tasks and resources;
- targeting the innovation at any specific segment;
- facilitating adoption by changing customers' mindsets favorably toward the innovation;
- creating awareness and educating the market;
- designing, configuring and positioning the innovation and its functionalities in a way that it meets early adopters' expectations; and
- launching the product only when the development of the product configuration is complete (Aarikka-Stenroos and Lehtimäki, 2014; Chiesa and Frattini, 2011; Perks and Moxey, 2011).

2.2 Market creation driven by diverse stakeholders – macrolevel approach

Innovation and particularly radical innovation trigger and anticipate changes in the market structure (Storbacka and Nenonen, 2011). New business fields around innovations emerge, as discussed by Möller (2010) with the example of the emergence of functional foods based on biotechnology, in comparison with traditional food networks. The actors and stakeholders in such settings should be able to perceive, interpret and construct the meaning of an emerging business landscape for markets to be created (Weick, 1995).

The emergence of a new business field deals with two aspects: exploring for future business in a changing environment and the construction and communication of a development agenda, targeting commercial applications. The business fields framework portrays sociotechnological structures that facilitate the emergence of markets (Möller, 2010). These structures are explained through macro–meso–microlevel layers. The macrolevel includes public authorities, political agents and cultural value systems, which influences the emergence of new industries through regulatory and policy support (Georgallis *et al.*, 2019). The mesolevel includes established business fields where the path to new markets is developed through evolving knowledge bases and activity patterns of actors, which modifies the macrolevel landscape. Microlevel has an influence on changes in the current established business fields. The actors who are involved in science and technology-based innovation activity are regarded as innovation niches who act as incubators for radical innovations and provide opportunities for radical knowledge creation. Innovation niches prompt changes at the macrolevel regarding regulations and policies. Proactive companies intentionally influence innovation niches to change the meso- and macrolevels to construct new markets. However, the markets might not necessarily evolve as managers expect, because of uncertainties in the process (O'Connor and Rice, 2013) and collective action problems (Struben *et al.*, 2020). The market creation activities are listed as:

- formulating unique technological designs and commercially viable product applications;
- influencing financial institutions, business partners, component and system suppliers and pilot customers on the value-creation potential of the new application concept;
- scaling up production and distribution networks;
- providing important regulatory rules and technological standards;
- forming collaborative networks;
- fostering new resource linkages among stakeholders to improve value creation and shape the market; and
- influencing the actions of legislators and regulators for ensuring compliance with law (Kaartemo *et al.*, 2020; Möller, 2010; Nenonen *et al.*, 2019; O'Connor and Rice, 2013).

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Diverse stakeholders are needed to undertake the market creation activities. As markets are dynamic structures that are intentionally initiated by market actors (Storbacka and Nenonen, 2011), it is important to consider the diverse stakeholders who can shape those structures and thus make the market structure more favorable for innovation commercialization.

2.3 Stakeholders contributing to innovation via commercialization and market creation support

Next, we build an initial understanding of how stakeholders can contribute to market creation of innovation and commercialization. According to the well-established stakeholder theory (Freeman, 1984), stakeholders include diverse groups or individuals involved in achieving an organization's objectives. Studies applying the stakeholder approach to innovation development (Driessen and Hillebrand, 2013) and commercialization (Aarikka-Stenroos *et al.*, 2014) have identified diverse contributive stakeholders. These are listed as employees, the mass of users and customers (lead users, boundary spanners and communities), suppliers, manufacturers, media, universities, public organizations, expert organizations, investors, financiers, competitors, communities, policymakers, regulators, governmental bodies, political groups, trade associations and trade unions, who can contribute by facilitating and accelerating further adoption, performing practical commercialization tasks and creating markets for innovations.

Regarding market creation for innovation, Kaartemo *et al.* (2020) discuss indirectly how stakeholders can contribute via institutional work, for example, by rule and price setting, generic campaigning and defining market boundaries and terms. Particularly in complex social and political contexts, the significance of the collaboration of multiple stakeholders in market creation has been pointed out by numerous scholars (Anderson and Gatignon, 2008; Hietanen and Rokka, 2015; Humphreys, 2010). Although collaboration is emphasized for market creation, the process may be hindered by prominent firms that dominate their industry that fail to come to an agreement on certain issues because of differing interests and backgrounds. This is especially relevant for markets that are emerging at the convergence of distinct industries and for firms that have no prior or inadequate experience of inter-industry cooperation (Ozcan and Santos, 2015).

Humphreys (2010) argues that new market creation is a political and social process, which is affected by the external environment of the firm or industry. To influence this external environment consisting of divergent stakeholders, economic, psychological, political and public relations related skills are required to address the needs and concerns of each stakeholder group (Freeman, 1984). Changing the regulatory, cultural-cognitive and normative structures by facilitating the constant flow of information can lead to the legitimation of new market creation (Humphreys, 2010; Kim and Mauborgne, 1999). Legitimation here means the process of making a practice or institution socially, culturally, and politically acceptable (Suchman, 1995). Transforming the regulatory structure requires a shift in the rule-setting and monitoring activities of authorities, while changing the cultural-cognitive structure implies shifting the taken-for-granted understandings about an organization or innovation. Lastly, changing the normative structure involves changing the norms and values in the social environment (Humphreys, 2010). To change these structures, collective action is needed that paves the way to market formation (Lee *et al.*, 2018).

3. Research methodology

3.1 Research design and the case

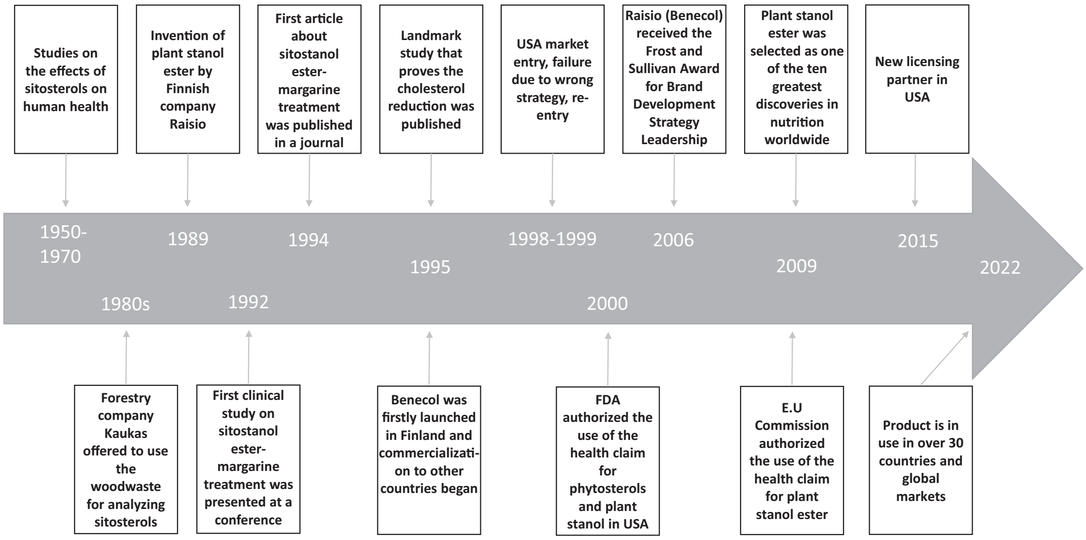
We have chosen and studied a radical innovation case, following the procedure of theoretical sampling (Patton, 1990) by analyzing a functional food innovation – a novel product category between food and medicine. We examined the commercialization activities by the innovator company, the stakeholders involved in related activities as well as market creation that was needed for a "novel to the world" innovation. Functional food has been defined to be any modified food or food ingredient that may provide a health benefit and reduce the risk of disease beyond the traditional nutrients it contains (Bloch and Thomson, 1995). The innovation in our case is a technology-based healthy food innovation that was launched by Raisio in 1995 and has been commercialized with the brand name Benecol. It is a vegetable fat spread that lowers cholesterol with its unique ingredient, plant stanol ester, that aims the prevention of cardiovascular diseases and is therefore categorized as a functional food in the markets. As the innovation concerns human health, a multitude of stakeholders was involved in its commercialization and market creation process over the years. Many medical studies and experiments were conducted by scientists and primary health-care actors to test the viability and positive health effects of the main ingredient (Miettinen *et al.*, 1995; Athyros *et al.*, 2011).

