Susanna Vanhamäki

IMPLEMENTATION OF CIRCULAR ECONOMY IN REGIONAL STRATEGIES

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Abstract

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One proposed solution to the sustainability crisis is to pursue a circular economy, which is a regenerative economic system that aims to design out waste while keeping products and materials in use for as long as possible. This dissertation focuses on the adoption of a circular economy in European regional-level strategies. It strives to discover how regional strategies can support society to promote a sustainable future approach, in this case, in the form of the circular economy. The research explores to what extent the circular economy is present in European regional strategies and how the circular economy is implemented in the framework of smart specialisation, and finally, it presents a regional circular economy strategy process from the Päijät-Häme region in Finland.

The thesis consists of four substudies. A qualitative research approach is utilised in the dissertation involving a qualitative survey in six European regions, semistructured interviews with 12 regions and a case study of one regional process.

Regions play a central role in the pursuit of circularity. For a successful transition, the implementation of regional strategies is in a key position. In this process, support on both the international and national levels is crucial. However, the perception of the circular economy needs to be broadened, moving beyond waste management and recycling towards a holistic and systemic understanding. The importance of a bottom-up approach in strategy processes is recognised and utilised in the regions, yet diversification needs to be supported. Combining the circular economy and smart specialisation goals can help support the sustainability transition. However, concretising priorities and roadmaps into organised action plans is still in the development phase, even if separate circular actions occur. In particular, the monitoring and evaluation of strategies needs more attention.

The regions have started the transition towards the circular economy. There is a need for developing the understanding of sustainability, strengthening stakeholder involvement, coordinating actions and monitoring goals and activities in order for regional strategies to support the transition. Innovative thinking can help regional actors find synergies in the strategy processes. The regional authorities responsible for development strategies are in a crucial position in supporting the development. Concrete activities and changes in perception are necessary on all levels, both in policy and practice, research and business, and above all, in the minds of citizens.

Keywords: circular economy, regional strategy, smart specialisation, strategy implementation

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First, I want to express my sincere gratitude to my supervisors, Professor Lassi Linnanen and Dr Kati Manskinen. Lassi, your guidance and supervision have given me peace and confidence that this research has been worth doing. Kati, the discussions, support and guidance have been a light and joy during this whole process. Without you, this thesis would never have been done. Thank you for believing in me.

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Susanna Vanhamäki
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Contents

List of publications

This dissertation is based on the following papers. The rights have been granted by the publishers to include the papers in this dissertation.

I. Vanhamäki, S., Medkova, K., Malamakis, A., Kontogianni, S., Marisova, E., Huisman, D. and Moussiopoulos, N. (2019). Bio-based circular economy in European national and regional strategies. *International Journal of Sustainable Development and Planning*, 14(1), pp. 31-43.

II. Vanhamäki, S., Rinkinen, S. and Manskinen, K. (2021). Adapting a circular economy in regional strategies of the European Union. *Sustainability*, 13(3), 1518.

III. Vanhamäki, S., Manskinen, K., Rinkinen, S. and Linnanen, L. (2021). Perspectives of sustainable circular economy in regional innovation policies. Conference article. Presented at t*he 27th International Sustainable Development Research Society Conference 13-15.7.2021*, Östersund, Sweden.

IV. Vanhamäki, S., Virtanen, M., Luste, S. and Manskinen, K. (2020). Transition towards a circular economy at a regional level: Case study on closing biological loops. *Resources, Conservation and Recycling*, 156, 104716.

Author's contribution

Susanna Vanhamäki is the first author of all papers. More detailed descriptions of the author's contributions are listed below.

I: The author developed the research plan together with the co-authors. The author organised the data collection and participated in it. The author wrote most of the manuscript and drew conclusions with the co-authors.

II: The author developed the research plan together with the co-authors. The conceptual framework was set up by the co-author Satu Rinkinen. The author conducted the interviews and part of the literature review. The author was responsible for the data analysis. The author wrote most of the manuscript and drew conclusions with the co-authors.

III: The author developed the research plan together with the co-authors. The author conducted the interviews and the literature review. The author conducted the data analysis and wrote the manuscript. The author drew conclusions with the co-authors.

IV: The author developed the research plan together with the co-authors. The author wrote the strategic approach and methodology. Together with the co-authors, the author wrote the manuscript and drew conclusions.

1 Introduction

1.1 Research environment and motivation

In the framework of European Union policies regarding the development of the circular economy, this dissertation focuses on a relevant topic that has yet to be well researched, that is, the adoption of the circular economy in regional level strategies. The research concentrates on how regional strategies, such as the smart specialisation strategy, can support society in promoting a sustainable future approach, in this case, in the form of the circular economy.

The world has been facing various crises and will continue to do so. Industrialisation has brought challenges on an international level. For example, over the last century, human activities have resulted in climate change, biodiversity loss and energy and resource shortages. This development has raised questions related to the earth's carrying capacity, and humans' role in reaching a balance with nature. This fundamental issue, caused by technological progress and economic development, has been framed as the sustainability debate (Du Pisani, 2006). It is commonly agreed that a transition to a sustainable society is necessary.

In response to the changing environment, efforts have been made in both theory and practice, that is, on academic, governance and action levels. One proposed solution to achieve a more sustainable future has been to pursue a circular economy, which is a regenerative economic system that aims to design out waste and pollution while keeping products and materials in use for as long as possible (Ellen MacArthur Foundation [EMF], 2012). The circular economy indicates a possible model of sustainable growth and has rapidly been developed into a relevant concept in the sustainability debate. The concept has been gaining wider use since 2012, and since 2015, it has been a central part of European Union (EU) policy. The urgency of limiting the use of natural resources and closing material loops has received increasing global attention, and the popularity of the circular economy concept in politics has resulted in a growing interest in the topic in scientific research.

To achieve long term and systemic changes towards a sustainable and circular society, a consensus on how to proceed is needed on all levels of governance: international, national, regional and local (European Commission [EC], 2015). The international and national levels guide the direction, whereas more concrete actions are planned and realised on the regional and local levels. Regional policy and regional strategies have a central role in supporting the systemic change in practice.

At the same time the circular economy came to the forefront, smart specialisation was launched as part of the EU regional innovation policy. First, smart specialisation was presented as an academic concept by Foray and van Ark (2007), but quickly thereafter, it was developed for policy purposes. The Europe 2020 strategy was set up in 2010, calling

for “smart, sustainable and inclusive growth” (EC, 2010a). The strategy identifies a set of grand challenges, for example, climate change, resource efficiency and raw material scarcity, to be tackled through regional policy and its funding instruments (EC, 2010a, 2010b). It steers regional development by emphasising a focus on “smart specialisation” in regional innovation policy (EC, 2010a). The concept of smart specialisation means identifying a region’s competitive advantages with the aim of developing targeted strategies for further improving its competitiveness (Barca, 2009; EC, 2010b; Foray, 2014). Regions have specific spatial, technical and social characteristics depending on, among other things, their national environment, industrial structure and background. Smart specialisation supports regional actors in building on the region’s existing strengths while aiming to see new possibilities. It encourages regional actors to focus research, development and innovation on regional potential strengths that are in line with the goals of the Europe 2020 strategy. In practice, the EU member states have been implementing the circular economy and smart specialisation policies side by side during the last programming period, 2014–2020.

In science, policy and practice, concepts are being debated and developed, especially new ones like the circular economy and smart specialisation. Hence, the perspective on the circular economy has changed since the beginning of this study in 2016. Since the publication of the Circular Economy Action Plan in 2015, the EU has carried out several policy reforms, for example, those related to landfilling, waste prevention, packaging, plastics and eco-design (Calisto Friant et al., 2021). In only five years, the research environment and understanding of sustainability as a fundamental part of the circular economy has evolved dramatically. For example, in 2018, the EU bioeconomy strategy was updated to include sustainability aspects, and in 2020, the EU circular economy action plan was revised more or less for the same reason. Furthermore, the concept of smart specialisation has been contested and developed. Subareas related to the process of setting regional priorities and moving towards actions have been renamed and clarified (see Foray, 2019; Hassink and Gong, 2019). For this study, the research material was gathered between the years 2015 and 2019, and the writing process continued until 2021. This means that the understanding of the sustainability in the circular economy and the implementation of smart specialisation in regional level policy evolved over the time of the data collection and research process of this dissertation.

Overall, circular economy research is still young. Much of the discourse development has been carried out by governments or the private sector (Korhonen et al., 2018b; Calisto Friant et al., 2020). In academia, the focus has been placed on the concrete implementation of the circular economy on the company and ecosystem levels and on debating the concept itself (e.g. Ghisellini et al., 2016; Kirchherr et al., 2017; Korhonen et al., 2018a, 2018b). In practice, circular economy strategies have been set up on the regional level, for example, in Dutch Flanders (Circular Flanders, 2017) and in Finnish Päijät-Häme and Southwest Finland (Lahti University of Applied Sciences, 2017; Circular Economy in Southwest Finland, 2021), and on the local or city level, for example, in Amsterdam and Paris (Amsterdam Circular, 2015; Mairie de Paris, 2017). However, the application of the circular economy in the implementation of regional level

strategies has not yet been a widely studied topic in academia. One study was conducted on a case in Scotland (Whicher et al., 2018). Silvestri et al. (2020) conducted a statistical comparison on the circular economy performance of European regions. Arsova et al. (2021) recently published a study on stakeholder involvement in regional circular economy policies. Furthermore, from a policy perspective, research on circular economy regional monitoring for supporting policies in the EU has been conducted (e.g. Avdiushchenko; 2018; Avdiushchenko and Zając, 2019).

Likewise, the design and compilation of smart specialisation strategies in general has been the focus of several studies (e.g. Camagni and Capello, 2013; Capello and Kroll, 2016; Hassink and Gong, 2019). Still, the implementation of the strategies in practice through the roadmap and action plan stages has not yet been well researched, as smart specialisation strategies have only been in place during the 2014–2020 EU programming period. Practically oriented reports on the implementation phase have been published (e.g. EC, 2016; Leino and Hunter, 2020), and a few academic case studies of single regions or countries implementing the smart specialisation process do exist (e.g. Pugh, 2014; Paliokaitė et al., 2016; Teräs and Mäenpää, 2016). However, multicountry comparisons and examples of best practices are scarce.

Supporting the circular economy transformation on the regional level is essential, as there is a need for a more focused approach than a national one, which still reflects wider territories than urban areas (Silvestri et al., 2020). The interest of this study is to discover what affects regional circular economy strategies and how the implementation of regional strategies, combined, for example, with the smart specialisation strategy, can support the transition to a circular economy. To the best of my knowledge, the relation between smart specialisation strategies and the circular economy has not yet been studied from this perspective.

The academic discipline of this research is sustainability science, as the study aims to develop solutions to fight the sustainability crisis. Sustainability science is a novel field of research characterised as being devoted to studying or transforming the way human societies interact with and depend upon the natural environment (Nagatsu et al., 2020). The results of this study increase the knowledge available to authorities and policymakers about what is needed on the regional policy level to support the transition towards a circular economy. In addition, the results are also applicable to other fields as a guideline of what should be taken into consideration when designing and implementing regional smart specialisation strategies.

As a geographer, my attention is directed on how external factors affect regional development and, further, how decisions may affect the actors in the region. It has been interesting to follow the sustainability discussion and the increasing focus on the circular economy in the regions. During my professional journey as a contributor in several research and development projects, mainly in the field of the circular economy, it has been fascinating to learn about the regional differences in European policy and practice as well as to try to understand the different starting and standing points of regional

development. Sometimes, even if we were talking about the same component of the EU policy, the situation can be totally dissimilar in one country than in the other. Moreover, the differences in circular economy development have provoked several eye-opening exchanges. The differences in government and regional interpretations have taught me that there are often several paths towards a desired outcome. Still, there is usually no solution that fits all regions; however, we can learn from each other and transform the knowledge to other regional settings.

1.2 Aim and research questions

This study intends to provide perceptions on the implementation of the circular economy in regional strategies within the EU. The dissertation bridges the gap between the interpretation and implementation of the circular economy in the regions. The aim of the study is to provide new insights into how the circular economy is presented and concretised in the regional strategies and to discover what affects the differences in regional situations.

This thesis consists of four research articles which answer one main research question and three subquestions. The main research question is as follows:

What aspects exist within the implementation of the circular economy in European regional strategies?

The aim is not to find an answer that fits all regions, because such a solution does not exist, but rather to provide knowledge on what affects the regional situations and how regional circular economy policy development is framed by the government, practice and academia. The main research question is addressed through the following subquestions:

SQ1: How is the circular economy present in European regional strategies?

The first subquestion is studied through Article I. This subquestion aims to examine, by studying both national and regional strategies, to what extent the concept of the circular economy appears and is understood from the perspective of six European regions. Additionally, the aim of the subquestion is to discover if circularity aspects are noted in the strategies, even if the term “circular economy” itself might not yet be in use. In its entirety, Article I covers an analysis of both the circular economy and bio-based circular economy strategies. However, for the purpose of this thesis, the examination is limited to the circular economy in general, while outcomes related to the bio-based circular economy are left in the background. The methodology used for answering SQ1 is presented in Section 3.2.1 and the results in Section 4.1.

SQ2: How are circular economy-related thematic priority areas formed and concretised in regional smart specialisation strategies?

This subquestion is addressed in two articles which are based on the same research data. The question focuses on material gathered from 12 EU regions that have named "circular economy" a priority in their smart specialisation strategies. The extensive research material enabled two different perspectives to be analysed. Hence, the subquestion is two-fold. First, it focuses on the smart specialisation process and the existence of a more detailed regional strategy – a roadmap – to the circular economy and whether the roadmap's objectives have been further defined in an action plan or concretised through actions taken (Article II). Second, it aims to explore the regional driving forces of the circular economy context and why it has been included as a concept in the regional innovation policy (Article III). The methodology used for answering SQ2 is presented in Section 3.2.2 and the results in Section 4.2.

SQ3: What are the challenges and opportunities of a regional circular economy strategy process?

The aim of the third subquestion is to study how a detailed regional circular economy strategy process, roadmap process, has been implemented in practice in one European region: Päijät-Häme, Finland. The goal is to detect an example of how to build a roadmap by bringing together stakeholders to lay the base for pursuing regional circular economy targets. In addition to the strategy process, Article IV also presents an example of a regional bio-based circular economy. However, as the focus of this dissertation is on the implementation of strategies, that part of the article is excluded from the study. The methodology used for answering SQ3 is presented in Section 3.2.3 and the results in Section 4.3.

This thesis consists of an introductory part and four scientific publications (Articles I–IV). The introduction begins by presenting the theoretical background of the topic. To increase the understanding of the central concepts and links between them, a literature review of the specific premises is elaborated. The thesis continues with the description of the research design and methodology. This is followed by a review of the results, a summary discussion and conclusions. The four original publications which form this thesis are found at the end. As explained, in this dissertation, the focus is on implementing the circular economy in regional strategies not on addressing any specific subfield of the circular economy. The publications are utilised in establishing the understanding with the two above mentioned limitations. In addition to the strategy perspectives, Articles I and IV contain analyses of the bio-based circular economy. However, for the purpose of this synopsis, this content is out of scope. The structure of the thesis regarding the research questions and articles is presented in Table 1:1.

Table 1:1: The structure of the thesis

Overall research question: What aspects exist within the implementation of the circular economy in European regional strategies?	
Subquestions	**Article(s) answering the subquestions**
SQ1. How is the circular economy present in European regional strategies?	Article I
SQ2. How are circular economy-related thematic priority areas formed and concretised in regional smart specialisation strategies?	Articles II and III
SQ3. What are the challenges and opportunities of a regional circular economy strategy process?	Article IV

Figure 1:1 presents the connections between the articles. It shows the names of the six studied countries and regions (Article I). It also introduces the 12 regions which have named "circular economy" as a priority in their smart specialisation strategy (Articles II & III). Finally, it presents the case study of the Päijät-Häme region in Finland (Articles IV). In addition, the figure shows that the Päijät-Häme region is a connecting factor between the articles, as it has been in focus in all four articles.

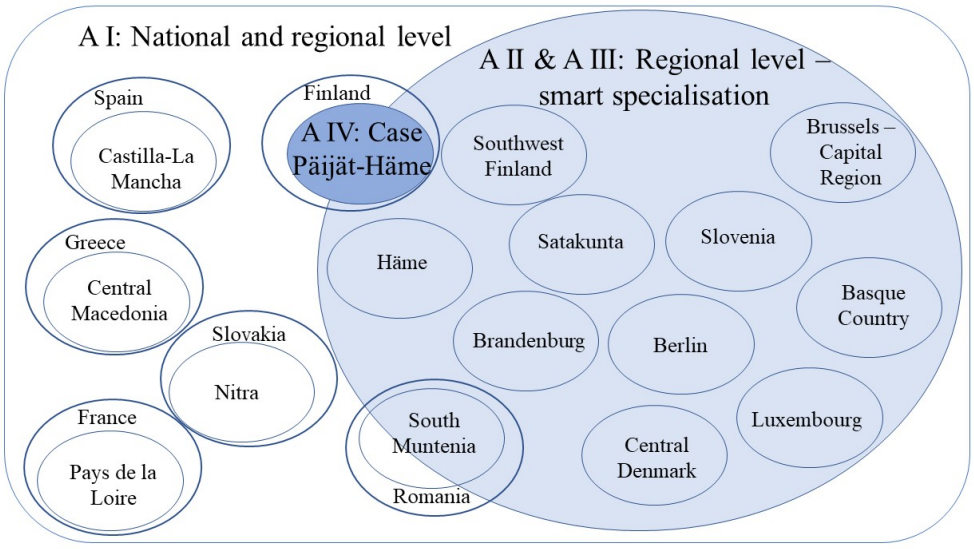

Figure 1:1: Connections between the articles (A) and the regions.

2 Theoretical background

2.1 Regional policy supporting a sustainable future

2.1.1 Regional policy and regional innovation policy

Before the 1990s, innovation and technology policy focused mainly on national technological competitiveness and economic growth (Koschatzky, 2005). In the 1990s, globalisation and the need to achieve competitiveness started to divert attention to the regional level, and focus was placed on gathering regional assets (Jauhiainen, 2008). Furthermore, the importance of the regional dimension was pointed out as central for economies to be able to act in a global environment (Oughton et al., 2002).

The basic idea of regional policy is that governments intervene in the markets with the aim of distributing welfare more evenly among territories, for example, through subsidising companies in peripherical areas or enhancing the attractiveness of such regions by investing in infrastructure, public utilities and industries with many network linkages (Lambooy and Boschma, 2001). Porter (1996) states that regional policy should support specialisation, upgrading and trade among regions, including encouragement for cluster formation; however, it should not drive firms to locate in areas where they would lack infrastructure or face competitive disadvantages. Regional policy is more likely to be successful when its objectives are strongly embedded in the surrounding environment; however, it also has to cope with uncertainty, as new development paths cannot be planned or foreseen (Lambooy and Boschma, 2001).

According to Jauhiainen (2008), innovation has lately taken a central role in organising regional policy. There is widespread consensus on the positive associations among knowledge, technological innovation and competitiveness. Innovation increases the competitiveness of companies and brings new possibilities to a region (Jauhiainen, 2008). In fact, the ability to innovate is seen as one of the key determinants of economic performance (Muscio et al., 2015). An innovation process involves flows of technology and information between diverse actors, and a central mission of innovation policy is to foster these flows and related interactions (Dodgson and Bessant, 1996). Furthermore, innovation policy aims to enhance the innovation capacity of companies, networks and economies. Innovations are especially vital for countries that are not able to compete with a large domestic market or with production due to high labour cost (Jauhiainen, 2008).

Innovation-based growth is the central approach to promoting economic diversification and competitiveness. However, innovation has begun to be seen not only as high-tech industries but, more broadly, as interactive learning to develop the competitiveness of heterogenic regions (Asheim, 2019). According to Morgan (2017), the central issue of a successful regional innovation policy is more precisely the place-based approach, where the spatial context of a region is understood and valued. In addition to the place-based approach, a need for a transformative perspective on innovations has also been identified

(Schot and Steinmueller, 2018). The transformation or change of sociotechnical systems is very different from developing innovative technological solutions, as it refers to radical systemic changes regarding, for example, skills, infrastructure and regulations (Schot and Steinmueller, 2018). As the understanding of the importance and versatility of innovations has increased, regional policy has developed more towards regional innovation policy.

In practice, the implementation of regional innovation policy is not uncomplicated. Oughton et al. (2002) have explained one of the implementation challenges as the regional innovation paradox. The regional innovation paradox refers to the contradiction where regions in greater need of innovations – lagging regions – host a lower capacity to absorb funding earmarked for the promotion of innovation and related activities compared to more advanced regions (Oughton et al., 2002; Muscio et al., 2015; Marques and Morgan, 2018). To solve this challenge, policies should increase the capacity of regions to absorb innovation funds. To achieve this, tighter regional linkages are needed. The innovative performance of a region depends on the innovative capabilities of companies, universities and research institutions and on their interaction and cooperation with government institutions (Oughton et al., 2002; Muscio et al., 2015), in other words, the triple helix model. In this interplay, the regional government plays a key role as a catalyst in strengthening the links and enhancing regional learning (Oughton et al., 2002).

The triple helix model of regional innovation systems has been further developed into a quadruple helix, where the cooperation between industry, government (i.e. public authorities) and academia is expanded to include the role of citizens and civil society (Carayannis et al., 2018). Citizens are not only the users, but they can also be an important element of the innovation system if their content contribution is enabled by the other actors. Furthermore, a quintuple helix has been introduced as taking a wider view through an additional spatial dimension (Carayannis et al., 2018; Alessandrini et al., 2019). This brings attention to the distinct characteristics of a place, including both physical- and people-related assets, such as the workforce, competences, natural resources and technical facilities (Alessandrini et al., 2019). The place-based approach that the quintuple helix presents highlights the importance of connecting the innovation policy in a spatial context.

2.1.2 Smart specialisation in the European Union's regional policy

Regional policy is the EU's main investment policy, and it targets all regions to support economic growth and sustainable development and improve citizens' quality of life (EC, 2021a). The EU regional policy, also referred to as cohesion policy, is probably the largest set of regional development policies in the western world operating under the same institutional framework (D'Adda et al., 2020). Support transfers are organised through funds, where the structural funds and Cohesion Fund subsidise infrastructure, education and labour markets (Becker et al., 2018). The allocation of funding follows EU strategic directions. The policy provides a framework for strategies, which, in turn, deliver more concrete plans towards action.

In response to major economic challenges, the Europe 2020 strategy was set up by the EC in 2010 (EC, 2010a; Foray et al., 2012). The grand challenges identified in the Europe 2020 strategy, including climate change, energy and resource efficiency, raw material scarcity and demographic ageing, are addressed through the regional policy and its funding instruments (EC, 2010a, 2010b). Creating favourable conditions for innovation, education and research is seen as capable of unlocking the growth potential of the EU regions. The core of the strategy is about investing more in research, innovation and entrepreneurship, which are seen as crucial elements to support "smart, sustainable and inclusive growth" (EC, 2010a). Regional level policy plays a key role as a principle of action in the strategy because it highlights a place-based bottom-up approach (EC, 2010a; Foray et al., 2012). The cohesion policy and structural funds are central delivery mechanisms of the strategy (EC, 2010a), while the strategy sets a plan for actions.

In the Europe 2020 strategy, "smart specialisation" was introduced as a key element for place-based innovation policies (EC, 2010a; Foray et al., 2012). The smart specialisation approach was developed as a reaction to the large research and development gap between Europe and its important trading partners (Camagni and Capello, 2013). National and regional governments were encouraged to develop smart specialisation strategies in order to maximise the impact of regional policy and other EU policies (EC, 2010b). Currently, smart specialisation is the dominant approach to regional innovation policy in Europe (Pugh, 2018).

Smart specialisation is based on two fundamental ideas: a) "specialisation", a region should ensure a more effective use of public funds by concentrating resources on a few key priorities instead of spreading the support thinly across several areas; and b) "smart", regional growth possibilities should be built around current capabilities, which are further developed together with stakeholders through research, development and innovation (Barca, 2009; EC, 2010b; Foray, 2014; Balland et al., 2018; D'Adda et al., 2020). Smart specialisation is a process of setting priorities in national and regional research and innovation strategies where the aim is to achieve competitive advantages and build a base for an economic transformation driven by innovation (Landabaso, 2014).

Smart specialisation is turned into policy by organising a process where these new opportunities are recognised and supported in a targeted governmental process (Foray, 2014). The aim of a Research and Innovation Strategy for Smart Specialisation, also shortened as RIS3 or S3 (in this research hereafter referred to as "smart specialisation strategy"), is not to narrow down possibilities but to generate new options and specialities in order to develop the structures of the regional economy (Foray, 2014; Landabaso, 2014; Foray, 2016).

An existing smart specialisation strategy was set as an *ex-ante* condition for receiving funding from the EU structural funds for research and innovation investments in the 2014–2020 programming period (EU, 2013; EC, 2014). Through this cohesion policy, the EC pushed the member states and regions to proceed with smart specialisation.

According to Morgan (2017), this was the start of a whole new era in European regional policy.

The design of the smart specialisation strategies introduces two main novel approaches. First, it emphasises "entrepreneurial discovery", which calls for public-private collaboration and a bottom-up approach in which the region discovers its capabilities (Capello and Kroll, 2016; Pugh, 2018). Smart specialisation addresses the challenge of regional prioritising and allocating resources by involving entrepreneurial actors in the cooperation (Foray et al., 2012). The entrepreneurial discovery process means including regional stakeholders, such as businesses, networks of companies, universities and research institutes, in setting up the regional strategy (Foray et al., 2012; EU, 2013; Foray, 2016; Asheim, 2019). In practice, input from companies could come through cooperative networks rather than individual companies. The entrepreneurial knowledge and collaboration in each region are built based on regional features. Through the entrepreneurial discovery, areas with the greatest innovation potential in the region should be discovered (Capello and Kroll, 2016). The second novelty is that regional actors are encouraged to focus on certain regional domains rather than industry sectors (Foray et al., 2011; D'Adda et al., 2020). This is seen to enhance innovation and diversification by creating new openings. The new fields most frequently appear at the interface where a current strong sector is discovered in a new innovative way and thus transformed. Furthermore, support should be concentrated on activities rather than on companies.

Smart specialisation can happen spontaneously, but if it does not, a smart specialisation strategy process to facilitate this dynamic is necessary (Foray, 2014). Originally, the smart specialisation approach was defined as a six-step process: (1) analysing the regional situation and potential for innovation, (2) agreeing on an appropriate governance structure, (3) setting up a future vision for the region, (4) identifying and selecting priorities, (5) creating a suitable policy mix, roadmap and action plan and (6) integrating monitoring and evaluating mechanisms (Foray et al., 2012). Foray (2016) later explained that, in the big picture, a smart specialisation strategy has two main faces: forming local capabilities to drive changes and making the actual structural changes. To simplify the process of smart specialisation, Foray (2019) redescribed it as a three-step procedure: (1) identifying thematic priority areas, (2) modifying the priority areas into roadmaps and (3) setting up an action plan for implementation of the activities. Roadmaps and action plans are strategy documents in which the thematic priority areas are translated to the implementation phase. Roadmaps define the nature, scope and meaning of the investments within the priority area (Foray, 2019). The action plan phase focuses on information related to funding research, development and innovation activities, investments, involved actors (names of organisations), schedules, monitoring and evaluating the results, as well as developing a plan for updating the content (Foray, 2019). Foray (2019) also pointed out that the step from priority area to roadmap is the most challenging in the smart specialisation process, as it cannot happen if all actors are not committed to moving in the same direction or if the direction is unknown by the actors. The sustainability of a smart specialisation strategy depends on the suitability and

coordination of policy actions and on regional governance, where the ways of engaging the stakeholders play a central role (EC, 2010b).

According to Morgan (2017), the smart specialisation concept is the most ambitious regional innovation programme in regard to resources and how it demands the public sector to organise a collaborative process to involve stakeholders. To support the member states in the implementation of the smart specialisation process, the EC has established a smart specialisation platform: the "S3 platform". The platform provides advice and guidance for regional actors to develop, implement and review their smart specialisation strategies (EC, 2021c). While the platform is mainly directed towards policymakers, actors representing regions and member states are advised to sign up to receive support with their smart specialisation strategy process. The platform is designed to facilitate capacity building in the regions, which is essential for upgrading and developing their capabilities (McCann and Ortega-Argilés, 2016). In addition, the platform also contributes to the academic discussion and development of smart specialisation through research on EU policy (EC, 2021c).

2.1.3 Challenges in the implementation of smart specialisation

Smart specialisation as a concept is still new and developing. However, thanks to efforts by academics and policymakers, much progress has already been made in how smart specialisation initiatives and strategies are conducted (Foray, 2019). Criticism against the functionality of smart specialisation policy has been directed towards several aspects, including regional resources and capabilities of implementing and benefitting from it (e.g. McCann and Ortega-Argilés, 2016; Marques and Morgan, 2018; Hassink and Gong, 2019; Benner, 2020). For example, the success of entrepreneurial discovery can depend on the size of the region in question. Benner (2020) states that an inclusive, participatory and bottom-up process is extremely challenging to achieve if the region has up to 20 million inhabitants. This raises the central question of a suitable region size for the smart specialisation process. Strategies for different spatial entities have a totally different procedure. If they are set on the national level, even if the country is small, the smart specialisation process usually does not allow cross-sectoral exchange between ministries, but also if they are set in regions that are too large, the participatory process is difficult (Benner, 2020). At the moment, it is up the member states and their regions to define the spatial scale of the smart specialisation.

Another challenge in applying regional innovation policy in Europe is in the great economic and institutional differences among the regions (McCann and Ortega-Argilés, 2016). Hassink and Gong (2019) point out that, in large and already successful regional economies, the smart specialisation process is not meaningful. In contrast, less advanced regions have had difficulties implementing the smart specialisation process. As the concept might not be as beneficial as for all types of regions, Foray, one of the developers behind the smart specialisation idea, states that the concept seems to be best suited for intermediate regions (Foray, 2019). The quality of governance, in particular, plays a central role in whether a region succeeds with smart specialisation. The process places

enormous demands on the public sector to organise entrepreneurial discovery, collect quantitative data on economic strengths and process this for the policy instruments (Marques and Morgan, 2018). All regions do not have this capacity, not to mention the capacity to implement the policies later on (Marques and Morgan, 2018). Peripheral regions especially suffer from institutional weaknesses that can challenge the smart specialisation strategy (Karo and Kattel, 2015; Balland et al., 2018). Also, Landabaso (2014) states that regional innovation policy has had a limited impact because some regional governments feel threatened by the transparent and inclusive bottom-up process that the smart specialisation programme calls for. Poor quality of governance that risks the smart specialisation process is also related to corruption, which has been seen to occur in several member states (Marques and Morgan, 2018). For example, local elites can aim to affect the process in steering prioritisation to areas where they maintain control (McCann and Ortega-Argilés, 2015). Some regions also lack research institutes, which play an important part in the entrepreneurial discovery process. However, overall, even if criticised, the idea of the self-discovery (or entrepreneurial discovery) process is fruitful for regional exchange and development (Benner, 2020).

Generally, innovation is no longer seen as only being related to high-tech industries but as broader, as a way of developing the competitiveness of regions (Asheim, 2019). Foray (2019) highlights that the smart specialisation process should include an extensive variety of innovative activities that are relevant for the regions in the specialisation, not all of them necessarily related to research and development or to high-tech industries. However, Benner (2020) argues that this has not been fully realised as the regions set their priorities, as important fields of the economy are missing from the EC's S3 platform. Instead of smart specialisation being utilised as a cross-sectoral document promoting innovation, sectoral policies coexist in several regions (Benner, 2020). Yet, benefits can be seen by combining a sectoral approach with a broader, more integrative one of science, technology, economy, environmental perspectives and social sciences. Moreover, when searching for regional strengths, it is obvious that the regional history of innovation policy plays a certain role. Here, Pugh (2014; 2018) points out the risk of reapplying already tried and tested approaches that earlier failed to deliver in the region.

An additional obstacle in the implementation of the smart specialisation process can occur regarding the fact that regional actors might be missing routines in bottom-up coordination (Karo and Kattel, 2015; McCann and Ortega-Argilés, 2016; Balland et al., 2018; Hassink and Gong, 2019). In Central and especially Eastern Europe, bottom-up coordination is still somewhat unfamiliar due to a lower stage of general economic development or the absence of a local collaboration culture (Karo and Kattel, 2015). In fact, according to Capello and Kroll (2016), several member states are in favour of traditional top-down planning because they are simply more used to it. Furthermore, giving too much room for bottom-up stakeholder involvement can also be a challenge from a political point of view (Capello and Kroll, 2016). It should be noted that the short time period for the member states to set up their smart specialisation strategies caused a situation where regional development authorities might have been tempted to follow old

methods, as the guidelines were given in 2012 and the programming period started in 2014. This has also been noted by Fitjar et al. (2019).

The path towards innovations in the regions is not secured only through investing in research and development and thereafter "wishing" for inventions and innovations; the innovation patterns are different among regions depending on their regional context (Camagni and Capello, 2013; Marques and Morgan, 2018). To boost the regional innovation policy in less advanced regions, the whole set of capabilities needs to be addressed (Foray, 2016; Asheim, 2019). To support regional actors, there is a need to gradually improve the policy and involvement of stakeholders to develop the administrative routines (Karo and Kattel, 2015), and the realisation of the process itself provides opportunities for this institutional learning and upgrading of governance (McCann and Ortega-Argilés, 2016). As Foray (2016) puts it, there is a need for the policy to support the public research infrastructure while also helping the networks of stakeholders see a new field of opportunities.

In general, the assumption that the universities, companies and government in a region are smoothly moving towards a universal goal is usually not the reality (Marques and Morgan, 2018). This is a challenge in all regions but even more so in lagging regions. As explained in the regional innovation paradox, there is a risk that the regions most in need of help cannot benefit from smart specialisation due to low institutional capacity (Muscio et al., 2015; Marques and Morgan, 2018). These regions exist in the peripheral areas, especially in Eastern and Southern Europe.

The implementation of a smart specialisation strategy process changes the space of the traditional policy setting. Europe has a long history of a top-down planning mode, where the government has preselected target industries (Capello and Kroll, 2016; Foray, 2016). However, the smart specialisation process does not exclude the need for government; rather, it aims to combine the top-down and bottom-up approaches. As Foray (2014; 2016) explains, the smart specialisation process recognises the need for the government in making strategic decisions and interventions to support the regional networks and ecosystems, but it also understands and pays attention to the need to not make mistakes associated with the central planning mode. The top-down approach is suitable when the priority area is chosen (Foray, 2019). Thus, the place-based approach of smart specialisation is intended to be formulated and developed by local actors and stakeholders on the basis of the analysis and engagement activities; that is, it cannot be enforced top-down by authorities (Barca, 2009; McCann and Ortega-Argilés, 2016). In the smart specialisation strategy process, the bottom-up should meet the top-down.

To be successful, a smart specialisation strategy should be supported by careful evaluation and empirical evidence of the regional potential as well as by ongoing monitoring and the use of outcome indicators (McCann and Ortega-Argilés, 2015; Kotnik and Petrin, 2017). However, interpreting, processing and extracting the relevant data can be a challenge for policymakers (Kotnik and Petrin, 2017). According to Nauwelaers' (2013) study, a wide range of methods for defining priority areas is broadly in use. Still,

challenges arise in narrowing down the specialisation niches. Furthermore, policymakers who were the subjects of their study were in many cases defining the regional priorities around societal challenges or lead markets (Nauwelaers, 2013).

As stated, EU innovation policy aims for a "smart, sustainable and inclusive Europe" (EC, 2010a). However, Fitjar et al. (2019) point out that the main focus has so far been on promoting the smart (i.e. competitive) aspects, while inclusive and sustainable regional economic development has often been left in the background. To address the challenge of involving inclusiveness and sustainability, they propose including responsible research and innovation elements in the smart specialisation approach in order to achieve regional responsible research and innovation policy (Fitjar et al. 2019). In line with this aim, Schot and Steinmuller (2018) suggest that science and technology policy could be used for meeting social needs and addressing the issues of sustainable and inclusive societies at a fundamental level.

In the scientific field, much focus has been placed on regional actors' abilities to set up smart specialisation strategies. However, the even more crucial challenge is how to implement them successfully in practice and follow up on the achievements. Marques and Morgan (2018) point out the concern in whether the strategies will be implemented with the same care as they were designed A study in Lithuania also highlights that, even if a smart specialisation process is successfully carried out, implementing it into actual policy decisions can be challenging and that value created can be lost in this "translation" process (Paliokaitė et al., 2016). Also Capello and Kroll (2016) state that the future success of the smart specialisation concept depends on the capacity of strategies to make innovation and knowledge serve their implementation in a way that regions would see their unused opportunities.

The EC's handbook for implementing smart specialisation strategies from 2016 provides practical examples on implementation through short case presentations of actions and projects related to smart specialisation priorities (EC, 2016). However, it is worth noting that, as Foray's (2019) explanation of the smart specialisation process has developed in the last years, the handbook does not emphasise the roadmap or the action plan stages. Even if the smart specialisation strategies have been a precondition for receiving funding from the EU structural funds during 2014–2020, it is still quite early to evaluate the success of the actual implementation or translation of the strategies, that is, setting up roadmaps, action plans or funding projects supported by the smart specialisation approach.

Several papers have been published on smart specialisation building processes (see e.g. Pugh, 2014; Kroll, 2015; Paliokaitė et al., 2016; Teräs and Mäenpää, 2016; Virkkala et al., 2017). Based on research, challenges have arisen in implementing smart specialisation policies into practice, which has been the case since the launch of the concept (McCann and Ortega Argiles, 2014). Pugh (2018) points out that little guidance exists in the literature on smart specialisation to help policymakers know what to include in the strategies and how. More research is needed to better understand the practical challenges

the regions face. For example, in a recent study, D'Adda et al. (2020) described experiences from the implementation phase in Italian regions where there have been difficulties for regional authorities in turning principles into actual plans and actions. To develop the implementation, successful examples would increase the knowledge. Fellnhofer (2018) points out that multicounty comparisons, including best practice analysis of smart specialisation strategies, would be needed in the academic field. Furthermore, regional actors and networks would benefit from knowing whether specialisation efforts actually have produced new value-added activities and processes with larger impacts in other territories (Teräs and Mäenpää, 2016).

Despite the criticism directed towards the concept of smart specialisation, it contains a lot of potential. Pugh (2018) suggests that the concept needs some "re-packaging" to adapt theory and practice to the political, economic and social change taking place. Concluding the discussion related to the implementation of smart specialisation, it can be said that the details of the smart specialisation policy design and implementation depend on the assets of each region. Economic and sectoral structures, institutional frameworks, entrepreneurial actors and place-based logic sets different starting points for the regions (McCann and Ortega Argiles, 2014). However, even if regional innovation is rooted in territorial elements of society and smart specialisation arises from regional resources, innovations can be diffused and shared in other places than from where they originate, for example, through interregional networks (Camagni and Capello, 2013). Interregional learning and networking are crucial in overcoming the challenges of the regional innovation paradox (Oughton et al., 2002). The aim of the EC is to support the development and exchange related to smart specialisation between member states and regions through the "S3 platform" and funding instruments (EC, 2021c).

Circulating back to the beginning of the section, where the aim of regional policy and innovation policy was presented as supporting the competitiveness of a region, I now move on to present circular economy aspects in the regional context. As the Europe 2020 strategy aims to address the grand challenges related to climate change, energy and resource efficiency and raw material scarcity through smart specialisation (EC, 2010a, 2010b), the discussion regarding ways to achieve sustainability is crucial and tightly related to regional activities. Supporting research and innovation is a main factor in encouraging the European circular economy transition, while at the same time contributing to the competitiveness and modernisation of the EU's industry (Alessandrini et al., 2019). In the new 2021–2027 programming period, the structural funds will support the environmental scope even more strongly than before, as the majority of the funding will focus on smart growth and the green economy (Alessandrini et al., 2019).

2.2 The framework of the circular economy

2.2.1 Sustainability and sustainable development

Pursuing a circular economy can be seen as a means of achieving a more sustainable future. First, the background of the sustainability discussion will be explained in order to justify its importance in the development of a circular economy.

Sustainability, as the concept is used today, originates from concern about damage to the natural environment caused by the technological progress and economic development after the world wars (Du Pisani, 2006). In the 1960s and 1970s, ecological disasters received much publicity. The Club of Rome's report in 1972, "The Limits to Growth", concerning the exponential economic expansion and population growth, launched the continuing environmental debate on the limitations of the earth's carrying capacity to support human economic development (Meadows et al., 1972). This can also be seen as the starting point for the discussion where the angle changed from imprecise environmental concern to a search for solutions for alternative societal development (Kenny, 1994; Du Pisani, 2006).

The concept of sustainable development was introduced in the 1970s as a compromise between the former conflicting ideas of development and conservation (Du Pisani, 2006). In the 1980s, the paradigm of sustainable development was popularised to a great deal due to the report "Our Common Future", also known as the Brundtland Repot, published in 1987 by the United Nations (UN) (World Commission on Environment and Development [WCED], 1987; Sneddon et al., 2006; Olawumi and Chan, 2018). In the report, sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainable development aims to find a balance between the natural ecosystem and meeting present and future human needs.

The three pillars of sustainable development – environmental, social and economic sustainability – should all be balanced to achieve sustainable development (WCED, 1987). However, the concept is interpreted in various ways depending on different value orientations. Janeiro and Patel (2015) explain how sustainable development looks different from the economic standpoint than from the ecologic or social view, depending on which forms of capital are being preserved: natural, human-made or moral. Environmental sustainability typically refers to fighting challenges related to climate change, pollution and loss of biodiversity. It comprises limiting human activities within the carrying capacity of the ecosystem related to materials, energy and use of land and water (WCED, 1987; Olawumi and Chan, 2018). Environmentally sustainable development is about sustainable levels of both production and consumption (Goodland, 1995). Economic sustainability includes efficient use of resources, both renewable and nonrenewable, as well as enhancing operational profit (Goodland, 1995). It also contains reuse and recycling (Olawumi and Chan, 2018). Social sustainability concentrates on

humans and societies with the aim of decreasing inequality and poverty, additionally implying social equity between generations (WCED, 1987; Goodland, 1995).

However, Levett (1998) claims that the environmental, social and economic factors of sustainability cannot be seen as equally important. This argument is based on the fact that the environment is a precondition for the two others. Without the environment, we would not have society or the economy. Furthermore, the economy has been created by society. Maintenance of life-support systems, such as environmental sustainability, is a prerequisite for the whole sustainability discussion (Goodland, 1995). This Russian doll model places the economy in the centre, surrounded by society and the environment. Furthermore, the Brundtland report marks the environment as a critically important feature of international governance, while also indicating that all three aspects are interconnected (WCED, 1987; Sneddon et al., 2006). Nevertheless, more widespread is the Venn presentation with three overlapping circles that describes environmental, social and economic factors as being equally important and interrelated (Dragicevic, 2018). However, both models are criticised for not showing the interaction or complexities between the three factors (Davidson, 2014; Dragicevic, 2018) or the time-dependent dynamics.

The relation between sustainability and sustainable development has been discussed by several scientists, as presented by Dragicevic (2018) and Olawumi and Chan (2018). For example, Shaker (2015) sees that sustainable development approaches and processes lead to sustainability. Axelsson et al. (2011) claim that sustainable development is a collective societal process in which multiple stakeholders contribute to governance. In this study, sustainable development is understood as environmental, social and economic development with the aim to reach sustainability.

In the last few decades, the ideal of sustainable development has been increasingly adopted in policies around the world (Janeiro and Patel, 2015). It has been recognised that environmental and economic problems are linked to many social and political factors and that it is impossible to separate them. In 2015, the UN General Assembly set up the 2030 Agenda for Sustainable Development, stating 17 global goals to achieve a more sustainable future (UN, 2015). The sustainable development goals define urgent necessary actions in all countries (UN, 2015). The goals and their related targets focus on interrelated ecological, social and economic issues that are crucial for the future of humanity and our planet. The sustainable development goals underline the fact that ending poverty has to be supported by improving health and education, increasing equality and economic growth, while also tackling climate change and protecting nature (UN, 2015). Thus, both ecological, economic and social systems all must also be included in research and practical work towards sustainability.

To achieve a sustainable development, the economy needs to develop its resiliency and low-carbon enterprises need to succeed, while people need to find meaningful employment (Jackson, 2011). Policies and academic literature combine environmental and sustainability discourses with industrial and economic policy to find effective

solutions for progress and success (Bina, 2013). However, the structural drivers of the conventional economy are not sufficient to deliver this. It has become commonly acknowledged that the traditional way, the "linear economy", of creating economic growth through extracting, manufacturing and using raw materials and finally throwing them away cannot lead to sustainable development (Millar et al., 2019). This development in society, along with academic research linked to sustainable development, has resulted in the birth of several related concepts and subfields (Billi et al., 2021; D'Amato et al., 2017). The sustainable economy concepts most relevant to this study are presented in the following.

2.2.2 Expansion of sustainability concepts

The discussion regarding the adequacy of natural resources for the modern economy and the transition from a fossil-based to a more sustainable path of development has been a driver behind the expansion of several new related concepts. Sustainability concepts share the ideal of reconciling economic, environmental and social goals. Over the past decade, the concept has gained political interest and has influenced several societal actors, for example, academia, non-governmental institutions and policymakers (D'Amato et al., 2017).

The terms "green" and "bio" link several environmentally oriented concepts to the sustainability discussion. Green economy and green growth became popular concepts through the UN Conference on Sustainable Development in Rio de Janeiro in 2012 (Lorek and Spangenberg, 2014; Loiseau et al., 2016; D'Amato et al., 2017). The two terms are often used interchangeably, and they refer to a range of interceptions, from a narrow frame of environmentally friendly production to renewing the whole economy (Bina, 2013). Most commonly, a green economy is seen as an umbrella concept that values all ecological processes, supports investments that reduce carbon emissions and pollution, encourages energy and resource efficiency and supports social inclusion (UN Environmental Program, 2011; Barbier, 2012; Louiseau et al., 2016; D'Amato et al., 2017). To succeed, the green economy transition would require both sustainable production and consumption as well as democracy and international cooperation to solve global environmental and social problems (Lorek and Spangenberg, 2014). However, Le Blanc (2011) and Louiseau et al. (2016) point out questions related to the concept's suitability to actually achieve sustainability, as its motivations related to economic growth and sustainability are, to some extent, not consistent. In addition, Lorek and Spangenberg (2014) claim that the green economy fails to provide the radical changes needed. They explain that growth does not lead to reduced environmental impacts nor does substantially reduce poverty. However, Bina (2013) points out that one important effect of the discussion on green economy has been an economisation of the sustainable development discourse.

Another concept linked to the sustainability discussion is the bioeconomy. The bioeconomy is based on the idea that biological processes are applied in the economy and that bio-based resources are replacing raw fossil materials in the economy (Dietz et al.,

2018). The bioeconomy relies on renewable biological resources, for example, plants, crops and animals, and their transformation into products, materials and energy (EC, 2012; McCormick and Kautto, 2013). The scope of the bioeconomy also includes the utilisation of organic waste (EC, 2018).

The bioeconomy and the bio-based economy are often used synonymously (Pfau et al., 2014). However, they have slightly different meanings. Staffas et al. (2013) explain that the term bioeconomy is usually used when defining the concept as related to biotechnology, life science and linked technologies and applications comprising a specific part of the existing economy. However, the bio-based economy is frequently mentioned in documents that focus on an economy based on the use of biomass resources rather than fossil-based products. The bioeconomy is often seen as a sector, while the bio-based economy refers to a transformation of the economy as a whole (Staffas et al., 2013). The bioeconomy has been criticised for not necessarily supporting sustainability, as bio-based production is not automatically sustainable (Pfau et al., 2014). For example, the research of Staffas et al. (2013) notes that sustainability was seldom mentioned as a driving force behind bioeconomy strategies during 2008–2012, but rather the main driving force was the growing economy and reaching or retaining a world-leading position in the field. However, recently, the bioeconomy has adopted more sustainability aspects, and it can be seen as an inclusive concept (D'Amato et al., 2017). The bioeconomy and the bio-based economy are central background concepts in understanding the biological cycles of the circular economy.

The sustainability discussion also involves themes and terms related to cleaner production of materials and energy. The clean technologies (cleantech) sector includes technological innovations that support cleaner production and a green economy (e.g. related to renewable energy, energy efficiency and storage, nanotechnologies and material efficiency technologies) (Chapple et al., 2011; Caprotti, 2016). Cleaner production is considered one of the preceding concepts that lead towards the circular economy, especially on the company level (Su et al., 2013; Ghisellini et al., 2016).

2.2.3 Towards the concept of the circular economy

Often, the birth of the circular economy concept is linked with Pearce and Turner (1990), who presented the functions of the environment as seen from an economics perspective (see e.g. Su et al., 2013; Murray et al., 2015; Ghisellini et al., 2016; Geissdoerfer et al., 2017; McDowall et al., 2017; Merli et al., 2018). However, the basic idea behind the circular economy is old and can be dated back to the 19th century (Murray et al., 2015). Effective use and recycling of resources is the foundation behind the concept of the circular economy (Merli et al., 2018). The origins of the need for a circular economy arise from the challenges explained by Frosch and Gallopoulos (1989) that the traditional economy model "extract-produce-use-dump" will not be sufficient in the future (Korhonen et al., 2018a, 2018b). Instead, they present the idea of an industrial ecosystem where material and energy flows would imitate biological ecosystems (Frosch and Gallopoulos, 1989). This is explained as an industrial ecology where closing material

loops is seen as increasing material efficiency (Yuan et al., 2006; Andersen, 2007; Geng and Doberstein, 2008; Blomsma and Brennan, 2017; D'Amato et al., 2017; Merli et al., 2018). Industrial ecology aims for closed-loop industrial ecosystems with a balanced and diverse material exchange and energy cascading (Ehrenfeld, 1997; Despeisse et al., 2012). The core idea of industrial ecology is industrial symbiosis where material, energy and waste exchanges form a network of synergies between companies (Chertow, 2000, 2007; Lombardi and Laybourn, 2012). In industrial symbiosis, the "waste" of one actor is utilised as a resource by another player in the network. Industrial ecology has probably had the strongest practical influence in the definition of the circular economy (Lazarevic and Valve, 2017; Merli et al., 2018).

Overall, the circular economy as an umbrella concept has been in wider use since 2012, when the Ellen MacArthur Foundation (EMF) introduced it to the larger public. The circular economy refers to a regenerative economic model, different from the traditional linear economy. According to both scientists and practitioners, the circular economy means an economic system which aims to close material loops, reduce the need for raw materials, reduce waste disposal and maintain the value of products and resources for as long as possible (Geng and Doberstein, 2008; EMF, 2012; Ghisellini et al., 2016; Kirchherr et al., 2017).

The idea of the circular economy can be explained through technical or biological cycles, where the technical approach focuses on recycling, reusing and prolonging products' lifespans before utilising the material, while the biological cycle aims to keep the nutrients circulating for as long as possible (EMF, 2012). Several "R" frameworks have been used by academia and practitioners to describe the technical part of the circular economy (Blomsma and Brennan, 2017; Kirchherr et al., 2017). Often, the circular economy has been defined through the three principles reduce, reuse and recycle (Geng et al., 2012; Ghisellini et al., 2016). Even though the circular economy is frequently associated with recycling, it should be highlighted that this is not one of the most preferred sustainable solutions. Reusing, remanufacturing and refurbishing should be the desirable options before this (Korhonen et al., 2018a). However, as the principles show, the manufacturing and waste management sectors are central in the circularity discussion. The R imperatives related to the circular economy have ranged to up to over 10 during the last decade, presented in the following order: refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover (Kirchherr et al., 2017). Moreover, the discussion has continued to add even more, such as resilient and regulate, to the repertoire (Xing et al., 2017). According to Kirchherr et al. (2017), it is important that the imperatives follow the waste hierarchy, where reduce is prioritised over reuse and recycle, while the last option is recovery (for the waste hierarchy, see EU, 2008). The hierarchy thinking might, however, decrease the popularity of the circular economy concept because it implies limiting consumption and economic growth.

Even if the circular economy has gained much attention among both policymakers and academia in the last few years, it is still a developing concept from a scientific point of view (Kirchherr et al., 2017; Homrich et al., 2018; Korhonen et al., 2018a). The concept

has been used and developed mostly by practitioners and policymakers, while the scientific discussion around it is still rather young (see e.g. Korhonen et al., 2018a; Korhonen et al., 2018b). So far, no single definition has been agreed upon for what a circular economy means and includes (see e.g. Kirchherr et al., 2017; Korhonen et al., 2018a; Korhonen et al., 2018b; Schroeder et al., 2019). In addition to the definition of a circular economy, researchers are debating on the scope and operationalisation of it (see e.g. Blomsma and Brennan, 2017; Kirchherr et al., 2017; Homrich et al., 2018; Korhonen et al., 2018a, 2018b; Reike et al., 2018). The circular economy is an overarching concept, studied in several fields of science, and it relies on transdisciplinary research (Sauvé, 2016). Efforts to understand the circular economy have been undertaken, for example, through framing the various definitions in the literature (Kirchherr et al., 2017; Korhonen et al., 2018a), defining its link to sustainability (Ghisellini et al., 2016; Geissdoerfer et al., 2017) and specifying its connections with other nearby concepts, such as green economy, bioeconomy, industrial ecology and industrial symbiosis (D'Amato et al., 2017; Saavedra et al., 2018; Millar et al., 2019). However, structural questions regarding circular economy conceptualisation still remain unsolved (Reike et al., 2018). Nevertheless, there is a need to establish a common understanding and approach to the circular economy to enable scientists to define it with regard to other concepts (Schöggl et al., 2020). Kirchherr et al. (2017) conclude that the definition should comprise the R framework, including an (R or waste) hierarchy and the system perspective as well as environmental, economic and social dimensions of sustainability. The challenge is to include all these facets in a clear and not overly long definition. The following section explains the essential holistic and systemic perspectives of the circular economy.

2.2.4 Holistic and systemic perspectives on the circular economy

According to Skawińska and Zalewski (2018), the operation of biotic systems sets an ideal example of maximising benefits and minimising "efforts" in balance with their environment; that is, they form functioning holistic sustainable solutions. Thus, in society, the biological model has to be expanded by considering the aspects of the surrounding society.

The circular economy is one of the central and commonly used concepts emerging from the sustainability debate. In recent years, the circular economy has gained more traction as an approach for achieving local, national and global sustainability (Schroeder et al., 2019). It has presented an alternative development path that could be both profitable and sustainable (Lazarevic and Valve, 2017; Korhonen et al., 2018a; Desing et al., 2020). The uniqueness of the circular economy concept lies in connecting the ideas of closing loops by "designing out" waste (Murray et al., 2017). Its roots in closing material loops are evident. In the early phases, research on the concept focused on win-win situations of economic and environmental sustainability (Schöggl et al., 2020). However, to support the circular economy, all dimensions of sustainability – environmental, economic and social – need to be considered (Kirchherr et al., 2017).

The environmental sustainability of the circular economy aims to reduce virgin material, energy input and waste and emissions output in the economic system (Korhonen et al., 2018a). The economic objectives of the circular economy refer to reducing costs related to raw materials and energy as well as the possible costs related to waste management, emissions and taxes (Korhonen et al., 2018a). In a circular economy, economic growth is redefined by decoupling it from resource consumption (Lazarevic and Valve, 2017). Korhonen et al. (2018a) define the social objective of the circular economy as being related to the sharing economy, participatory involvement of citizens in decision-making and encouraging community use as well as increased employment.

Until recently, circular economy research has prioritised the economic system and the benefits for the environment while leaving narrow focus on social aspects (Geissdoerfer et al., 2017). However, earlier research already recognised the lack of social sustainability in the circular economy as being a challenge (Andersen, 2007; Geng and Doberstein, 2008), and the situation still seems to be the same (Sauvé et al., 2016; Kirchherr et al., 2017; Murray et al., 2017). Furthermore, Merli et al. (2018) confirm the absence of a social perspective in the circular economy by explaining that the social impacts are only marginally tackled in scholarly research. So far, social aspects have been studied through, for example, job creation (Geissdoerfer et al., 2017), health and safety, and participation (Padilla-Rivera et al., 2020). Academics see that more research on social issues are required on the impacts on social well-being (Merli et al., 2018), eradicating poverty, increasing food security (Padilla-Rivera et al., 2020) and social equality in terms of inter- and intragenerational equity, gender or financial equality (Murray et al., 2017). The research of Padilla-Rivera et al. (2020) explains that, in order to see the circular economy as a tool to advance sustainable development, a framework to show how circular economy strategies can promote social equity together with other aspects must be developed.

Korhonen et al. (2018b) state that the majority of circular economy research addresses the practical side, for example, the flows of materials and energy in industries and regional economies. This is supported by Merli et al. (2018); however, they specify that most of the effort has been dedicated to business models for closing resource loops and that slowing down the loops, which requires a drastic change of consumption and production, has only been slightly touched.

Even if a range of scientists, practitioners and policymakers see the circular economy as a possible solution and step to sustainability, criticism has been directed towards the idea. In the big picture, material cycling is not environmentally sustainable as such because the important point is not only that the cycle be closed but to address the question of how large or fast the cycle actually can or should be (Zink and Geyer, 2017; Desing et al., 2020). A cyclic flow does not secure a sustainable outcome. Even if the core of the economy is that a product, value or service is utilised many times, it should lead to decreased resource extraction for new products (Korhonen et al., 2018a). The idea of a circular economy fails if overall production and use of products is increased (Zink and Geyer, 2017). To truly reduce environmental impact, less production and consumption are required. This is also where the essence of the R hierarchy is evident.

Velenturf and Purnell (2021) state that, while the sustainable development goals put the people in the centre, the circular economy is still focused on technological solutions aimed at traditional economic growth. Recently, the call for a more holistic and inclusive circular economy approach has increased (Schöggl et al., 2020). However, researchers have already previously stated that developing inclusion would increase public acceptance and participation in the circular economy (Andersen, 2007; Geng and Doberstein, 2008). According to Schöggl et al. (2020), consumption patterns and citizen inclusion should be given more attention in the circular economy debate. A fundamental transformation in production and consumption systems is necessary to achieve a change in society (Kirchherr et al., 2017; Korhonen et al., 2018a). As pointed out, the circular economy should extend its concerns to the societal level to involve consumers and support radical shifts in their behaviour. Lazarevic and Valve (2017) highlight that the shift in roles from consumer to user is an important feature of developing the circular economy. When striving towards a circular society, it should be remembered that economic action should not primarily create material wealth but should enable quality of life for all members of a society (Jaeger-Erben et al., 2021). In addition, Millar et al. (2019) have contributed a critical view to the circular economy discussion, especially regarding the social aspects. They state that it is still unclear if the circular economy actually can promote economic growth while both protecting the environment and ensuring social equity, and they emphasise that the social welfare should be a research priority (Millar et al., 2019). However, Murray et al. (2017) and Korhonen et al. (2018b) state that the successful adoption of the circular economy has a holistic contribution to all three dimensions of sustainable development.

When complementing the holistic understanding of the circular economy, the systemic approach is a central perspective. Simplified, from the viewpoint of an individual business, material efficiency is easy to understand as a path to circularity. Circular economy principles encourage a company to improve its efficiency, reduce the material and energy input and minimise waste (Desing et al., 2020). However, when circularity is viewed from a broader standpoint – a system perspective – the setting changes. There are numerous links to other actors, which are connected to the actions of one company, to its operating conditions, the surrounding ecosystem and society as well as its retail and customers. For example, today most products are produced for interregional or international markets, which means that, even if a company achieves a high level of efficiency and circularity in its own premises and its closest network, challenges can occur elsewhere, at the beginning or end of the chain (Korhonen et al. 2018a). Therefore, a thorough interpretation of an industrial symbiosis and its overall situation is necessary to understand the general impacts and influence of the activities (Mattila et al., 2010). It needs to be ensured that the actual environmental impacts of a circular economy promote sustainability. For example, the utilisation of bio-based materials is not always sustainable, nor is the sustainability easy to measure (Korhonen et al., 2018a). Furthermore, the potential for recycling a product needs to be promoted by paying attention to the decisions made in the production phase, for example, the treatment of material inputs into the manufacturing processes (Murray et al., 2017). The need for a holistic and systemic perspective is also crucial from the regional perspective. For

example, Paiho et al. (2021) point out that, in circularity studies on the city level, the focus is often only on individual sectors, while holistic thinking is missing.

Promoting the shift to a circular economy requires efforts on different scale levels or system levels: micro level, meso level and macro level (Geng and Doberstein, 2008; Su et al., 2013; Kirchherr et al., 2017). The scale levels are presented in Figure 2:1. The micro-level actions in a circular economy refer to a single actor, for example, companies, products or consumers (Su et al., 2013; Ghisellini et al., 2016; Kirchherr et al., 2017; Merli et al., 2018; Hedlund et al., 2019). The meso level means actions in symbiosis with other actors, including industrial symbiosis or companies collaborating in eco-industrial parks (Geng and Doberstein, 2008; Su et al., 2013; Ghisellini et al., 2016; Kirchherr et al., 2017). Macro-level actions are development on the city, region or national level where networks of ecosystems operate (Su et al., 2013; Kirchherr et al., 2017; Merli et al., 2018). However, Silvestri et al. (2020) present a slightly different view of the level division, implying that the regional approach would belong to the meso level. In any case, Kirchherr et al. (2017) highlight the need to understand the necessity for a systemic change. Overall, it can be seen that the macro level forms the operating environment for the lower levels. A systemic transition towards a circular economy at the macro level requires the collaboration of the private sector, policymakers and associations (Saavedra et al., 2018). Schöggl et al. (2020) underline that, to achieve a holistic circular economy approach, all aspects affecting the economy need to be considered, including consumers, materials, processes and the strategy level.

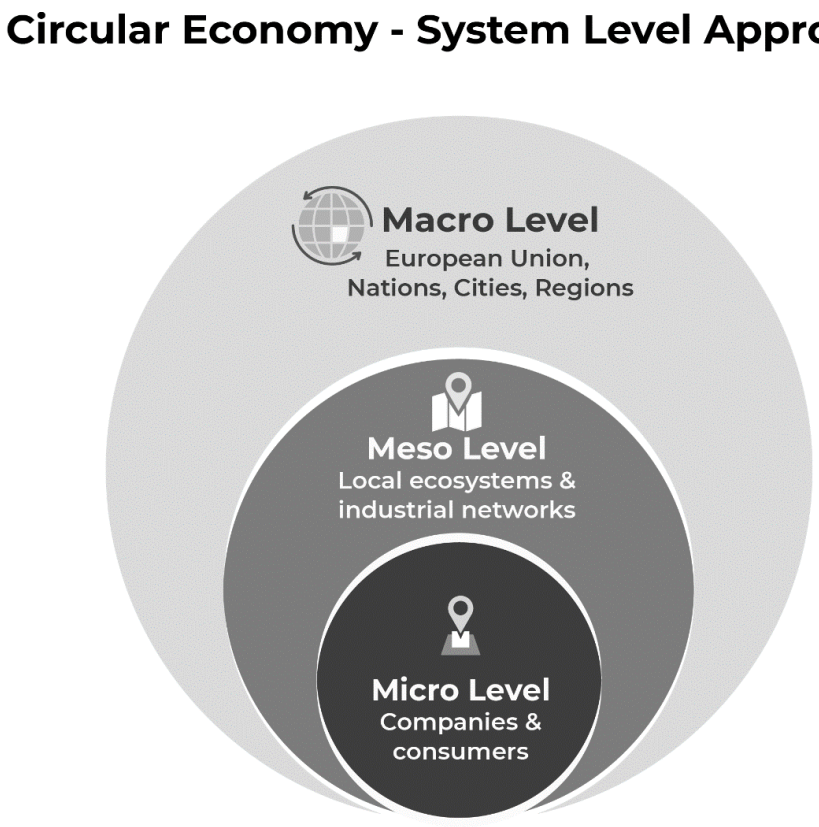

Figure 2:1: The system level approach to the circular economy describes the actors on the macro, meso and micro levels (Geng and Doberstein, 2008; Su et al., 2013; Ghisellini et al., 2016; Manskinen, 2016; Kirchherr et al., 2017). (Article I)

To achieve a paradigm shift towards a sustainable circular economy, research is needed on both a practical and paradigm level, where, for example, system boundary limitations and critical theoretical discussions are considered (Korhonen et al., 2018b). The final goal of a circular economy should be to redefine the socioeconomic system; however, academic research has focused more on waste and recycling practices (Merli et al., 2018). For example, determining which practices and systemic changes can be seen as sustainable and circular requires rapid assessment tools with a system perspective. However, the tools available are usually not rapid, nor do they include holistic indicators (Velenturf and Purnell, 2021). Scientific research is important for ensuring that the actual impacts of the circular economy will aim towards a sustainable society, both in the short

term and long term (Korhonen et al., 2018b). Korhonen et al. (2018b) state that only a few circular economy studies so far have focused on issues typical for the paradigm stage, for example, values, organisational culture or interorganisational learning. Organisational studies are typical for social sciences, an academic field still underrepresented in circular economy research (Korhonen et al., 2018b).

Deep insight into the circular economy is challenging, as it includes the understanding of all aspects of sustainable development (environmental, economic and social), the different levels of the circular economy (micro, meso and macro), the entirety of system thinking and the necessary transformation based on the R hierarchy. To achieve changes in society, the macro level sets the boundary conditions for the development. In the context of this research, the macro-level regional strategies, which direct regional goals and actions, are in focus. Next, we will examine the role of policies in supporting the transition to the circular economy.

2.2.5 The circular economy from a policy perspective

Sustainability and governance are tightly related and together strive for the well-being of contemporary society and future generations (Billi et al., 2021). To support sustainability, a crucial issue is how to implement it into governance. The circular economy concept is widely accepted among policymakers and is seen as a key concept in the aim for sustainability in society (Sauvé et al., 2016; Geissdoerfer et al., 2017; Korhonen et al., 2018a; Schroeder et al., 2019; Lin, 2020). Obviously, to achieve results, many actions towards a circular economy, such as increases in recycling capacity and policy coordination to encourage recycling, must be launched simultaneously (Lin, 2020).

Germany was a pioneer in including the idea of circularity into national laws with the Closed Substance Cycle and Waste Management Act in 1996 (Su et al., 2013). However, China was the first to formally start using the circular economy in terms of policy. In 2002, the central government of China accepted it as a new development strategy (Geng and Doberstein, 2008), and in 2009, a law for circular economy promotion came into force (Su et al., 2013; McDowall et al., 2017). The interpretation of the circular economy concept had transformed from environmental protection to a sustainable economic development model as a holistic concept (Jiao and Boons, 2014). Chinese universities were also the leaders in academic publishing related to the circular economy between 2005 and 2013 (Merli et al., 2018). The Chinese Circular Economy Promotion Law framed the circular economy as a holistic concept, where pilot experiments and theoretical research resulted in an overall understanding (Jiao and Boons, 2014). However, in practice, there are challenges in the implementation of the Chinese central government's orders and achieving a circularity development through this top-down approach. Geng and Doberstein (2008) point out that, for example, resource taxes are very low, which increases the use of virgin raw materials instead of recycled ones. Su et al. (2013) state that the technology level, which is a prerequisite for the circular economy, is underdeveloped and that companies are not encouraged to invest in more environmentally friendly technologies, as the financial support from banks and inefficient public taxes do

not support this. Lo (2014) presents examples of local Chinese governments challenging the central government's order and low-carbon policies for the sake of local interests. Furthermore, Su et al. (2013) claim that China lacks the human and institutional capabilities to encourage public participation in a circular economy. Still, it is fair to state that the example of the Chinese policy has inspired circular economy development in other parts of the world.

In Europe, the EU legislation with directives tackling climate change (EC, 2008), emphasising energy efficiency and the use of renewable energy (EC, 2011a; EU, 2012) and focusing on waste handling according to the waste hierarchy (EU, 2008) has reinforced the focus on cleaner production, cleantech, resource efficiency and furthering the circular economy. Moreover, the development of the European bioeconomy strategy (EC, 2012) affected the policy discussion linked to the circular economy, as both concepts are related to the sustainability debate.

In 2011, the EC presented a flagship initiative on resource efficiency (EC, 2011b). It made official that a long-term framework, a "strategy (roadmap) to make the EU a 'circular economy', based on a recycling society with the aim of reducing waste generation and using waste as a resource", was going to be set up. The development of the concept in Europe was also supported by the active work of the EMF. Since then, the circular economy has been an essential part of EU policies. In 2014, the EC launched "Towards a Circular Economy: A Zero Waste Programme for Europe", which strongly promoted the circular economy (EC, 2014). It was followed in 2015 by the first action plan, "Closing the Loop – An EU Action Plan for the Circular Economy" (EC, 2015). The action plan included measures to support Europe's transition towards the circular economy, establishing a concrete programme of action that included measures for production, consumption, waste management, the market for secondary raw materials and a revised legislative proposal on waste (EC, 2015). The annex to the action plan set out a timeline for the actions to be completed.

In the last years, especially after the adoption of the UN's sustainable development goals in 2015 (UN, 2015), the demand to include a stronger sustainability perspective into policies has grown. In response to the discussion and critique, the EU first published a review of its bioeconomy strategy in 2018 that underlined the union's role as a leader in sustainable use of natural resources (EC, 2018). Also, in 2018, when all the actions of the first circular economy action plan were delivered, the EC presented additional strategies and initiatives related to the sustainable circular economy of plastics, critical raw materials and a monitoring framework with circular economy indicators (EC, 2021b). Furthermore, a new action plan was adopted in 2020 as a part of the European Green Deal, the Circular Economy Action Plan (EC, 2020). The new action plan emphasised the importance of a sustainable circular economy, not only for products, but also for services. The plan aims for a systemic transition through "cooperation of all stakeholders at all levels – EU, national, regional, local, and international" (EC, 2020). It states that EU financing instruments will support circular economy investments on the regional level,

including awareness raising, cooperation and capacity building as well as strategy implementation (EC, 2020).

The European approach to the circular economy has been concentrating on waste, its reuse and disposal (Marino and Pariso, 2020), and the waste hierarchy principles have been evident in the European circular economy legislation (Fitch-Roy et al., 2021). For example, compared to social and cultural aspects (e.g. citizen's lifestyle transformation), the EU policies give disproportionate attention to the technical and economic factors of circularity (Calisto Friant et al., 2021). According to Calisto Friant et al. (2021), and even when social and cultural challenges and inequalities are mentioned in the policy, the solutions are presented through future economic gains and not through redistributing existing wealth. The EU's circular economy policies are also criticised for only updating the directives and targets and not striking by looking for a transformative change merely due to the interest in securing economic growth (Fitch-Roy et al., 2020). Indeed, the new circular economy action plan focuses a great deal on the recycling industry (EC, 2020), which is a key element, yet to achieve a sustainable circular economy, the structural socioeconomic change must be driven forward.