In this study, qualitative analysis of a single case and multisourcing methodology (interviews and extensive secondary data) are used. The case can also be considered to be a distinctive case (Patton, 1990), as plant stanol/sterols were among the ten greatest innovations in nutritional research introduced in the years between 1976 and 2006 (Katan *et al.*, 2009). Benecol has been one of the first functional food products that created a completely new market category and attracted many licensing partners from around the world; thus, it is an optimal case to study commercialization and market creation facilitated by stakeholders to form a totally new product category. The case allows us to examine both microlevel commercialization activities by the innovator company (via detailed interviews with top management) and macrolevel market creation activities by stakeholders (via documents and interviews with stakeholders) and to map stakeholder contributions that occurred during a long timeframe. The case applies historical analysis that allows examining large-scale phenomena such as market creation. The timeline of the important events in Benecol's commercialization process and related market creation is illustrated in Figure 1.

3.2 Data gathering

Multisourcing and various data collection methods were used to capture the viewpoints of both business actors and societally relevant stakeholders. The primary data includes semistructured interviews with open-ended questions to internal and external stakeholders. As secondary data, an extensive set of over 100 documents are examined: media articles on Benecol's commercialization, market creation and stakeholders; scientific research on plant stanols

Figure 1 Timeline of the important events in Benecol's commercialization and market creation



published in various academic journals; the innovator firm's website for comprehensive information on the relevant stakeholders; and publicly accessible documents and books, which enabled to identify the stakeholders involved in the study. The LexisNexis news search engine was used to gather relevant news articles. The data sources are listed in Table 1.

The interviewees represent different key stakeholder roles: commercial and legislative counselors from a regulatory authority, public health expert, scientist, science and nutrition communication manager from the innovator firm, the inventor of Benecol, the brand/marketing director of the innovator firm and two business partners from the value chain. The interviewees were selected based on their experience and their contribution to Benecol's market creation and commercialization process over 20 years. The interviews were retrospective, aiming to track the outcomes of market creation and commercialization activities over the years. They were conducted face to face, online and recorded. Different interview questions were designed according to stakeholder type, to uncover their specific activities. The details of the conducted interviews are listed in Table 2.

3.3 Data analysis

In the analysis phase, thematic content analysis was used, and the focus was on identifying the events, decisions, activities, opportunities and challenges in the market creation and commercialization process from the primary data. As an example of thematic analysis, business partner from the USA stated, "People don't eat margarines in US so we came up with new products such as chocolate chews and coffee cream." Business partner from Indonesia also stated, "The challenge is coming from the ingredient that it must be consumed after you have a meal. This is a problem in Indonesia since they (people) don't eat bread. Therefore, we need to exist in that liquid food format." These statements were interpreted to explain the market creation activity of the business partners, which is labelled as making product adjustments to meet consumer preferences in the local markets. The expert opinion leader stated, "We started to have a project not just for patients but in the community of North Karelia and asked people to change their diet to reduce saturated fat, increase vegetable, fruit, and berries consumption. And later on we also took the salt issue because salt is something that increases blood pressure. There is a

Table 1 Data sources

Source of data	Details
Interviews	2017: 4 interviews with the innovator firm 2018: 6 interviews with regulatory authority, public health expert, innovator firm, business partners from the value chain and scientist
News articles	>100 news articles about Benecol and lowering cholesterol were retrieved from sources such as The Daily Telegraph, The Guardian and The New York Times (1996–2019)
Websites	>10 websites of Benecol in different regions, Ministry of Agriculture and Forestry of Finland, Finnish Food Authority, European Food Safety Authority and related industry associations such as European Atherosclerosis Society
Publications	>50 journal articles and a book on Benecol, plant stanol ester, functional foods and cardiovascular diseases

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Table 2 Overview of interviews

Actor type	Role	Date	Duration	Theme
Regulatory authority	Commercial and legislative counsellors (food division, food safety unit)	26.04.2018	52 min	Novel food regulation and product authorization procedure
Opinion leader	Former director of a research and development institute and current member of Finnish Parliament	21.05.2018	45 min	Awareness creation on cardiovascular health and healthy diet
Innovator	Science and nutrition communication manager	11.06.2018	52 min	Communication activities targeting consumers and health-care professionals
Innovator	Inventor and brands and marketing director	2017	120 min	Regulations, abroad markets, communication activities targeting consumers and health-care professionals
Business partner	General manager	13.06.2018	45 min	Competitive environment, consumer preferences, product variations, regulations in the market
Business partner	Business unit head	25.07.2018	35 min	Competitive environment, consumer preferences, product variations, regulations in the market
Scientist	Contributor to the research of plant stanols	04.07.2018	87 min	Activities that contributed to the research and validity of the health claims of plant stanols

model explaining how the risk factors predict heart disease and we know how the risk factors have reduced. Out of the individual risk factors, half of the reduction in heart disease mortality seems to be explained by cholesterol reduction and it is mainly diet." This statement was interpreted to explain the market creation activity of the opinion leaders, which is labelled as creating risk awareness on certain issues in the society and explaining the potential impacts of the issues.

Secondary data, particularly news articles in Benecol and Raisio's history, enabled us to analyze the critical stakeholders in the fields of science and medicine, regulation, market and society. Based on the analysis and data triangulation from the combination of primary and secondary data, we created in the final model a figure depicting the multidirectional interactions among stakeholders.

4. Diversity of stakeholder contributions to commercialization and market creation of a radical and societally relevant innovation

Next, we discuss the results of the case analysis and the contributions of the diverse stakeholders to the commercialization of the innovative product, Benecol, and market creation of functional foods. To provide an overview of our results, Table 3 concludes the stakeholders who influenced the innovation commercialization (microlevel) and market creation (macrolevel), partly contributing also via value chains (mesolevel). The stakeholder types and their contributions to market creation and commercialization are listed in Table 3.

4.1 Stakeholders contributing particularly at macrolevel market creation

4.1.1 Regulatory authorities

Based on the case analysis, regulatory authorities were found to be one of the significant stakeholders that contributed to the creation of the functional food market and commercialization of its products. The European Food Safety Authority (EFSA) is the authority that conducts safety assessments for all food products marketed in Europe, therefore the assessments by EFSA are needed to launch functional food products on the market. Another key stakeholder in this case are the legislative and commercial counselors from the Ministry of Agriculture and Forestry of Finland. The scope of work of the relevant regulatory authorities is listed in Table 4.

Among these organizations, the Finnish Food Authority and MMM are the Finnish authorities that are responsible for novel food regulation; the EFSA and European Commission are higher-level European regulatory authorities. In this regulatory chain, although the last decision is made by the European Commission, EFSA has the greatest authority and has the most influence on a marketed product regarding safety assessments and the validity of the health claims. The authorization procedure of a novel food in Finland is illustrated in Figure 2.

In this authorization chain, the activities performed by the depicted regulatory authorities help create the market by evaluating the novelty level of the food products and assessing their safety, as these activities ensure that products carry no risks to health. To give an example, some activities performed by MMM are explained by the Commercial Counsellor and Legislative Counsellor respectively:

> I am in charge of drafting new legislation, implementing current legislation, helping interpreting legislation as my background is in functional foods and gene technology. We are taking care of a regulation that regulates everything novel entering into the food chain. Safety is the main concern for novel foods.

> One area I am responsible for is food labeling including health claims and nutrition claims. There is a link to functional foods because when a company comes up with a new innovation, it tends to claim a health benefit.