Some European countries have been quicker than others to adopt specific circular economy policies. Denmark was a pioneer in adopting a national-level circular economy strategy in 2013, followed by Finland and the Netherlands in 2016, and Greece, France and Slovenia in 2018 (Fitch-Roy et al., 2021). Policies of other nations have also touched on circularity, while their main topic has been emphasising green and sustainable applications overall, for example, Portugal's Green Growth Commitment (Government of Portugal, 2015). The international- and national-level policies have, in turn, motivated regions, cities and municipalities to set up circular economy strategies. For example, the Finnish regions of Päijät-Häme and Southwest Finland introduced regional circular economy roadmaps in 2017 (Lahti University of Applied Sciences, 2017; Circular Economy in Southwest Finland, 2021), as did the French capital region of Paris in 2017 (Mairie de Paris, 2017) and the Slovenian municipality of Maribor in 2018 (WCYCLE Institute Maribor, 2018). The City of Amsterdam in the Netherlands had already published its first roadmap in 2015, even before the national-level strategy (Amsterdam Circular, 2015).

As acknowledged, the idea of a circular economy builds on rethinking the traditional linear economy process, which is described as "take-make-dispose" (see e.g. Merli et al., 2018). In practice, so far, policy efforts to promote sustainability and the circular economy have focused mainly on the last stage of the linear process, that is, on waste management as well as recycling and reusing (Hartley et al., 2020; Fitch-Roy et al., 2021). As explained above, this is evident in the EU-level policy. Accordingly, the same trend seems to also appear on the national level. Fitch-Roy et al. (2021) recently studied national circular economy policies around the world and came to the understanding that the countries are mainly adopting circular economy strategies to supplement their pre-existing resource and waste management policies. However, to achieve the required radical transformation towards circularity, a system-wide change is needed.

Consequently, it might not be possible through initiating incremental transformation (Fitch-Roy et al., 2021). Overall, the transition to the circular economy on a policy level has not yet been widely researched. In addition to the study by Fitch-Roy et al. (2021), studies on circular economy policies focus mainly on waste treatment (Saavedra et al. 2018; Hartley at al., 2020). Calisto Friant et al. (2021) studied circular economy policies on the EU level, and national level policies have been in focus, especially in China (e.g. Su et al., 2013; McDowall et al., 2017). However, academic studies on the implementation of the circular economy in regional-level policy are scarce. The purpose of this study is to contribute to filling this gap.

3 Research design and methodology

3.1 Research design

This thesis adopts a qualitative research methodology inspired by critical theory and constructivism. Guba and Lincoln (1994; 2003) explain the differences between the philosophical paradigms: positivism, post-positivism, critical theory and constructivism. The paradigms differ depending on their view on ontology, epistemology and methodology. Ontology concerns the form and nature of reality, while epistemology focuses on the relationship between the researcher and the reality, and methodology is the analysis of the methods of a study, quantitative or qualitative (Guba and Lincoln, 1994). According to Guba and Lincoln (1994, 2003), the positivistic paradigm describes that there is only one true reality and this reality is identifiable and measurable. Post-positivism accepts that the knowledge and values of the researcher can influence what is observed. Its assumption is that the findings are probably true. Both of these positivistic paradigms prefer quantitative methods and aim at explanation through prediction and control. In contrast, critical theory aims at transformation. In critical theory, it is assumed that the investigator and the studied subject are linked, and therefore, values influence the findings, which are often collected through qualitative methods. Constructivism aims to increase understanding through qualitative research methods. It describes that multiple, constructed realities exist rather than a single, true reality. Perspectives of critical theory and constructivism are combined in this research, where transformation is studied through seeking an understanding of current contexts.

In scientific practice, research methodologies are divided into qualitative and quantitative. However, the distinction is not always clear, and both approaches can be used to find answers to a research question. Qualitative research refers to the meanings, concepts, definitions and descriptions of things, whereas quantitative research focuses on counting or measuring (Lune and Berg, 2017). Furthermore, the aim of a qualitative assessment is not to reach a large sample size or to generalise results. Instead, qualitative research aims to understand a social context or complex phenomenon. It is particularly useful for understanding a phenomenon that needs to be studied in its real-world context. Qualitative studies contain in-depth research of a small number of cases (Lune and Berg, 2017). The data for a qualitative analysis usually come from fieldwork, and they can be collected through, for example, interviews, observations or documents (Patton, 2015). In qualitative research, the data are analysed at the same time they are collected. Moreover, the data processing is iterative, where the researcher becomes familiar with the data in several loops. When the researcher knows the data well, thematic patterns start to emerge, and the researcher is able to connect content from different contexts in the research material. Triangulation, that is, making use of multiple types of data, researcher viewpoints, theoretical frames and methods of analysis allows for exploring a problem from different sides at the same time, as it deepens understanding and supports interpretation (Tracy, 2010).

Central terms in evaluating the quality of research are reliability and validity. They have been developed from quantitative perspectives and thus have been criticised in qualitative research; however, they are still relevant in reviewing the research process and its outcomes (Creswell and Miller, 2000). Reliability is about the consistency and repeatability of a research procedure. Repeatability is a challenge in qualitative research, as the role of the researcher is central; however, repeatability is enhanced through carefully depicting the research process, thus enabling it to be repeated (Yin, 2014). Validity refers to the accuracy and the question of whether the research concerns the initial topic that the researcher aimed to study. The validity of a research can be increased through triangulation (Creswell and Miller, 2000; Tracy, 2010). Moreover, to improve the understanding, King (2004) suggests that direct quotes from participants are an excellent way to expand the interpretation.

As defined, the role of the researcher is central in qualitative research. In the research process, the researcher becomes an instrument for analysis. Each qualitative research approach has detailed techniques for conducting, documenting and evaluating data analysis processes. However, it is the researcher's responsibility to make sure that the process is implemented and documented in a reliable way (Nowell et al., 2017). The researcher's skills and understanding determine the reliability and validity of a study.

The qualitative approach is inductive in nature. Inductive reasoning leads to the development or creation of a theory, compared to deductive reasoning, which is a form of testing of a preconceived theory (Lune and Berg, 2017). Inductive reasoning may not give the absolute truth, but it increases the knowledge of a phenomenon. According to Tracy (2010), worthy topics in qualitative research often arise from disciplinary priorities or timely societal issues, and research challenging well-accepted ideas is often especially worthwhile.

The topic of this dissertation fits the frame of utilising a qualitative research approach because the aim is to focus on understanding the differences in a regional setting. The circular economy represents a solution for a timely societal issue, the sustainability debate, which is seen as crucial on the international level. However, its implementation is carried out on a regional level, whereas the regional differences form fruitful examples for policy practice. This dissertation applies a number of different ways of utilising qualitative data, and its research questions are built around different theories. Several researchers have been involved in elaborating the scientific dialogue. The research design for each article was established based on the aim of the specific study in question. The methods applied in the articles to provide answers to each subquestion of the research are presented below. They consist of a qualitative survey, semi-structured interviews and a case study.

3.2 Research methodology

3.2.1 Qualitative survey (Article I)

The dissertation's first subquestion, "SQ1: How is the circular economy present in European regional strategies?", is answered through Article I. The data were gathered through a qualitative assessment carried out in the form of a survey. A qualitative survey is a collection of data, which can contain information gathered through, for example, interviews, field notes, responses to open-ended survey questions or documents (Fink, 2003). A qualitative survey does not count the frequencies of categories; instead, it searches for empirical diversity among units, even if the content might also be expressed in numbers (Jansen, 2010).

In the research aiming to answer the first subquestion, the data were gathered through strategy documents and then through a set of questions answered based on those documents during discussions with the authorities in charge of the regional development. The data were gathered in six European regions, which were chosen to present wide socioeconomic and geographical coverage of the EU. The most relevant regional and national strategies from a circular economy point of view were identified, and a set of questions were answered based on them. The discussions and assessment were implemented by regional co-operators in the respective local languages. This enabled an in-depth understanding of the national and regional policy documents, as a translated English version was not available in several cases. However, it is worthwhile to be aware that a diversity in data collectors might cause the possibility of different perceptions of the content in the collection process. In this case, the differences between interpretations were minimised, as the regions involved cooperated in an interregional research and development project in which an in-depth exchange of understanding had taken place and because the co-writers of the article represented half of the studied regions.

The data for the assessment were gathered in all studied regions during November 2017 and represented the current policy situation at that time. Each reply represented the view of one region and its corresponding national situation. The analysing process was conducted through carefully reviewing, organising and, when possible, grouping the replies to make them comparable. When necessary, the data collectors (project partners) in the regions were consulted to clarify the interpretations of the replies. Finally, the outcomes of the data analysis were presented in overview tables and as a map, which are all found in Article I. A summary table is found in Section 4.1 of this dissertation.

3.2.2 Semi-structured interview (Articles II and III)

Articles II and III provide an answer to the second subquestion, "SQ2: How are circular economy-related thematic priority areas formed and concretised in regional smart specialisation strategies?", by utilising thematic analysis of semi-structured interviews as the main research method. The scope of the collected data allowed for two perspectives

on the study, resulting in two articles. Article II focuses on the smart specialisation strategy process and Article III on the environment of the circular economy concept's development in the regions.

Thematic analysis is a method of analysing qualitative data (Guest et al., 2012). In thematic analysis, the data are identified, described and organised into themes, while the process, at the same time enables the researcher to better understand and interpret the collected data. During the data collection and throughout the data analysis, the interchange between the data and theoretical knowledge forms an interplay (Schmidt, 2004). According to Guest et al. (2012), thematic analysis is the most commonly used method of analysis in qualitative research because it is the most useful method for capturing the complexities of meaning within a textual data set.

Semi-structured, or semi-standardised, interviews are implemented according to a predefined frame, but one that provides freedom in the formulation of questions (Hopf, 2004). Certain themes and questions are included in the discussion, but the interviewees can also share their experiences freely within the given framework. Semi-structured interviews combine open-ended and theoretically driven questions to explore both the experience of the interviewee and the data based on the existing constructions (Galletta, 2013).

In the search for an answer to this dissertation's second subquestion, the semi-structured interview approach allowed the dialogue to move from pre-listed questions to more in-depth discussions about the regional strategy formation and processes. The possibility of deepening the discussion during the interview increased the quality of the interview data.

The sample of regions were identified on 10 May 2019 at the Eye@RIS3 database on the EC's S3 platform. The regions were searched with the keywords "circular economy". Altogether, 14 European regions fitted the search; that is, they used the words "circular economy" in the name or in the definition of a smart specialisation regional thematic priority. The organisations responsible for the regional smart specialisation process were contacted with interview requests. Finally, representatives for 11 of the regions were reached for telephone interviews, and a representative from one region requested to reply through email (n = 12). The interviews were conducted between May and August 2019.

The questions asked in the interviews covered the background of the smart specialisation priorities related to the circular economy, with a focus on the strategy process, including actions, funding and updating. The set of questions can be found in the appendix of Article III. The interviews were recorded and transcribed. The content related to the circular economy and smart specialisation as well as the entrepreneurial discovery process was identified. Then, this content was classified, coded and summarised. All along the process, and in more detail after the coding phase, the outcomes were compared to the development of the circular economy concept and to the conceptual framework of smart

specialisation. The outcomes of the research were presented in a conceptual framework figure and through concluding tables in Articles II and III, also found in Section 4.2.

3.2.3 Case study approach (Article IV)

The third subquestion, "SQ3: What are the challenges and opportunities of a regional circular economy strategy process?", answered through Article IV, was researched as a case study. The case study is an appropriate method for investigating complex phenomena that are not easily separable from their real-world contexts (Yin, 2014). When setting up a case study, it is important that the researcher knows why a specific case is of interest, either based on theory or empirical logic. A case study process involves an empirical analysis that investigates a contemporary phenomenon in its natural environment (Eisenhardt and Graebner, 2007). The type of information gathered in a case study process is extremely rich, detailed and in depth. In addition, the researcher is able to capture various nuances that other research approaches might miss (Lune and Berg, 2017).

The case study is often utilised in social sciences when there is a need to understand a complex societal phenomenon. The studied case should involve versatile actors and stakeholders, and it should cover the entire strategy process and allow the observation of how the focus developed over time (Eisenhardt and Graebner, 2007; Aarikka-Stenroos et al., 2017). The case study is often seen as a tool that works well because many issues cannot be properly understood without an in-depth focus on the uniqueness of one case. Nevertheless, Eisenhardt and Graebner (2007) and Yin (2014) point out that case studies should comprise a variety of data collection methods to enable the best possible understanding. This increases the validity of the research. Based on the comprehensive understanding of one case, other similar settings or cases in other regions can be better understood. However, the case study has also been criticised from the perspective of its subjectivity and generalisability. It must be kept in mind that a case study cannot be generalised because it describes only the studied case. The case study can be condemned as only a descriptive method, as the researcher might have challenges in gathering all available data (Lune and Berg, 2017). Furthermore, the open-endedness of a case study can leave researchers unguided on the structure and can potentially cause them to miss some important points, leading to challenges (Thomas, 2011). These questions can be tackled through careful assessment and cooperation between the research team. Still, the case study method is well placed if the focus of the research is to answer *how* and *why*.

In this dissertation, the case study as a research method is applied to answer the third subquestion, where the application of one regional circular economy strategy is investigated. The studied case was the Päijät-Häme region in Southern Finland. The study explored how a detailed regional strategy process was implemented in practice. The process consisted of setting up a regional roadmap towards the circular economy with specific goals and concretising one of the defined goals in a detailed action plan. The case study process took place between November 2015 and May 2019.

In this case study, multiple data sources and data collection techniques were used: desktop research, workshops and meetings with stakeholders, as well as other types of informal cooperation with stakeholders through discussions and emails. The process of strategic circular economy development in the region was explained through describing the type of activities, the topic of their content, the date of each event and the stakeholders involved. The process was summarised in a table, which is presented in Article IV. The result of the process, the roadmap towards the circular economy, the definition of the regional vision and the goals and actions leading towards the circular economy are gathered in a figure presented in Article IV and also in Section 4.3 of this dissertation.

4 Results

This chapter presents the results of the four research articles which form a base for the replies for the dissertation's research questions.

4.1 The circular economy in European regional strategies (Article I)

To achieve a systemic change towards the circular economy, a system-level approach on different regional levels is needed. On the macro level, it is vital that the change towards the circular economy is supported through strategies on all levels of governance. Obviously, the regional-level strategies are affected by international and national policy. In Article I, a macro-level study focusing on the circular economy in national- and regional-level strategies was carried out in six EU regions: Päijät-Häme (Finland), Pays de la Loire (France), Central Macedonia (Greece), South Muntenia (Romania), Nitra (Slovakia) and Castilla-La Manca (Spain). In this thesis, the focus is on the generic circular economy outcomes of Article I, placing less attention on the bio-based circular economy perspective. The outcomes are analysed from the perspective of regional strategies that are supported by corresponding with the national ones.

The most suitable national and regional strategies for addressing the circular economy were chosen for analysis. The results show that, at the time of the study (November 2017), the policy field was in transformation. The EC's circular economy action plan had been released two years before, with the effects of the policies beginning in the member states. At the time of data collection, circular economy as a term was recognised in all studied national strategies, except in Greece. However, the reviewed Greek national-level strategy also included concepts such as recycling and avoidance of (bio)waste disposal, even if the concept of a circular economy was not mentioned as such.

The studied national strategies vary in the way that they approach the circular economy objectives. At the time of the study, out of the countries in focus, Finland was the only one that had a national-level circular economy strategy, which was published in 2016 (Sitra, 2016). The Finnish roadmap strategy shows an integrative focus and different levels of action are addressed. It sets the guidelines for achieving social, economic and environmental benefits, such as increased employment, a diversified market and a lower impact on the environment (Sitra, 2016). The Finnish roadmap aims to promote the circulation of raw materials, prioritise clean technology research and, eventually, achieve self-sufficiency. The multidisciplinary approach aims to integrate stakeholders into a model where technological and biological flows are connected.

The analysed strategies from the other countries are the ones closest to circular economy, mainly in the field of waste management. Consequently, Spain, Slovakia, Romania and France share a common view regarding the circular economy, as their studied national-level strategies focus on waste management and raw material circulation. The Spanish national waste management strategy has goals related to waste production and an

ambitious plan to reduce the end-of-life material in accordance with the circular economy model. In Slovakia, the government supports a transition to a circular economy that ensures resource and energy efficiency and reduces environmental impacts. In Romania, waste management is addressed through waste prevention. However, in the French strategy, the circular economy is somewhat holistically mentioned as a strategic topic of its own in relation to reducing waste, but the strategy also includes developing product design and recycling. In Greece, waste management is also a central focus; however, in contrast with the other countries, at the time of the research, the strategy did not yet mention the circular economy. At the time of the data collection, France, Greece, Slovakia and Spain were expecting to have national-level circular economy strategies published in 2018. Also, in Romania, the circular economy strategy work had begun, even though challenges with the implementation of previous waste programmes existed. Efficient use of resources was the main starting point with regard to the circular economy in these programmes.

The results of the strategy documents analysed are summarised in Table 4:1. As the table shows, regional-level strategy development is connected to the respective national situation. At the time of the research, the circular economy was included as a term in the main strategic documents in four of the six studied regions: Finnish Päijät-Häme, Spanish Castilla-La Manca, French Pays de la Loire and Romanian South Muntenia. However, the national-level focus on waste strategies is accordingly evident on the regional level.

The analysed strategy of the Päijät-Häme region defines three focus areas of smart specialisation, one of them being the circular economy. In the regional context, the circular economy mainly equals material and energy efficiency and new solutions for the bioeconomy. The circular economy as part of the regional strategy is described in more detail in the Päijät-Häme roadmap towards the circular economy and includes five comprehensive goals related to technical loops, new consumption models, sustainable energy solutions as well as piloting and demonstrating solutions (see more in Article IV).

Castilla-La Mancha connected the circular economy as a guiding principle of the regional waste management strategy. The plan supports minimising potential risks to human health and the environment through efficient waste management based on the principles of the circular economy. In Pays de la Loire, the circular economy's focus on the Performance Agreement for a Regional Dynamic about Waste and Circular Economy is strong. The region aims to take a leading position in the nation with regard to waste management, the circular economy and energy transition. In South Muntenia, the analysed smart specialisation strategy mentions the circular economy when describing the bioeconomy. The strategy aims to promote circularity, mainly in the bio sector, for example, in the production of biofuels, ecological fertilisers and bio-composites. The other fields of smart specialisation in South Muntenia are related to the food industry and smart localities, which are also fields with implications for the circular economy. Neither the analysed strategy of the Nitra region in Slovakia nor the Regional Waste Management Plan of Central Macedonia in Greece mention the circular economy, though they do both refer to effective use of resources.

Table 4:1: Overview of the studied national- and regional-level circular economy strategies, November 2017 (combined based on Article I)

Country	**Finland**	**Spain**	**Slovakia**	**Greece**	**Romania**	**France**
Strategic document in focus	The Finnish Roadmap to a Circular Economy	Waste Management State Plan (PEMAR)	The Waste Management Programme of Slovak Republic	National Plan for Waste Management	National Waste Management Strategy	Energy Transition for Green Growth Act
Validity period	2016–2025	2016–2022	2016–2020	2015–2020	2014–2020	2015–2030
Circular economy included	Yes	Yes	Yes	No	Yes	Yes
If no, specify other corresponding terms				recycling, biowaste disposal avoidance		
Region	**Päijät-Häme**	**Castilla-La Manca**	**Nitra**	**Central Macedonia**	**South Muntenia**	**Pays de la Loire**
Strategic document in focus	Päijät-Häme Regional Strategy and Programme	Integrated waste management plan of Castilla-La Mancha	Programme of Economic and Social Development of the Nitra Region	Regional Waste Management Plan of Central Macedonia	Smart Specialisation Strategy of South Muntenia Region	Performance agreement for a regional dynamic about waste and circular economy (CODREC)
Validity period	2018–2021	2016–2022	2016–2022	2016 onwards	2014–2020	2016–2020
Circular economy included	Yes	Yes	No	No	Yes	Yes
If no, specify other corresponding terms			sustainable growth, effective use of resources	effective use of resources		

As Table 4:1 presents, the year of issue does not necessarily indicate if the circular economy is present or not. The analysed Romanian strategies were both issued in 2014, before the EU circular economy action plan, and they proactively refer to the circular economy. In contrast, the Slovak and Greek regional strategies issued in 2016 do not yet mention the term.

The results show a connection between the national and regional awareness of bringing the term circular economy into use in strategies. The four regions where the circular economy is included in the strategy documents are supported by their corresponding national-level strategies. At the time of the data collection, Nitra and Central Macedonia had not yet included the circular economy in their regional strategies, though the Slovak national-level strategy did mention the concept. It is also worth mentioning that Päijät-Häme and South Muntenia have connected the regional circular economy strategy with their smart specialisation priorities.

Though not mentioned in the terminology, the idea of circularity, at least in the basic form of improved waste and resource management, is present in all national- and regional-level strategies. However, for the circular economy to become an integral part of governance, a more comprehensive understanding of the concept is needed. The results show that waste management appears to be the main driver in the transition towards a circular economy, as the strategies closest to a circular economy come from this field. However, if the perspective is not broadened as new related or specific circular economy strategies are set up, there is a risk that the full potential of the circular economy will not be understood and utilised.

The results also show that the circular economy is very much a developing concept. Already at the time of publishing Article I, the situation had developed from what it was when the research data were gathered. For example, the French roadmap towards the circular economy was published in April 2018, and an update of the Slovak regional-level strategy that included the circular economy was approved in June 2018. Furthermore, after the publication of Article I, several updates and new national and regional strategies have been approved.

4.2 The circular economy in smart specialisation strategies (Articles II and III)

Smart specialisation strategies were launched as a condition for receiving funding from the EU structural funds at the same time as the circular economy debate was beginning to escalate in Europe. As explained in Section 2.1.2, smart specialisation priorities should be based on existing regional strengths but also flexible enough to develop future potential for moving the region forward. To study how the circular economy has been applied in smart specialisation strategies, 12 European regions that had defined the circular economy as a smart specialisation thematic priority were studied. The scope of the collected research material allowed for studying two perspectives of the circular economy and smart specialisation. Therefore, the Articles II and III are based on the same data. Together, the results from these two articles make up the results of this section and the basis for replying to SQ2, which focuses on how the circular economy-related thematic priority areas in regional smart specialisation strategies are formed and concretised. Article II concentrates on analysing the construction process of regional smart specialisation strategies, the existence of a more detailed roadmap and an action plan from a circular economy perspective. To explain the structure of the process, the analysis is conducted through a conceptual framework that was set up based on the literature review. Article III presents the driving forces behind the circular economy concept in the context of smart specialisation policy.

Smart specialisation strategies focusing on the circular economy (Article II)

As a result of the literature review on smart specialisation, an elaborated conceptual framework was set up. The spatial adaption of a circular economy in the regions was

analysed through this conceptual framework of smart specialisation. Figure 4:1 summarises the smart specialisation process, focusing on the implementation phase. The conceptual framework was built based on the smart specialisation literature, especially in accordance with Foray's (2019) suggestions. The figure names the two main faces as "Planning" and "Construction of transformative activities". After defining the thematic priority areas in the planning phase, the regional actors should create a roadmap that includes more specific content on how to reach the priorities and, further on, a detailed action plan on how to proceed to concrete actions. The action plan phase should include information on what kind of funding is planned to accomplish the actions, as well as details on monitoring and evaluation. Though the figure presents a simplified liner process, in reality, the phases overlap and go in loops.

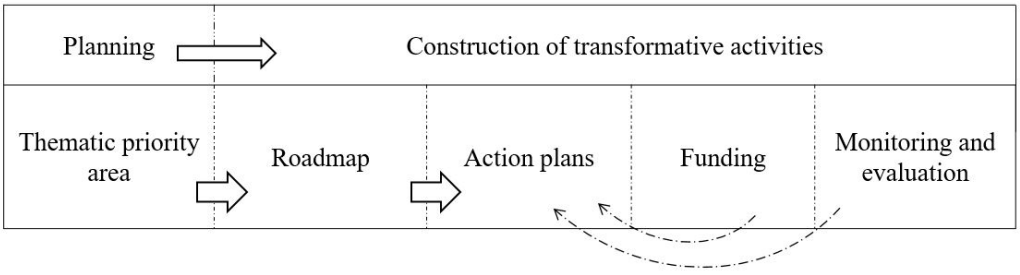

Figure 4:1 The conceptual framework and simplified smart specialisation process. (Article II; figure developed by Satu Rinkinen.)

After setting up the conceptual framework, the regional research data were analysed by comparing the findings with each step. Table 4:2 presents the results of the interviews following the structure of the conceptual framework. This allowed a coherent examination of the regional approaches through a literature-based framework. When assessing the results of the interviews, it should be remembered that, due to the differences in naming the thematic priority areas, the regions are not completely comparable. However, the results present a current example of the smart specialisation process in the regions where the circular economy is a central smart specialisation focus.

The differences in naming thematic priority areas reflect the background and wide perspective of the multiple aspects in which the circular economy is framed in general and as part of the innovation policy. The recent development of the terminology behind the circular economy is shown in the names of the thematic priorities; "clean technologies", "green economy" and "sustainable use of natural resources" reflect the roots of the circular economy discussion. The regions also have different starting points for how visible the circular economy is in their strategy. The five regions where the circular economy is mentioned in the thematic priority have a clear political mandate for proceeding further with the construction of transformative activities in the context of the circular economy. Nevertheless, the strategies in the other seven regions also support the

circular economy, as it is mentioned in the description of the regional thematic priority areas.

Table 4:2: Thematic priority areas and the construction of transformative activities related to the circular economy (CE). (Article II)

Country	Region	Planning	Construction of transformative activities			
		Thematic priority area related to CE	Roadmap	Action plan	Funding	Monitoring and evaluation
Belgium	Brussels Capital Region	Environment: Green Economy	CE as part of strategy. Bottom-up process, companies directly involved.	Ongoing actions.	CE projects funded with European Structural Funds (ESF).	Update upcoming, continuous process. No targets.
Denmark	Central Denmark	Growth drivers	CE as part of business development strategy. Bottom-up process, companies directly involved.	Action plans for each initiative (subpriority). Ongoing actions.	CE projects funded by ESF, other regional and EU funding.	No specified regional targets. Update in progress.
Finland	Southwest Finland	Innovative food chains	CE roadmap including defined categories. Bottom-up process.	Action plans for subpriorities. Ongoing actions.	Smart specialisation related projects funded by ESF, other regional, national and EU funding.	CE roadmap update in progress. Targets under preparation.
Finland	Häme	Sustainable use of natural resources	CE roadmap under preparation. Bottom-up and top-down approach.	Ongoing actions.	CE projects funded by ESF, other regional, national and EU funding.	No targets.
Finland	Päijät-Häme	Circular economy	CE roadmap with subpriorities defined. Bottom-up and top-down approach, companies directly involved.	Action plan for one subpriority; others under development. Ongoing actions.	CE- and smart specialisation-related projects funded by ESF; other regional, national and EU funding.	CE roadmap updated annually. Targets for one subpriority; others under discussion.
Finland	Satakunta	Bio and circular economy	Growth programme for bio and circular economy. Bottom-up process.	Actions defined in growth programme. Ongoing actions.	CE- and smart specialisation-related projects funded by ESF; other regional, national and EU funding.	Annual update of growth programme. General-level targets defined.
Germany	Berlin*	Clean technologies	CE as part of strategy. Cross-sector approach, bottom-up process, companies directly involved.	Ongoing actions.	Smart specialisation related projects funded, not specifically CE.	Updates with no specific schedule. No targets concerning CE.
Germany	Branden-burg	Clean technologies	CE as part of strategy. Cross-sector approach, bottom-up process, companies directly involved.	Ongoing actions.	Funding from ESF is linked with masterplans.	Updates with no specific schedule. No targets concerning CE.
Luxem-bourg	Luxem-bourg	Clean & eco-technologies	CE integrated into broad goals. CE strategy under preparation. Bottom-up and top-down approach.	Ongoing actions.	No ESF available from CE. National and EU funding.	No specific update process for CE defined yet. Targets defined for one subpriority.

Romania	South Muntenia	Bioeconomy: Developing circular economy	Defining of priorities in progress. Bottom-up process.	Lack of CE actors for actions.	CE projects funded by ESF, other EU funding.	Update in progress. No targets defined yet.
Slovenia	Slovenia	Networks for the transition to circular economy	Roadmap with priority areas defined. Bottom-up process; companies directly involved.	Strategic research and innovation partnerships' action plan for transition to CE. Ongoing actions.	CE projects funded from cohesion fund; national and other EU funding.	Evaluation in process. Targets defined.
Spain	Basque Country	Building a new circular economy	CE strategy almost final. Bottom-up process; companies directly involved.	Action plan under preparation. Ongoing actions.	No ESF available. Regional funding.	Updated every 2.5 and 5 years. Targets under preparation.

*email reply

The thematic priority areas should be further translated in roadmaps. This is a critical phase of the smart specialisation process. Due to the regional differences in naming thematic priority areas, the roadmap phase is not completely comparable, as some regional priorities do not specifically target the circular economy but have a wider or narrower approach. In most cases, the thematic priority related to the circular economy was already concretised in a strategy document. Six of the studied regions (Brussels, Central Denmark, Southwest Finland, Päijät-Häme, Satakunta, Slovenia) have a roadmap, meaning a strategy document or a programme, where the regional circular economy targets are defined. However, all regions do not necessarily see the circular economy strategy document as defining the smart specialisation thematic priority of, or related to, the circular economy. In some regions, the circular economy strategy is a parallel document which only partly overlaps the smart specialisation strategy. In four of the regions, a roadmap or strategy related to the circular economy was in preparation (Häme, Luxembourg, South-Muntenia, Basque Country). In the two remaining regions, the circular economy plays an important horizontal role in several sectors, even if it does not have its own strategy (Berlin, Brandenburg).

The main characteristic of smart specialisation as a policy process is the combination of the top-down and bottom-up approaches in governance (Foray, 2019). The findings confirm that the entrepreneurial discovery process had been taken seriously in the regions. The process had been mainly led by the regional authorities. However, there were examples of regions having an outside actor that was responsible for facilitating the roadmap process in practice. In the case of Päijät-Häme, this was a university, and in Slovenia, it was the chamber of commerce. In Central Denmark, the process was implemented by a consultant who focused specifically on communicating with the private sector. The top-down aspect in the process was mentioned in three regional interviews, while all the studied regions proceeded with a bottom-up approach to define roadmaps related to the circular economy. One of the interviewees described the process as follows: *"So the top-down part is 'Well, these are the sectors that we consider important and that we know are most innovative so that's why we want to define them as our RIS3 (smart*

specialisation strategy)', and then, we invited research institutions and other companies and other stakeholders in order to define which topics are important within the specific sectors."

The bottom-up processes included administration and academia, development organisations or associations and, in most cases, the private sector. The entrepreneurial discovery has mainly been organised through workshops, focus groups or other kinds of meetings. Also, face-to-face communication, through interviews and discussions with the stakeholders, provided additional information in some regions. The involvement of citizens in the strategy process was mentioned in two interviews (Basque Country and Päijät-Häme).

After the roadmap phase, the next step is to form action plans to implement the activities. From the circular economy perspective, only two regions (Satakunta and Slovenia) have refined their roadmaps into action plans. These two regions are among the five that have defined the circular economy directly in the name of their thematic priority, as seen in Table 4:2. In two other regions (Southwest Finland and Päijät-Häme), actions were defined for some specific parts of the circular economy. For example, the region of Päijät-Häme has defined an action plan for the subpriority "bio-based circular economy". No specific action plan exists in the majority of the regions" however, in all the regions, circular economy actions are ongoing, and funding circular economy-related projects is taking place. The link between smart specialisation priorities and the structural funds is obvious in the regions where this funding is available. However, as the 2014–2020 programming period began around the same time that the smart specialisation concept was launched, the regional development authorities were in a hurry to combine the aims. This might have influenced the strategic distribution of the funding. As the smart specialisation strategies continue to guide the allocation of structural funds in the 2021–2027 programming period, having a circular economy defined in the strategy will probably increase the availability of funding for implementation of circular economy-related actions and projects in the future. Moreover, several regions have utilized other types of funding for circular economy actions.

According to the findings, the monitoring and evaluation of circular economy roadmaps and action plans seem to be mainly in the development phase. Of the regions that identified the circular economy as a specific thematic priority and where action plans have been prepared, only Satakunta and Slovenia have defined targets to measure the circular economy. In Päijät-Häme, targets exist for the specific subpriority that hosts an action plan. The other regions in the research do not have defined targets, or they are in the preparation phase. Regarding the updates of the process, three regions have a clear plan. In Satakunta and Päijät-Häme, annual updates are planned, and the Basque Country is going to update its strategy every two and a half years. The majority of the regions in the research either conduct continuous updates by checking the priorities when funding new projects or look at circular economy priorities when the general regional-level strategy or smart specialisation strategy is updated. Otherwise, they do not have any specific update

process for the circular economy content. According to the study, the monitoring and evaluation of roadmaps and action plans seem to be rather challenging to define.

Perspectives on the concept of circular economy in smart specialisation (Article III)

The smart specialisation thematic priorities related to the circular economy should be based on regional strengths and, at the same time, be open to new directions to support regional development. Article III explores how the circular economy has been defined in the context of regional innovation policies, more precisely, in smart specialisation policy. It explores the environmental themes that lie in the background of the transformation of regional circular economy policies.

In the interviews, the representatives of organisations responsible for the regional smart specialisation process explained why they ended up placing a circular economy-related priority in their smart specialisation strategy. The discussions revealed the different premises and regional strengths lying behind the regional decisions. The replies were analysed and grouped into three types of factors found to influence the strategy development: 1) EU legislation, 2) national priorities and 3) a holistic approach. Several examples below are related to Finland due to the fact that the Finnish regions represent one third of the regions in focus.

The development of EU environmental legislation on energy efficiency and waste recycling was seen as a driving force in developing the circular economy in several regions (e.g. EU, 2008; EC, 2011a, 2011b). Five interviewees mentioned strengths related to energy (energy efficiency, energy technology), and furthermore, a background in waste management-related issues was revealed by five regional interviewees, which was partly different from reasons given related to energy focus. “Clean technologies” was written as a priority area in three regions, which indicates the support and focus on cleaner production of regional industry. In addition to these regions, clean technologies were mentioned in four other interviews when discussing the background of the circular economy. Concludingly, in over half of the studied regions, cleantech can be seen as a predecessor or driving force behind the circular economy. One regional representative commented, *“There has been a long tradition working related to circular economy in the region. Already 30 years ago they started implementing some of the practices related to waste recycling. And a very strong industrial symbiosis which has been operating in the area.”*

National priorities are obviously related to the regional ones. For example, five regional interviews highlighted the bioeconomy or strengths in bio-related value chains in the background of the circular economy. These five regions comprise all the Finnish regions and one German, representing countries with a strong national bioeconomy focus. Industrial symbiosis was mentioned as a background factor in four interviews, three of them from Finland. Also in this case, industrial symbiosis has been encouraged by Finnish political instruments, for example, through waste reduction targets (Lehtoranta et al., 2011). The national-level influence on Finnish regional smart specialisation choices has

also been noted by Nauwelaers (2013) in an earlier study. In addition, nearby regions have been encouraged by each other's example. In Finland, also the national roadmap (Sitra, 2016) has inspired the regions to follow on its example, and several regions have been setting up regional circular economy roadmaps at the same time.

A sustainable and holistic approach to the circular economy was revealed in the discussions with the majority of the regions. In half of the interviews, sustainability or regional strengths related to sustainable development were mentioned. Furthermore, in the interviews with seven partly different regions, the importance of seeing the system as a whole was brought up. One interviewee explained the situation as follows: *"One of the things we realised quite quickly was that the circular economy is a complex thing to do. And it's not a little thing that you can do just in a few months and it's also not something that you can do in a specific sector only, it's very cross-sector you will basically need to change the whole system."* However, the discourse on sustainability is simple in theory, while understanding and implementing sustainable actions from a holistic perspective is far more complex. One additional insight in four of the discussions with regional representatives was that the circular economy was introduced in their regional smart specialisation priorities because it is a current trend in the EU policies. The EU policy indeed has an effect on the regional policies; however, there is a difference between adopting the policy content and embracing a trend. As the circular economy has become a popular concept, there is a slight risk for actors following the trend with a somewhat uncertain knowledge base. The findings are concluded in Table 4:3.

Table 4:3: Themes in the discussion behind the circular economy-related thematic priority areas (Article III)

Country	Region	Thematic priority area related to circular economy	Themes behind the priority (circular economy)							
			Energy	Waste	Cleantech	Industrial symbiosis	Bioeconomy	Sustainability	Holistic	Trend
Belgium	Brussels Capital Region	Environment: Green Economy	**x**					x		
Denmark	Central Denmark	Growth drivers			x			x	x	x
Finland	Southwest Finland	Innovative food chains				x	x	x	x	
Finland	Häme	Sustainable use of natural resources	x	x	x	x	x			
Finland	Päijät-Häme	Circular economy			x		x	x	x	
Finland	Satakunta	Bio- and circular economy	x			x	x			
Germany	Berlin*	Clean technologies			x			x	x	
Germany	Brandenburg	Clean technologies	x	x	x		x		x	x
Luxem-bourg	Luxembourg	Clean & eco-technologies							x	
Romania	South Muntenia	Bioeconomy: Developing circular economy		x	x					x
Slovenia	Slovenia	Networks for the transition to the circular economy	x	x					x	x
Spain	Basque Country	Building a new circular economy		x		x		x		

*email reply

4.3 A regional circular economy strategy process (Article IV)

In Finland, in the Päijät-Häme region, the European and national targets for a circular economy have been implemented in the regional strategy and defined in a roadmap. The Päijät-Häme regional development strategy and plan, which at the same time include the regional smart specialisation strategy, emphasise a circular economy as one of its targets (Päijät-Häme Regional Council, 2017). To concretise the regional strategy, a circular economy roadmap was set up and published in 2017 (Lahti University of Applied Sciences, 2017). To find out how the move towards a circular economy was supported through a regional roadmap with specific goals and how one of the defined goals was concretised in a detailed action plan, a case study on the process was conducted. The

study, which tackles SQ3 of this research, is presented in detail in Article IV, and its results are concluded in this section.

The process of creating a regional circular economy roadmap was inspired by the Finnish national roadmap and the need for its implementation at the regional level. At the beginning of the process, the key actors were the Regional Council of Päijät-Häme and Lahti University of Applied Sciences, who planned the process together. In the process, the university served as a facilitator, which was supported by a joint research and development project with several actors and funded by the structural funds. The project funding enabled further studies on regional material flows that gave important background information for the roadmap process.

The main stakeholders involved in the process included regional and municipal authorities, academia (several universities), a regional development company and private and public businesses. The roadmap development process described in the study included several important data sources and steps, beginning in 2015 when the need for a roadmap was recognised and ending in 2019 when the bio-based circular economy action plan was published. Background studies, preparatory data gathering and a stakeholder workshop formed the base for defining the common vision, regional aims and concrete actions. Moreover, other workshops, events, meetings and additional desktop studies as well as personal communication between the researchers and the stakeholders occurred during the process face to face, by telephone and email. Comments on the roadmap draft were also requested directly from additional stakeholders. Through the process, the university of applied sciences supported the regional council with the implementation of activities. The detailed process of the case study's activities, topics, dates and stakeholders involved in each step is presented in Article IV.

Through the joint activities described above, the roadmap process delivered a vision of the regional circular economy, "Päijät-Häme – the successful resource-efficient region". The vision was defined through five goals, and the goals were further concretised in a list of actions. The goals were identified as 1) closed loops of technical streams to create added value, 2) towards energy self-sufficiency by applying sustainable transport and energy solutions, 3) new consumption models and business opportunities, 5) piloting and demonstrating innovative circular economy solutions and 5) sustainable business from the bio circular economy. The framework of the roadmap is presented in Figure 4:2.

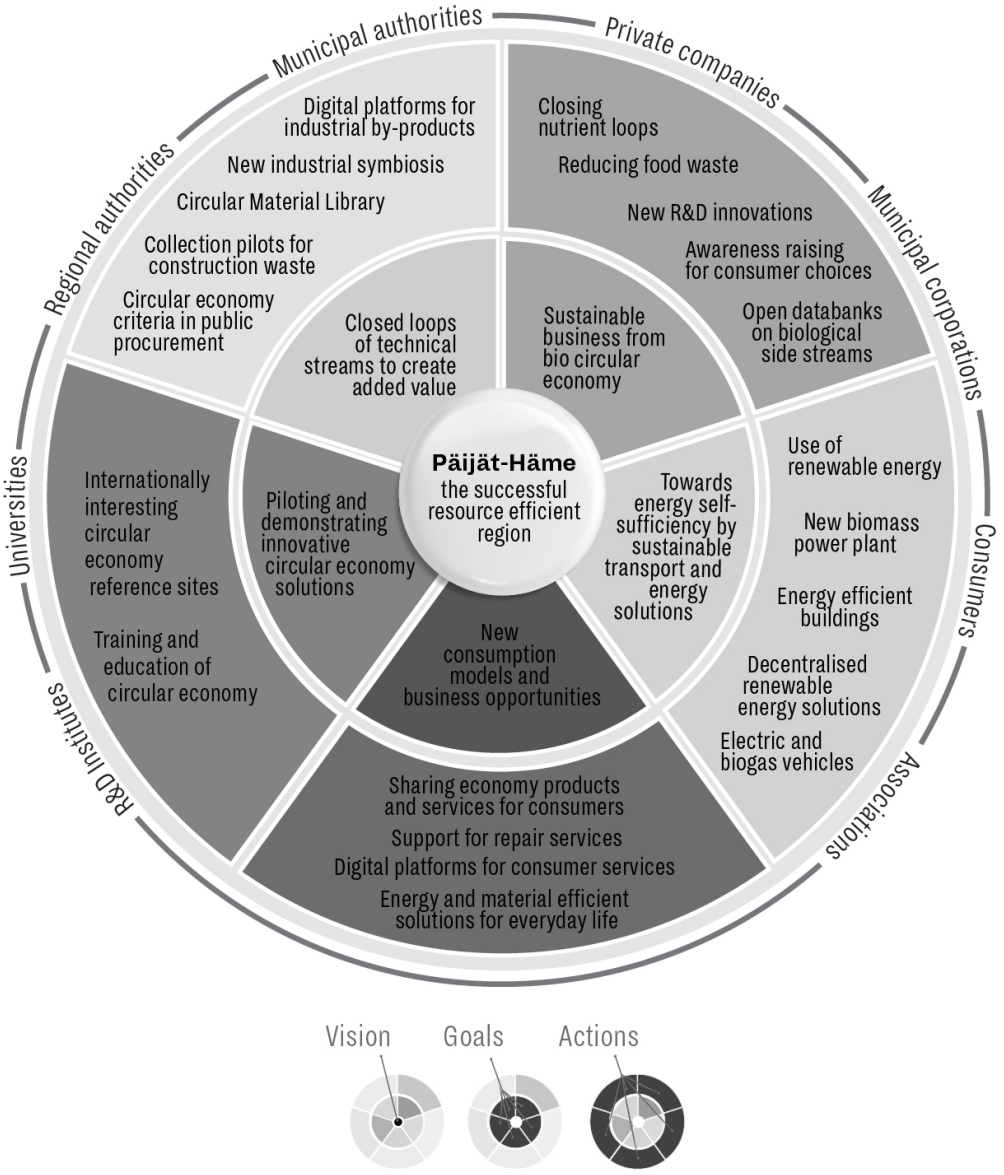

Figure 4:2: The vision, goals and actions towards the circular economy in the region of Päijät-Häme, Finland. (Article IV)

The first goal, “closed loops of technical streams to create added value”, is in accordance with one of the main principles of the circular economy (see e.g. EMF, 2012). It highlights the importance of maintaining the value of products, materials and resources in the economy for as long as possible. At the same time, the generation of waste is minimised.

In the circular economy, material flows have usually been classified into biological and technical materials. Technical materials refer to flows which are not of biological origins but come from some manufacturing or treatment processes. In the case of Päijät-Häme, the following technical material flows have been researched: ferrous metals, non-ferrous metals, plastics, textiles and ashes. For example, the material flow analysis shows that in the region, approximately half of all plastic and textile wastes are incinerated instead of being used as raw materials. Hence, these materials have large reuse opportunities, such as in industrial symbiosis. Already, the region hosts several examples of industrial symbiosis. However, the roadmap process showed that new ones are also required. In general, a lack of comprehensive knowledge exists regarding recycled materials' properties and potential uses. One of the actions in the roadmap is to develop a circular material library, a tool that includes information and examples of waste materials produced in the region (Virtanen et al., 2017). The circular material library was seen to support small- and medium-sized companies, in particular, in their efforts towards the circular economy. Furthermore, the importance of including circular economy criteria in public procurement was identified as one of the actions that should be taken. For example, based on the regional material flow analysis, ashes originating from energy production processes have the potential to be utilised in the public construction of roads. Finally, digital and smart platforms have a central role in closing the material loops.

The goal "towards energy self-sufficiency by applying sustainable transport and energy solutions" addresses the broad energy sector, which is highly relevant in the circular economy discussion. The importance of the energy sector in the macro-level debate on the circular economy has also been pointed out in previous research (see e.g. Ghisellini et al., 2016). This goal and related actions highlight the importance of developing the utilisation of renewable energy sources. In 2020, the regional energy company aimed to replace the old coal boiler and switch to generating district heating through bio-based energy sources, such as wood chips. The plan was fulfilled, and it has had significant effects on regional CO_2 emissions. Furthermore, developing decentralised renewable energy solutions in rural areas was seen as important. In addition, the utilisation of renewable energy sources, actions to support the energy efficiency of buildings and promoting the use of electric and biogas vehicles have also been included in the roadmap.

The third goal of the roadmap highlights the importance of new types of businesses that aim to change citizens' consumption habits. "New consumption models and business opportunities" emphasise the sharing economy and social aspects of sustainability in the circular economy. This has been recognised as a field which has not yet received enough attention in the circular economy debate (see e.g. Korhonen et al., 2018a; Merli et al., 2018). The new ways of consuming and the shift from selling products to selling services are seen as important in the regional roadmap. New business opportunities related to renting, sharing and repair services and comprising products, services and labour could be developed in the region. The establishment of new digital platforms is in the core of this goal.

An area where the Päijät-Häme region wants to be a pioneer is summarised in the fourth goal: "piloting and demonstrating innovative circular economy solutions". As the circular economy is a new and still developing concept (see e.g. Kirchherr et al., 2017, Homrich et al., 2018; Korhonen et al., 2018a), it is crucial to spread knowledge among actors about successful examples. The plan is to create internationally interesting reference sites in the area, for example, those based on pre-existing industrial symbiosis areas, new residential and industrial areas or new industrial plants that are based on closed-loop systems. An existing industrial symbiosis in Päijät-Häme involves the regional waste centre area that provides an exchange of materials and energy among several nearby industries.

The last goal is the "sustainable business from the bio circular economy", which aims to develop the bio-based circular economy in the region. Closing the biological cycles is one of the key aspects of the circular economy (EMF, 2012). The roadmap emphasises closing nutrient loops, supporting local food supply chains and reducing the loss of raw materials. The region already has successful examples from the field. For example, it hosts the largest biogas and composting plant in Finland, which is part of the abovementioned industrial symbiosis. The concept is identified as an advanced bio-based circular economy good practice (Interreg Europe, 2021c).

The circular economy roadmap of Päijät-Häme is designed as a process rather than a report, and the aim is to update it regularly in cooperation with the regional stakeholder group. After the roadmap was published in September 2017, the regional cooperation continued with stakeholder meetings and events.

The first update and expansion of the roadmap was prepared in 2018, and it focuses on the goal related to the bio circular economy. As a continuation, the stakeholder cooperation and the roadmap process generated an action plan focusing on the bio circular economy, and it framed concrete actions that included a schedule and responsible partners. The Päijät-Häme Bio-Based Circular Economy Action Plan was finalised in 2019 (Päijät-Häme Regional Council and Lahti University of Applied Sciences, 2019). It included three action entities specifically aimed at developing the utilisation of biowaste streams: 1) promoting a sustainable bio-based circular economy and enhancing nutrient cycles, 2) establishing pilot projects for biowaste collection and recovery and 3) promoting the use of bioproducts and bioenergy. The fourth action is framed on the general level and is to support developing Päijät-Häme as an international reference area for the circular economy. The action plan was at the same time a part of an interregional research and development project, where the Lahti University of Applied Sciences and the Regional Council of Päijät-Häme cooperated (Interreg Europe, 2021a).

5 Discussion

5.1 Contribution to theory and practice

Throughout the last decade and while this research was taking place, the EU policies have been continually updated, as the understanding of the circular economy has developed towards being more sustainable and inclusive (see e.g. EC, 2015, 2018, 2020). This research shows that, accordingly, the same development of understanding and implementation has taken place on both the national and regional levels. Already between the time of data collection and the time when the articles were published, information was out of date, as several new circular economy strategies were published. For example, in France and Greece, national-level circular economy strategies were adopted in 2018. In Finland, an updated version of the original circular economy roadmap published in 2016 was approved in 2019. In the Slovak region of Nitra, a sustainable circular economy was stated in the updated regional development programme in 2018.

At the time of data collection for Article I, two years after the EU circular economy action plan was published (EC, 2015), circular economy as a term had been recognised in almost all studied strategies, both on the national and regional levels. This rapid policy development shows the novelty of the circular economy concept and how it was quite quickly taken into use. However, as this new concept was rapidly adopted, the full understanding of it was, and still is, only developing. In academic terms, the concept of the circular economy is very young. Yet, since the beginning of this dissertation study in 2016, the scientific discussion on the circular economy has evolved dramatically.

The results revealed that, as the circular economy discussion on the European level was already speeding up, several national and regional strategies were still focusing on waste management. The titles of the strategies and their focus was on waste, but the circular economy was mentioned in the text. As pointed out in Section 2.2.5 (see e.g. Hartley et al., 2020; Fitch-Roy et al., 2021), this research confirms that the discourse on waste management and recycling can be seen as the predecessor of the circular economy. However, it is important to note that, if the perspective on the circular economy stays limited to waste and recycling, the full potential and holistic understanding of the concept cannot be reached. Until recently, the debate on the circular economy has been dominated by non-academic sectors, and thus, this can be a reason why the perspective of the concept has stayed rather narrow. As stated by, for example, Millar et al. (2019) and Calisto Friant et al. (2020), the discussion has so far failed to build a systemic and holistic understanding, especially related to the social perspective and sustainability implications of the circular economy. The challenge of reaching a holistic understanding is identified in this study.

In striving towards a circular economy, the role of existing policies and authorities promoting the policy development is essential. The macro-level actions on the international, national and regional strategy levels play an important role in how the

region supports and develops circular actions. The macro-level perspective ranges from the international, national, regional to local level, which is a very broad setting. In practice, the approach differs depending on whether matters are analysed on, for example, the local or international level. Related to this, as Silvestri et al. (2020) also imply, the regional focus would belong to the meso level. However, it is generally agreed that a multilevel governance is essential to achieving a societal change towards a sustainable system.

According to Fitjar et al. (2019), the main focus of smart specialisation has so far been on promoting the "smart" aspect, while the "inclusive" and "sustainable" parts have been left in the background. However, as this study focuses on regions where the circular economy is in focus, the generalised perspective is not comparable. However, the representatives of the actors in charge of the smart specialisation process in the studied regions see the circular economy as a building block in their regional innovation policy.

When the smart specialisation thematic priority areas are named, a number of aspects must be explored. The regional strengths and future possibilities form the scope of the priority. However, an overly broad definition of the thematic priority area can make it difficult to generate the crucial concentration and specialisation effects of smart specialisation. Setting up a roadmap and, further on, an action plan for the thematic priority areas is central to the smart specialisation process (see Foray, 2019) and a necessary part of specifying the focus.

In half of the studied European regions that mentioned the circular economy in the description of their smart specialisation thematic priority, the circular economy-related thematic priority areas in regional smart specialisation strategies are concretised through a roadmap in the meaning of a strategy. However, it is important to note that, if the circular economy is not specifically named within a thematic priority (i.e. the circular economy exists only in the defining text of the priority), the regional preferences of setting up a roadmap in the context might not be a main interest. The smart specialisation process should also be supported by monitoring and evaluation tools to measure performance. In practice, the monitoring of roadmaps and action plans related to the circular economy is challenging due to difficulties in defining and setting circular economy targets. The lack of measurements is also due to the infancy of the circular economy concept in general. Moreover, monitoring the direction of change can also be advantageous. For the regions to maximise the benefits of both smart specialisation and circular economy, the focus should be set on clearly defined priorities and concrete yet still somewhat flexible plans on how to achieve the targets. Nevertheless, the results show that the implementation of the smart specialisation process is still in the development phase. The findings indicate that the regional development authorities and actors have a will to develop the transformative activities involving the circular economy, but as seen, there are differences in the implementation models and stages of success. The themes prioritised in the smart specialisation strategies need to be concretised and connected to the regional entrepreneurial bases and innovation activities. If this does not take place, smart specialisation remains only a regional branding effort or even a form of "greenwashing".

As the smart specialisation process has been received positively in the EU regions (McCann and Ortega-Argilés, 2016), it can serve as a base for renewing and updating the regional policy processes. Moreover, in the 2021–2027 programming period, the smart specialisation strategies continue to guide the allocation of structural funding to specific themes or activities, and overall, the environmental focus will be even stronger. Having the circular economy as a defined part of the smart specialisation strategy will surely support and increase the availability of funding for the regional implementation of circular economy-related projects. The research gives an example of how the smart specialisation strategy as a policy framework has been utilised throughout Europe in the developing circular economy in the regions. The results show that, in some regions, the smart specialisation process is strictly seen as a way to promote innovation and not as a strategic instrument for developing the circular economy, even if the theme of the two concepts overlaps in the case of the studied regions. Seeing the synergies and promoting the circular economy as a strategic priority through the smart specialisation process can help and has helped the regional development authorities in other regions define their circular economy targets and actions.

The main characteristic of smart specialisation as a policy process is the combination of the top-down and bottom-up components. One of the factors that can affect the desired results of smart specialisation implementation in the regions is the ability of important stakeholders to collaborate in all phases of the smart specialisation process, from identifying the priority areas to implementing policy actions. To a certain degree, the top-down approach is suitable, especially in setting up the priority areas, whereafter the bottom-up process should take over. In the roadmap and action plan phases of the smart specialisation process, stakeholder involvement in the form of entrepreneurial discovery becomes central. In case some exchange in the entrepreneurial discovery process is weak or some stakeholder presence is missing, the base of the joint understanding might not be strong enough. Arsova et al. (2021) have lately come to the same conclusion that the transition towards a circular economy needs to be stimulated by a mix from bottom-up initiatives top-down efforts in order to have full inclusion of stakeholders. In this research, the entrepreneurial discovery process, including a bottom-up approach, was applied in all the studied regions. However, slight differences in the level of involvement, for example, regarding private companies, occurred.

European countries and regions have a tendency to follow successful peers instead of trying to find an original area of expertise (Foray and van Ark, 2007). However, controversially, the smart specialisation logic builds on regional strengths. Realising this and truly discovering the regional premises can be seen as a learning opportunity for regional actors. The circular economy-related thematic priority areas in regional smart specialisation strategies should be formed based on regional assets. However, the driving forces of why the circular economy was chosen as one focus of the smart specialisation strategies in the studied regions revealed slightly different premises leaning on regional strengths. The EU environmental legislation on energy efficiency and waste recycling was a driver for developing the circular economy in several regions. National priorities on specific content or sectors affected regional preferences. For example, in the Finnish

regions, a focus on the bioeconomy and industrial symbiosis was seen as a theme, where national priorities were mirrored in regional directions.

This study confirms the findings of previous researchers that the circular economy concept is widely accepted among policymakers when aiming for sustainability (Sauvé et al., 2016; Geissdoerfer et al., 2017; Korhonen et al., 2018a; Schroeder et al., 2019; Lin, 2020). Related to the sustainability discussion, it was found that, in the majority of the studied regions, a sustainable and holistic approach to the circular economy was a background driver in the development of the concept. This is promising news. However, the discourse on sustainability is simple in theory, while deeper understanding and systemic implementation of sustainable actions in practice are far more complex. The circular economy has become an extremely popular policy concept, and some actors might follow the trend without a proper knowledge base. This creates a risk that the concepts of both sustainability and the circular economy may be misused. To avoid this, the interplay between academia and key stakeholders, especially policymakers and the business sector, becomes vital. The holistic understanding of the necessary systemic change to achieve a sustainable circular economy is essential for bringing it into practice. Furthermore, the study showed that in four of the studied regions the circular economy was prioritised in the smart specialisation priorities because it is seen as a current trend in the EU policies. The full understanding of these comments remained unopened in detail; however, they can mean several things depending on how the words involved are understood. If the interviewees meant that their region is following the flow only because of the trend, it is indeed concerning; however, they might have meant that the general trend towards circularity and sustainability is increasing.

The sustainability discussion and the European Green Deal supporting the sustainable development goals has also affected the interpretation of the smart specialisation concept. An update of the smart specialisation logic to include more perspectives on sustainability has been proposed in the EC's recent research report (McCann and Soete, 2020). The report introduces changing the European regional development strategies from "S3" to *smart specialisation strategies for sustainable and inclusive growth* (S4+) in order to support achieving the targets of the Green Deal (McCann and Soete, 2020). However, Benner (2020) criticises the realistic possibilities of affecting the global challenges with regional policy and states that the smart specialisation process should not be seen as capable of solving global problems. He notes, that instead, the entrepreneurial discovery process should guide the regional course to which global sustainability challenges are relevant for their priority domains (Benner, 2020). Both perspectives are understandable and true. The regional decisions have a great effect on local actions, which indeed are the core of the move towards the circular economy. However, Benner is right that the challenges should be tackled and the steps justified through "regional lenses".

Based on the literature (see e.g. Foray 2014, 2016) and the case study of the Päijät-Häme region, a successful smart specialisation process should include both a top-down and a bottom-up approach, with bottom-up being dominant through the entrepreneurial discovery. An integrated and systemic approach allows and supports synergies. To

achieve this, a regional commitment and coordinating body are needed. The public authority in charge of setting up the regional strategy has a great responsibility in planning the process and triggering the "right" actors to cooperate. In addition, the regional abilities involved in collaborating in the process, organising it and, if necessary, facilitating it are in a key role. However, the detailed organisation of the process and the type and extent of the stakeholders involved are specific from region to region.

In the Päijät-Häme case, the regional university of applied sciences (Lahti University of Applied Sciences) acted as a facilitator, and structural funding for research and development was used to support the process. Throughout the process, the central role of academia was visible as a coordinator, but together with other actors, also in form of conducting background studies, facilitating workshops and drafting the roadmap. Furthermore, the cooperation between the regional development authority and Lahti University of Applied Sciences continued in the organisation process of setting up the detailed action plan for the bio-based circular economy.

An identified challenge in regional strategy processes is how to enrich the entrepreneurial discovery through creating an active dialogue with the business sector. This was also noticed in the Päijät-Häme case. To achieve inclusiveness and involve especially private companies in a, sometimes not so concrete, strategy processes is not easy. However, this is a controversial dilemma, as the target of the circular economy and the smart specialisation strategy is to create new sustainable business based on regional characteristics where companies form the core. This means that the active role of the business sector already in the regional strategy process is important. Thus, it is crucial to achieve an inclusive dialogue and find suitable ways to activate many companies in the strategy process. In Päijät-Häme, the companies were mainly represented through a regional development company and some key public and private companies. Alessandrini et al. (2019) proposes that a starting point for reaching the companies could be achieved by focusing on business sectors where the public sector plays an important role, such as construction, energy, mobility and water. In the studied case, this was partly achieved through the public companies.

The cooperation between industry, government, academia and citizens in the spatial context (quintuple helix) of an innovation system is crucial (Carayannis et al., 2018; Alessandrini et al., 2019). In the system, the regional development authority plays a key role as a catalyst in enabling and enhancing the regional cooperation or, in the worst case, slowing or hindering it from blossoming. The cooperation between stakeholders towards a shared vision takes the region forward. This can be enabled through an organised exchange of knowledge. For example, an advisory board with local stakeholders could support local companies in their development (Alessandrini et al., 2019). Furthermore, the necessity of involving the civil society and citizens in the circularity dialogue is an aspect that is perceived to be important from the social sustainability perspective, yet one that is not widely developed in practice. Without a change in the behaviour of the people, a sustainable circular economy cannot succeed. One of the goals of the Päijät-Häme roadmap aims at developing new business models, for example, the sharing economy,

which builds on the activities of citizens. To promote this part of the circular economy, education of and communication with citizens as stakeholders is vital.

Where the circular economy is clearly economically advantageous, industries are most likely already implementing the concept due to the economic benefits (e.g. obvious cases of industrial symbiosis). However, innovative circular economy strategies can bring about new incentives for companies to change their operations. As defined in the goals of the Päijät-Häme roadmap, governmental actors should act through their own example by following circularity principles in their actions, for example, in public procurement.

As pointed out, the circular economy needs to be considered from a holistic perspective in order to succeed. The five goals of the Päijät-Häme roadmap concretise that the different aspects of the circular economy have been taken seriously in the region: emphasising recycling targets but moving beyond them. The goal related to new consumption models and examples of actions listed under other goals related to, for example, awareness raising for consumers or training and education refer to social sustainability aspects.

One special feature of the success in the case study is the utilisation of projects as supporting tools in the strategy process, both in delivering the strategies and updating them later on. The regional structural fund-financed project led by the university of applied sciences enabled, for example, the material flow studies of the region and the facilitation of the roadmap process. At the same time, it brought together several key stakeholders as project partners in the circular economy strategy discussion, and thus, the cooperation could easily deepen and include more actors. Moreover, the fact that the university of applied sciences and the regional council, in the meantime, also cooperated in interregional projects in the field of circular economy strategic development gave an extra boost to the collaboration. The Interreg Europe programme supports regions in developing action plans on specific issues addressed by the projects. In the case of Päijät-Häme, the BIOREGIO project focused on setting up a regional action plan to develop the bio-based circular economy (Päijät-Häme Regional Council and Lahti University of Applied Sciences, 2019; Interreg Europe, 2021a). The project aim was combined with the circular economy roadmap, and thus, the delivery of the bio-based circular economy action plan defined one of the roadmap's objectives while at the same time contributing to the regional smart specialisation strategy.

The results of the case study show that cooperation among authorities, municipalities, academia and businesses across sectors is crucial to achieving successful regional circular economy policy. The regional circular economy stakeholder ecosystem or cooperation group was strengthened during the roadmap process and it supports a way to enable and continue a dialogue among the regional actors. The stakeholder-based approach and its continuation is crucial in order to enable ongoing development towards a circular society. There is great potential for developing new ways of involving stakeholders, especially companies and citizens, in the cooperation. In summary, the challenges and opportunities

of a roadmap process are wrapped around a successful balance between the top-down and bottom-up approaches to the regional policy.

The Päijät-Häme roadmap process was identified by the Interreg Europe programme's policy experts as a good practice, that is, a transferable example of how to develop the circular economy in a region (Interreg Europe, 2021b). Both the process itself and academia's role in it were recognised as successful implementation models for other regions. There is a strong potential for transferring the Päijät-Häme roadmap experience to other regions aiming for the transition towards a circular economy. For example, the model of Päijät-Häme has triggered the Spanish region of Castilla-La Manca to be the first region in Spain to set up a regional circular economy law that came into force 1 April 2021 (Castilla-La Mancha, 2021).

5.2 Limitations

This research has limitations especially related to the extent of the source material. The most central ones are explained in the following.

The data utilised in this dissertation only covers instances from the EU. The regions for Article I were chosen to represent a wide geographical and socioeconomic scope; however, it is still an example. A wider view would give an even better understanding of the situation. Furthermore, the cases of Articles II and III are limited to the information found on the EC's Eye@RIS database. All regions might not have the data on the platform updated. For example, the Finnish region of Pirkanmaa also has the circular economy as a thematic priority area. However, the information was not updated on the platform. Yet, the data collection has to be limited, and the EC's database provided an applicable way to proceed.

The findings in Article III present the discourse behind the circular economy concept from the point of view of the smart specialisation key organisers. These limited representatives might not host the best knowledge in the regional circular economy development; however, they provided an understanding of the concept's background from the view of smart specialisation. The research could be deepened by studying regional policy documents or broadening the interviews to several stakeholders in the regions.

Article IV is a case study. When implementing a case study, several methods for data collection are used, the decisions made by the researchers affect the data used. Furthermore, the case study gives one example of regional strategy implementation. If another region would have been studied, the outcome of the research would indeed be different.

6 Conclusions

In this dissertation, the implementation of the circular economy in regional strategies was researched. The focus was set on a multicountry comparison, and an example of one regional strategy process was studied in detail.

The implementation of a circular economy is presented as a possible solution to respond to the sustainability crises. A range of actors from policymakers, businesses and practitioners to scientists seem to agree that the future economy has to be circular. It is likewise agreed that regions and regional strategies play a central role in promoting the transition towards the circular economy. As a strategic tool, the smart specialisation process can be an effective way to accelerate the regional debate towards defining regional circular economy goals and assets. To achieve successful and sustainable regional circular economy development supported by smart specialisation, certain aspects need to be endorsed in the region. Consequently, great demands are placed on regional development authorities and their strategy approaches to succeed in this important task.

First, support on the international and national levels is crucial for developing successful regional policy in a specific context, in this case, the circular economy. Therefore, the role of EU policies related to the circular economy has been central in the development of regional circular economy strategies. Circular economy strategies have been emerging during the last few years in Europe, increasingly since the release of the first EU action plan on the circular economy in 2015. The circular economy, as an idea, was present in most of the analysed national and regional strategies of this research in November 2017. However, the strategies mainly referred to circularity through waste management and resource efficiency, comprising the circularity in a quite narrow perspective. Yet, it should be noted that the field of circular economy and implementing it in regional strategies is a constant process. During the last few years, several new strategies have emerged, and existing ones have been updated.

Second, the importance of understanding the circular economy as a holistic and systemic transition and, through this, getting the full potential out of the concept is still developing. The concept of the circular economy is still young, the scientific discussion around it is still in its infancy. Generally, an academic discussion widens the view and brings up a number of new aspects to a concept, which is very important to its conceptual maturing. To meet sustainability challenges, the world is facing an in-depth understanding of the circular economy concept, and the regional possibilities of supporting the structural change are crucial. The circular economy should be concretised, while ensuring a holistic and systemic approach. A holistic circular economy includes all dimensions of sustainability: environmental, economic and social. The social dimension has been especially underrepresented until now. A systemic change incorporates multilevel governance and connections between different actors in society. It requires changes at various levels in society, involving actions on the macro (EU, national, regional), meso (ecosystems, networks) and micro (companies, consumers) levels. Academia has a central role in broadening the understanding of the sustainable circular economy. Research and

innovation are essential in achieving the transition, as they are a means of rethinking ways of producing, using and transforming material and services.

Overall, the European approach to the circular economy has been concentrating on waste, its reuse and disposal (Marino and Pariso, 2020). Through the analysed strategic documents, as well as through the regional discussions on the circular economy priorities, this study also confirmed that the background of the circular economy lies in waste management, resource efficiency and industrial symbiosis. It seems as if, in some cases, circular economy principles exist as ideas in text but are implemented only when they enter through, for example, waste management legislation. A critical question is to understand what the circular economy comprises and how it actually can enable systemic and holistic sustainable change. Thus, while the discourse on the necessity of sustainability and circularity is simple, implementation is far more complicated. A holistic view of science is more complex but can be a lot more rewarding than the study of fields in isolation. The presented example of the Päijät-Häme circular economy roadmap is a step in the right direction, as it includes goals beyond the waste recycling focus, for example, related to new business models, thus providing a broader view on circularity.

A holistic and systemic approach to the circular economy that includes both short-term and long-term sustainable solutions is necessary to ensure that policies enable and support the socioecological change. Nevertheless, the understanding of the importance of a sustainable approach to circularity development is moving forward. The current debate on the relationship between the circular economy and sustainability, including academic critical engagement on the topic, is fruitful and necessary for the circular economy to develop towards being a consolidated concept. For example, in EU-level policy documents, the sustainability dimension has been highlighted in the recent EU circular economy action plan update (EC, 2020) and in a proposal for updating the smart specialisation strategies to support achieving the targets of the Green Deal (McCann and Soete, 2020). There are several expectations on social, environmental and economic benefits. To achieve a sustainable circular economy on the regional level, joint efforts are needed by all levels of government in setting up supporting policies. Moreover, the holistic approach needs to be developed in both the circular economy and regional policy. There is a need for long-term thinking to ensure that strategies do not remain focused on "end-of-pipe solutions" but can achieve smart socioecological transformation.

Third, regional smart specialisation strategies can be utilised to support the implementation of the circular economy on the regional level. However, concretising priority areas and roadmaps into action plans remains a challenge. Over the last decade, parallel with the circular economy debate, the smart specialisation concept has evolved as a part of the EU regional policy. A sample of 12 European regions which have included the circular economy as a regional smart specialisation priority striving to support their sustainability transition was studied. As Foray (2019) highlights, a regional smart specialisation strategy should include actions, funding and a monitoring framework to follow up the actions. The researched regions have regional strategies and roadmaps with

goals to circular economy. However, only in a couple of the studied regions have the roadmaps been concretised into action plans in the smart specialisation process. This can be related to the challenge of narrowing down the priorities – if the priorities or goals are too wide, defining actions is diffuse. Furthermore, monitoring roadmaps and action plans seems to be challenging, as circular economy monitoring overall is still in the development phase. The research also revealed that, in some regions, the smart specialisation process is strictly seen as fostering innovation and not as a strategic tool for developing the circular economy, even if the themes overlap.

Smart specialisation is linked to the distribution of structural funds in the regions, as an existing smart specialisation strategy was set as an *ex-ante* condition for receiving funding from the EU structural funds for research and innovation investments in the 2014–2020 programming period (EU, 2013; EC, 2014). Nevertheless, as the smart specialisation concept was introduced in 2012, near the start of the funding period, not many regional authorities were able to fulfil the smart specialisation process properly before the beginning. In several regions, the process progressed straight from setting up regional priorities and roadmaps to funding projects. However, the action plan phase would give a more coordinated structure to the regional activities towards the circular economy.

Smart specialisation strategies can be seen as an ongoing process of upgrading and developing governance and policymaking. Both the Green Deal and the smart specialisation strategies are defined as transformational policy frameworks (Arsova et al., 2021). The sustainability demand on smart specialisation and circular economy strategies highlights the fundamental aim of these strategic concepts. Combining circular economy and smart specialisation goals can help support the sustainability transition in the regions.

Fourth, including central stakeholders in the regional circular economy strategy process is crucial. The entrepreneurial discovery process of smart specialisation calls for public-private collaboration and a bottom-up approach, where the actors discover the regional capabilities. This study confirms that, when it comes to the implementation of regional strategies, the participatory nature is highlighted in the regions. The foundation of a successful regional strategy process is in the cooperation ability and will of the regional development authority to implement bottom-up regional policy. The bottom-up approach, which involves authorities, academia, development organisations, associations, companies and citizens in defining a circular economy roadmap, enables the expertise of stakeholders to be brought into the process. Different and innovative approaches in the organisation of stakeholder contribution and collaboration can provide support for the authorities, both in widening the knowledge base and in practical arrangements. For example, as in the case of Päijät-Häme, academia can provide in-depth expertise and serve as a facilitator in the strategy process. However, it is challenging to be fully inclusive and encourage stakeholders to be involved in a strategy procedure. In particular, private companies might not find enough value in collaborating in a long-running process. Yet, the target of both the circular economy and the smart specialisation strategy is to create new sustainable business based on regional characteristics, and consequently, the best possible outcome is not achieved without a dialogue with the business sector. Supporting

companies towards a more active cooperation is smoothest when started with the business sector, where the public sector plays an important role. Another group of stakeholders that is becoming more and more important in the holistic scope of the circular economy is citizens. Including citizens in the circular economy transition is also crucial; without a change in citizens' behaviour, companies and a sustainable circular economy cannot succeed.