Another example clearly explains the crucial role of regulatory authorities in commercialization and market creation. When the company decided to enter the markets in the USA, they faced problems. US market entry was delayed for about six months because of a wrong strategy applied by Benecol's worldwide marketing partner, as it decided to market the product as a dietary supplement, which was not the product's right category according to the US food regulation requirements. The US Food and Drug Administration (FDA) later approved the product as a regular food with the "Generally Recognized As Safe" status, which made it possible for Benecol to be launched in the USA. In the USA, functional foods are still an unclear product category for

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Table 3 Stakeholder types and contributions

Type	Contribution: Market creation (macro)	Contribution: Commercialization (micro)
Regulators	• Allowing society to start accepting the novelty • Drafting new legislation, implementing current legislation • Conducting and evaluating risk and safety assessments	• Authorizing products to be marketed and sold • Providing guidance on the authorization procedure
Scientists	• Generating objective scientific knowledge • Publishing articles, attending seminars and conferences around the world and thus disseminating the knowledge	• Increasing the credibility of an innovation • Revealing the functionality of the innovation/novelty through studies and experiments, which can be used as marketing argument for a product
Experts as opinion leaders	• Creating risk awareness on certain issues in the society and explaining the potential impacts of the issues • Influencing public perceptions and producers' actions to shift to operations that are more sustainable • Publishing articles, attending seminars and conferences around the world and thus disseminating the knowledge	• Increasing the credibility of an innovation • Making the network actors more aware of the benefits of the innovation
Business partners in the value chain	• Providing access to local user base in different countries • Making product adjustments to meet consumer preferences in the local market and thus ensuring the fit between innovation and different market settings	• Distributing the products locally and making them available for users • Contributing to the diffusion of the innovation by representing the innovation in local markets
Innovator firm	• Managing the innovation network by facilitating constant information flow between stakeholders	• Initiating the innovation process by discovering or inventing the novelty
Media	• Raising awareness on healthy living and cardiovascular health	• Communicating the value that a product or service would create for its user
Users	• Using the innovation and experiencing its benefits at first hand	• Providing feedback about the products' strengths and weaknesses • Carrying out word-of-mouth marketing
Health-care professionals	• Changing the attitude on markets	• Recommending the product personally to the users • Conveying the product information to the users who are the target audience
Associations	• Organizing educational sessions for health-care professionals for awareness creation	• Mentioning the innovation in their guidelines

Table 4 Focus areas of regulatory authorities

Organization	Scope
Ministry of Agriculture and Forestry of Finland (MMM)	MMM is responsible for the legislative work on food products as part of the Finnish government and it collaborates with European Union (EU) institutions to get support in decision-making
Finnish Food Authority	The Finnish Food Authority is a centralized body operating under MMM. It conducts risk assessments and scientific research
European Food Safety Authority (EFSA)	EFSA is the agency of the EU that provides independent scientific advice and communicates on existing and emerging risks associated with the food chain
European Commission	European Commission is an institution of the EU, responsible for proposing legislation, implementing decisions, upholding the EU treaties and managing the day-to-day business of the EU

FDA. Functional foods are regarded as foods with health claims and subject to the Federal Food, Drug, and Cosmetic Act.

Regulations in some countries can be strict and challenging, and obtaining approval for product registration or a health claim may require repetitive clinical trials for different product types, which can be time-consuming and expensive. The requirements and rules for getting approval to market a food product differ on various continents and might even vary in countries on the same

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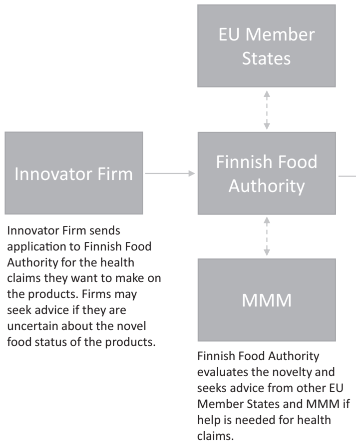
Figure 2 Authorization procedure for novel foods in Finland: stakeholders assessing risks and claims of the novelty



continent, as is the case in Asia. As the authorization that is granted in the European Union (EU) is valid in many countries, it is convenient for a food company that intends to market its products in Europe. Especially in Asian countries, the long process of product authorization may be a bottleneck for a company and require substantial resources. Furthermore, it may prevent small- and medium-sized enterprises from entering Asian markets because of inadequate resources. However, Benecol was able to become authorized in many Asian markets despite the long authorization processes, and its presence was secured with newly developed products that meet the needs of the consumers in this region. This success paved the way to shape the functional food market in Asia in its favor. As stated by the Benecol's inventor:

> There are some country-specific requirements for product authorization. The approval process can be very complicated and might have to repeat some of the experimental animal studies that have been done to prove the product's safety. For example, if stanol is to be added to a yogurt product and to a soymilk product, separate clinical trials might be needed depending on the country regulation (Translated from Finnish).

4.1.2 Scientists

The empirical results uncover that scientists contributed to the research and validity of the health claims of plant stanol ester, the main ingredient in Benecol. Their work on plant stanols and experiments conducted with different doses of daily consumption revealed the health benefits of plant stanols, contributing to the creation of a novel functional food for a new market and attracting many global audiences. The research group's findings on the effect of different doses of stanol consumption on serum cholesterol levels validated the impact of the innovative ingredient (Miettinen *et al.*, 1995; Athyros *et al.*, 2011), enabling other stakeholders to rely on this knowledge. Using different types of equipment, scientists measured the functionality of the arteries. As stated by a Professor of Medicine at the University of Helsinki:

> We analyzed the plaques that block the arteries and analyzed the vascular effects of Benecol, measured how the arteries are functioning before and after the use of Benecol. We measured how much blood enters to a very small area in a limited time.

Scientists contributed by publishing journal articles about the effects of plant stanols and attending cardiovascular seminars and conferences around the world to explain the positive health effects of plant stanols to health-care professionals. This promoted the market creation of the innovation in many regions, as some of these scientists possess an excellent reputation in the field of plant stanol and sterol research.

4.1.3 Experts in public health as opinion leaders

Another important group of stakeholders in the case was public health experts who shape other stakeholders' perceptions of the innovation and influence their willingness to adopt it. In this study, public health experts were found to hold the status of opinion leadership in the field. In this case, we refer to a specific individual who has been recognized by public and who has great impact on society. Here, the key opinion leader is the former director of the National Institute for Health and Welfare of Finland (THL) (2009–2013). He was formerly the director of the North Karelia Project initiated in 1972 in Finland. The initiative succeeded in reducing the male coronary heart disease mortality rate by 73% in 25 years in the North Karelia region and by 65% overall in Finland (Puska, 2002). He was also a member of the Finnish Parliament. Thus, the opinion leadership relied on both specified expertise and status/legitimacy, thereby strengthening the relevance of expert commentaries given by the key expert opinion leader of the focal case.

Because of wide, compelling experience in the focal field, including his studies and knowledge on the risk factors of cardiovascular diseases and his success in improving the diet of a nation, he was later involved in the commercialization activities of Benecol. He gave conference speeches and spoke at annual meetings of Benecol's business partners, explaining the positive health effects of Benecol's main ingredient, plant stanol ester, which raised interest in this innovative ingredient. The growing trend and attitude toward healthy eating among consumers have prompted some other companies in the industry to develop similar healthy food products:

> We spread all kinds of health information for the adoption of a healthier diet and lifestyle, but we realized that this was not enough. We needed products to convey the message so that it would be easier for people to switch to healthier eating habits.

This movement and effort promoting healthy eating led by a public health expert and also other companies increased the demand for such products that have health benefits and promoted the emergence of the functional food market, particularly for the cholesterol-lowing products. In this case, the public health expert's previous efforts in the North Karelia Project to lower the cholesterol levels of a population and being a well-known expert in the cardiovascular field made it easier for wider audiences and companies to trust him and his recommendations, which created awareness and facilitated Benecol's diffusion in various regions.

4.1.4 Media

Based on the secondary data, we share some examples of information about Benecol that have been published in various media over the years, and we discuss how the news associated with Benecol led to progression of its commercialization and market creation.

Right after its launch in the UK, the company made a deal with Carol Vorderman to be the face of Benecol's UK marketing campaigns in press ads and on TV as a part of its commercialization strategy. As Carol Vorderman was a well-known and well-liked celebrity in the UK, Benecol's diffusion in the UK market accelerated.

The firm was involved in several campaigns that increased its visibility in public, such as the campaign for Women Against Cholesterol to raise awareness of the risk factors related to high cholesterol. Additionally, the awards that the company received, such as the Frost and Sullivan Award for Brand Development Strategy Leadership for demonstrating superior market growth, increased the credibility and strengthened the brand image of the company in many markets. The company also used unconventional ways to promote the brand, such as sponsoring a classical music radio show that was popular especially among over 55 years olds, the brand's target audience.