The authorities responsible for regional development act at the strategic level as enablers of the circular economy. The actions and open-mindedness of the authorities can allow for synergies between different strategies and the use of different tools to bring the region towards the same goal. A successful smart specialisation strategy process is usually a combination of a top-down and bottom-up approach, with the top-down being applied in the beginning of the strategy process when defining the priorities, and shortly overtaken by the bottom-up. Generally, innovation is seen to be created near the grass-roots level rather than coming from the top. The stakeholder-based approach is essential for continuous development towards a circular society. Yet, the regional authorities' role is essential in organising and enhancing a successful exchange between the stakeholders, or in the worst case, slowing it down.

Finally, regional actors and development authorities should look for innovative ways to support their circular economy actions as well as their strategy processes. The implementation of the circular economy principles in strategies, and strategies finally leading to actions, is a long process. While reforms at the strategic level are time-consuming, actors should not wait to also take proactive practical action. The promotion of the circular economy is best realised in practice when activities and strategies are implemented in parallel but with intense interchange: companies promote their own sustainable and circular goals, academia produces research data, residents implement practical actions and public authorities support various parties through strategy work, enabling an exchange of knowledge and channelling of regional development funding. It is important that understanding and knowledge of holistic system-level change increases in both theory and practice.

In addition, regional development authorities should also look around among their stakeholders for support with designing and setting up the strategy. For example, different types of project funding can be utilised in preparing background information, defining regional properties and finding support through cooperation with regions from near and far, not to speak of concrete pilot activities. Smart specialisation should serve as a tool for building on regional strategic potential and strengths to direct funding to concrete regional actions and new openings, in this case, for promoting a circular economy. Combining regional strategic goals with project aims is not anything revolutionary. However, innovative solutions and generating win-win situations between project goals and regional strategy processes can help boost and renew the regional strategies, not only in the case of the circular economy but also in a larger scope. Research and innovation play a key role in the realisation of the circular economy, as they support reforms related to the production, use and conversion of materials in the circular economy. New ideas

bring fresh openings, as the basic idea of smart specialisation is to think “smart” while building on existing strengths. In the case of Päijät-Häme, the regional development authority has seen the possibility of combining smart specialisation with promoting the circular economy goals of the regional strategy. The targets have been pursued in cooperation with regional stakeholders through various practical means, including project funding.

Academic studies on the implementation of the circular economy in regional strategies of the EU are rare. This research provides an attempt to partly fill this research gap. However, the concept discussion and the situation in the regions is constantly developing as strategies are updated. Further research is needed, as the sustainability discussion continues and the circular economy inspires policymaking worldwide. The topic of this research is related to seeking sustainable future solutions and implementing them through strategies; thus, future research proposals are closely linked with achieving better policy supporting circularity. As highlighted, both central concepts of this research, the circular economy and smart specialisation, are new and therefore open a field of unexplored combinations.

On the road towards sustainability, circular economy implementation is a current way to proceed. However, there is a crucial need for further research to find out how it can be applied in a sustainable way on different levels. Recent research has pointed out that innovative solutions can improve sustainability in some value chains but maintain significant rebound effects at the system level (Levänen et al., 2021). Regional and local authorities need support for developing the understanding of what a systemic and holistic approach would mean in practice in order to work towards strategies supporting circularity. Here the cooperation with academia steps into a central role.

Regarding concrete proposals for future studies on the strategy process, it would be fruitful to find out more about good practices for monitoring regional circular economy strategies, especially related to the implementation of activities. Furthermore, even if the design of the smart specialisation process has been researched, the actual implementation of the strategies, including action plans, has not yet been well studied. For example, the combination of top-down and bottom-up approaches, as well as experiences organising successful entrepreneurial discovery processes, would provide useful knowledge for strategy implementation.

In conclusion, overall, less production and less consumption are required to utilise natural resources wisely. The circular economy provides a possible solution towards sustainability, a step in the right direction. Yet, society works as a spatial system. Efficiency and success on a local or regional scale can result, either directly or indirectly, in problems elsewhere. This underlines how important it is to understand the entirety of the global system. Fundamentally, the world needs a joint understanding of how to find a sustainable balance. The discussion of different concepts of socioeconomic progress based on various understanding of the relationship between humans and nature is necessary and has taken the development further. To achieve the transition towards a

sustainable circular economy, long-term commitment and systemic change is necessary at all levels of government. Authorities are either enabling and accelerating the transition or unintentionally slowing it down. In this process, regional-level strategies play a vital role.

Several regions have started the transition towards the circular economy. However, increased understanding of the holistic and systemic transition, support for smart activities and suitable ways to follow up the change are needed. Concrete actions and change of perception are necessary on all scale levels, both in policy and practice, research and business and, most of all, in the minds of people.

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Publication I

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BIO-BASED CIRCULAR ECONOMY IN EUROPEAN NATIONAL AND REGIONAL STRATEGIES

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ABSTRACT

In circular economy (CE), the value of products and materials is maintained for as long as possible. What has previously been considered waste is now a resource that can be reused and reintroduced to the production cycle. Therefore, waste management of both technical and bio-based waste streams plays a central role in the transition towards CE. In bioeconomy, the materials are to a certain extent circular by nature. However, biomaterials may also be used in a rather linear way. According to the European Commission, the transition towards CE needs to be supported on local, regional and national levels. Thus, to enhance sustainability and get the full potential out of bioeconomy, the CE principles should be applied to reach bio-based CE. This paper presents the results of a qualitative assessment that was carried out in Finland, Spain, Slovakia, Greece, Romania and France. Selected national and regional strategies were identified, compared and analyzed from the perspective of CE and bio-based CE. At the time of the study, the added value of CE was recognized in most of the national and regional level strategies studied, through objectives concerning e.g. waste management or bioenergy. Bio-based CE was hardly ever included as a term but circularity aspects were referred to for example through bio-waste management. Waste management appears to be the main driver in the transition towards CE. This is evident also in the case presented from Slovakia. Yet, in order for CE to become an integral part of national and regional policies, a more comprehensive understanding of the CE mechanisms should be achieved. Supported actions on both small and large-scale are needed. The research is partly an outcome of the ongoing Interreg Europe project BIOREGIO, where the bio-based circular economy is boosted through a transfer of expertise about best practices, aiming at changing regional policies to support bio-based CE.
Keywords: bio-based materials, circular economy, national strategies, regional strategies.

1 INTRODUCTION

Sustainability is the capability to remain productive for an indefinite period [1]. This is reflected ecologically in the natural systems, where resources and diversity stay constant and available for future generations to come [2]. Defined as a common goal of the United Nations [3], sustainable development encompasses environmental protection in balance with social and financial sustainability.

Sustainability, in terms of economic models, is defined as the achievement of current needs without directly or indirectly compromising the needs of future generations [4]. This is closely linked to Circular Economy (CE) [5], [6]. CE differs from an 'unsustainable' traditional linear economy by introducing a cyclical flow model. CE is a regenerative industrial system, which aims at elimination of waste through closing material loops [7], [8]. According to Ghisellini *et al*. [5], CE promotes an environmentally sound use of resources and the idea of new business models. According to the definition by the European Commission [9], CE aims at enabling the maximization of resource efficiency and minimization of waste production, benefiting the environment and tackling production costs at the same time. The technical approach to CE focuses on the recycling, reuse and prolongation of a product's lifespan

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before utilizing the material whilst the aim of the biological cycle is to keep the nutrients in flow as long as possible [7].

The term 'bioeconomy' can be defined as exploration and exploitation of bio-resources [10]. McCormick & Kautto [11] define bioeconomy as an economy where materials, chemicals and energy are developed and derived from renewable biological resources. In the Bioeconomy Strategy, the European Commission [12] has defined bioeconomy as an economy that relies on renewable biological resources (e.g. crops, forests and animals) and their conversion into food, feed, products, materials and energy. Bioeconomy includes agriculture, forestry, fisheries, food production, and pulp and paper production, as well as parts of the chemical, biotechnological and energy industries.

However, bioeconomy is not necessarily always sustainable; in fact, Loiseau *et al*. [13] have identified bioeconomy as a form of 'weak sustainability' due to its technological aspect, where a complete change in our consumption patterns is not regarded as necessary. On the other hand, CE is seen as supporting 'strong sustainability', based on its aim of closing the material loops. Furthermore, Allen [14] and Bezama [15] point out the importance of the circular aspect in bioeconomy. D'Amato *et al*. [16] state that CE principles should be integrated into bioeconomy in order to achieve bio-based CE. Bioeconomy and CE need each other in order to maximize their social and economic impacts [17]. In bio-based or bio CE, biological resources are managed and used in a way that the value of the materials is maintained at the highest utility in the economy for as long as possible [18]. In other words, bio-based CE is not considered circular only because it is based on renewable resources, but because it is designed to fulfil maximum efficiency while respecting the waste hierarchy [15], [16]. The waste hierarchy creates a prioritized order how to proceed with the management of waste, optimizing sustainability and resource efficiency [19]. As a conclusion, it can be said that the concepts of bioeconomy and circular economy have somewhat similar targets and they overlap to a certain degree [20].

An approach that enhances the concept of CE is industrial symbiosis, where industries create a network to share resources and minimize waste production [21], [22]. A company's waste can be harnessed by another company in a way that promotes the reuse of resources and enhances CE. Industrial symbiosis can also be bio-based, e.g. when biowaste is processed into biogas and upgraded to fuel, while the digested solid residual substitutes for organic fertilizers, contributing to soil fertility [23].

Due to the changed policy context and the introduction of CE, the EU Bioeconomy Strategy and action plan will be updated by the European Commission in 2018 [24]. Reflection on the relevance of the objectives and actions is needed on the EU level. The aim is to bring bioeconomy and CE closer to each other.

The term CE was presented in the EU context in 2011 through the Flagship Initiative under the Europe 2020 Strategy concerning a resource-efficient Europe [25]. The initiative stated that there was a need for a strategy to make the EU a 'circular economy'. In 2015, the European Commission released a CE package [9], proposing a series of actions towards CE. In order to achieve the goals of the CE package, it is essential that both national, regional and local authorities are enabling this transition. Also Loiseau *et al*. [13] and Geissdoerfer *et al*. [6] see that the shift towards strong sustainability and CE needs to have comprehensive support from governments. Consequently, CE requires efforts at different scale levels to reach a holistic approach: macro, meso and micro levels are all essential [26–29], [5]. The macro-level efforts refer to e.g. policy changes on national and regional levels, which will be discussed in this article. Meso level includes industrial networks and symbiosis between companies while micro level focuses on the companies and citizens as consumers. Figure 1 presents the CE framework on different levels.

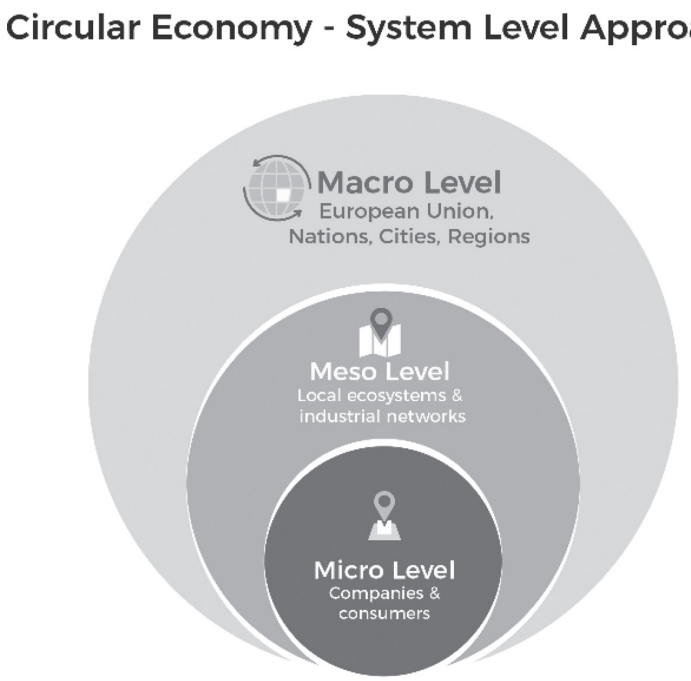

Figure 1: The system level approach to circular economy describes the actors on macro, meso, and micro levels (presented in [30]; based on e.g. [5], [26–29]).

2 METHODS

This paper presents the results of a qualitative assessment that was carried out in selected European countries: Finland, Spain, Slovakia, Greece, Romania and France. In these six countries, the most relevant national and regional strategies from the CE point of view were identified, compared and analyzed from the perspective of bio-based CE. The regions, which cooperate in the Interreg Europe financed project BIOREGIO [18], were selected to cover a wide socio-economical and geographical perspective of the European situation. The project boosts bio-based circular economy through a transfer of expertise about best available technologies and cooperation models, and runs from 2017 to 2021.

The data was gathered through a survey during November 2017. Project partners, in cooperation with their respective regional authorities, were responsible for identifying the most relevant strategies and replying to a set of questions based on them [31]. In addition, the case of Slovakia is presented more in detail bringing a quantitative aspect to the results.

3 RESULTS ON THE NATIONAL LEVEL

3.1 CE in National strategies

The questions of the survey concern the presence of CE and bio-based CE in the most relevant national and regional programs in order to analyze the situation of policy development

in the country. Strategies reflect the status of implementation of an economic model, useful in giving an overview of the situation.

The increasing environmental awareness and push from the EU towards a more sustainable economic model, especially through the 2015 CE Package [9], are reflected on a strategic level in the partner nations. In all countries, except for Greece, the term CE exists in the main national level strategy [32].

The studied national strategies vary in the way they approach the CE objectives. Finland, for example, showed an integrative focus where different levels are addressed in the strategy. A national CE roadmap has been created, which sets the guidelines to achieve social, economic and environmental benefits such as increased jobs, a diversified market and a lower impact on the environment [33]. The road map aims at promoting the circulation of raw materials, prioritizing clean technology research and, ultimately, achieving self-sufficiency. The Finnish multidisciplinary approach integrates stakeholders into a model where technological and biological streams work together.

Spain, Slovakia, Romania and France share a common view regarding CE, as their national strategies are focused on waste management and raw material circulation [34]–[37]. Efficient use of resources defines the setting related to CE in these programs. The Spanish national waste management strategy aims to reduce 50% of domestic waste production and 70% of construction waste production by 2020. There is an ambitious plan to promote the reduction of the end of life material in accordance with the CE model. In Slovakia, the government supports a transition to CE ensuring resource efficiency and energy efficiency, and reducing environmental impacts [34]. In the case of Romania, this should be achieved through waste prevention as it directly influences environmental impacts and production efficiency [36]. In the French strategy, CE is somewhat holistically mentioned as a strategic topic of its own, related to fighting waste but also developing product design and recycling [36].

On the other hand, CE is not yet included in the studied Greek national level strategy [32]. Also in Greece, waste management seems to be the main modus operandi the country starts from when implementing CE on a national scale. In this case, Greece centers its attention on the creation of a biowaste management scheme to improve sustainability and reduce direct pollution.

As noticed, waste management is the most common national approach that is linked to CE. However, this perspective is limiting the full potential of the multidisciplinary CE model.

3.2 Bio-based CE in National strategies

Bio-based CE or bio CE as a term is included only in the Finnish national program (‘circular bioeconomy’). However, all other strategies have mentioned concepts regarding circularity of nutrients. Table 1 is an overview of National Strategies, showing the main findings regarding how CE and bio-based CE are presented in current national programs.

Finland has an integrated national CE roadmap in order to achieve a leading position in the world by 2025 [38]. In the roadmap, also bio-based CE is emphasized. The road map has a multidisciplinary approach where sustainable bioeconomy solutions are among the strategic goals, presenting the circularity of bioeconomy. There is a strong economic approach when dealing with bioeconomy, as it plans on reinforcing and utilizing the financial potential of bio-based materials. Bio-based CE is set to bring new usage to organic materials e.g. through sustainable food systems and recycling nutrients, as well as enhancing forest-based loops and producing bioenergy.

Table 1: Overview of the studied national level strategies, November 2017 [31].

National level	FINLAND	SPAIN	SLOVAKIA	GREECE	ROMANIA	FRANCE
National Strategy name	The Finnish Roadmap to a Circular Economy	Waste Management State Plan (PEMAR)	The Waste Management Program of Slovak republic	National Plan for Waste Management	National Waste Management Strategy	Law Relative to EnergyTransition for Green Growth
Validity period	2016 - 2025	2016 - 2022	2016 - 2020	2015 - 2020	2014 - 2020	2015 - 2030
Circular Economy included	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
If no, specify other corresponding terms				recycling, biowaste disposal avoidance		
Bio-based Circular Economy included	**Yes**	**No**	**No**	**No**	**No**	**No**
Circularity of nutrients mentioned	**Yes** sustainable food systems, closing the loop	**Yes** collecting and processing biowaste	**Yes** recycling of biodegradable waste	**Yes** separate collection and management of biowaste introduced	**Yes** circulation of organic waste fractons	**Yes** reducing foodwaste, separate collection of biowaste
Status for new National CE Strategies	Existing (2016)	Circular Spain 2030: Spanish Strategy for Circular Economy (Expected 2018)	Greener Slovakia - Strategy of the Environmental Policy of the Slovak Republic until 2030 (Expected 2018)	Greek National Circular Economy plan (Expected 2018)	Under preparation	French National Circular Economy Roadmap (Expected 2018)

The Spanish, Slovakian, Romanian and French strategies point out the circulation of organic waste fractions mainly through a focus on collection and processing of biowaste. In addition, Greece, even if CE on a general level is not addressed, points out the circularity issues regarding biowaste. The Greek strategy mentions secondary materials as the bio-approach of the national waste management program in order to decrease greenhouse gas emissions. Also, the French and Romanian strategies mention the transition towards using renewable energy.

The parallelism in national policies among the studied countries emphasizes the necessity of a standardized bio-based CE approach, as waste management is the only focus observed in every studied nation. Thus, biowaste management is indeed the first step in the application of a sustainable bio-based economic model.

On another note, according to the study, developing renewable energy sources also seems to be one common interpretation of CE. Linking it to bio-based CE enhances bioenergy systems such as biogas plants.

3.3 Upcoming National CE strategies

Meanwhile, the countries are preparing new strategies to reinforce CE on a national level. Table 1 presents the situation of upcoming CE-related strategies. In this direction, Spain is planning to implement the Circular Spain 2030, focusing on bioeconomy enhancement emphasizing the internationalization of Spanish companies. Similarly, by 2030 Slovakia aims to establish a sustainable, circular industry framework within its borders. ‘Greener Slovakia’ focuses on the prevention of biodegradable waste generation as well as the enforcement of the ‘polluters pay’ principle, regulating waste management towards a circular economy. At the time of the study, France was developing a national CE roadmap. The plan was to set the steps towards a regenerative economic model, similar to the existing Finnish roadmap issued

in 2016. The Greek government is also catching up by creating a financial plan aimed at providing the necessary resources and tools for the promotion of CE practices. The plan is a focused approach, which will shape the current status of the CE models in the country's industries.

In the case of Romania, the situation is quite different. In April 2017, the European Commission took Romania to the Court of Justice of the EU for failing to review and adopt its national waste management plan and waste prevention programme, in line with the objectives of the EU Waste Framework Directive [39] and the CE [37]. On the following day, the Ministry of the Environment published the first draft of the National Waste Management Plan for public consultation. At the time of the study, the situation was still in process.

4 RESULTS ON THE REGIONAL LEVEL

4.1 CE in regional strategies

At the time of the research, CE was mentioned as a term in the main strategic document in four out of six studied regions (Table 2). The regions from Finland, Spain, Romania and France have strategic documents, which all specify CE.

The Finnish Region of Päijät-Häme updated its regional strategy and program in 2017 [40]. It defines three focus areas of Smart Specialization, one of them being CE. In the regional context, CE mainly equals to material and energy efficiency and new solutions for bioeconomy. The CE part of the regional strategy is described in more detail in the Päijät-Häme road map towards CE [41]. The road map focuses on regional goals and presents examples of how to achieve them. The goals are related to bio-based CE, closing technical loops, new consumption models, sustainable energy solutions as well as piloting and demonstrating solutions. This regional CE road map is also recognized as a Good Practice, a valuable example to be shared through the European Policy Learning Platform [42].

In the region of Castilla-La Manca in Spain, the integrated waste management plan was updated in 2016. It includes the term CE as a guiding principle. The plan supports minimizing potential risks to human health and the environment through efficient waste management based on the principles of the CE [43].

The Smart Specialization Strategy of the Romanian region South Muntenia [44] mentions circular economy when describing bioeconomy. 'Bioeconomy, developing circular economy' is defined as a smart specialization field. The aim is to promote circularity in the bio sector, e.g. in the production of bio-fuels, ecological fertilizers and bio-composites. The other fields of smart specialization in South Muntenia are related to the food industry and smart localities, which are also fields with implications for CE. The strategy, set up in 2014, proactively referred to CE, even before the EU's CE package was launched. The strategy brings up to CE according to the EU Communication of the Commission from year 2011 [25].

The regional strategy of the Region of Pays de la Loire, the Performance Agreement for a Regional Dynamic about Waste and Circular Economy (CODREC) [45] strongly promotes CE. In the agreement, the region took the position of a leading territory for waste management, CE and overall energy transition in France. It aims at developing the regional plan for prevention and management of waste and it has a chapter on CE.

The Program of Economic and Social Development of the Nitra Region in Slovakia [46] does not mention CE, nor does the Greek document Regional Waste Management Plan of

Table 2: Overview of the studied regional level strategies, November 2017 [31].

Regional level	PÄIJÄT-HÄME FINLAND	CASTILLA-LA MANCHA SPAIN	NITRA REGION SLOVAKIA	CENTRAL MACEDONIA GREECE	SOUTH MUNTENIA REGION ROMANIA	PAYS DE LA LOIRE FRANCE
Strategic document in focus	Päijät-Häme Regional Strategy and Program	Integrated Waste Management Plan of Castilla-La Mancha	Program of Economic and Social Development of the Nitra Region	Regional Waste Management Plan of Central Macedonia	Smart Specialization Strategy of South Muntenia Region	Performance Agreement for a Regional Dynamic about Waste and Circular Economy (CODREC)
Validity period	2018 - 2021	2016 - 2022	2016 - 2022	2016 onwards	2014 - 2020	2016 - 2020
Circular Economy included	**Yes**	**Yes**	**No**	**No**	**Yes**	**Yes**
If no, what other corresponding terms are used			Sustainable growth, effective use of resources	Effective use of resources		
Bio-based circular economy/circular bioeconomy included	**Yes**	**No**	**No**	**No**	**Yes**	**No**
Circularity of nutrients mentioned	**Yes** closing the loops	**Yes** recovery of biowaste	**Yes** recovery of biowaste	**Yes** separate collection of biowaste	**Yes** production of bio-based products	**No**

Central Macedonia [47], both issued in 2016. Nevertheless, they both refer to effective use of resources, which is linked to CE.

4.2 Bio-based CE in regional strategies

At the time of the study, the terms bio-based CE or bio circular economy only appear in the Finnish and Romanian regional strategies. In the Finnish region of Päijät-Häme, bio CE is seen as providing sustainable business. The strategy emphasizes closing of nutrient loops, supporting local food supply chains with less waste, and reducing the loss of raw materials. As mentioned before, the Romanian region of South Muntenia has a regional strategy that links bioeconomy closely with CE. The focus is on an innovative use of biomass, e.g. the production of biofuels from biomass, animal manure and other by-products, production of organic fertilizers, as well as production of biomass products and by-products of biological processes.

However, the circularity or sustainability of bioresources is in some way brought up in almost all the other regional strategies studied. Developing the biowaste management, i.e. collection systems and processing patterns, seems to be the core starting point. Free-access platforms indicating the generated waste of any facility may present an opportunity for cooperation. Regional support and encouragement of such cooperation present a stepping-stone towards industrial symbiosis among facilities that use various biological streams and eventually facilitate the application of the CE concept on a larger scale.

The region of Nitra in Slovakia presents an example where bio-based CE is not mentioned in the regional strategy; however, waste management and bio-based circularity is promoted through small and large-scale instruments in the region. The key stakeholder Nitra Self-Governing Region (NSGR) has, as a part of the regional strategy, introduced a unique instrument, which provides funding for small-scale local projects [48]. In 2017, an amount of EUR 549,479 was allocated for the instrument named LEADER NSK. The instrument reflects local needs through the ‘bottom-up’ principle. NSGR is currently the only Slovak

region that financially supports local actions by a programme. Other Self-Governing Regions are aiming to introduce a similar programme.

In 2017, LEADER NSK funded following activities related to developing environmental activities, waste management and CE: Collection point for separated waste from the flat houses in the municipality Trávnica (EUR 3,500); Cleaning and treatment of surrounding water bodies and watercourses (EUR 1,000); Drainage of the public roads in Cedron-Nitrava (EUR 1,100); Collection point for waste in the municipality of Mudroňovo (EUR 2,680); Cleaning and treatment of rainwater ditches in the municipality of Podhorany (EUR 2,915); Educational project in the youth educational centre in municipality of Kuzmice 'Do not separate yourself and start to separate!' (EUR 1,530).

On the other hand, an example of a large-scale bio-based CE project in Nitra region is financed by the Operational Programme Environment: 'Separate Collection and Recovery of Biodegradable Waste' [49]. The project addresses waste management in municipalities in a unified way and it is based on the principles of circular bioeconomy. It also represents an example of a Good Practice published on the European Policy Learning Platform [50]. The project's total budget is EUR 10,192,582 (95% EU funding).

5 DISCUSSION AND CONCLUSIONS

Since the data for this study was gathered, further development has taken place. In France, a new bioeconomy strategy was published in January 2018. It presents circularity as a strategic topic of its own. Also, a road map towards CE was published in April 2018, where biowaste management is presented as one of the goals. Furthermore, in Greece, the Hellenic Governmental Economic Policy Council approved the public policy framework for Circular Economy in March 2018, as being a key element of the country's Development Strategy update. The introduction of the CE aspect to the primary and secondary sector of economy is expected to create job opportunities, to increase small and medium-sized entrepreneurship and eventually upgrade social economy. In Slovakia, the government supports a transition towards CE. The existing raw material policy will be developed by identifying critical raw materials for the development of the Slovak economy. In Romania, the National Waste Management Plan was adopted by Government Decision in December 2017 together with the Waste Prevention Programme, and EU's infringement procedure was closed in March 2018. The situation is still under development as authorities are now developing a new strategy, which will revitalize the Romanian CE model, in accordance with the EU law. Figure 2 combines the situation of CE in national level strategies at the time of the study (November 2017) with the updated strategy development until June 2018.

Moreover, on the regional level, the update of the Slovak Program of Economic and Social Development of the Nitra Region was approved in June 2018. Sustainable CE is now stated in the program. In the future, there is further development expected also in other regions. Castilla-La Mancha will be the first region in Spain to have a law on CE. The law is expected during 2018. In Greece, the update of the Smart Specialization Strategy of the Region of Central Macedonia is expected to incorporate core elements of CE, also aiming at the circularity of bioeconomy. The update is estimated to be commenced during late 2018. In France, based on the national bioeconomy strategy, a regional biomass scheme will be adopted in Pays de la Loire in the beginning of 2019. It aims at directing the available biomass resources, including biowaste, for energy use.

To conclude, the comparison of the national policies of the countries shows that waste management is the key focus when addressing CE. Currently in Finland and France, and in

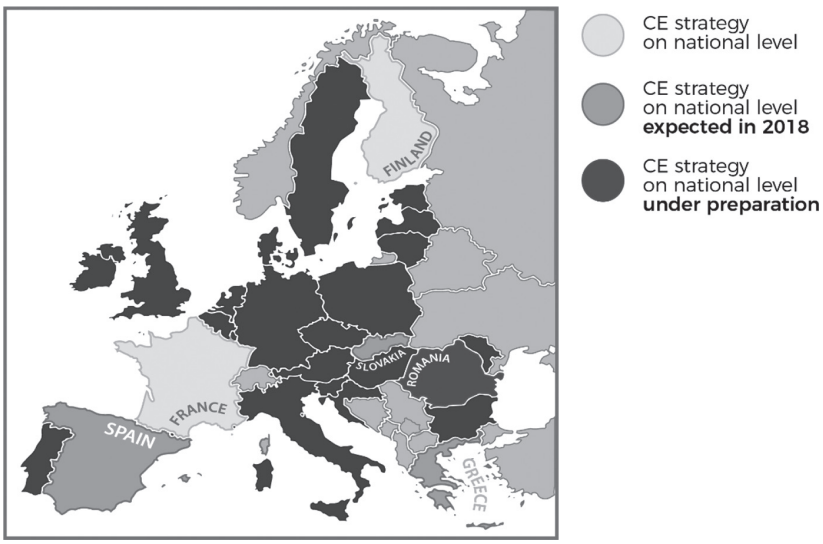

Figure 2: Map about the current situation of national level strategies, June 2018 [31].

the near future in Spain, Slovakia and Greece, there is a common approach to introduce CE as a multidisciplinary framework most likely enhancing the focus on the bio-based CE.

As Tables 1 and 2 present, the year of issue does not necessarily tell if CE is present or not. The Romanian strategies were issued in 2014, before the EU CE package, and they proactively already refer to CE. On the other hand, the Slovak and Greek regional strategies issued in 2016 do not mention the term.

On the national level, Finland and its Roadmap strategy is the only one that has included a focus on bio-based CE. However, in Spain, Slovakia, Greece, Romania and France bio-based CE is present in the analyzed strategies through a focus on biowaste management. They strive for the collection, recycling, and conversion of waste from biological streams in order to reduce environmental impacts. The focus on waste management is also evident in the funding instruments presented in the case of Slovakia.

Overall, it has been found that even if the bio-based CE is not mentioned as such, most countries address it in their strategies. Waste management, or in this case biowaste management, appears to be the main driver in the transition towards CE. However, the waste management focus in many cases limits the full potential of CE in biological streams. It should be understood that bio-based CE is more than separating, collecting and processing biowaste. The CE approach starts from reducing food waste. In striving towards CE on all levels, the authorities' role in pushing the development and setting up frameworks is essential. In this process, the macro-level actions in national and regional strategies play an important role. However, we suggest that the level division (micro, meso, macro) should be further discussed. In practice, the national and regional policies and their implementations differ from each other in scale and accuracy. Due to this, it would be helpful if the macro, meso and micro level divisions would be reconsidered, as the macro level including international, national, regional and local actions is seen as very broad in current literature. Nevertheless, in order for CE to become an integral part of national and regional policies, a

more comprehensive understanding of the CE mechanisms needs to be achieved. At the same time, actions on different scale are needed in the regions in implementing the strategies.

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Article

Adapting a Circular Economy in Regional Strategies of the European Union

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Abstract: The transition towards a sustainable circular economy (CE) model is seen as a solution to keep the consumption of the earth's resources within planetary boundaries. In the regional context, the CE is promoted through various policy actions, one being the smart specialisation concept. This paper provides a novel approach to examining the spatial adaption of a CE through a conceptual framework of research and innovation strategies for smart specialisation (S3) in Europe. This interdisciplinary research presents a multi-country comparison of S3 implementation in Europe in 12 regions that have defined the CE as a priority area. The data consist of interviews with representatives of organisations responsible for the regional S3 process. The findings indicate that a political demand exists for proceeding further with the construction of transformative activities involving the CE, but the models and stages of implementation vary. In addition, most regions still struggle with building specific monitoring and evaluation measures and mechanisms for the CE. Despite these challenges, promoting the CE as a strategic priority through the S3 process has, at least in some regions, helped define the CE targets and actions by focusing on existing regional assets and future potential.

Keywords: circular economy strategies; regional policy; smart specialisation

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1. Introduction

The global consumption of different materials is expected to double within the next 40 years [1]. The transition towards a circular economy (CE) is seen as a solution for sustainable consumption issues. The CE can be defined as an economic system based on closing material loops and maintaining the value of products and resources for as long as possible [2–4]. In 2015, the European Commission (EC) released an action plan concerning the European Union's (EU) transition towards the CE [5]. The EC's action plan stated that broad, long-term commitment is needed at all levels of government to develop the CE, that is, with the local, regional and national authorities acting as key agents in enabling the transition [5]. The political importance of developing the CE has been increasing in the EU since 2015. The EU's new CE action plan published in 2020 addresses the need to accelerate the transition towards regenerative growth through a CE model that gives back to the planet more than it takes and keeps the consumption of the earth's resources within planetary boundaries [6].

In addition to saving natural resources, the transition towards the CE develops a sustainable, low-carbon, resource-efficient and competitive economy through increasing growth and jobs [5]. Because the CE has been widely perceived as a solution for economic growth and environmental sustainability, it has been adopted by several governments and businesses. Other similar concepts of operationalising sustainable development for businesses include the green economy and green growth [1,7].

The emergence of the CE and research and innovation strategies for smart specialisation (S3) has developed in tandem in European regions over the last years [5,8]. The S3 concept was introduced as part of the EU's cohesion and innovation policy to ensure the targeted use of European Structural Funds (ESF) and to guide investments in research and innovation by focusing on the fields with the most competitive advantage and future potential [8,9]. Some regions in Europe have recognised the possibility of combining their S3 and CE goals. Selecting regional priority areas for development is one of the key steps of the S3 process [8]. This paper provides a novel approach to examining the adaption of the CE in the European regions that have defined the CE as an S3 priority area.

The aim of this research is not to study whether S3, as such, is a useful way of realising cohesion policy or regional innovation policy. Rather, the S3 is viewed as an existing policy approach under which the concretisation of regional CE targets is studied. The study defines the thematic priority areas, along with the existence of a more detailed strategy, or 'roadmap', regarding the CE and, furthermore, whether the roadmap has been defined in an action plan or through actions.

This paper aims to answer how S3's thematic priority areas related to the CE are concretised and implemented in regional objectives or priorities (roadmaps) and actions (action plans). The paper is organised as follows. First, a brief theoretical background of the CE and S3 concepts is presented. Second, the research approach, data collection method and analytical approach are introduced. Third, the key findings on how the CE-related thematic priorities are concretised in S3, as well as examples of regional implications, are described. The paper concludes with a discussion of the challenges and possibilities of combining S3 with the CE. Moreover, areas for future research are suggested.

2. Theoretical Background

2.1. Towards Systemic Change of the CE

The concept of the CE has drawn increasing interest since 2012, when the initial CE report by the Ellen MacArthur Foundation was published [10]. However, trending concepts tend to diffuse in their meaning, and researchers claim that this has also happened to the CE [4]. Numerous attempts have been made to define the CE concept. The term's varying definitions may generate confusion and reduce opportunities for international cooperation [11]. Kirchherr et al. [4] analysed 114 definitions of the CE concept. They highlighted the significance of the systemic change of the CE, even though, based on their research, only around 40% of the definitions conceptualise the CE from a systems perspective.

The systemic change of the CE operates at all levels: the micro level (products, companies, consumers), the meso level (ecosystems, industrial symbiosis) and the macro level (city, region, nation) [12–16]. To manage the CE transition on different systemic levels, CE-related measuring instruments need to be used. Saidani et al. [16] classified 55 circularity indicators into 10 categories based on, for instance, the level of implementation (micro, meso, macro), the CE loops (maintain, reuse, remanufacture, recycle) and the perspective of circularity (actual, potential). Their research showed that CE indicators exist, but holistic indicators and knowledge on the usability of the different types of indicators are still lacking.