4.2 Stakeholders contributing at microlevel, to company's commercialization efforts

4.2.1 Complementing business partners in the value chain: licensing partners from the USA and Asia

With regard to value chain partners in the Benecol case, business and licensing partners using the same ingredient in diverse end products, ranging from margarine to beverages, contributed primarily to the commercialization and secondarily to market creation in several ways. To create functional food markets in different countries, companies need to consider consumer preferences and dietary trends in those countries. Therefore, local product adjustment strategies were applied to attract consumers in various countries and to create the user base for the market. Benecol's business (licensing) partners from very different global market contexts from the USA and Indonesia explained their perspective on commercialization as well market creation of an innovative product.

The licensing partner from the USA is a food manufacturing company that produces spreads and cooking products and is best known for its olive oil-based margarine-like spread. American consumers tend to eat less fat spreads than consumers in Europe, therefore product adjustments were made in the content of the Benecol spread. The efforts were directed to the products that are widely consumed particularly by consumers in the USA. As explained by the general manager of the business partner from the USA:

> People don't eat margarine in the US, therefore, we came up with new products under the Benecol brand, such as chocolate chews and coffee cream.

Using health claims on packaging and in marketing channels influences the buying decision and eases the commercialization of products. The wording of the health claim on the packaging of a certain product might be different in different countries depending on the food and safety regulations of the country in question. As stated by the general manager of the US business partner:

> In the European markets, it is possible to claim that using Benecol reduces cholesterol by 10%, but such claim is not allowed in US. The Food and Drug Administration of the US allows the claim that 2 grams of stanol or sterol may help reducing cholesterol levels.

The partnership with the Indonesian business partner started in 2008 and since then, no other competitor has entered the functional food business in Indonesia, making the Finnish company the market leader in this area. In the Indonesian case, the main consideration for a partnership with Raisio and incorporating Benecol products in the product range was the uniqueness of the ingredient. Having the approval from regulators for claiming health benefits of plant stanol ester enabled the Benecol brand to appeal to the partner and create a market, as it is the only brand that can use and contain plant stanol ester in Indonesia. The business unit head (BUH) of the Indonesian business partner explained the reason behind the partnership with Benecol:

> Since Benecol's plant stanol ingredient is acknowledged by institutions, healthcare professionals, and medical bodies and has exclusivity, we wanted to use the Benecol brand in our cholesterol lowering product range.

The healthy food products are differentiated with different price levels and the health claims in Indonesia; therefore, they are regarded as a new product category that is subject to different regulations, monitoring and safety assessments, which created a new market network. The BUH explained the advantage they gained over their competitors and increased consumer awareness after obtaining permission to use the health claims in 2014:

> Since 2014, we have been able to claim the cholesterol lowering effect on the packaging and due to that, people are now more aware of the effects of plant stanol. However, we still need to provide education because Benecol is not like medicine.

4.2.2 Health-care professionals

Benecol products as a preventive solution for high cholesterol are recommended in different health-care systems around the world. Health-care professionals are crucial target groups in the local markets; informative and factual messages on the unique health enhancing qualities of the novel product are needed to target those who meet patients. Therefore, the innovator firm realized that it is extremely important to train primary health-care actors to promote the health benefit of a product to public to set up the user base for the innovation. As these actors are in close contact with patients, they can influence product diffusion with their product recommendations. Therefore, health-care professionals act as one of the supporting forces in the commercialization of functional foods. As stated by the Science and Nutrition Communication Manager of the Innovator Firm:

> Communication toward healthcare professionals is of high importance since these experts are influential and can spread the health benefit information of Benecol to those who have high cholesterol levels and who need cholesterol lowering products and treatments. We develop marketing materials for our business partners to guide healthcare professionals in their regions. We also work with opinion leaders who are aware of the latest science in the field of cholesterol lowering and influence the opinions of other healthcare professionals.

Both information spread by health-care professionals and direct consumer communication messages can impact marketing efficiency, and they complement each other. The degree of the emphasis that is put on a certain type of communication depends on the health-care system of the country. Having an approved health claim for plant stanol ester in different regions is crucial in the context of both health-care professional and consumer communication. This is an important step in commercialization, which provides a positive brand image to the firms that can obtain this valuable key criterion.

4.2.3 Associations

In addition to the health-care professionals' contribution to the market creation of Benecol in different regions, several associations around the world (e.g. European Atherosclerosis Society, European Society of Cardiology, International Atherosclerosis Society, American Diabetes Association and the National Heart Foundation of Australia) mention the use of plant stanol ester to be an effective way to lower cholesterol in their dyslipidemia treatment and cardiovascular disease prevention guidelines. These associations act as a group of actors that feed health-care professionals with relevant information. In the congresses of these associations, innovator firm-sponsored educational sessions have drawn the attention of health-care professionals to this alternative way of lowering cholesterol, which has promoted Benecol in various markets.

5. Discussion

5.1 Key stakeholders' contributions to commercialization and market creation of radical innovations

We studied the activities of multiple stakeholders and how they facilitate the creation of a new market on the macrolevel and make it possible for an innovation to be commercialized because of increased adoption, on the microlevel. These results and insights based on empirical research data also reveal the interactive nature of market creation and commercialization. We argue that, as our case results show, stakeholders' contributions regarding commercialization activities directly address the innovation marketing goals of the focal innovator company, whereas their contributions to market creation are more on the societal level and thus require deeper involvement from the macrolevel actors and scientists to change the market structure. Therefore, very diverse contributions from various contributors are needed to advance the commercialization and market creation of a societally relevant innovation. These include scientists, public health experts as opinion leaders, regulatory authorities (ministries, risk management authorities and regional commissions), (primary healthcare) professionals in different countries, associations, complementing business partners from the value chain, media, users and managers of the innovator company. These actors contribute:

- directly to the commercialization efforts of the innovation led by the innovator company (e.g. business partners distributing the products locally, thus making them available for users);
- directly to market creation (e.g. regulators conducting safety assessments and assessing the validity of the health claims) that makes the markets more favorable to the commercialization activities by the innovator company; and
- to the intersection of these two above activities, thereby fortifying the dynamics and change in the markets, as multiple contributors' contributions accumulate and fortify each other in the momentum (e.g. scientists validating the functionality of the innovation/novelty through studies and experiments that enable regulators to allow the innovation at macrolevel and business partners to gain more profit from the innovation, which supports both the innovator's and its business partners' commercialization efforts at the micro- and mesolevels).

Our study showcases how actively involving scientists and public health experts in market creation activities provide benefits to the innovator firm and increases its credibility. The good reputation of scientists and public health experts makes it possible for business partners to trust the innovator firm's innovation and assess how much they can create value from it, which also encourages them to initiate a partnership with the innovator firm. Having participated in academic conferences and seminars and having published scientific articles about the benefits of the innovation in well-established journals, scientists and public health experts as opinion leaders have the power to indirectly influence business partners and expert actors that encourage consumers to adopt and use the innovation. Scientists seem to play a major role by validating the value of the innovation and related impacts, particularly when the product concerns a societal issue, such as public health. The scientific experiments by scientists are also needed to prove that the product is safe to use, causes no harm and generates the intended positive effects.

The commercialization and market creation process may be negatively affected by certain stakeholders. For instance, market entry of Benecol to the USA was temporarily hindered by FDA because of the wrong strategy applied by the licensing partner at that time. A competitor that has a similar product in markets where Benecol exist may sue the company for the similarity of the brand name. Such examples show that it is important to consider these stakeholders that might hinder the process.

5.2 Modelling the commercialization and market creation of a radical innovation via stakeholder contributions

While stakeholder contributions to commercialization activities are mainly supported (and initiated) by the focal company whose innovation is commercialized, contributions to market creation activities take place on macrolevel and market structure level. These cover both direct contributions to market creation (regulators' ability to control what can be marketed and how) and

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indirect or interlinked contributions (scientists' ability to both guide societally relevant stakeholders' actions and validate the value of the innovation marketed by business actors). When putting these together, we see that market creation entails cocreating and renewing market structures, allowing innovations (particularly radical innovations) to emerge and to be commercialized. Finally, we develop a model that captures how stakeholders contribute to commercialization and market creation of radical innovations (Figure 3).

6. Conclusions

6.1 Theoretical contributions

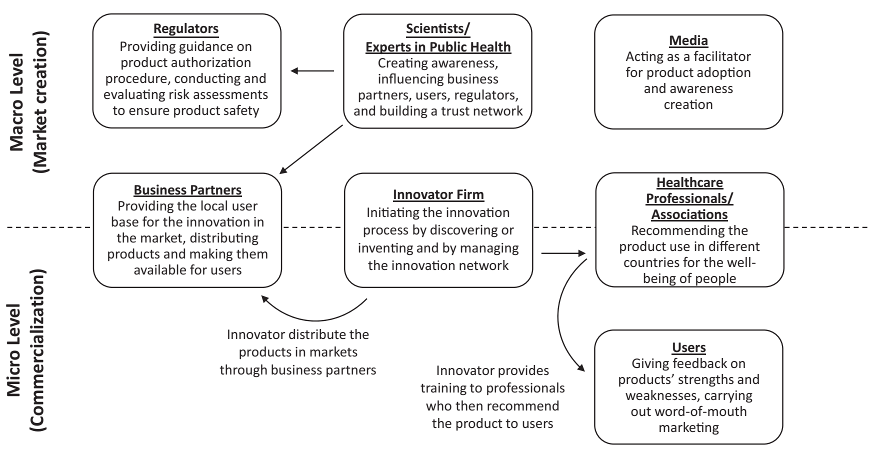
Our empirical analysis of the diverse stakeholder activities for market creation and commercialization of a radical, societally relevant innovation generates contributions to several research streams.

First, we contribute to the market creation literature, bringing forth the diverse stakeholders' contributions to market creation of innovations. Building on the argumentation that single actors facilitate the market creation of an innovation (Fehrer *et al.*, 2020; Lipnickas *et al.*, 2020; Storbacka and Nenonen, 2011), our empirical study showcases how diverse actors affected and changed the perception of the relevance of the functional foods in society and on the markets. Following the emerging and radical business fields literature (Möller, 2010), our study shows how innovator companies can use experts and scientists that can influence stakeholders at the microlevel, such as suppliers, distribution and customer networks, and stakeholders at the macrolevel, such as regulatory authorities in sociotechnological structures for the creation of a new market. Second, we contribute to the innovation marketing and commercialization literature, as our empirical analysis of stakeholder contributions to commercialization clarifies the activities that are needed to support commercialization efforts and innovation diffusion in markets (Aarikka-Stenroos *et al.*, 2014; Chiesa and Frattini, 2011; Makkonen and Johnston, 2014; Schiavone and Simoni, 2019). We show how the activities of seven types of stakeholders influence the commercialization of radical innovations along with their contribution to the facilitation of an innovation's market creation in global settings. The results of this study are aligned with earlier insights that diversity of actors improve the commercialization outcomes (Corsaro *et al.*, 2012) and that stakeholder marketing capabilities have an impact on organizations' performance in the long term (Hillebrand *et al.*, 2015). Third, we have contributed to the discussion on stakeholders' contributions to innovation development (Driessen and Hillebrand, 2013; Hillebrand *et al.*, 2015) by developing a framework that captures the supportive activities of stakeholders in creating markets, commercializing the radical innovation, and interlinkages between them (Aarikka-Stenroos *et al.*, 2014). As our final contribution, we clarify the relationship between market creation and commercialization of radical innovations, which support each other. We underline that to commercialize a radical innovation, the existing market structures should be modified in favor of the radical innovation to emerge via commercialization.

6.2 Managerial implications

The study generates practical advice for managers who commercialize (radical) innovations, beyond food innovations and functional food industry, and need support in market creation as well from diverse stakeholders. The research findings indicate that the focus of the collaborative activities with stakeholders should not be restricted only to R&D activities but should also focus on commercialization and market creation. In the first stage of the commercialization of a radical innovation, managers should be in close contact with the regulators in the target market to comply with the health claim regulations. Many commercialization decisions by companies are strongly linked to the development stage of market and needed market creation, and managers should acknowledge this carefully. For example, in our case, applying for the feasible product category before launch has been crucial, as the products may be placed in different categories in different countries. An undeveloped, not-yet-created market

Figure 3 Stakeholders in commercialization and market creation of radical innovations and their interlinkages



missing a feasible product category may cause companies lose revenue because of market launch delays.

Our study also shows that companies should involve very diverse stakeholders in radical innovation commercialization and related market creation, for example, regulators could guide the innovator companies in their attempt to launch their radical innovations and the managers should proactively seek feedback from the regulators regarding market regulations. Active cooperation with scientists and societally legitimate experts plays an important role in creating a market, credibility and building a successful brand image. The key point here is to involve these stakeholders well in advance and establish shared goals and interests. Feedback from business partners in value chain on marketing practices and new product development activities would enhance the collaboration and communication among parties and introduce and educate on new ways of doing business and task partitioning, thereby improving the commercialization efforts. For example, in our case, licensing partners provided important contributions to commercialization and market creation by providing information on how to adjust product features and contents based on the user habits in target markets. Such learnings from business partner stakeholders would provide innovator companies better returns on their investment to enter new markets.

6.3 Limitations and future research

This study is based on a single case study and explored the major stakeholders and their activities in the functional food industry. Our findings on relevant stakeholders and their contribution to market creation and commercialization can be generalized to many other industries and business settings. As innovation activities in the food industry have increased in the last decade (e.g. innovations such as pulled oats), the findings of this study can be generalizable not only to the functional food industry but also to the food and health-care industry where health is a concern. Stakeholder contributions are also relevant in many societally grounded settings that involve experts and regulators (e.g. environmental, sustainable and circular economy innovations). Although the user perspective was not included in the empirical part of this study because of the nature of the numerous viewpoints of user perspectives and because of our focus on B2B actors, users of the innovation can contribute to R&D activities to a great extent by using the innovation themselves, further developing it, forming innovation networks and providing feedback (Lettl *et al.*, 2006). Therefore, we call for further research to include user perspective in more detail when examining stakeholders' involvement in market creation and commercialization of radical innovations.

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PUBLICATION V

Bringing environmental sustainability and the circular economy into entrepreneurship education with stakeholders: four case methods from hackathons to role-model cases

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4
Bringing environmental sustainability and the circular economy into entrepreneurship education with stakeholders: four case methods from hackathons to role-model cases

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INTRODUCTION

Modern society is facing a sustainability transition that also touches on entrepreneurship education. The rise of environmental sustainability issues, such as climate change, the need to save natural resources, and increased material circulation through the circular economy (CE), highlights the need to incorporate environmental sustainability into education (Kirchherr & Piscicelli, 2019). Many higher education institutions have progressively incorporated sustainability education into their curricula, and novel examples of diverse education methods and courses on how to educate students on CE and sustainability issues have been proposed (Kirchherr & Piscicelli, 2019; Kopnina, 2019; Mendoza et al., 2019). This global megatrend calls upon entrepreneurship education to develop its content and methods to train entrepreneurial change-makers who should learn not only how to start and run businesses but also how to do so in a more sustainable way. Therefore, this chapter aims to develop understanding of how entrepreneurship education and environmental sustainability can go hand in hand and how different case methods allow students to be sufficiently educated on both relevant aspects.

Combining entrepreneurship and environmental sustainability provokes some pressing questions: how can one initiate a new business that is economically feasible but environmentally sustainable? What are the relevant skills and competences of the next-generation entrepreneurs and experts needed to conduct environmentally sustainable business? Is it possible to be a successful entrepreneur in a way that does not harm the environment—and how? The starting point of this chapter is to explore and discuss how we can employ diverse case methods to support the development of 'conventional' entrepreneurial skills (such as the ability to turn business ideas into plans or to see entrepreneurship as an attractive career path) in higher education while simultaneously providing educational guidance on how to do so in an environmentally sustainable way. In this chapter, we discuss and compare different case methods that enable the attainment of both goals. We also pay special attention to how to involve and engage entrepreneurs and other stakeholders from society in education when aiming to teach environmentally sustainable entrepreneurship via case methods.