The CE concept as a policy instrument is an increasingly popular regulatory policy to address. In China, the CE is promoted as a top-down national political objective, while in other areas and countries, such as the EU, Japan and the United States, it is seen as a tool for designing bottom-up environmental and waste management policies [3]. However, the importance of top-down political development of the CE has been increasing in the EU as well. EU-level actions to develop the CE have inspired national debates [17]. Several EU member states have already adopted or are in the process of adopting national CE strategies [18]. The EU's national-level strategy actions have been repeated or are in the process of being replicated at the regional and local levels, bringing the transition to the CE closer to action in businesses and among citizens [19].

Within business, the investment in clean technologies is considered an essential step towards the CE [20]. Clean technologies are new industrial processes or modifications of existing ones that are intended to reduce the impact of production activities on the environment, including through reducing the use of energy and raw materials [21]. In the EU, the adoption of clean technologies is being accelerated through various policy actions. At the beginning of 2020, the EC presented the European Green Deal Investment Plan, which will mobilise at least a trillion euros of sustainable investments over the next decade [22].

Despite the relevance of the CE within the current policy and economic debate, the concept remains open to interpretation and has received criticism. Saltelli et al. [23] have claimed that a truly circular economy is not going to happen in the near future. Giampietro and Funtowicz [24] see the CE concept as 'socially constructed ignorance' where an in-depth sustainability debate is set aside. The CE should rely on the 4R framework of reduce, reuse, recycle and recover [25]. However, the findings of Kirchherr et al. [4] indicate that only 3–4% of CE definitions reflect the 4R framework, particularly with regard to CE implementation based on definitions that do not outline the reduce stage. Although a properly used CE is based on the 4R framework, it may become very problematic due to the conventional definition of material flows [26]. Furthermore, in circular systems, the concept of waste is changing; for example, material may turn into an energy resource with variable economic values, and the waste can be transformed into by-products. The concept of waste is related to culture, society, community, history and the level of societal development. Thus, all CE proposals and suggestions should be placed into and considered within their temporal, spatial and cultural contexts [26].

2.2. From Planning to Action in Smart Specialisation

The need for investing more in research and innovation was recognised as a crucial part of boosting the European economy in the Europe 2020 strategy [8,9]. Thus, the S3 concept has been an integral part of the EU's cohesion policy framework during the latest budget period of 2014–2020, and the S3 framework has been widely applied in EU member countries. Defining a national or regional S3 was set as a requirement for allocating EU research and development funding [8,9]. The aim is to channel research and innovation resources to selected priority areas which are seen to have the greatest potential for the region to excel in the future. When analysing and selecting the priority areas, the regions are encouraged to go beyond the traditional sectoral approach and utilise the related variety (see [27,28]) type of diversification within a priority area, meaning diversification into related areas based on new technologies or processes [8]. The idea of the S3 process is to build on existing regional structures and transform these structures utilising new related research activities [29]. The post-2020 cohesion policy will support and encourage regions to improve their existing S3 and interregional cooperation [30].

Previous research has provided a significant amount of knowledge, examples and experiences from both the theoretical (e.g., [28,31,32]) and practical (e.g., [33–35]) points of view. Based on the previous literature, the challenge of implementing S3 policies into practice in a variety of different regions is evident, which has been the case since the concept was launched [36]. Case studies of single regions or countries implementing S3 do exist (e.g., [33,34,37]), as do research papers on the regional comparisons of the S3 preconditions and processes as well as the implementation of S3 processes in the different countries (e.g., [25,38,39]), but what is mostly lacking are multi-country comparisons [40].

One of the often-discussed challenges of S3 is the variety of regional capabilities for S3 implementation due to their differences in size, economic conditions, institutional capacity, industrial structure and governance issues [36,38,39,41,42]. This raises the question: For which type of region is the S3 approach most beneficial? Hassink and Gong [29] revealed this dilemma in more detail and highlighted the 'regional innovation paradox' [43,44], which can hinder the successful application of S3 in less favoured regions. Regarding the question of which type of region the S3 approach would be most beneficial for, Foray [45],

one of the original developers of the S3 concept, admitted that S3 may not be the most beneficial policy framework for the most advanced and largest (in terms of GDP per capita) regions nor for the regions at the other end of the spectrum. However, a great number of intermediate regions within and outside Europe could benefit from S3 [45].

The RIS3 Guide [8] is a methodological guide and an orientation document for policymakers and implementing bodies when designing and implementing S3. The guide presents the S3 design as a six-step process—not necessarily a linear one—that includes (1) analysing the regional context and innovation potential, (2) ensuring participation, (3) creating a future vision for the region, (4) identifying priorities, (5) creating a suitable policy mix and (6) monitoring and evaluating mechanisms. However, in his response to Hassink and Gong [29], Foray [45] suggested simplifying the S3 process down to three steps: (1) identifying the thematic priority areas, (2) translating these priority areas into transformational roadmaps and (3) implementing the transformational activities with an action plan. The first phase has a clear (top-down) planning aspect, whereas the following two transformative activities are influenced by the (bottom-up) self-discovery aspect of the entrepreneurial discovery process (EDP), which was originally also an essential part of the selection of the regional priority areas. The EDP is an interactive process bringing together regional stakeholders [9,45]. The process of creating a roadmap and action plan is also what differentiates a region from others within the same priority area, as these activities are based on region-specific capacities, potentials and opportunities. Foray [45] emphasised the second step of creating transformational roadmaps for the selected priority areas and noted that many regions that have successfully conducted their prioritisation task have found it difficult to concretise and implement these priorities. Steps two and three focus on the construction and development of transformative activities through a collection of projects that lead the transformation path in the region. These projects have a clear link to funding in the EU, especially to ESIF. Following the logic of the EDP, the projects and the way these transformative activities are developed also require appropriate monitoring, measuring and evaluation mechanisms to ensure an understanding of the degree of progress or the need for readjustments [45].

In Europe, some regions have seen it possible to combine their S3 and CE goals and ambitions. While the EU supports CE as a potential and necessary path for development, regions seek to identify and develop their competitive advantages through S3. Adopting CE should be aligned with strategic documents and identified strengths and needs, which are set in the S3. If a certain topic is defined as a priority in the S3 there should be a strong connection to how it is concretised in the region through roadmaps, activities and funding.

The current research aims to discover how various regions have concretised S3′s thematic priority areas related to the CE, and it provides examples of effective ways to enable the implementation of CE priorities within the regional context. Despite the already wide adoption of the policy approach, S3 processes face many challenges, including implementation challenges [31,46]. Although several papers have been published on S3 building processes and implementation challenges (see e.g., [35,47]), examples of best practices of implementation processes are still scarce. Research on how CE has been implemented or concretised though the S3 process is, to the best of our knowledge, not found in the literature. The current paper aims to fill this research gap.

3. Materials and Methods

To discover the logic behind how S3′s related to the CE have been concretised in the regional policy, a qualitative research approach that included thematic analysis was applied. In thematic analysis, a data set is systematically processed, identified and organised in search of themes, that is, patterns of meanings [48], which enable the researcher to better understand and interpret the collected data. Furthermore, case overviews can be created, and accordingly, individual cases can be selected for in-depth analyses [49]. This method is suitable for identifying commonalities in the way a topic is presented [48]. In qualitative research, the data are analysed alongside the data collection as thematic patterns

emerge [50]. The data analysis is also iterative, requiring several loops, during which the researcher gains greater familiarity with the data. For example, the relevant data related to a specific theme might not always be found in the context of the exact question asked. The guiding principle in the analysis is the interchange between the collected data and theoretical knowledge [49].

In this research, the data collection was conducted mainly through semi-structured interviews. In semi-structured, or semi-standardised, interviews, researchers orient themselves according to a predefined frame, but one that provides freedom in the formulation of questions [51]. Semi-structured interviews enable concentration on a specific theme and allow for discussion on the topics. They combine both open-ended and more theoretically driven questions that aim to explore both the experience of the interviewee and the data based on the existing constructions [50]. In this study, the semi-structured approach allowed the interviewer to ask—in addition to the questions listed in the interview frame—more in-depth questions about the regional strategy formation and processes in cases where it was found necessary. This helped strengthen the quality of the interview data.

The EC Joint Research Centre's (JRC) Smart Specialisation Platform and its tool for visualising public investment priorities for innovation across Europe, Eye@RIS3, gives an overview of the regions' priorities [52]. The purpose of the database is to support strategy development and find partners for collaboration. However, it also enables the comparison of S3 across Europe to achieve a better understanding of how regions and countries are developing their policies and innovation priorities. Even if the S3 approach is a requirement of research and innovation investments for the programming period 2014–2020 [35] registration on the JRC's platform is voluntary although desirable. Regions are advised to join the S3 platform on the most relevant NUTS level with respect to innovation strategies and manging ESF [53]. The platform covers almost all territories of the EU member states. However, there are regional differences. Large countries have not registered on NUTS 1 level but rather on NUTS 2 or 3, which means that if certain regions have not been active in the S3 they are missing from the platform, this concerns for example a few regions in Germany, France and Greece [54].

The sample regions on which this research focuses were identified from the Eye@RIS3 database on 10 May 2019. The regions were searched with the keyword 'circular economy'. On that date, 14 European regions on Nomenclature of Territorial Units for Statistics (NUTS) levels 1–3 described thematic priorities related to the CE. Due to the low number of hits, the decision was made to keep a wide focus that included all the mentioned NUTS levels. Responsible persons in these regions were contacted though email, and a telephone interview was proposed. In the end, 11 regions accepted the interview invitation, and one additional region proposed replying through email. This indicates a relatively high rate of involvement of the regions in focus. All the interviews were conducted by telephone, except in the Päijät-Häme region, where the interview was conducted face to face. The persons interviewed in the regions represented the organisations responsible for the regional S3 process. Usually, the interview was conducted with one person, but in three of the regions, two or three people attended the discussion. The interviews were conducted in English, except for one that was done in Finnish at the interviewee's request. The interviews lasted 20–50 min. Table 1 provides information on the regions that participated in the research, their organisations, dates of the interview and NUTS levels.

Semi-structured interviews were utilised as the primary data source to allow for concentration on the specific themes and were carried out in a conversational style. This enabled the research to target the key persons involved in the S3 processes and to focus on the specific characteristics of CE implementation in each region. The questions asked from each region covered the background of the S3 priorities related to CE, with focus on regional priorities, updating process, actions, and funding. The interview questions are presented in the Appendix A. For this, paper questions 4–9 were in focus. In some cases, clarifying questions were sent afterwards to the interviewees through email. To ensure the anonymity of the interviewees, all quotes and in-text citations have been given a code

number (e.g., (1), (2)). The numbers do not reflect the alphabetical order or any other order. In addition to the interviews, detailed data retrieved from the JRC's Smart Specialization Platform were utilised [52].

The interviews were recorded and transcribed; they were then classified and coded based on the theoretical framework. The content related to the region's CE concept in S3 as well as the EDP was identified. Subsequently, this content was coded and summarised, and finally, it was compared to the conceptual framework of S3.

Table 1. Study regions.

Country	Region	Interviewed Organisation	Date of Interview	NUTS Level
Belgium	Brussels-Capital Region	Innoviris	1 July 2019	NUTS 2
Denmark	Central Denmark	Central Denmark Region	17 June 2019	NUTS 2
Finland	Southwest Finland	Regional Council of Southwest Finland	26 August 2019	NUTS 3
Finland	Häme	Regional Council of Häme	17 June 2019	NUTS 3
Finland	Päijät-Häme	Regional Council of Päijät-Häme	31 May 2019	NUTS 3
Finland	Satakunta	Regional Council of Satakunta	19 June 2019	NUTS 3
Germany	Berlin	Senate Department for Economics, Energy and Public Enterprises	5 June 2019 [1]	NUTS 2
Germany	Brandenburg	Economic Development Agency Brandenburg	1 July 2019	NUTS 2
Luxembourg	Luxembourg	Ministry of Economy	11 July 2019	NUTS 1
Romania	Sud-Muntenia	South Muntenia Regional Development Agency	14 June 2019	NUTS 2
Slovenia	Slovenia	Government Office for Development and European Cohesion Policy	17 June 2019	NUTS 1
Spain	Basque Country	Basque Government	12 July 2019	NUTS 2

[1] Email reply.

4. Results and Discussion

4.1. Conceptual Framework of the Study

The policy-based conceptual framework of this study presented in Figure 1 was created based on the literature background of S3 and leans particularly towards the policy lessons and suggestions presented by Foray [45]. The framework summarises the updated S3 process and highlights the practical implementation phase after thematic priority areas have been defined. Although the steps are presented here as a simplified linear process, in practice, the process phases partly overlap and include feedback loops between different phases. The monitoring and evaluation phase refers to the monitoring and evaluation of the concrete actions and how the set targets have been reached. It should also be noted that the S3 strategy as a whole requires continuous evaluation regarding the chosen priority areas and the desired direction of change. A regular review of the priorities allows for flexibility in changing economic and other framework conditions [34].

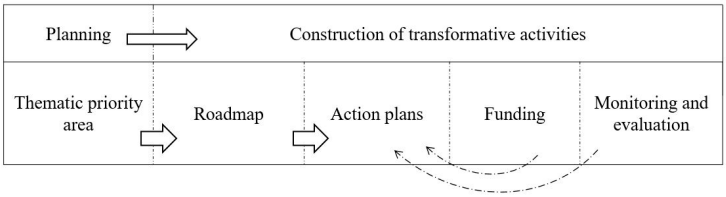

Figure 1. Conceptual framework of the study.

The novel approach of this paper lies in analysing the regional research data through the conceptual framework of the S3. The paper explains the stage of the CE adaption in the European regions that have defined the CE as an S3 priority area. The results of the interviews are presented in Table 2 following the structure of the conceptual framework. This allows a coherent examination of the varying regional approaches through a literature based S3 framework.

Table 2. Thematic priority areas of the study regions and the construction of transformative activities related to the (CE).

		Planning	**Construction of Transformative Activities**			
Country	**Region**	**Thematic Priority Area**	**Roadmap**	**Action Plans**	**Funding**	**Monitoring and Evaluation**
Belgium	Brussels—Capital Region	Environment: Green Economy	CE as part of strategy. Bottom-up process, companies directly involved.	Ongoing actions.	CE projects funded with European Structural Funds (ESF).	Update upcoming, continuous process. No targets.
Denmark	Central Denmark	Growth drivers	CE as part of business development strategy. Bottom-up process/dialogue, companies directly involved.	Action plans for each initiative (subpriority). Ongoing actions.	CE projects funded by ESF, other regional and EU funding.	No specified regional targets. Update in progress.
Finland	Southwest Finland	Innovative food chains	CE roadmap including defined categories. Bottom-up process.	Action plans for subpriorities. Ongoing actions.	S3 related projects funded by ESF, other regional, national and EU funding.	CE roadmap update in progress. Targets under preparation.
Finland	Häme	Sustainable use of natural resources	CE roadmap under preparation. Bottom-up and top-down approach.	Ongoing actions.	CE projects funded by ESF, other regional, national and EU funding.	No targets.
Finland	Päijät-Häme	Circular economy	CE roadmap with subpriorities defined. Bottom-up and top-down approach, companies directly involved.	Action plan for one subpriority, others under development. Ongoing actions.	CE and S3 related projects funded by ESF, other regional, national and EU funding.	CE roadmap updated annually. Targets for one subpriority, others under discussion.

Table 2. *Cont.*

		Planning	Construction of Transformative Activities			
Country	**Region**	**Thematic Priority Area**	**Roadmap**	**Action Plans**	**Funding**	**Monitoring and Evaluation**
Finland	Satakunta	Bio and circular economy	Growth programme for bio and circular economy. Bottom-up process.	Actions defined in growth programme. Ongoing actions.	CE and S3 related projects funded by ESF, other regional, national and EU funding.	Annual update of growth programme. General-level targets defined.
Germany	Berlin	Clean technologies	CE as part of strategy. Cross-sector approach, bottom-up process, companies directly involved.	Ongoing actions.	S3 related projects funded, not specifically CE.	Updates with no specific schedule. No targets concerning CE.
Germany	Brandenburg	Clean technologies	CE as part of strategy. Cross-sector approach, bottom-up process, companies directly involved.	Ongoing actions.	Funding from ESF is linked with masterplans.	Updates with no specific schedule. No targets concerning CE.
Luxembourg	Luxembourg	Clean & eco-technologies	CE integrated into broad goals. CE strategy under preparation. Bottom-up and top-down approach.	Ongoing actions.	No ESF available from CE. National and EU funding.	No specific update process for CE defined yet. Targets defined for one subpriority.
Romania	Sud-Muntenia	Bioeconomy: Developing circular economy	Defining of priorities in progress. Bottom-up process.	Lack of CE actors for actions.	CE projects funded by ESF, other EU funding.	Update in progress. No targets defined yet.
Slovenia	Slovenia	Networks for the transition to circular economy	Roadmap with priority areas defined. Bottom-up process, companies directly involved.	Strategic research and innovation partnerships' action plan for transition to CE. Ongoing actions.	CE projects funded from cohesion fund, national and other EU funding.	Evaluation in process. Targets defined.
Spain	Basque Country	Building a new circular economy	CE strategy almost final. Bottom-up process, intense stakeholder involvement, companies directly involved.	Action plan under preparation. Ongoing actions.	No ESF available. Regional funding.	Updated every 2.5 and 5 years. Targets under preparation.

4.2. Thematic Priority Areas

The S3 process begins with identifying the thematic priority areas. Table 2 shows the thematic priority areas and the construction of transformative activities related to the CE for the regions in focus. The thematic priority areas reflect the CE through naming either directly or indirectly through subpriorities. The results for the search term 'circular economy' on the JRC's platform also included regions where CE is not present in the priority's name but is mentioned in the description of the priority. As Table 2 shows, five of the regions have CE in the name of the thematic priority area [52]. The differences in the naming of the priority reflect the background and wide perspective of the multiple aspects in which the CE is framed in general and as part of innovation policy. The recent

development of the terminology behind CE is shown in the names of the thematic priorities; 'clean technologies', 'green economy' and 'sustainable use of natural resources' reflects the roots of the CE. However, from a totally different S3 perspective, one region has defined the CE as being one of the boosters in their priority 'growth drivers'.

Studying the thematic priorities as a basic element of the research setting shows that the regions have different starting points for how visible the link between CE and S3 can be. The five regions naming the CE as a thematic priority have a clear political mandate for proceeding further with the construction of transformative activities. Nevertheless, the policy and strategy structures related to the CE in the other seven regions also support S3 as it is mentioned in the description of the regional priorities.

As Foray [45] pointed out, too broad of a definition of the thematic priority area can make it difficult to generate the crucial density and agglomeration effects of S3. From the perspective of this research, it can be discussed to what degree and under what kinds of circumstances the concept of the CE fits this definition. The CE is surely seen as a potential direction of change in the regions involved; however, its broadness can create a challenge. In the cases where the thematic priority is quite broad, the importance of translating it into a transformational roadmap and a transparent action plan becomes even more vital.

4.3. Roadmaps for Concretising S3

As Foray [45] described, S3 priority areas should be further translated into transformational roadmaps. This is the crucial phase of the S3 process because many regions have had difficulties implementing the priorities. In this research, the focus was specifically on the S3 strategies or roadmaps related to the CE. Due to the regional differences in naming thematic priority areas, the roadmap phase is not completely comparable as some regional priorities are not specifically targeted on CE. Hence, the interviews were important in supporting the understanding of the regional differences.

In the interviews, the regional approach to the CE as a part of S3 was determined. All regions have defined regional CE priorities, which, in most cases, are already concretised in a strategy document. Six of the studied regions (Brussels, Central Denmark, Southwest Finland, Päijät-Häme, Satakunta, Slovenia) have a roadmap, in the meaning of a strategy or a programme where the regional CE targets are defined. In some of these regions, the roadmap or the strategy can be seen to tightly define S3 priorities: 'The circular economy roadmap has specified the regional priorities [of the S3]' (8). However, all regions do not necessarily see the CE strategy document as defining the S3 thematic priority of, or related to, the CE. In some regions, the CE strategy is a parallel document, which only partly overlaps the S3: 'One of the components of this strategy [S3] is to further develop research and innovation in the field of the environment and more specifically the circular economy. And we also have this circular economy plan, so for research and innovation those two plans overlap' (1). In some cases, the S3 and CE roadmaps are seen as separate documents: 'We have two plans that are working side by side here, the roadmap [towards CE] and the smart specialisation strategy' (6). In four of the regions, a roadmap or strategy related to the CE is in preparation (Häme, Luxembourg, Sud-Muntenia, Basque Country). In the two remaining regions, the CE plays an important horizontal role in several sectors, even if it does not have its own roadmap (Berlin, Brandenburg).

In the five regions where the CE is mentioned in the name of the thematic priority area, a CE roadmap (named also CE strategy or growth programme with specified regional priorities) either exists (Päijät-Häme, Satakunta, Slovenia), is almost finalised (Basque Country) or is in the planning phase (Sud-Muntenia). This could mean that the thematic priority status given through the naming can speed up the roadmap process. However, based on the interviews, in some regions, the roadmap does not clearly define the S3 priority but rather promotes regional CE possibilities in general.

The main characteristic of S3 as a policy process is the combination of the top-down and bottom-up components [45]. According to Navarro [45], typically, the process of setting priorities has been led by regional governments (top-down) and involves a participatory

aspect. The top-down approach is suitable when the priority area is chosen [45]. However, in the roadmap and action plan phases, the entrepreneurial discovery logic becomes especially important [45]. Even though an equal and well-organised EDP is not easy to accomplish as political and social interests of stakeholders emerge [29]. The challenges related to the EDP are touched in several studies and provide its own area of research [28,29]. The findings of this research confirm that the EDP has been taken seriously when defining the CE roadmaps. The interviews pointed out that the process has been mainly led by the regional authority, and some regions mention the top-down element; however, all the roadmaps have been set up or are in the process of being prepared in a bottom-up approach. One of the interviewees described this quite clearly:

So the top-down part is 'Well, these are the sectors that we consider important and that we know are most innovative so that's why we want to define them as our RIS3', and then, we invited research institutions and other companies and other stakeholders in order to define which topics are important within the specific sectors (3).

All regions included in this research have proceeded with a bottom-up approach to define roadmaps related to the CE. The bottom-up processes were described as including administration and academia, development organisations or associations, and in most cases, the private sector. The cooperation has mainly been organised through workshops, focus groups or other kinds of meetings. However, face-to-face communication, such as interviews and discussions with the stakeholders, has also been undertaken in a few regions: 'We have organised focus groups for each priority, involving the Ministry, research institutes, universities, association of [a specific sector], entrepreneurs, chambers of commerce, public authorities, a municipality' (11).

There were examples of regions having an outside actor that was responsible for facilitating the roadmap process in practice, for example, a university (Päijät-Häme) or chamber of commerce (Slovenia). In Central Denmark, the process was implemented by a consultant specifically responsible for communicating with the private sector. Furthermore, two regions mentioned the involvement of citizens in their strategy processes: 'We included all levels of administration; we also integrated the private sector; we invited the clusters; we invited the companies, also private. Finally, the citizenship was also called to the participations' (5).

4.4. Actions, Monitoring and Evaluation

When the priority areas have been translated into roadmaps, the next step is to form action plans to implement the activities. Action plans mean strategy documents including information related to funding research, development and innovation activities, investments, actors (names of organisations) involved in the actions, schedules, monitoring and evaluation of the results, as well as a plan for 'feedback' i.e., updating the content [45]. From the CE perspective, only two regions (Satakunta and Slovenia) have refined their CE roadmaps into action plans. As mentioned above, these two regions are among the five that have defined the CE in their thematic priorities. In two regions (Southwest Finland and Päijät-Häme), actions were defined for some specific parts of the CE; for example, Päijät-Häme has defined an action plan for the subpriority 'bio-based CE'. As defined in Table 2, no specific action plan exists in the majority of the regions, but in all the regions, CE actions are ongoing. However, due to the differences in the thematic priority areas, the regions are not completely comparable.

In all regions, the funding of CE-related projects is taking place. As Table 2 shows, the link between S3 priorities and the ESF is obvious in the regions where ESF is available. Moreover, several regions mentioned that other types of funding for developing CE are utilised. Nevertheless, in several regions the S3 was adopted quite late with regards to the programming period 2014–2020. Due to this it was not translated into budgetary provisions. This might have influenced how strategic and well connected the funded actions have been. However, as the S3 strategies continue to guide the allocation of ESIF funding to specific themes or activities also during the new funding period 2021–2027, having CE as

a defined part of S3 may increase the availability of funding for implementation and CE related projects in the future.

For most regions, the monitoring and evaluation of the CE roadmaps and action plans are in the development phase. This finding supports the conclusions of previous studies implying that regions have very varying approaches to monitoring and evaluation, and that this phase is in many regions only under development [34,35]. Of the regions that identified CE as a specific thematic priority and where action plans have been prepared, Satakunta and Slovenia have defined targets to measure the CE. In Päijät-Häme, where the action plan has been defined for one subpriority, targets also exist for this specific part. The other regions do not have defined targets, or they are in the preparation phase.

Regarding the updating of CE roadmaps, only three regions seem to have a clear answer and active updating process. In Satakunta and Päijät-Häme, annual updates occur, and in the Basque Country, an update every two and a half years is planned. However, the majority of the studied regions either conduct continuous updates in the form of checking the priorities when funding new projects or looking at CE priorities when the general regional-level programme (or S3) is updated. Otherwise, they do not have any specific update process for the CE content. The monitoring and evaluation of roadmaps or action plans seem to be somewhat challenging to define.

5. Conclusions

To react to the severe challenges of sustainability in today's world, the CE is seen as a solution. When facing this entity at the regional level, policies and strategies are needed. This article explains how the CE is concretised in S3's of 12 European regions. It provides an attempt to clarify the actual stage of development in the regional innovation policy from the CE perspective, and how the S3 as a policy framework has been utilised around Europe in promoting CE in the regions.

S3 have existed in European countries since the early 2010s but concretising the chosen strategic priority areas into regional activities remains a challenge. As we have seen, only a couple of the studied regions have achieved setting up regional action plans in the S3 process. This research revealed that some regions see the S3 process strictly as fostering innovation and not as a strategic tool for developing the CE in their region, even if the themes overlap. The aim of S3 is to improve the sectors concerned and to transform the existing economic structures with the support of research, development and innovation. Furthermore, the linkage between CE and S3 is reinforced by the ESIF and distribution of regional funding: if the CE is visible in the S3, regional research, development and innovation projects in the theme are naturally supported. S3 should build on regional strengths, but 'new openings' are also absolutely applicable to the CE. To support the CE in the regions, the regional cluster strategies could more efficiently and innovatively be combined with S3 to minimise the situation in which the regions are spreading their efforts too broadly by having partly parallel and overlapping strategies to address the same topic. This combination would also help clarify the S3 and bring the still somewhat abstract concept closer to other regional strategies. Thus, the transformation and direction of change should lead the process.

All the studied regions have included a bottom-up approach or are aiming to proceed in this direction to define the CE roadmap. The bottom-up process was described as including public sector actors, such as authorities, academia, development organisations, associations and, in many cases, private companies. This study confirms the idea that when it comes to the implementation of regional strategies, the participatory nature of activities should be highlighted. Yet, the depth of participation, or the actual contribution of the participation from the transformation point of view, was not targeted in the interview questions. An interesting question for future research would be: Does the bottom truly meet the top?

S3 should be supported by monitoring and evaluation tools to measure performance [8,34,45]. However, the monitoring of roadmaps and action plans is challenging

because of the difficulties in defining and setting CE targets. Moreover, the S3 concept itself is new, and the regions do not have much experience to share related to monitoring the development and success of S3 priority areas in the regional and spatial contexts. Being able to monitor the direction of change can also make the change more manageable from the regional development and policy point of view.

As a limitation of this study, it should be noted that not all European regions with the CE as an innovation priority have shared their information on the JRC's database. The database is constantly developing, and regions update their S3 information. Also, after the interview phase, some data were found to already be outdated at the point of research; for example, Berlin had updated its thematic priorities, but the information was not yet available on the database. As we have seen, both S3 and CE are constantly evolving concepts, which sets challenges for empirical studies. It should also be noted that as S3 strategies and processes are always based on region-specific institutional and governance context as well as long and varying industrial and economic histories [36,42,46], it was not feasible to study the target regions in as detailed level as it would be possible in a case study or in a cross-case analysis of only a few regions. However, the strength of the chosen methodological approach of this study lies in the EU-wide examination and the coherent multi-country comparison.

This study contributes to the previous S3 literature by presenting a conceptual framework for analysing the S3 process and policy implementation, which also enables interregional comparisons. Based on the analysed data, many regions have the CE as a chosen priority area in their S3. Unless these prioritised themes are concretised and connected to the regional entrepreneurial bases and innovation activities, the S3 remains no more than a regional branding effort. An updated S3 framework which moves from planning to the concrete construction of transformative activities can work as a useful framework in regions, regardless of whether it is labelled as regional S3 work. The framework integrates the latest conceptual discussion of S3 with practice-level regional innovation policy activities and can be utilised as a part of practical policy and strategy planning processes in regions as an alternative to the original six-stepped S3 process [8].

The empirical part of this study not only presents the state-of-the-art of S3 within the CE priority area but also highlights the gaps and challenges in promoting ambitious cross-sectoral priority areas as well as where these challenges originate from. The results reveal how the CE is concretised through the S3 process and implementation in European regions and show the potential of utilising the S3 policy approach in combining sustainability-based goals and regional economic development.

The S3 themes should be based on regional strengths but be flexible to meet the changing requirements for moving the region forward. Based on this study, it is recommended that in order to maximise the benefits of both S3 and the CE, regions should focus on clearly defined priorities and concrete—yet adjustable and flexible enough—plans on how to achieve the set targets. Furthermore, the possibilities for synergies should be recognised. Due to the novelty of both the CE and S3, the concepts are still in development, and the regions do not yet have mature practices with a combination that can be shared. Despite the challenges, promoting the CE as a strategic priority through the S3 process has developed regional abilities in defining CE targets and actions by focusing on existing strengths and future potential.

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Appendix A

Interview questions: Concretising Circular Economy in European Smart Specialisation Strategies

Background

1. Name of the region in focus
2. When was circular economy (CE) chosen as an S3 priority in your region? (year)
3. Why was CE chosen as a RIS3 priority in your region? Please describe the background and regional strengths.

Priorities and targets

4. Have you specified regional priorities to reach CE?
5. If yes,
    a. please name the priorities
    b. Have you specified measurable targets for your CE priorities?
    c. Have you specified concrete actions for reaching your CE priorities? If yes, please mention examples
    d. How where the CE priorities defined? (e.g., responsible body, bottom up/top down, stakeholder involvement)
    e. Have you defined a process for updating the CE content in your S3?
    f. If yes, please shortly describe (responsible body, stakeholder involvement, frequency)
6. If no,
    a. Why are the priorities not defined?
    b. Are you planning to define the priorities?

Funding circular economy development

7. Which sources of funding has enabled promoting CE in your region?
8. What is the proportion of structural fund projects promoting CE related to all approved structural fund projects in your region?
9. Is there a link between the S3 and the extent of financed CE projects?
10. Any additional comments

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Publication III

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Perspectives of Sustainable Circular Economy in Regional Innovation Policies

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Perspectives of Sustainable Circular Economy in Regional Innovation Policies

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Abstract

Circular economy (CE) is a trending concept that aims to increase the potential productivity of the economy while using fewer resources. In a CE, natural resources are used and recycled effectively; however, despite the circularity, the input in a circular system should not exceed the limits of planetary environmental constraints. If properly implemented, the CE supports the sustainable use of natural resources while at the same time contributing to solving climate crises and supporting biodiversity. Currently, the transition towards the CE is widely promoted through policymakers and governance, although this popular concept may have different meanings and origins depending on the region. Through interviews with CE policy developers in 12 European regions, this paper explores how the CE has been defined in the context of regional innovation policies. The selected regions, along with their regional stakeholders, have defined the CE as a priority in their research and innovation strategies for smart specialisation (S3), which involves the European innovation policy approach of channelling research and innovation resources to selected priority areas. The paper presents S3 priorities related to the CE and to environmental themes that lie in the background of the transformation of regional CE policies. The analysis showed that the regional CE context originates from environmental awareness, clean technologies and energy and waste management. Findings also showed that national policies, such as bioeconomy strategies, affect some regional priorities. In four regions, one reason behind prioritising the CE was because it was seen as a current trend in EU policies. The findings indicate that, as the CE becomes mainstream in regional policy, the importance of a holistic sustainable approach emerges. However, it seems that the term holistic can be understood in different ways in the CE context. Regions and regional authorities are challenged by the pressure to achieve concrete circular actions. Sustainable development should guide the transformation of CE policies. To manage the transition towards the CE on a global scale, its implementation on the regional level is crucial. However, the proper understanding of all CE dimensions among regional actors might challenge the regions' capabilities to achieve sustainable change. This research contributes to increasing the understanding of sustainability aspects of the CE in regional innovation policies by exploring its implications for Sustainable Development Goal targets 11.6 and 12.2. Target 11.6 involves how CE relates to

developing waste management in the regions. Target 12.2 refers to the transformation of regional CE policy to achieve sustainable management and efficient use of natural resources. This paper relates to the ISDRS Conference topic, as it enhances the importance of a sustainable, proactive and transformative regional CE policy that involves relevant stakeholders in strengthening the regions' abilities to overcome the crisis.

Keywords: circular economy, regional innovation strategies

1. Introduction

The world is facing climate and biodiversity crises, as technological advancements, progress and growth has for centuries been moving faster than natural development. A pressing need exists for humanity to transition towards a sustainable society where natural resources are used within planetary environmental limits. Several terms and models have been developed that aim to define a balanced interplay between nature and humanity (D'Amato et al., 2017). The overarching aim of sustainability and sustainable development (SD) is a key concept in this discussion in scientific research and policy development (Billi et al., 2021). Moreover, one of the trending concepts which has been widely promoted through governance and policymakers is the circular economy (CE), which aims to increase the potential productivity of the economy while using fewer resources (D'Amato et al., 2017; Geissdoerfer et al., 2017). When properly implemented, the CE supports the sustainable use of natural resources while at the same time contributing to solving climate crises and supporting biodiversity. However, the CE concept may have different meanings and policy origins (Korhonen et al., 2018a).

The European Union (EU) has launched several horizontal actions and strategies with a focus on environmental protection, climate change mitigation and CE, for example, directives that tackle climate change (European Commission [EC], 2008), energy efficiency and renewable energy (EC, 2011a, EU, 2012), waste handling (EU, 2008, 2014), action plans on the CE (EC, 2015, 2020) and strategies to support the bioeconomy (EC, 2012, 2018). In addition to these substance-oriented policies, the EU also supports regions in developing their abilities by concentrating on their potential strengths (Foray, 2015; Foray et al., 2012). Research and innovation strategies for smart specialisation (S3) were introduced as part of the EU's cohesion and innovation policy to steer investments in research and innovation by supporting regions to focus on fields with the most competitive potential (Foray et al., 2012; Teräs and Mäenpää, 2016). Some regions in Europe have combined the aim to achieve a CE with their innovation policy (Vanhamäki et al., 2021).

This paper presents novel results on the discussion about what lies in the background of regional CE and how CE-related innovation policies have developed in the regions from a sustainability perspective. The paper utilises interview material that has partly been used in an article concerning the current implementation of the CE in S3 (Vanhamäki et al., 2021).