The chapter focuses on four different case methods and is based on our education experiences from educational acts and courses at two Finnish universities (Tampere University and its technical campus and the University of Eastern Finland) and one university of applied sciences (Turku University of Applied Sciences). The discussed case methods vary from short-term educational acts, such as listening to visiting lecturers and personal narratives by sustainable entrepreneurs and intensive hackathons, to long-term collaborative methods, such as solving business cases. The aim is to enable students to develop an entrepreneurial mindset and the ability to identify business opportunities that arise from the society going through sustainability transition, and at the same time to breed more environmentally sustainable entrepreneurs and companies for the future. Our presumption is that different case methods call for different pedagogical and didactical approaches but also enable different learning goals; therefore, we also compare the methods.

BACKGROUND: IMPLEMENTING THE CASE METHOD IN TEACHING AND ENTREPRENEURSHIP EDUCATION, PARTICULARLY IN TEACHING ENVIRONMENTAL SUSTAINABILITY

Conventionally, the case method is based on problem-based learning. It enables students to make sense of complex problems related to professional issues and to assess how certain actions result in different outcomes (Hammond, 1976). In doing so, students learn about facts, conventions, and procedures while discussing different viewpoints relating to the problem. Typically, the basic elements of a case are a rich, complex case narrative and an analytical discussion/reflection of that case. This also entails solving a problem in the case by identifying meaningful determinants and options, evaluating choices of actions, predicting and assessing the effects of such actions, and communicating a solution and action plan.

In entrepreneurship education, case-based teaching methods have been recognized but are underexplored (e.g. Samuel & Rahman, 2018). Case studies present complex examples by illustrating the core issues and offering insights into the context of the issues, and therefore the case method promotes active learning, provides a means of linking theory and practice, and enhances students' understanding of the topics (Mustoe & Croft, 1999). Learning from real cases can particularly increase the authenticity of entrepreneurship education (Aadland & Aaboen, 2020). Real-life entrepreneurs can also serve as role models and influence the entrepreneurial intentions of their followers (Van Auken et al., 2006), which means assuming that entrepreneurs telling their case narratives can serve as role models for students.

Case-based teaching methods have also recently been studied in the field of sustainability and CE education. Some recent studies have provided good examples of how to use higher education courses and games to educate students about environmental sustainability and the CE (Kirchherr & Piscicelli, 2019; Mendoza et al., 2019; Whalen et al., 2018). However, other studies have critically demonstrated that implementing CE principles, such as reduce, reuse, and recycle, in 'real-life' situations and business cases often seems to be more challenging than the most optimistic visions may suggest (Kopnina, 2019). Therefore, in this chapter we posit that particularly authentic entrepreneurship education methods (Aadland & Aaboen, 2020), such as real-life cases from stakeholder companies, provide a fruitful method for students to experiment in practice and to learn how to conduct environmentally sustainable yet profitable business.

PEDAGOGICAL DEVELOPMENT: TOWARDS NEW COMPETENCES AND ORIENTATIONS VIA INTEGRATING ENVIRONMENTAL SUSTAINABILITY AND ENTREPRENEURSHIP EDUCATION

In this chapter, pedagogical development concerns how diverse case methods allow the integration of entrepreneurship education and environmental sustainability aims. As we broadly consider case methods, we will include not only the conventional notions of case methods with predetermined case descriptions, but also other related case approaches. This includes comprehensive yet open-ended real-life narrative cases that allow students to develop deeper understandings of complex settings comprising diverse relevant actors, meaningful factors, and essential actions in the focal context. We focus on four distinct case methods that allow the integration of business and entrepreneurship education with sustainability education: real-life business cases addressing business problem-solving (e.g. Kopnina, 2019), entrepreneur and start-up cases allowing students to identify role models (Van Auken et al., 2006), hackathons (Briscoe & Mulligan, 2014) addressing tech-business problem-solving in a short time, and live cases where practising professionals in Executive Master of Business Administration (EMBA) programmes develop sustainable versions of their current business (Berggren & Söderlund, 2011; Kearins & Springett, 2003). We assume that such different case methods call for different pedagogical and didactical approaches but also enable different ways of learning.

Here, pedagogical development also concerns the necessary novel competences students need to learn, as environmental sustainability shapes the entrepreneurial, business, and tech landscape and consequently calls for new learning content and emphases in education. Researchers agree that the environmental sustainability shift pushes all actors in society—consumers, public actors, and companies—to reduce the use of natural resources and the generation of waste (Geissdoerfer et al., 2017; Ghisellini et al., 2016). This shift also shapes business opportunities, business models, and the logic of value creation for both individual firms and whole value chains, networks, and ecosystems (Aarikka-Stenroos et al., 2021;

Lehtimäki et al., 2020). When pursuing more environmentally sustainable business, students need to learn more about sustainable business models and ideas, as many novel companies can compete by serving customers' developing needs for more sustainable offerings (Martín-de Castro, 2020) by providing innovative services such as cars or clothing as a service instead of providing products (Tukker, 2015), or new sustainable technologies, such as plastics substitutes that are biodegradable. Needs and demands for more sustainable offerings are also shaped by social institutions that determine what is valuable and how things are created and captured in certain business settings and locations (Ranta et al., 2018).

Solving environmental challenges often requires companies to interact and innovate with stakeholders, making stakeholder engagement and collaboration crucial in business (Engez et al., 2021). Therefore, it is important to learn how to associate with stakeholders, to obtain their support for the new sustainable offering, and to collaborate extensively, even with competitors, to create markets for more sustainable solutions (Bacq & Aguilera, 2022; Brown et al., 2019, Manzhynski & Figge, 2020). Mature businesses are also renewing and developing more environmentally sustainable operations to which start-ups can contribute by providing new and innovative materials, digital technologies, and products and services (Giudici et al., 2019). However, to capture these business opportunities, new understanding of the rapidly evolving global business contexts must be developed. Sustainability transition also pushes new types of entrepreneurship to emerge, such as ecopreneurship, a type of entrepreneurship that combines strong environmental and social values with an entrepreneurial attitude and a goal of creating an economically viable business (Magala et al., 2007).

In summary, environmental sustainability and CE transition call for the development of particular competences, understandings, and orientations among students interested in entrepreneurship. How such learning goals can be pursued via different case-based methods is explained next.

APPROACHES: FOUR DIFFERENT CASE METHODS ALLOWING THE INTEGRATION OF ENTREPRENEURSHIP AND BUSINESS AND ENVIRONMENTAL SUSTAINABILITY EDUCATION

Next, we explain how we have used the four chosen case methods—real-life business development cases, role-model cases, hackathons, and embedded cases—to educate on entrepreneurship and sustainability concurrently.

Method 1: Solving Real-Life Business Challenge Cases by Sustainable Start-Ups and Companies

The first experience involves real-life business development challenges presented by sustainable companies. This experience comes from a course titled Turning CE Technologies into Business that has 100+ domestic and international engineering students. The course is realized in stakeholder collaboration with companies ranging from pre-start-ups to corporations whose business challenges are solved by international, cross-disciplinary student teams. The business areas of the involved companies vary, including developing a process technology that converts used textiles or pulp into textile fibres, the collection of surplus construction materials to promote reuse and recycling, and underground high-temperature heat storage of solar or wind energy. These real-life cases typically concern business models or commercialization developments. The learning goal here is to develop competences to advance profitable business-making in sustainable CE companies.

In our example, six companies were invited to the course to offer a case challenge to students. The challenges included such elements as competitor analysis, finding new markets, and business model analysis, depending on the company's need. The important variables in the course are the number of staff and students. In our example, there were three course staff members and around 100 students, totalling over 20 student groups or teams. Each staff member was responsible for two case companies and seven teams of four or five students each; thus, each case company accommodated three or four teams. Teams were required to develop a solution to one company's business challenge and return a presentation and a comprehensive proposal, report, or plan. Students formed their teams, acquired some background information on company cases, and selected their preferred company.