2. Background

The Oxford Dictionary defines sustainability as 'the ability to be maintained at a certain rate or level' and 'avoidance of the depletion of natural resources in order to maintain an ecological balance' (as cited in Lexico, 2020). Sustainability, as most of us use the concept today, originates from the great concern about poor resource management and environmental degradation emerging in the 1960s (Kopnina, 2017; McKenzie, 2004). Environmental awareness emerged even stronger in 1972 after the publication of the Club of Rome's report 'The Limits to Growth' (Meadows et al., 1972), which launched the still ongoing debate on the limitations of the earth's capacity to support human economic expansion.

Sustainable development as a term was placed into the political agenda in 1987 when the United Nations (UN) published the report 'Our Common Future', also known as the Brundtland Report (Sneddon et al., 2006; UN, 1987). The report defined SD as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs', thus underlining that it comprises environmental, social and economic aspects (UN, 1987, p. 41). Since then, the ideal of SD has been increasingly adopted in policies around the world (Janerio and Patel, 2015). In 2015, the UN General Assembly set up the Agenda for Sustainable Development, which declared 17 Sustainable Development Goals (SDGs) defining urgent necessary actions in all countries (UN, 2015). The goals and targets focus on interrelated ecological, social and economic issues that are crucial for the future of humanity and our planet (UN, 2015).

Since the start of the sustainability debate, it has been commonly accepted that the linear economy for generating economic growth in which raw materials are extracted, manufactured, used and thrown away cannot lead to SD (Hoekstra and Wiedmann, 2014; Millar et al., 2019). Yet, the societal development and academic research linked to SD has resulted in several new related concepts and subfields (Billi et al., 2021; D'Amato et al., 2017). The most relevant to this article are presented in the following.

Green economy and green growth have been commonly used since the 2012 UN Conference on Sustainable Development in Rio de Janeiro (D'Amato et al., 2017; Loiseau et al., 2016). A green economy is an umbrella concept that values all ecological processes, supports investments that reduce carbon emissions and pollution, encourages energy and resource efficiency and also supports social inclusion (Barbier, 2012; D'Amato et al., 2017; Louiseau et al., 2016; UNEP, 2011). However, Le Blanc (2011) and Louiseau et al. (2016) have pointed out challenges related to the concept's usefulness and appropriateness to achieve sustainability, as its motivations related to economic growth and sustainability are, to some extent, contradictory and require clarification.

The use of renewable natural resources is a central part of the sustainability discussion; thus, the concept of bioeconomy has been introduced. The bioeconomy relies on renewable biological resources, for example, plants and animals, and values their transformation into products, materials and energy (EC, 2018; McCormick and Kautto, 2013). D'Amato et al. (2017) found the bioeconomy to be an inclusive

concept, as it has recently also embraced more sustainability aspects. The bioeconomy is a commonly used concept in European policies due to the initial EU bioeconomy strategy launched in 2012 (EC, 2012) and several national bioeconomy strategies. The bioeconomy has been criticised for not supporting sustainability, as all bio-based actions are not automatically sustainable. A review of the EU's bioeconomy strategy published in 2018 highlighted the need for a sustainability approach (EC, 2018).

In addition to these wide concepts, terms linked to environmental awareness and sustainability are, for example, waste management, renewable energy, energy efficiency, resource efficiency and clean technologies or cleaner production (referred to as cleantech). Cleantech as a term was born around the turn of the new millennium. Cleantech is defined as a sector that includes technological innovations (e.g. related to renewable energy, energy efficiency and storage, nanotechnologies and material efficiency technologies) aimed towards a green economy (Caprotti, 2016; Chapple, 2011). EU legislation has reinforced the importance of cleantech through directives that tackle climate change (EC, 2008), energy efficiency and the use of renewable energy (EC, 2011a, EU, 2012) and the handling of waste according to the waste hierarchy in legislation and policy (EU, 2008). Cleaner production is considered one of the main concepts leading to the CE (Ghisellini et al., 2016; Su et al., 2013), which is one of the most central concepts arising from the sustainability debate.

The CE is often associated with efficient and sustainable waste management, and therefore, waste management can be seen as a subsector of the CE (Merli et al., 2018). The CE can be defined as an economic system which aims to close material loops and maintain the value of products and resources for as long as possible (EC, 2015; Ellen MacArthur Foundation, 2012; Geng et al., 2019; Ghisellini et al., 2016; Kirchherr et al., 2017). The idea behind the CE is old and can be dated back to the 19th century (Murray et al., 2015). Often, scientists associate the concept with Pearce and Turner (1990), who presented the functions of the environment as seen from an economics perspective (e.g. Geissdoerfer et al., 2017; Ghisellini et al., 2016; McDowall et al., 2017; Merli et al., 2018; Murray et al., 2015; Su et al., 2013).

The CE has industrial ecology in its background, with the core idea of closing material loops (Blomsma and Brennan, 2017; D'Amato et al., 2017; Geng and Doberstein, 2008; Merli et al., 2018; Yuan et al., 2006). Industrial ecology can be defined as nearly closed-loop industrial ecosystems which are balanced and diverse in terms of material exchange and energy cascading (Despeisse et al., 2012; Ehrenfeld, 1997; Li, 2018). Furthermore, as a part of the industrial ecology, industrial symbiosis aims to develop material, energy and waste exchanges, that is, a network of synergies within and across different companies to achieve closed material loops and energy efficiency (Chertow, 2000, 2007; Li, 2018; Lombardi and Laybourn, 2012). In industrial symbiosis, the 'waste' of one actor is utilised as a resource by another in the network.

The CE concept has been developing around the world. In China, the CE was formally accepted in 2002 by the central government as a new development strategy, and in 2009, a law for CE promotion came into force (McDowall et al., 2017; Su et al., 2013). In Europe, a flagship initiative on resource efficiency was presented by the EC in 2011 (EC, 2011b). It stated that, among other steps, a long-term framework would be set up as a 'strategy (roadmap) to make the EU a "circular economy", based on a recycling society with the aim of reducing waste generation and using waste as a resource'. In general, the CE as an umbrella concept has gained wider use since 2012 when the Ellen MacArthur Foundation (2012) introduced it to the public at large. The concept has been used and developed mostly by practitioners and policymakers (Korhonen et al., 2018a, 2018b). The CE is currently widely accepted among policymakers and is in general seen as a central concept aimed at sustainability (Geissdoerfer et al., 2017; Korhonen et al., 2018a; Lin, 2020; Sauvé et al., 2016; Schroeder et al., 2018). It provides an attempt to conceptualise economic activities and environmental well-being in a sustainable way (Murray et al., 2015). Since the concept was introduced, it has been an integral part of EU policies. In 2014, the EC launched the Zero Waste Programme for Europe (EC, 2014), which was strongly based on the CE and was followed by the first CE action plan in 2015 (EC, 2015) and an updated version in 2020 (EC, 2020).

Even though the CE has received great attention from scholars in the last few years, Korhonen et al. (2018a, 2018b) and Homrich et al. (2018) have pointed out that the CE is still very much a developing concept from the scientific point of view. Researchers have made efforts to fully understand the width of the CE, for example, by framing the various definitions in the literature (Kirchherr et al., 2017; Korhonen et al. 2018a), defining its link to sustainability-related concepts (see Geissdoerfer et al., 2017; Ghisellini et al., 2016) and specifying links to other associated concepts, such as the abovementioned green economy, bioeconomy, industrial ecology and industrial symbiosis (D'Amato et al., 2017; Millar et al., 2019; Saavedra et al., 2018). However, there is a need for a continuing scientific discussion to establish a joint interpretation and approach to the CE that would enable scientists to define the CE with regards to other concepts (Merli et al., 2019; Schöggl et al., 2020).

The main critique and concern towards the CE has been that sustainability is not self-evident in the concept. It has been debated whether it is possible to achieve economic growth while at the same time protecting the environment and supporting social sustainability (Kallis, 2011; Millar et al., 2019). The connection between the CE and SD, and whether the CE is indeed sustainable, has been discussed in the literature (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Kirchherr et al., 2017; Millar et al., 2019). According to Korhonen et al. (2018a, 2018b), it is crucial to ensure that the actual environmental impacts of the CE promote sustainability in both the short and long term. This has been supported through scientific research. Another critical point of view has been that the CE should focus more on the proactive systematic change in production and consumption to develop towards a sustainable circular model (Merli et al., 2018).

To meet the sustainability discussion, an update of the CE definition is necessary to underline the three dimensions of SD as well as the use of renewable energy sources and cascading types of energy flows (Korhonen et al., 2018a). Also, the European Green Deal and EU's new CE action plan (EC, 2020) highlight global sustainability and support achieving SDGs through the CE. For the environmental impacts to stay within planetary boundaries, the use of natural resources should not exceed regional limits.

Combining SD and CE goals with regional-level policy has been topical in European regions over the last decade. The Europe 2020 strategy raised the need for increasing investments in research and development as a central part of developing Europe's competitiveness (EC, 2010; Foray et al., 2012). Regional-level policy plays a key role in the strategy, as it highlights a bottom-up approach (EC, 2010; Foray et al., 2012; Teräs and Mäenpää, 2016). The smart specialisation concept was introduced by the EU before the previous 2014–2020 programming period (EC, 2010; EU, 2013; Foray et al. 2012). The aim of the research and innovation strategy for smart specialisation (S3) is for regions to concentrate their resources on developing new specialties that are likely to transform their existing strengths and economic structures through research, development and innovation (Foray, 2015; Foray et al., 2012). The S3 process strongly builds on an entrepreneurial discovery process, which means including the regional economy and stakeholders, such as companies, universities and research institutes, in building the strategy (EU, 2013; Foray, 2015). An existing S3 was set as a condition for receiving structural and investment funding for the 2014–2020 programming period (Foray et al., 2012; EU, 2013).

The S3 concept has been under development since the sustainability discussion and the European Green Deal. From the Green Deal perspective, an update of the S3 logic to include more perspectives on sustainability was proposed in the EC's report by McCann and Soete (2020). Thus, they introduced changing the European regional development strategies from S3 to smart specialisation strategies for sustainable and inclusive growth (S4+) to support achieving the Green Deal targets (McCann and Soete, 2020). The EC has underlined that, to achieve the CE, long-term commitment is needed at all levels of government (EC, 2015). Authorities on different levels are either enabling and accelerating the transition or inadvertently slowing it down. Furthermore, the Green Deal and the updated CE action plan (EC, 2020) emphasise that joint efforts are needed on international, national, regional, and local levels to achieve systemic change.

The holistic and systemic change to the CE has been defined in several ways in the literature. The holistic transition to the CE can be seen as implementing a systemic change to the CE on different levels: macro (policy changes on national and regional levels), meso (industrial networks and symbiosis between companies) and micro (companies and citizens) (Geng and Doberstein, 2008; Ghisellini et al., 2016; Kircherr et al., 2017; Sitra, 2016; Su et al., 2013; Vanhamäki et al. 2019, 2020). It has been agreed that systemic change requires efforts on all levels. Scientists have also defined the holistic perspective of the CE as emphasising all aspects of SD: environmental, social and economic (Desing et al., 2021;

Geissdoerfer et al., 2017; Korhonen et al., 2018b). Furthermore, Jiao and Boons (2014, pp. 21) wrote that the CE is 'a holistic concept including the activities of "reduce, reuse, and recycle" in the process of production, circulation, and consumption'. The holistic CE is also understood as the crosscutting interplay between different sectors, following a value chain perspective rather than a sector or product approach (Hedlund et al., 2020). For example, a ban on landfilling in one area can lead to waste shipping and increased incineration rather than improving reuse or recycling or focusing on the beginning of the value chain, that is, product design.

Calisto Friant et al. (2021) stated that, overall, the EU has managed to start the transformation and transition towards the CE in member states, yet a holistic perspective needs to be emphasised to ensure structural change. The EU action plan (EC, 2020) focuses a great deal on the recycling industry, which is indeed a key part of the CE. However, an emphasis on structural change towards a sustainable society is necessary to support holistic change (Calisto Friant et al., 2021; Lin, 2020). Transition towards a sustainable CE requires systemic change, which can be enabled when environmental concerns are integrated into other fields in which life-cycle thinking and long-term effects are prioritised over short-term interests (Desing et al., 2020). However, to enable the change to a circular society, supporting the government actors, companies and other stakeholders is critical to developing their understanding of the CE. If the CE continues to be used and grasped without a systemic understanding, the term can become 'a refurbished form of greenwashing' (Calisto Friant et al., 2020).

To enable CE development, policymakers and companies should focus their efforts on regional actions while keeping the regional strategic focus on supporting the overall system (Reike et al., 2018). In practice, the EU has supported and continues to boost CE implementation through funding instruments, including necessary investments in the regions as well as research, development and innovation projects. On the regional level, the major instrument supporting the CE is the European Regional Development Fund, which is connected with the implementation of S3 (EC, 2020), as mentioned above. However, the timing, focus and depth of understanding varies regarding how EU member states and regions have reacted to the Commission's CE action plans and proceeded towards the CE at the strategic level and in practice (Vanhamäki et al., 2019, 2020, 2021). Some regions have combined the aim to develop the CE with their innovation policy and S3 (Vanhamäki et al., 2021). This paper focuses on these regions and presents environmental themes lying in the background of the transformation of policies related to smart specialisation and the CE.

3. Methods

A comparable sample of regions with current interests in developing the CE was searched to enable an analysis of the background of the regional CE discussion. For this purpose, the S3 framework provided a solution, as EU member states are obliged to develop national and/or regional S3 for the implementation of the 2014–2020 programming period (EU, 2013). As the S3 are integrated, place-

based economic transformation agendas to guide investments in research and innovation in EU regions (Foray et al., 2012) should build on each region's strengths, competitive advantages and possibilities for excellence; that is, they should rely on long-time regional development while fostering future potential.

Regional innovation priorities of the EU member states are gathered on the EU Joint Research Centre's Smart Specialisation Platform's Eye@RIS3 database for visualising the public investment priorities for innovation across Europe (EC, 2021). The aim of the database is to boost strategy development and connect regions for collaboration. It also enables the comparison of regional S3 priorities.

The regions compared in this paper were searched in the Eye@RIS3 database on 10 May 2019 with the key term 'circular economy'. The search found 14 European regions that use the term CE in the description of their thematic priorities. The regions represented levels 1–3 of the Nomenclature of Territorial Units for Statistics (NUTS). Regions from all NUTS levels were kept within the study because of the low total number. The named contact persons from these regions were reached through email, and an interview was proposed. Responses were received from 12 regions. Interviews were conducted in English for 10 regions and in Finnish for one at the interviewee's request. One region preferred to reply through email. The interviewees (1–3 persons per organisation) represented organisations in charge of the regional policy processes. Table 1 presents the participating regions, the organisations represented and the dates of interviews.

Table 1. *Studied regions.*

Country	Name of Region	NUTS level	Organisation
BE	Brussels-Capital Region	2	Innoviris
DE	Berlin	2	Senate Department for Economics, Energy and Public Enterprises
DE	Brandenburg	2	Economic Development Agency Brandenburg
DK	Central Denmark	2	Central Denmark Region
ES	Basque Country	2	Basque Government
FI	Southwest Finland	3	Regional Council of Southwest Finland
FI	Häme	3	Häme Regional Council
FI	Päijät-Häme	3	Päijät-Häme Regional Council
FI	Satakunta	3	Regional Council of Satakunta Regional Council
LU	Luxembourg	1	Ministry of Economy
RO	Sud - Muntenia	2	South Muntenia Regional Development Agency
SI	Slovenia	1	Government Office for Development and European Cohesion Policy

A qualitative research approach with thematic analysis was applied to discover the background of the CE discussion in the regions. According to Galletta (2013), in qualitative research, the data are analysed during data collection as thematic patterns start emerging. The iterative data analysis requires several loops to gain an understanding of the data. Usually, one exact question will not reveal the whole truth behind a theme, but other information might appear in another context. This paper is based on semi-structured interviews, where a predefined frame of questions was used to offer the freedom to formulate exact questions (Hopf, 2004). This enabled focusing on the characteristics of each region. The recorded and transcribed interviews were classified, coded and summarised and then compared to the discussion framework of the CE concept. This paper contributes to existing knowledge by comparing the findings of the interviews with an interpretation and evaluation of the existing literature.

4. Results and Discussion

The regional interviewees explained the background of why they have set a CE related priority in their S3. The discussions revealed different premises and regional strengths. In the following, an overview of the situation is reviewed. The innovation priorities related to the CE and the themes in the background discussion are presented in Table 2.

During classification of the interview data, three types of factors influencing the strategy development were identified: 1) EU legislation, 2) national priorities and 3) a holistic approach. First, the development of EU environmental legislation on energy efficiency and waste recycling was seen within the background of developing the CE in several regions (e.g. EC, 2008, 2011a; EU, 2008, 2012). This was evident, as five interviewees mentioned strengths related to energy (energy efficiency, energy technology). Furthermore, a background in waste management-related issues was revealed by five regional interviewees, which was partly different from mentions of the energy focus. As Table 2 shows, three regions have ‘clean technologies’ in the name of the priority, which indicates the support and focus on cleaner production of regional industry. In addition, clean technologies were mentioned in four other interviews in discussion of the background in the field of CE. This means that, in over half of the studied regions, cleantech is seen as a background for the CE. The Zero Waste Programme for Europe (EC, 2014) and the first CE action plan in 2015 (EC, 2015) speeded up the development of related regional strategies.

Second, national priorities affected which CE-related elements were identified as strategically important strengths. For example, five regional interviews highlighted bioeconomy or strengths in bio-related value chains in their background for the CE. These five regions comprise all the Finnish regions and one German, and they represent countries with a strong national bioeconomy focus (see Federal Government, 2020; Finnish Bioeconomy Strategy, 2014). The national-level influence on Finnish regional S3 choices was also noted by Nauwelaers (2013) in an earlier study. Industrial symbiosis was

mentioned as a background factor in four interviews, three of them from Finland. In Finland, symbiosis has been previously encouraged by political instruments, for example, through waste reduction targets (Lehtoranta et al., 2011), and was first mentioned in the national material efficiency programme in 2013 (Finnish Ministry of Employment and the Economy, 2013) and further emphasised in the government programme in 2015 (Prime Minister's Office, Finland, 2015).

It can also be noted that regions from the same country may follow each other's example in strategic development, emphasised by national-level strategies. For example, several Finnish regions have set up CE strategies in the last couple of years: Päijät-Häme in 2017, Southwest Finland in 2017 and Satakunta in 2019 (*Circular Economy in Southwest Finland*, 2020; Päijät-Häme Regional Council, 2020; Satakunta Regional Council, 2019). The regional process is, in addition to the EU level, also connected to and encouraged by the Finnish national CE strategy from 2016, the world's first national-level roadmap, thus emphasising the importance of regional actions (Sitra, 2016).

Third, in half of the regional interviews, sustainability or SD-related regional strengths were mentioned, and over half commented on the importance of the holistic approach towards the CE. Regardless of the different backgrounds, the majority of the regions in focus recognised the importance of the sustainable and holistic approach to the CE. In total, seven regions brought up the importance of seeing the system as a whole. One interviewee stated, 'One of the things we realised quite quickly was that the circular economy is a complex thing to do. And it's not a little thing that you can do just in a few months and it's also not something that you can do in a specific sector only, it's very cross-sector you will basically need to change the whole system.' Another said, 'If we really want to become circular, it only works if we work on the European level.' The results are summarised in Table 2.

Table 2. *Innovation priorities related to the circular economy and their regional background themes.*

Country	Region	Innovation priority related to circular economy	Themes in the background of the priority (circular economy)							
			Energy	Waste	Cleantech	Industrial symbiosis	Bioeconomy	Sustainability related	Holistic approach	Trend
BE	Brussels-Capital Region	Environment: Green economy	x					x		
DE	Berlin*	Sustainable use of natural resources			x			x	x	
DE	Brandenburg	Circular economy	x	x	x		x		x	x
DK	Central Denmark	Clean technologies			x			x	x	x
ES	Basque Country	Networks for the transition to circular economy		x		x		x		
FI	Southwest Finland	Clean technologies				x	x	x	x	
FI	Häme	Growth drivers	x	x	x	x	x			
FI	Päijät-Häme	Building a new circular economy			x		x	x	x	
FI	Satakunta	Innovative food chains	x			x	x			
LU	Luxembourg	Bio and circular economy							x	
RO	Sud - Muntenia	Clean & ecotechnologies		x	x					x
SI	Slovenia	Bioeconomy: Developing circular economy	x	x					x	x

* Email reply

The discourse on sustainability is simple in theory, while implementation of sustainable actions from a holistic perspective is more complex. The in-depth understanding and regional actions to support a structural change are crucial. Holistic and long-term solutions and thinking are necessary to ensure policies that do not concentrate on ‘end-of-pipe’ solutions but instead enable socio-ecological change (Calisto Friant, 2021). One additional insight noted from the comments of four regions involves the

understanding that the CE was prioritised in their S3 because it is seen as a current trend in the EU policies. As commonly known, the CE has become an extremely popular concept, and with it, a 'go with the flow' attitude might occur. If there is a somewhat uncertain knowledge base, there is a risk that the concept may be misused. The aim here is not to point out that this would be the case in these regions, only to point out the possibility of it. This is the point where the interplay between scientists and stakeholders, especially policymakers and the business sector, becomes vital. The holistic understanding of the necessary systemic change to achieve a sustainable CE is essential to bringing it into practice.

The CE concept is built on subterms or subconcepts, which emerged in the regional interview. These include waste management, energy efficiency and renewable energy, cleantech and industrial symbiosis. As a general concept, the CE provides a path towards sustainability. The challenge is how to concretise the CE while still pursuing the regional strategic focus on supporting overall sustainability – environmental, social and economical. The focus of this paper was on presenting S3 priorities related to the CE and environmental themes that lie in the background of the transformation of regional CE policies. To meet the sustainability challenges the world is facing, the CE needs to be concretised while ensuring a sustainable, holistic and systemic approach. If utilised successfully, the S3 can serve as a tool for building on regional strategic potential and sustainable strengths to direct funding to concrete regional actions.

The research has limitations related to the use of the source material. The findings only present the discourse behind the CE concept and limited representative's understanding of the regional CE background. The background study could be deepened by studying regional policy documents from all regions or broadening the interviews.

5. Conclusions

The CE as a sustainability paradigm has been a key topic in European policies over the last decade. When properly implemented, the CE supports the sustainable use of natural resources, contributes to solving climate crises and maintains biodiversity. However, the CE concept is still scientifically young, and interpretations of what it comprises vary. Along with the CE concept, S3 was introduced into European policy. The 12 EU regions that have defined CE as a priority in their S3 were the focus of this research. In addition, the origins of the regional CE focus and how the CE has been defined in the context of regional innovation policies were analysed.

The analysis showed three types of background factors influencing the strategy development: EU legislation, national priorities and a practice concluded as the holistic approach. Obviously, EU and national legislation and policy priorities are reflected in regional-level strategy development. Cleaner production, including waste and energy perspectives, were the most central themes behind regional CE thinking. Nevertheless, over half of the regions mentioned a holistic or systemic approach as a

motivation behind their regional CE focus. This is indeed a positive reflection; however, at the same time, it raises further questions.

As the CE begins to become mainstream in regional policy, the relation and contribution of the CE to SD and, hence, to a more sustainable society is under discussion. A fact that needs to be highlighted is that sustainability is not self-evident in the CE. The CE discussion has developed in practice and through policies, with the scientific dialogue lagging behind. Several of the studied regions described holistic intentions; however, strengthening of the understanding is necessary, as the CE concept is young. CE development can be seen as an important driving force of SD because it appeals to both business and policymakers, though scientific research is urgent to make sure that the CE is sustainable. Moreover, both policy- and scientific-based discussion are needed to develop a mutual understanding of what a systemic change to a holistic sustainable CE is. At the same time, the EC's proposed update of S3 to S4+ to enhance sustainability and inclusiveness would support this direction.

To sum up, SD should guide the transformation of CE policies. In recent times, the EU's CE policy has begun to pay more attention to sustainability (EC, 2020), which in turn affects the policies and actions of the member states. To manage the transition towards the CE on a global scale, its successful implementation on the regional level is crucial. The CE as a concept gives guidelines on how to solve environmental challenges. However, we argue that, in order to meet SD, the CE needs to be concretised and defined through actions to achieve a systemic change. While regions are challenged by the demand to achieve these concrete actions, the proper understanding of all CE dimensions among regional actors might still be developing. Regions need knowledge and factual understanding to base their decisions and actions on rather than simply 'following a current trend'. The horizontal sustainable perspective should guide regional policies and actions to enable the regions to achieve sustainable circular change.

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Transition towards a circular economy at a regional level: A case study on closing biological loops

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ABSTRACT

The transition towards a circular economy requires a systemic change, where regions play a vital role. In Finland's Päijät-Häme region, European and national targets for a circular economy were implemented on a regional level. The regional development programme and strategy of the area emphasises a circular economy as a key feature. In practice, a circular economy strategy was set up through a road map process involving stakeholders from local government, industry and academia. The strategy aims to strengthen circular economy implementation in real-world systems through five identified goals. The goals focus on closing both technical and biological loops, as well as promoting sustainable energy technologies, new consumption models and demonstration sites. This paper illustrates how a move towards a circular economy is supported through regional strategy implementation. Furthermore, opportunities and challenges related to the transition towards the circular economy are presented via a case analysis of a local bio-based industrial symbiosis where biogas and fertiliser are produced from biowaste streams and sewage sludge. New technologies such as these create more business opportunities at the interface of material and energy cycles even where their implementation faces financing challenges. Regulations need to support the implementation of effective symbioses emerging from new solutions, but are also needed to safeguard the environment and human health when closing biological loops. The regional circular economy strategy described and the case of bio-based industrial symbiosis are both recognised as transferable good practices at the European level. A stakeholder-based approach is shown to be crucial to continuous development towards a circular economy society.

1. Introduction

The circular economy (CE) concept is currently promoted at international and national policy levels (European Commission [EC], 2015; Sitra, 2016; EC, 2018a; Sitra, 2019) and increasingly discussed among researchers (e.g., Blomsma and Brennan, 2017; Kirchherr et al., 2017; Korhonen et al., 2018). The transition towards a CE requires a systemic change, where regions play a vital role. However, research on practical cases at the regional level remains underexplored. More in-depth discussions concerning the opportunities and challenges presented by circularity are required to enable the realisation of a CE in real-world systems.

A CE involves a regenerative industrial system where resource input and waste, as well as any kind of leakage, are minimised by slowing down and closing material and energy loops (Geissdoerfer et al., 2015; Ghisellini et al., 2016; Kirchherr et al., 2017). Kirchherr et al. (2017) define a CE as a system based on business models promoting reducing, reusing, recycling and recovering materials operating at different levels, with the aim of achieving sustainable development. Since a CE entails a systemic change, it requires broad co-operation among stakeholders, such as authorities, companies, academia and consumers. Furthermore, to achieve a CE, it is essential for national, regional and local authorities and governments to enable such transition (Loiseau et al., 2016; Geissdoerfer et al., 2017). This means that a CE requires efforts at macro, meso and micro levels in order to promote the change (Geng and Doberstein, 2008; Geng et al., 2012; Su et al., 2013; Ghisellini et al., 2016). On a macro-level the approach comprises policy changes at national, regional and city levels. Industrial symbiosis (a model where surplus energy or residual resources of one company are used by another), ecosystems and networks among companies constitute the meso level, whereas the micro level focuses on single companies and consumers (Kirchherr et al., 2017).

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A systemic change towards a CE should be based on regional characteristics depending on geographic, environmental, economic and social factors. Renewable resources, which are key elements of the bioeconomy, play an important role in implementing CE principles (Birner, 2018). In other words, a CE's renewable segment is based on the bioeconomy, which makes the closing of biological loops one of the most essential aspects of a CE. The recently updated European Union (EU) Bioeconomy Strategy also underlines this fact (EC, 2018a).

A bioeconomy can be defined as an economy where materials, chemicals and energy are developed and derived from renewable biological resources (McCormick and Kautto, 2013; Birner, 2018). Bugge et al. (2016) also argue that a bioeconomy focuses on reducing waste streams of bioresources, as well as developing new products and economic value chains based on such waste streams. According to the EC's (2018a) updated definition, a bioeconomy relies on renewable biological resources (e.g., crops, forests, animals and organic waste) and their conversion into food, feed, products, energy and services. A bioeconomy includes all primary production sectors (agriculture, forestry, fisheries and aquaculture) and all economic and industrial sectors based on biological resources. Conversion of biowaste, residues and discards into valuable resources, such as products and energy, lies in the core of a CE. To support a sustainable bioeconomy, innovations and incentives are also needed to help retailers and consumers reduce food waste.

This paper focuses on regional practical cases of CE implementation as recommended by Singh et al. (2019). In a departure from research that provides perceptions of the conceptualisation of CE on a more theoretical level (e.g. Kirchherr et al., 2017; D'Amato et al., 2017; Korhonen et al., 2018), this paper provides an overview of transition towards CE on a regional level. The main research focus is on how a CE is implemented regionally through a road map process working as a strategic instrument to bring together regional stakeholders (horizontal), with connecting regional goals with EU and national level CE targets (vertical). Furthermore, the concrete opportunities and challenges related to the CE transition are presented through a case analysis of a bio-based CE. To the best of our knowledge, there is little research on regional level CE transition for the horizontal and vertical matrix, although there is currently increasing interest in creating regional CE strategies.

2. Background

2.1. Towards a CE at international, national and regional levels

Transition towards a CE requires a broad systemic change at all levels. However, according to Kalmykova (2018), the scope of CE implementation often encompasses product, material or industrial-sector levels, with little emphasis on systemic changes to the broader economy. The CE approach has been criticised for failing to adequately address not only sustainability concerns, especially those related to social aspects, but also broader environmental implications (e.g., Geissdoerfer et al., 2017; Camilleri, 2018; Korhonen et al., 2018). For instance, the recycling of some materials is difficult, and even if recycling is possible, its net impacts over the short and the long term should be taken into account, since recycling requires energy and often the transportation of materials. According to Geissdoerfer et al. (2017), the sustainability scope of CE tends to be limited to closing material loops and improving resource use, which means that the main beneficiaries are economic actors. Furthermore, Reike et al. (2018) have criticised CE for still focussing on downcycling instead of upcycling or reducing resource use via new product service concepts rather than product ownership. Another issue of concern involves hazardous substances present in waste and side streams, which can re-emerge and pose risks in the end products that utilise waste (Bodar et al., 2018).

In 2015, the EC released its action plan concerning the EU's transition towards a CE. Since then, the action plan has been supplemented with revised legislation on waste and packaging waste (EC, 2018b), as well as plastics (EC, 2018c). The action plan and its related legislation should gradually lead to needed investments on new innovations. Furthermore, the plan states that broad, long-term commitment at all government levels is needed to develop an EU-wide CE. Similarly, Winans et al. (2017) state that CE-related initiatives require both bottom-up and top-down approaches. Support from decision makers through top-down policy instruments (e.g., subsidies and tax incentives) is feasible if there are clear objectives to achieve short- and long-term goals.

The CE and bioeconomy policy strategies are complementary, aiming at lowering greenhouse gas emissions and wisely utilising resources. The (EC (2018a) has recently stated that a successful bioeconomy needs to be sustainable and circular. D'Amato et al. (2017) also emphasise that CE principles should be adopted into the bioeconomy to achieve circularity. Terms such as 'bio-based CE', 'bio CE' and 'circular bioeconomy' all focus on the CE of bio-based materials. These concepts combine CE and bioeconomy. In a bio-based CE, biological resources are managed and used in a way that maintains the materials' value at the highest utility in the economy for as long as possible. Bioeconomy and CE need each other to maximise their positive social and economic impacts (Aguilar et al., 2018). Nevertheless, it is worth pointing out that a bio-based CE is considered circular because not only is it based on renewable resources but is also designed to attain maximum efficiency while respecting the waste hierarchy (Bezama, 2016; D'Amato et al., 2017). However, it can be argued that both the CE and bioeconomy concepts are inadequate in addressing all aspects of sustainability dimensions (D'Amato et al., 2017). On one hand, Loiseau et al. (2016) point out that bioeconomy assumes that natural capital can be substituted by human-made capital. On the other hand, CE assumes that human-made and natural capital are complementary but not always interchangeable. Therefore, CE emphasises the win-win aspect for both the economy and environment. According to Loiseau et al. (2016), concepts such as a CE, in hosting so-called 'strong sustainability', require more systemic changes in the way that societies work. The shift towards strong sustainability and a CE needs comprehensive support from governments but at the same time, should be driven by private-sector investors (Loiseau et al., 2016; Geissdoerfer et al., 2017). However, major knowledge gaps remain regarding how the shift towards strong sustainability concepts can be achieved in practice. This case study makes an effort to partially bridge this gap at the regional level.

Finland and the Päijät-Häme region were selected for this study, because the country can be considered a forerunner in its efforts to address CE having published its first national CE roadmap 2016. Furthermore, the Päijät-Häme CE roadmap (Lahti University of Applied Sciences, 2017) was one of the first Finnish regional roadmaps. Moreover, the Finnish governance system with its multi-stakeholder co-operation is interesting from the point of view of CE implementation because Finnish municipalities are granted a high level of authority, while regional governments consist of a consortium of such municipalities (Beckers, 2019). The key role of municipalities has been acknowledged in, for instance, climate change mitigation, where they have been leading the way with stricter greenhouse gas emission reduction targets than those developed at the national level (Deloitte, 2018).

As stated in Finland's road map to a circular economy 2016–2025 (Sitra, 2016), a CE means a systemic change, requiring both high-level political support and agile pilots. A CE can also be perceived as a source of new innovations, but open-minded co-operation and boldness in taking risks are needed to benefit from the transition. Sitra (2019) further emphasised the key role of all actors in different sectors in enabling the critical move to CE in the first update of the Finnish CE road map in 2019. Whereas the Finnish national road map to a CE provides the outline for the transition, there remains the need to concretise and implement the vision at the regional level. The Päijät-Häme region was one of the first in Finland to launch a CE road map. At the time when

the Päijät-Häme road map was published, only mainly larger European cities had CE strategies or road maps, for example, Circular Amsterdam (2016), Circular Glasgow (2016) and the London CE Route Map (London Waste and Recycling Board, 2017).

The Päijät-Häme region lies in southern Finland, with over 200,000 inhabitants. The traditional process industry in the forestry, furniture manufacturing, metal, plastic and textile sectors plays a significant economic role in the region. Forests and water are among its most important resources. Moreover, agriculture still represents an essential source of income in the rural areas. Based on the region's characteristics, with strong agricultural and wood sectors, and a developed food industry, the closing the biological loops is emphasised in the regional CE road map. In Päijät-Häme, CE means material and energy efficiency and new bioeconomy solutions that depend on regional strengths and know-how to create innovations that support sustainable growth in the region. The CE concept provides a holistic approach to regional development, combining environmental protection and technology, as well as product design, education, new services and a sharing economy.

The Päijät-Häme regional development strategy and programme 2018–2021 was updated in 2017 (Päijät-Häme Regional Council, 2017). The three spearhead areas of the strategy are a CE, design, and sports and experiences (Päijät-Häme Regional Council, 2017). To define the goals and fully utilise the opportunities of a CE, the Päijät-Häme Regional Council decided to create a regional CE road map (Lahti University of Applied Sciences, 2017), which simultaneously serves as the regional CE strategy. The CE specialisation is a natural choice in the Päijät-Häme region because of its continued efforts improve environmental protection and promote clean technology.

2.2. Biological streams in the CE

The importance of developing a 'sustainable and circular biobased economy', i.e. 'a circular bioeconomy' or 'a bio-based CE', has become more evident in recent years (D'Amato et al., 2017; Bell et al., 2018; Lewandowski et al., 2018; Vanhamaki et al., 2019). In addition to an economy being based on biological materials, it is crucial that the biobased economy is managed in a sustainable way. In a bio-based CE biological streams, i.e. bio raw materials, organic wastes, co-products and residues are used as feedstock for bio-based production aimed at developing new products or services, e.g. green chemicals, organic fertilizers or biofuels, and bioenergy (Philp and Winickoff, 2018; EC, 2018a). The utilisation of municipal biowaste and wastewater treatment sludge offers huge potential, however, the various possibilities for transforming these waste streams into resources are still underexplored (Venkata Mohan et al., 2016; Bell et al., 2018).

Circulating biological streams have focused on biodegradable waste from communities from the beginning of 2016, since these streams were banned from landfill in Finland (331/2013/Finnish State Council). Accordingly, the EU supports the transition towards a CE by limiting the landfilling of organic waste and promoting more efficient material and energy recovery (Directive 1999/31/EC). The current treatment method that replaces the landfilling of municipal waste is incineration (Häkkinen et al., 2014). However, waste incineration is not the solution for achieving the EU's sustainability goals for material recycling. As such the development of biodegradable waste management is one of the main focus areas of the forthcoming national waste disposal plan in Finland. Besides developments at the national level, biowaste flows and their management have a key role to play regarding the regional transition toward CE implementations in Päijät-Häme (Päijät-Häme Regional Council, 2019).

Composting and anaerobic digestion are the most common biological treatments (Lin et al., 2019). These methods are popular for stabilising biowaste-, sewage- and cellulose-based industrial sludge. An increasing number of biogas plants (38 reactors based on anaerobic digestion) have recently been built for biowaste management in Finland (Alhola et al., 2014). The same stabilisation technique for sewage sludge has already been utilised in wastewater treatment plants for several decades (23 biogas reactors; Huttunen et al., 2018). Biodegradable waste is also generated in the construction and demolition industry; and from industrial wood, pulp, paper and paperboard processing; board and furniture manufacturing; as well as from and municipal waste treatment.

In most treatment plants, wastewater treatment sludge is treated with septic tank sludge from rural households and rural industries. Digested sludge (i.e., digestate) is dried mechanically. The most common methods of further processing are composting, calcium stabilisation, digestion, thermal drying, combustion and storage (Jamal et al., 2011; Feodorov, 2016). The slurries generated by agriculture are usually dried with litter material, composted or digested. Forest- and wood-processing industry slurries are in most cases incinerated for enhanced self-sufficiency in energy (UNEP, 2013).

Biogas as a renewable and regionally produced fuel based on biomass stabilisation. Moreover, it also produces refined stabilised intermediates and products that can be utilised as fertilisers and/or soil improvers. Biogas production requires a value chain, of several actors and sectors (e.g., agricultural material/waste producers, logistics, stabilisation service, energy delivery and end users, agriculture) seeking benefits from a CE industrial symbiosis. This process usually requires technology investment, but the planning or emergence of such systems stems from the characteristics of the biomaterials, and the existing value chain. The simplest, already existing capacity in the form of wastewater plant digesters could be enhanced via co-digestion, pretreatments of the materials (e.g., hygienisation; Bougrier et al., 2008), production of digestate with more nutrient content (Field et al., 1985) and further building of the area's industrial symbiosis. For future energy supply systems biogas plants are a promising option to supply demand-driven electricity to compensate for the divergence of mismatch between energy demand and energy supply by uncontrolled sources such as via wind and solar production (Mauky et al., 2017).

The biogas concept itself is relatively flexible, but the utilisation of the stabilised end products depends on the national-level regulations. At least 25% of all European bioenergy originating from farming and forestry could be produced via the biogas process (Holm-Nielsen et al., 2007). This calculation includes the biogas obtained from manure, with a 40–70% (230 TW h/a) implementation level, and energy crops produced on 5% (570 TW h/a) of the arable farmland (Holm-Nielsen et al., 2009). If sewage sludge and other organic by-products, as well as landfill gas, are included, the available biogas reserve would be notably higher. According to general estimations in the statistics of EU energy programmes, the potential biogas production in Europe (EU15) amounts to 600–1200 TW h/a (14 TW h in Finland), which would also mean a reduction in CO_2 emissions amounting to 136,000–270,000 t/a 3200 t/a in Finland; Luste, 2011). Biogas technology has a small carbon footprint (Uusitalo et al., 2014), and waste-based biogas has the lowest-lifecycle greenhouse gas emissions among all traffic biofuels (Lampinen, 2007).

According to local administration statistics, the amount of municipal waste generated annually in the Päijät-Häme region is about 160,000 tonnes, of which bio-waste's share is around the national average of 10%. The highest biomaterial resource flows are generated in agriculture (Animal manures ~800,000 t/a; Luostarinen et al., 2017, Straw plant-based biomasses ~450,000 t/a; BIOINVEST, 2018) and forest/wood industry (~360,000 t/a; BIOINVEST, 2018). The regional quantity of sewage- and industrial sludges are not known, but according to the environmental permits of the largest treatment plants and the article by Vilpanen and Toivikko (2017) the volume is at least > 250,000 m^3/a.

Methane can be utilised as a vehicle fuel, for heating, electricity production or used as an industrial raw materials. Upgrading biogas for traffic use is the most profitable for biogas producers. However, the number of vehicles able to run on biogas and also the location of the materials/digestion plants may have limited uptake. However, the use

of transportation biogas increased by 41% in 2017 compared with the previous year (Huttunen et al., 2018). This development trend may influence the future viability of anaerobic digestion and the utilisation of biological streams. Co-digestion and possible pre-treatments before the stabilisation process also enhance the digestate's quality and reuse opportunities as a fertiliser. The most valuable waste fraction is phosphorus, which the EC (2017a) has already listed as one of the most critical raw materials, crucial to Europe's economy due to its relative scarcity in nature and resource exploitation pressures worldwide.

Sewage sludge forms a significant phosphorus stream in the CE. The concentration of phosphorus in sewage sludge is notably higher than in manures, for example. Phosphorus returning to the nutrient cycle of food production industry has paramount importance in the closure of nutrient cycles loops (EC, 2015). This is also a question of economics since mineral fertilizers cost Finland 240 million €/year and could be 80% replaced by recycled fertilizers from manure and sewage sludge (BSAG, 2016). However, 1,100 t of sewage sludge are currently produced daily without utilisation or beneficial disposal possibilities Kangas, 2018). This practice contradicts one of the national CE goals, that is, to optimise nutrient recovery by 2025 (Finnish State Council, 2015). Conventional biological processes perform a significant role in closing the phosphorus loop because thermochemical methods (i.e., incineration and pyrolysis) decrease the fertiliser value of phosphorus in the final product (Ylivainio et al., 2017).

In conclusion, it can be said that the handling of biological streams has multiple effects not only on the management of material and energy flows, but on the factors relating to environmental and social sustainability. Different implementations, environmental specifications and suitable refinement states of material intermediates are highly case specific. Thus, regional research, planning, monitoring and dissemination of best practice is needed to achieve the multiple benefits described above.

3. Materials and methods

This research has been conducted as a case study, which is an appropriate method for conducting qualitative, applied "in-depth" research of a phenomenon or process in a real-world context (Gerring, 2014; Yin, 2018). In a case study, the researcher aims to understand a phenomenon by observing variables and their interacting relationships (Dooley, 2002). Such a strategy and methodology provide tools to study and understand complex phenomena that are not easily separable from their contexts (Dresch et al., 2015; Yin, 2014). A case study process entails an empirical analysis that investigates a contemporary phenomenon in its rich, natural context (Eisenhardt and Graebner, 2007; Yin, 2014). Simultaneously, a case study seeks to preserve the wholeness of an identified limited perspective of the case in focus (Silverman, 2013). It should be conducted if the focus is to answer the *how* and *why* questions, which underlines why it was suitable to be used in this system level scenario analysis. Based on the in-depth understanding of one case, a foundation is laid for the purpose of understanding other similar cases (Gerring, 2004). However, a case study can not be generalised to other situations, because it describes only the studied case. Consequently, the role of the researcher and the data used are the keys in applied research. In order to take this into account, case studies comprise a variety of data collection methods, including e.g. document analysis, observations and interviews (Eisenhardt and Graebner, 2007; Baxter and Jack, 2008; Yin, 2014). Data triangulation involving the use of multiple sources establishes the data validity in this type of research. Each data source is one piece of the puzzle, contributing to the researchers' understanding of the whole case.

The methodology of this case study is based on multiple sources and multiple data collection techniques: desktop research, workshops and meetings with stakeholders, as well as other types of informal cooperation with stakeholders through discussions and emails. As is common with case studies in general, limitations and disadvantages exist, especially from the perspective of subjectivity and generalisability. For instance, subjectivity in the data collection and analysis process can be a challenge due to the researcher's own viewpoints and possible influence over the participants (Iacono et al., 2009). Furthermore, the research is limited spatially to the unique geographic area in question and temporally to the specific study period.

Despite attempts to define CE there is not yet a commonly agreed concept of what CE should depict (Moraga et al., 2019). In fact, Iacovidou et al. (2017) and Moraga et al. (2019) state that there is no indicator or methodology alone that is capable of monitoring all the characteristics of a CE. The lack of clear indicators has been acknowledged also in the implementation of the Päijät-Häme regional CE road map. The aim is to develop indicators alongside updates of the road map and also in cooperation with national level research projects addressing this challenge (CIRCWASTE, 2019). A comprehensive research of CE indicator development is given in our previous paper (Virtanen et al., 2019). This present system level scenario research focuses on the actions implemented in the Päijät-Häme region to enable its transition to CE according to the definitions of Singh et al. (2019). It describes the opportunities and challenges via two horizontal level cases that illustrates how the CE is enabled and monitored in real world systems and actual approaches applied.

In this research, the road map process was suitable for illuminating the phenomenon of the development of a regional strategy with a specific focus. The case involved versatile actors and stakholders; it covered the entire strategy process and allowed the observation of how the focus developed over time as a case study should according to Eisenhardt and Graebner (2007) and Aarikka-Stenroos et al. (2017). The process of the CE and bio-based CE development, and the most important multiple data sources of this case study (e.g. workshops, events, meetings and a desktop study of background material) as well as the developed documents, are listed in Table 1. In addition to the information presented in the table, personal communication between the researchers and the stakeholders occurred during the research process face-to-face or by telephone and email.

The process of creating the regional CE roadmap was inspired by the Finnish national road map and the need to implement it at the regional level. At the beginning of the process, the key actors were the Regional Council of Päijät-Häme and Lahti University of Applied Sciences, who planned the process together. The university served as a process facilitator, supported by a research and development project that received EU funding. The funding enabled further studies on regional material flows that were implemented together with the other project partners, consisting of a university, a regional development company, and one private and one public company.

The regional CE road map process included background studies, preparatory data gathering and a stakeholder workshop to define the common vision, regional aims and concrete actions. Comments on the road map draft were requested from additional stakeholders through direct emails. The main stakeholders involved in the process included regional and municipal authorities, academia, a regional development corporation and private and public companies. The roles of academia were to implement the studies, facilitate workshops and draft the road map. Designed as a process rather than a report, the road map will be updated regularly. The regional road map was published in September 2017, and the first stakeholder meetings to review and update it were held in May 2018 and September 2018, respectively. The roadmap update was followed by a bio-based CE action plan concretising the specific goals related to biological streams.

4. Results and discussion

4.1. Regional circular economy strategy

The regional CE road map for Päijät-Häme was launched as part of the regional development programme. The strategic CE vision for the

Table 1
The process of strategic CE and bio-based CE development in Päijät-Häme region.

Activity	Topic	Date	Stakeholders involved
Meeting	Need for a regional CE roadmap recognized	18.11.2015	Regional Council, University of Applied Sciences
International background data/ Desktop research	EU CE Action Plan (European Commission)	2.12.2015	Researchers
Decision	Start of regional project including CE roadmap preparation	1.3.2016	Regional Council, academia, regional development company, public and private companies
Company visits	Regional material flow analysis	8/2016-10/2017	Academia, regional development company, public and private companies
Desktop research	Regional material flow analysis, statistics	8/2016-10/2017	Academia, municipalities
Data gathering	Regional material flow analysis, questions to companies	7-8/2016	Academia, regional development company, public and private companies
Preparatory workshop	Modelling circular economy	2.9.2016	Regional Council, academia, municipalities, regional development company, public and private companies
National background data, Desktop research	Finland's roadmap towards CE published (The Finnish Innovation Fund, Sitra)	16.10.2016	Academia
Meeting	Planning the stakeholder workshop	13.1.2017	Regional council, University of Applied Sciences
Data gathering	Orienting questions about regional vision themes and targets	1-2/2017	Regional council, academia, municipalities, regional development company, public and private companies
Workshop	Setting up regional vision, themes and targets	14.2.2017	Regional council, academia, regional development company, public and private companies
Reporting	Workshop results	3/2017	Advisory company
Meeting	Further processing of draft	14.6.2017	Regional council, academia, regional development company, public and private companies
Email exchange	Requests for comments on the roadmap draft from additional stakeholders	6/2017	Public and private companies
Benchmarking	Biogas and composting plants, e.g. legislation, waste hierarchy	6-12/2017	Academia
Launch of roadmap	The CE roadmap published on the website	20.9.2017	Regional council, University of Applied Sciences
Regional background data, Desktop research	Päijät-Häme regional development strategy and programme	27.11.2017	Regional council
Launch of good practice	Defining the roadmap as a European CE Good Practice	1.2.2918	Regional council, University of Applied Sciences
Launch of good practice	Defining the biogas and composting plant as an European CE Good Practice	6.2.2018	Waste management company PHJ, LABIO, University of Applied Sciences
Stakeholder event/seminar	Updating and specification of roadmap targets on biowaste, textiles and plastics	8.5.2018	Regional council, academia, regional development company, municipalities, public and private companies, national actors
Meeting	Planning the stakeholder workshop	9.8.2018	Regional council, University of Applied Sciences
Workshop	Updating roadmap priorities	14.9.2018	Regional council, academia, regional development company, municipalities, public and private companies
International background data/ Desktop research	Update of the EU Bioeconomy Strategy (European Commission)	11.10.2018	Academia
Launch of update	Päijät-Häme CE roadmap updates published on the website and in media	16.10.2018	Regional council, University of Applied Sciences
Desktop research	Preparing the Päijät-Häme biobased CE action plan based on the roadmap update	11/2018-2/2019	Regional council, University of Applied Sciences
Meeting	Presenting the Päijät-Häme biobased CE action plan		Regional council, academia, regional development company, municipalities, public and private companies
Email exchange	Requests for comments on the bio-based CE action plan draft from additional stakeholders	2/2019	Public and private companies
Launch of action plan	Bio-based CE action plan signed by the Regional Mayor	8.5.2019	Regional council, University of Applied Sciences

region is defined as 'Päijät-Häme – the successful resource-efficient region' (Lahti University of Applied Sciences, 2017). In this context, resource efficiency points to the sustainable use of natural resources and closing of material loops. The vision also emphasises the need to innovate CE solutions to progress beyond recycling and resource efficiency in order to enhance economic growth in the region. To achieve this vision, the following five strategic goals have been identified:

- Closed loops of technical streams to create added value
- Towards energy self-sufficiency by applying sustainable transport and energy solutions
- New consumption models and business opportunities
- Piloting and demonstrating innovative CE solutions
- Sustainable business from the bio CE

Based on the results, Fig. 1 was developed illustrating the regional vision, goals and actions towards a CE (Lahti University of Applied Sciences, 2017).

The goal 'closed loops of technical streams to create added value' is in accordance with one of the main principles of the CE theory: the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised (EC, 2015). The CE concept traditionally classifies material flows into biological and technical materials. Technical materials refer to those that are not of biological origins but come from some manufacturing or treatment processes. In the case of the Päijät-Häme region, the following technical material flows have been researched: ferrous metals, non-ferrous metals, plastics, textiles and ashes. The material flow analysis shows that in the region, approximately half of all plastic and textile wastes are incinerated instead of being used as raw materials. Therefore, these materials in particular have a large re-use opportunity, such as in industrial symbiosis, which plays a key role in moving towards CE (Geng et al., 2012). In industrial symbiosis, one industry's waste or by-products become key inputs for another industry. Despite several examples of industrial symbiosis in Päijät-Häme, the CE road map process shows that new ones are required in the region. Moreover, there is a lack of comprehensive knowledge about recycled materials' properties and potential uses. Hence, one of the actions in the

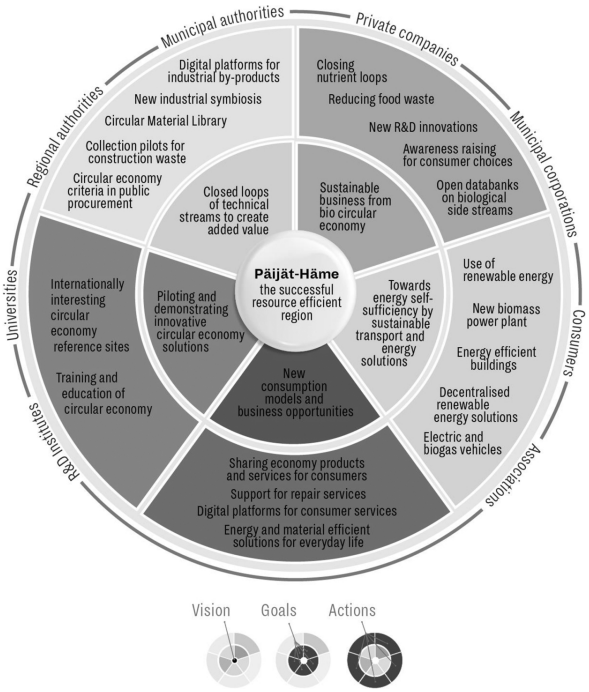

Fig. 1. The vision, goals and actions towards circular economy in the region of Päijät-Häme, Finland.

regional CE road map is a circular material library, a new concrete tool including information and examples of waste materials generated in the region (Virtanen et al., 2017).

In the EU, only 25% of waste materials from small and medium-sized companies (SMEs) are re-utilised (Circular Economy Factsheet, 2016). According to Ruiz Puente et al. (2015), SMEs can have fewer incentives and resources for reducing their environmental impact than larger, resource-incentive companies and can also be more sceptical of the benefits. Päijät-Häme region has a large number of SMEs, and during this research, it was estimated that SMEs would especially benefit from a circular material library tool. The material library is connected to wider regional efforts on research and development co-operation between companies, academia and other regional development actors to support SMEs transition towards a CE. Also on national level, SMEs are encouraged to invest in CE development through research and development funding, cooperation with academia and publicity offered by Sitra[1] and other national actors (Sitra, 2019).

In 2016, the EC published the new Green Public Procurement criteria for office buildings, roads, and computers and monitors (EC, 2016). These can be used by public authorities on a voluntary basis, and they include requirements relevant to the CE. During the CE road map process, the importance of including CE criteria in public procurement was discussed and determined to be one of the actions that should be taken. According to the regional material flow analysis, ashes originating from energy production processes, for instance, have a huge potential to be utilised as raw materials in the public construction of roads. In closing the material loops, another area of focus will involve the close monitoring and traceability of material flows and new logistics solutions, which can create new business opportunities in the sector and new services for consumers. In the Päijät-Häme region, various digital and smart platforms are regarded as among the potential innovations in the journey towards the CE, which was also defined as one of the actions in the CE road map. This is in accordance with the findings of Pagoropoulos et al. (2017), who reported that digital technologies play an important role in the transition towards a CE even though still lacking concrete case studies. Their research shows that CE digital platforms can be grouped under three architecture perspectives; data collection, data analysis and data integration (Pagoropoulos et al., 2017). New, concrete CE digital solutions e.g. for recycling of electronic devices (Franquesa et al., 2018) and for reducing the food waste (ResQ, 2019), have also recently been reported.

Due to its energy-intensive primary process industries and cold climate, Finland has a high energy consumption per capita (International Energy Agency, 2013). Hence, the goal 'towards energy self-sufficiency by applying sustainable transport and energy solutions' is relevant on the journey towards the CE in Päijät-Häme, and it was set up as the third goal of the regional CE road map. Likewise, previous research (Geng et al., 2012; Ghisellini et al., 2016) points to the significance of energy issues at the macro level, that is, the regional level of the CE. The actions related to this goal highlight the utilisation of

[1] Sitra (Finnish: Suomen itsenäisyyden juhlarahasto), the Finnish Innovation Fund, is an independent public foundation which operates directly under the supervision of the Finnish Parliament. The objective of the foundation is to promote stable and balanced development in Finland, qualitative and quantitative economic growth and international competitiveness and cooperation by means of supporting projects that increase the efficiency of the economy, improve the level of education or research, or study future development scenarios.

renewable energy sources. This complies with the revised Renewable Energy Directive, which set a national target value of 38% for Finland's share of energy from renewable sources by 2020 (EC, 2017b). Other concrete actions have been launched to support the utilisation of renewable energy sources. By 2020, a new energy boiler that will generate the district heating in Lahti and utilise bio-based energy sources (e.g., wood chips) will start to operate, replacing the old coal boiler. This will naturally have a significant effect on regional CO_2 emissions, which will be decreased by approximately 600,000 t annually. Since agriculture is an essential source of income in the region's rural areas, actions to promote decentralised renewable energy solutions in those locations have also been set up. The importance of renewable energy solutions in rural areas has also been underlined by Chel and Kaushik (2011). Besides the utilisation of renewable energy sources, the actions to support the energy efficiency of buildings have also been set up in the regional CE road map. According to research by the VTT Technical Research Centre of Finland et al. (2011), Finnish buildings have a relatively high potential for energy efficiency improvements compared with other sectors, such as transportation or industry. Moreover, actions to promote the use of electric and biogas vehicles have been included in the CE road map.

The regional goal, 'new consumption models and business opportunities', highlights the importance of new types of businesses that are enabled by changing consumption models. Over the last decade, digitally facilitated economic exchanges have emerged in accommodation, transportation and various kinds of lending services. As Puschmann and Alt (2016) state, sharing products and services is not new in and of itself, but in recent years, it has spread into consumer-to-consumer transactions. The drivers behind this change include the gradual move away from product ownership towards social networking and electronic services. According to the European Parliament (2017), these transactions are characterised by market-based exchanges, high-impact capital and crowd-based networks that have replaced centralised institutions. The sharing economy both creates positive economic impacts and brings social elements into commercial activities.

In addition to the sharing economy, the shift from selling products towards selling services through product service systems (PSSs) has been promoted as a way to improve resource efficiency and enhance the move from the maximisation of product sales towards the CE (Tukker, 2015). A PSS can be product oriented, user oriented or result oriented, where the latter criteria is perceived as the most promising in providing an incentive to reduce material usage. However, adopting PSSs would also require a radical change in business models, which together with the still-prevailing societal preference for ownership, has hampered PSS implementation. In the Päijät-Häme region, new business opportunities can be developed related to renting, sharing and repair services, comprising products, services and labour. Most of the existing new sharing and renting services are based on digital applications and platforms that facilitate customer access and help optimise logistics and the use of resources. Since the uptake of new services and PSSs requires thorough changes in both product design and business strategies, the Päijät-Häme region should take advantage of another one of its smart specialisation areas – design in introducing new CE services and products. Actions to reach this goal include the establishment of new digital platforms and concrete pilots to test the viability of centralised product repair services for customers, for example. At the regional level, another important feature of the sharing economy is its social aspect. Sharing economy services can be applied to neighbourhoods, institutions or different interest groups.

A CE requires extensive societal changes and the involvement of various stakeholders. Accordingly, it is important to provide information on tangible possibilities, an aspect which is addressed in the road map goal 'piloting and demonstrating CE solutions'. Furthermore, CE demonstration platforms showcase technology solutions that can support business and export activities. In Finland, work is underway to create an international demonstration platform for bioproducts and services that originate from forest-based material loops. Other national pilots include industrial symbiosis and new innovations on packaging, lignin and cellulose (Sitra, 2016). One of the aims in the Päijät-Häme region is to create internationally interesting reference sites. Such sites can be based on pre-existing industrial symbiosis areas, new residential and industrial areas or new industrial plants that are based on closed-loop systems. An existing industrial symbiosis in Päijät-Häme involves the Kujala Waste Centre area, which provides possibilities for the exchange of materials and energy among several nearby industries (PHJ Päijät-Hämeen Jätehuolto, 2018).

The aim of the goal 'sustainable business from the bio CE' is to find new businesses based on these aforementioned strengths. To develop a bio-based CE, the Päijät-Häme CE road map emphasises closing nutrient loops, supporting local food supply chains with less waste, and reducing the loss of raw materials. Tackling biowaste is crucial because the world currently hosts unsustainable habits regarding food production and consumption. At present, over 30% of food produced in the EU is wasted (Schulze, 2016). Due to this inefficiency in the food economy's productivity, energy and natural resources are lost. Additionally, huge costs are incurred by throwing away food. In the case of food systems, closing the loops entails developing the circulation of certain materials (i.e., fertilisers) in the systems, as well as minimising the exclusion of materials as waste. For instance, local food networks can offer simpler and more easily controlled structures (Jurgilevich et al., 2016), and traditional agroecosystems can provide a model for designing sustainable food systems (Gliessman, 2015). According to Jurgilevich et al. (2016), innovative technologies and food waste reduction form the core of developing a sustainable food system. Research on the regional food system has already been conducted in Päijät-Häme (e.g., Uusitalo et al., 2016).

The regional importance of the goal related to developing bio-based CE is concretisised as a part of the latest update of the CE road map in September 2018 (Regional Council of Päijät-Häme, 2019). This shows that the focus on closing bio-based nutrient loops and offering new possibilities for utilising sewage sludge are considered the most central issues to be developed in the region. This indicates the ongoing regional interest in tackling the challenge of utilising biowaste streams, which is further explained within the case analysis of the following chapter.

4.2. Closing biological loops by industrial symbiosis

The Päijät-Häme bio-based CE action plan, which is based on the update of the CE roadmap, includes three entities specifically aimed at developing the utilisation of biowaste streams: 1) more efficient use of sludge flows, 2) developing separate collection of bio-waste from residential areas 3) enhanced utilization of bio-products and bioenergy together with regional companies, i.e, bio-based industrial symbiosis (Päijät-Häme Regional Council, 2019). In the Päijät-Häme region, biowaste is transported to Kujala Waste Centre for the biogas and composting plant of LABIO Ltd, where it is refined to biogas and fertilizer. This concept is one of the advanced circular economy examples and defined as a bio-based CE good practice in Päijät-Häme region (Interreg Europe, 2018b).

LABIO Ltd., the largest biogas production and refining plant in Finland, is part of the above-mentioned industrial symbiosis at the Kujala Waste Centre in the City of Lahti. The company's composting plant was established in 2003 and the biogas plant in 2014. LABIO is an independent company that finances all costs by selling waste treatment services and biogas. It produces biogas and fertilisers from biodegradable materials produced in agriculture, forestry, fishing, horticulture, households, food production industry including, trade and wholesalers, as well as from sewage sludge from wastewater treatment plants (Fig. 2). Biowaste entering the waste centre with mixed waste could be separated from the other waste streams in a mechanical waste treatment plant (LATE), however, to date it is sent for energy utilization due to its high contaminant concentrations. The possibilities for further

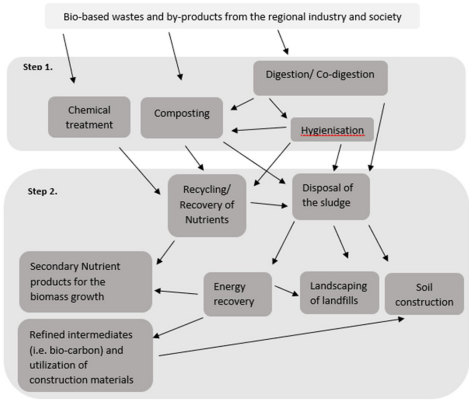

Fig. 2. The flow chart of the bio-based industrial symbiosis in Päijät-Häme region, Finland. Step 1. includes the stabilisation and hygienisation operations. Step 2. includes recycling and recovery of nutrients.

utilization of the fraction are at the moment under development (Päijät-Häme Regional Council, 2019).

The first step (see Step 1. in the Fig. 2) in the process operations comprises stabilisation and hygienisation, where the pathogens are destroyed, and the biodegradation of organic materials is finalised to avoid subsequent greenhouse gas emissions and odour problems. The second step (see Step 2. in the Fig. 2) involves recycling and recovery of nutrients for re-use. Recycling can generate fertiliser products for agriculture and for the green areas. According to Finnish Food Safety legislation, "secondary nutrient products must be beneficial for plants or significantly improve plant growth". The final step is the disposal of the sludge, carried out via energy recovery (i.e., incineration) or use in the landscaping of landfill sites, for example.

LABIO processes 70,000 t of waste/year, producing 50 GW h/a biogas and 20,000 t/a compost for use as agricultural fertilisers and raw materials for mould manufacturing. The upgraded methane is sold as vehicle biogas and to industry via the national gas grid owned by Gasum Ltd. These treatment services for biological streams are sold to municipalities and public companies, wastewater companies and waste market operators. In 2017, its turnover was 5.8 M€ (Gate fees: 4.8 M€; biogas income: 1 M€). The plant was financed through public companies, Päijät-Häme Waste Management Ltd. and Lahti Aqua Ltd., with total investments amounting to 15 M€. The investment in the plant was made based on the owners' waste treatment needs and in conformance to the public strategy.

The carbon footprint of the nitrogen fertiliser products produced by LABIO is 0.6 $kgCO_{2eq.}$/kg N when the average value for the nitrogen fertilisers is 3.7 $kgCO_{2eq.}$/kg N. The corresponding values for phosphorus are 1.4 and 3.3 $kgCO_{2eq.}$/kg N (Savolainen, 2016) (see Table 2).

The LABIO biogas plant is based on co-digestion where sewage sludge offers a steadily produced co-digestion matrix for the more energy-efficient organic materials (i.e., biowaste and food industry residues). Co-digestion increases energy production, improves fertiliser characteristics of digestate and hence profitability (e.g., gate fees). Recycling is performed according to the national Fertiliser Product Act (Ministry of Agriculture and Forestry, 2006) that is more stringent than the Sewage Sludge Directive (86/278/EEC). The biogas plant was the first dry digestion plant in Finland. The dry digestion concept (total solids > 20%; Nallathambi Gunaseelan, 1997; Jha et al., 2011) is not widely used but has a smaller footprint, is relatively more efficient and is a more flexible concept for energy production compared with the wet process (Jha et al., 2011).

Table 2
Nutrient volumes obtained back to the cycle by LABIO Ltd (Savolainen, 2016).

Nutrients	% of total solids	t/year
Nitrogen (N)	3.1	440
Phosphorus (P)	1.2	180
Potassium (K)	1.1	160
Calcium (Ca)	1.8	250
Magnesium (Mg)	0.8	120
Sulphur (S)	0.9	130

There are limit values for heavy metals but no limit values or recommendations concerning other micro pollutants in sewage sludge. So far, Finland has effectively utilised renewable fertilisers, produced from animal- and sewage-based sludge, for example. In 2016, the agricultural use of sludge in Finland was ~40% where ~50% of this sludge was used in landscaping (Vilpanen and Toivikko, 2017). However, the above-mentioned issue about micro pollutants and chemicals has raised concerns in the food industry which has set purchase limitations for grain produced using sewage sludge-based fertiliser products (Kangas, 2018). The change in the value chain has also reflected the management of biological flows. The LABIO digestion plant changed to a two-line production in 2018, where fertiliser is produced from the co-digestion of biowaste, and sewage sludge is only used for producing substrate and forest fertilisers.

More effective material recycling requires the introduction of new applications and hybrid technologies at the interface of materials and energy cycles. This is also one way to implement needed actions, for example to enhance co-operation with local companies and generate new bio-products. Many treatment technologies (for the treatment of biological flows) not only produce energy but also refine biofuels and/or raw materials back to the industrial cycle (e.g., pyrolysis, wet pyrolysis). However, the regulations do not necessarily recognise the enhanced CE contribution introduced by the refinement step, but in a regulatory sense, it is still considered a form of 'waste disposal' or 'waste incineration' action. Additionally, 'big data' and integrated GIS systems can take into account resources in "reserve" to promote CE, as well as environmental safety regarding the final disposal/utilisation of recycled end products (i.e., ashes and digestates). Such different perspectives able to devine new meaning in data of CE transition promoters, requires strong horizontal co-operation and systematic inclusive development.

5. Conclusions

This research shows how the CE is implemented regionally in practice through a road map process working as a strategic instrument. Moreover, the concrete opportunities and challenges related to the CE transition in real-world systems are presented through a case analysis of a bio-based CE. The results highlight that systematic change towards CE in closing biological loops requires both regional-level policy actions and practice-based business development with a long-term perspective. By its very nature, co-operation among authorities, municipalities, academia and businesses and across sectors is highlighted in the CE. Through a more integrated and systemic approach, more synergies can be created. The regional level shows the need for a regional commitment and a coordinating body. In this case, the regional systematic co-operation was organised through the road map process facilitated by academia. It generated several concrete CE actions, which have been agreed to be implemented in the region. Both the road map process and academia's role in it have been proven successful. The EU also emphasises the importance of involving stakeholders in sustainable development processes (EC, 2018a). However, it is challenging to be fully inclusive and involve all possible stakeholders, especially private companies, in the strategy processes. Even if the CE is perceived as an attractive concept to operationalise sustainable development for

business (World Economic Forum, 2014), the road map process in this case study shows the difficulty in activating the collaboration of private companies. Over and above all, the CE's target is to create new sustainable businesses where companies form the core.

CE business opportunities base on regional characteristics. In this regional case study, biowaste flows and their management are emphasised in order to create new CE business. Closing bio-based nutrient loops and utilising sewage sludge are considered the most central issues to be developed in the region. The local bio-based industrial symbiosis (LABIO Ltd) where biogas and fertiliser are produced from biowaste streams and sewage sludge is one of the advanced CE business concepts. Treatment and refining of biological streams (e.g., in the biogas process) require a value chain, including several actors seeking economic benefits from the CE industrial symbiosis. The new technology creates more CE cooperation opportunities at the interface of material and energy cycles. Regulations should support environmentally beneficial symbioses arising from new hybrid solutions and/or enhanced production and refinement of intermediates. Moreover, the implementation of new references at the practice level often faces financing problems that may also limit the holistic-level CE development. Increasing amounts of chemicals that are of concern for health and the environment, such as micro plastics and medicines, are being identified in sewage sludge (e.g., Jelic et al., 2011; Browne, 2015). Consequently, it is worthwhile to point out that this issue should be considered when closing biological loops. Currently, one of the main bottlenecks is the safe utilisation of renewable fertiliser products. This reflects back to the value chain and requires flexibility/scalability for the technique and for the participants contributing to the value chain. Enough resilience in planning value chains cannot be over-emphasised.

Both the road map and the LABIO example presented in this paper have been recognised as good practices at the EU level (Interreg Europe, 2018a, 2018b). They are presented on Interreg Europe's Policy Learning Platform, which boosts EU-wide policy learning and capitalisation on practices from regional development policies. Both have been validated as positive and transferable examples of how to develop a CE at the regional level. There is a strong potential for transferring the Päijät-Häme road map experience to other regions aiming at the transition towards a CE. LABIO presents an example of how public investment in a biogas and composting plant can bring economic and environmental benefits to the region (Interreg Europe, 2018b). The industrial symbiosis in the regional waste treatment centre makes the case especially valuable for other regions that are developing innovative solutions for biowaste and sewage sludge treatment. Although the road map and the LABIO case offer transferable good CE practices, they represent just the beginning of the transition towards a CE. The CE ecosystem that is created in the road map process provides a way to enable awareness and continuing dialogue among the actors. Future updates on the road map offer much potential for developing new ways of involving stakeholders, especially companies and citizens. The stakeholder-based approach is crucial for continuous development towards a CE society.

Declaration of Competing Interest

None.

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