Before the casework, some pre-understanding and competences were acquired via lectures on commercialization and business model development, related 'tools' such as models and canvases, and a mid-term exam covering lectures and journal articles on the CE, commercialization, and business model development. The casework consisted of four processual phases held at weekly intervals—a case launch session, case clinics, a group presentation and feedback session, and the final solution. In the case launch session, company representatives explained the challenge and its background and answered questions. The teams then developed initial solutions and obtained feedback from the course staff in the case clinics. In the subsequent presentation session (the week after), the student groups pitched and justified their solutions and received more feedback from the course staff and company representatives. Based on feedback, the teams provided their final solution (commercialization plan or developed business model) and a comprehensive final report. The learned tools helped build students' understanding of the business model elements, the strengths and weaknesses of the companies, and their external environment, but also allowed the students to develop a structured action plan for the companies. The final solutions were assessed by the course staff and the company representatives.

Method 2: Role-Model Cases via Involving Successful Sustainable Start-Ups and Entrepreneurs

The second method was applied in the 'conventional entrepreneurial' course on Growth Entrepreneurship. Here, entrepreneurs from sustainable businesses shared their personal stories of ecopreneurship and entrepreneurship through guest lectures. The case was the entrepreneur's personal narrative of what sustainable entrepreneurship is about, how it happens, and how the sustainable business idea developed. The learning goal was to get a quick look at the sustainable entrepreneur's work and personal life, career path, and motivation to start a sustainable business. The entrepreneurs described their motivation to engage in sustainable business by reflecting on their own thoughts and experiences. The students were instructed to get acquainted with the company and its business model beforehand and submit their own considered, focused questions for the entrepreneurs. Thus, the guest lecturer had some prior understanding of the students' interests, allowing them to prepare answers. Discussion and questions during the lecture were encouraged to enhance the interaction between the students and the guest lecturers and thus to build the case narrative through dialogue.

In presenting their motivation, drive, and enthusiasm for their missions, the sustainable entrepreneurs acted as inspirational role models for the students. Their personal narratives intertwined with the success stories of their growing companies, including manageable twists and turns, demonstrating it is possible to build a profitable business and promote sustainability simultaneously. One particular example of an inspiring guest lecturer was the CEO of Norsepower, a company reducing fuel usage for vessels through a wind propulsion system. The entrepreneur described his strong drive towards sustainable business and inspired the students to follow their own interests, values, and motivation to create meaningful careers. For every guest lecture, the students wrote a reflective learning diary where they analysed the personal career and organizational growth paths in the case.

Role-model cases were not only 'given' by the teachers but were also chosen by the students; in one learning event, the students pitched the company's business model to their peers who then selected one and created a growth strategy for it. These companies included a wide variety of sustainable businesses as the students were allowed to choose them according to their own interests. These case tasks allowed students to understand sustainable entrepreneurship and personal career paths and pushed them to gain a deeper understanding of the prerequisites of growth in sustainable businesses.

Method 3: The Hackathon Method Allowing Students to Solve Sustainability Challenges by Companies

The third case method example is hackathons—intensive events where small teams apply creative ideas to solve real-life challenges and come up with novel solutions. The word 'hackathon' combines the words 'hack', which relates to creative and experimental problem-solving, and 'marathon', which refers to the duration of the event. Hackathons offer networking and collaboration opportunities for participants and encourage them to build long-term connections despite the short duration and high intensity of the event. The event has a specific topic, location, and challenges provided by stakeholders, such as companies or governments. Traditionally, hackathons are mostly related to tech problems and are highly focused on software development and programming. Today, they can be used for any topic without the inclusion of the software development aspect, making them similar to case competitions. Topics can include contributing to a business objective or developing a solution to a social issue. In our hackathons, the focus was sustainability and CE issues. The central characteristics of our hackathons in relation to the other methods are their intensity, competitiveness, and the need for students to work under pressure.

From the students' perspective, these sustainability hackathons increase their creative problem-solving skills while reinforcing motivation and engagement in sustainability issues. Students who have experienced climate anxiety in particular gain a strong sense of agency and empowerment when attending sustainability hackathons. By participating in such hackathons, the student groups get a chance to influence the sustainability-related decisions of the organization that introduce a specific challenge to be solved. In the final phase of the event, the student groups present their solutions to the stakeholders, thus allowing them to develop their presentation skills. From the stakeholders' perspective, hackathons demand significant effort and involvement before and during the event, such as in formulating the challenge and working with and giving feedback to the students. At the same time, the stakeholder representatives can get novel and creative solutions to their sustainability problems and be more inspired and motivated to work towards a more sustainable future. From the teachers' perspective, the hackathon method requires significant effort to organize the event and cooperate with the stakeholders.

In our hackathon example, one company provided a sustainability challenge related to their tech business. For 24 hours, the five multidisciplinary student teams competed to create the best solution. Each team had a more experienced student tutor who provided support relating to different problem-solving methods. In addition to the teachers was a business-minded coach who facilitated the whole process and guided short sessions on ideation, prototyping, and pitching. A jury comprising company representatives and other experts chose the overall winner of the hackathon. The teams' solutions were assessed based on specific criteria, such as feasibility and sustainability, and the winning team was awarded a prize.

Method 4: EMBA Embedded Case and Adult Education through Experimental Learning

Our fourth example concerns continuing education and professional training for an EMBA where the students increased their understanding of the wide-ranging perspectives on a sustainable CE in different organizations and business areas. Students discussed the implications of a sustainable CE in different industries, critically evaluated the different approaches of case companies, and assessed their personal values and assumptions on sustainable business and sustainability transition.

Cases were selected to cover the different aspects, tasks, and processes of the CE, such as designing for durability, reuse, remanufacturing, and recycling to keep products, components, and materials circulating. The cases were selected from among the organizations where the EMBA students worked to make use of their work experience and insider knowledge. The business models of the case organizations and the opportunities and risks were analysed from the triple-bottom-line perspective (environmental, social, and economic). The proposed solutions ranged from transformative, radical change (e.g. new designs for products and processes) to incremental changes (e.g. recycling initiatives and solutions related to compensation). The students were requested to analyse whether the solution transformed the industry or whether it was an adaptation, what the time frame of the solution was (short, middle, or long term), and what the implications of the solution were for the organization (e.g. hiring, culture, and systems). Students presented their analyses, discussion, and feedback to the whole group. The diversity of the cases and guest lecturers from various industries ensured that students learned how different organizations and industries approach and implement CE principles.

To encourage mature, experienced students to adopt novel ways of thinking and become exposed to different world views, self-reflection and assessment of personal views on sustainability were encouraged via diaries. Students reflected on how their career and sustainability intentions may intertwine and what sustainability goals they wanted to achieve and how. In summary, the case studies and guest speakers and supportive group and individual assignments enabled students to reflect on how sustainability may feature in their day-to-day work, expert tasks, acts, decision-making, initiatives, and careers.

DISCUSSION: COMPARING THE CASE METHODS AND SUMMARIZING

After explaining the diverse methods and experiences of integrating environmental sustainability and entrepreneurship/business education, we compare case-based methods in a structured way to highlight their particular features and expose their differences (see Table 4.1). The methods mainly differ in relation to their level of *intensity and length* (from single-day to longer course implementation), *collaboration* (with different peer students and stakeholders and companies), and *reflection versus solution* (the focus being on reflecting students' own values and orientations versus developing problem-solving skills for sustainability). The comparison also builds structured understanding of the pedagogical pains and gains from students' and educators' perspectives and how to engage relevant stakeholders in implementation. Table 4.1 highlights the most important considerations and lessons learned for each method.

Based on the comparison, we propose the most optimal usage of each case method for integrating sustainability, the CE, and entrepreneurship. Solving real-life business cases enables students to interact with companies, generate new ideas and solutions for contemporary sustainable business problems, and improve their teamwork and project management skills because of the method's long-term approach. Role-model success cases deepen students' understanding of sustainable entrepreneurship in practice and personal ambition where sustainability and business orientation may combine. The hackathon is a high-intensity method of engaging students with sustainable entrepreneurship through personal involvement and co-creation with companies. Finally, the embedded EMBA cases allow the mature (postgraduate) student to reorient towards sustainability.

Our four case method examples and their comparisons extend the discussion on entrepreneurship education and the case method towards environmental sustainability learning contents. Our structured comparisons of methods reveal how the different methods enable pursuing versatile environmental sustainability and entrepreneurship education goals. Our case examples with Methods 1 and 4 support earlier papers discussing the implementation of real-life sustainable business cases (Kirchherr & Piscicelli, 2019; Kopnina, 2019), Method 2 explores how role-model cases (Van Auken et al., 2006) encourage ecopreneurial thinking (Magala et al., 2007), and Method 3 shows that sustainability hackathons enable intensive, multidisciplinary learning and engage students with sustainability on a personal level, thus extending current understanding of hackathons (Briscoe & Mulligan, 2014).

Table 4.1 Key aspects of the four different case methods and a comparison

	Applied case methods for integrating sustainability, the CE, and entrepreneurship education			
Aspects to compare	1. Solving real-life business challenge cases	2. Reflecting role-model success cases	3. Hackathon	4. Embedded company cases with EMBA students
Target group	Students from diverse disciplines, bachelor and master levels	Students from diverse disciplines, bachelor and master levels	Students from diverse disciplines, bachelor and master levels	Postgraduates/executives with work experience in private and public sector organizations
Case method-related learning goal and contents concerning entre-preneur-ship and business and sustain-ability	Through real-life business development and commercialization cases, students learn to solve real business challenges of CE companies and understand their business contexts. They learn multidisciplinary teamwork and reporting skills.	Through success case stories of sustainable entrepreneurs, students learn about the career paths and everyday work of entrepreneurs who seek both sustainability and growth. They learn pitching and presenting skills.	Through specific, intensive case problems, students learn multidisciplinary teamwork and collaboration, creative problem-solving tools for sustainability challenges, how to work well under time constraints, and how to prioritize tasks.	Through analysing and comparing their own employer company cases, students learn their own sustainability-related values and actions, understand how their organizations can implement CE in practice, and learn how to develop their own organizations.
Key stakeholders to be engaged	CEOs, owner/founders, marketing and R&D managers, researchers, innovation advisers, project managers bring real-life cases.	Entrepreneurs, CEOs, starting members in charge of sustainable business explain the story and their paths.	CEOs, innovation advisers and company experts bring the challenge, and local universities and entrepreneurship societies serve as jury members.	Employer companies of the students are the stakeholders. Students are peer stakeholders for each other.
Organizing for the case method implem-entation—key tasks per actor from preparation to assessment	Educators contact and instruct case companies. Companies formulate the case for students and provide feedback to student groups. Students seek relevant information, allocate and schedule tasks within their groups, and present their solutions/plans. Companies and educators jointly provide feedback and assess/grade the business and commercialization plans based on their feasibility, soundness, and clarity.	Educators invite the guest lecturers with their case stories, facilitate the lectures (e.g. sending the students' questions to the lecturers beforehand), and assess the learning diaries on the success cases. Company representatives tell their stories and answer students' questions.	Educators contact companies and organize facilities and catering. Educators and companies formulate the challenges together. Educators facilitate the hackathon. Educators and companies coach the teams and provide feedback and assessment together with the jury after the final presentations. Educators and companies award the winning team.	Educator and students select the cases among the students' organizations to ensure variation of CE businesses. Organizations where the students work provide the cases, students share and reflect on their insights on the cases, and teachers select the cases and facilitate discussion. Instead of assessments with grades, students expect discussions to ensure learning, unlearning, and professional development.

	Applied case methods for integrating sustainability, the CE, and entrepreneurship education			
Time frame for case method implementation: intensity and length	Longer duration (one period recommended to enable iterations and plan improvement rounds); sequential intensity	Longer duration (one period recommended to ensure reflection time between cases) and lower intensity	Short duration event (24–48 hours) and high intensity (work around the clock)	Duration varies depending on the available time frame and needed change-maker reflections: intensive 1-day event or one-period course
Educators' reflections on challenges and opportunities	Opportunities: students learn to assess the business models and commercialization of CE companies. Challenges: company representatives need to attend both case launch and presentation and feedback sessions. In case of a cancellation, a substitute representative is needed. The rule to mix and integrate is beneficial to ensure heterogenous student groups with international students to learn even more about different contexts for CE businesses.	Opportunities: students learn and get inspired for change-making 'with profit' through direct interaction with ecopreneurs themselves. Students understand the prerequisites and drivers behind the entrepreneurs' choices and career paths. Challenges: active, enthusiastic role-model entrepreneurs and CEOs typically have busy schedules. Therefore, getting in touch and scheduling can be challenging.	Opportunities: students learn about the challenges of sustainability businesses and how to overcome them through joint creative problem-solving. Students engage with sustainability on a personal level and realize their potential to act as change-makers. Challenges: demands active participation from the companies and much organizing by the educator before and during the event; catering expenses must be covered. Students must be motivated to work hard during the event.	Opportunities: students learn about sustainable decision-making and risk assessment and the complexity of circumstances from their peers' real-life situations. Students understand the diverse ways organizations implement the CE and adopt change-making orientation while developing their own organizations more sustainably. Challenges: time for discussion is limited and deep learning requires much independent work and time investment from busy students.

IMPLICATIONS FOR CASE TEACHING PRACTICE AND REFRAMING THE CASE METHOD FOR ENTREPRENEURSHIP EDUCATION

We conclude with the implications of our case method experiences for entrepreneurship education, a discussion of our contributions, and suggestions regarding directions for future research and practice seeking to integrate environmental sustainability into entrepreneurship education.

Our case experiences and analyses contribute to entrepreneurship education and case method understanding (Hammond, 1976) by illuminating how four different case-based methods allow the integration of environmental sustainability aspects. This chapter provided four case method examples varying from intense and fast-paced hackathons to longer courses, from business problem-solving to career and role-model cases (all real-life cases). Thus, we also extend current understanding of how to use entrepreneurship education methods that rely on authenticity (Aadland & Aaboen, 2020). Our structured comparison of different methods complements single method-based studies on how to teach environmental sustainability and entrepreneurship or business (Kirchherr & Piscicelli, 2019; Kopnina, 2019; Whalen et al., 2018). Our chapter also looked at how stakeholders, particularly sustainable companies and entrepreneurs, can be involved and contribute to entrepreneurship education by bringing their real-life business cases and background knowledge and serving as role models in person. This, however, means that stakeholders must benefit from the collaboration by gaining new ideas and solutions to their problems, seeking fresh views from 'the next generation' on how to enhance the sustainability of their businesses, or being able to present themselves as an attractive employer to sustainability-oriented students. In all methods, stakeholder involvement requires critical input and time investment, such as learning event preparation, interacting with and providing feedback to students, and organizing.

Practical recommendations for entrepreneurship educators, education developers, and companies emerge from our case method experiences and comparison. Table 4.1 provides some insights into how and when each method can be optimally implemented. It is recommended to use the *real-life business problem method* for educational settings where long-term work between companies, students, and educators is possible. Stakeholders can easily be engaged as the participating companies can improve their business development and commercialization performance based on student solutions. *Role-model success cases* allow the students to reflect on their orientations and competences for sustainable growth during a longer period. They can be chosen by the educators to display the diversity of role-model entrepreneurs, but it is just as important to allow students to choose their own role models. The *hackathon* method can serve as an intensive introduction to sustainable entrepreneurship for students from all levels and fields, as it provides a platform for more advanced students to apply their sustainability knowledge in practice and increase the multidisciplinary teamwork.

Our method comparisons reveal the value of diversity and variation in learning. The diversity of students, disciplines, and involved companies and stakeholders supports case-based learning. Therefore, it is beneficial to nurture multidisciplinary, multinational, and cross-industry collaboration, to have mixed student groups (students with tech, humanities, and business backgrounds, and with international and domestic backgrounds), and to engage different-sized companies from diverse industries.

The methods discussed in this chapter can also easily be implemented in the digital learning space by using platforms such as open-source learning management systems and online real-time communication and teleconferencing. This allows remote working; increased communication, such as instant notifications, announcements, forums, and information about the related events; and video recordings and access to presentation materials through digital platforms to facilitate students' learning process.

Regarding further research and development, we suggest that company and stakeholder involvement should be further analysed to understand the diverse roles and involvement modes in education. For example, role-model and business cases could extend to field trips that require strong company involvement and access. Second, student diversity should be further examined in relation to case methods to understand how this complicates or facilitates learning. We hope that our experiences stemming from the Finnish university context can bring valuable insights to all entrepreneurship educators and inspire them to integrate sustainability aspects into their entrepreneurship education via diverse case methods.

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