Lappeenranta-Lahti University of Technology
School of Business and Management
Business Administration
Master's Programme in Supply Management

Evgeniya Tsytsyna

RISKS AND BENEFITS OF A CIRCULAR ECONOMY WITHIN GEOPOLYMER ECOSYSTEM FOR SOUTH KARELIA REGION

Master’s thesis, 2019

Supervisors: Professor Katrina Lintukangas
Professor Veli Matti Virolainen

ABSTRACT

Author:	Evgeniya Tsytsyna
Title:	Risks and benefits of a circular economy within geopolymer ecosystem for South Karelia region
Faculty:	School of Business and Management
Master's Programme:	Supply Management
Year:	2019
Master's Thesis:	Lappeenranta-Lahti University of Technology, 83 pages, 14 figures, 11 tables, 1 appendix
Examiners:	Professor Katrina Lintukangas Professor Veli Matti Virolainen
Keywords:	Circular economy, ecosystem, circular economy ecosystem, geopolymer

Circular economies have become an alternative way of economic development in the world today. Ecosystems are moving a focus towards the circular economy core, creating circular economy ecosystems. In turn, these sustainability-oriented ecosystems have a significant influence on stakeholders. One of such ecosystems located in South Karelia region and focused on geopolymer production is an example of the circular economy implementation. The aim of this thesis is to study the circular economy within geopolymer ecosystem in South Karelia region and identify what risks and benefits the circular economy generates for the region. The study encompasses the earlier findings of risks and benefits of a circular economy in the literature and empirical results obtained from interviews with representatives of the local ecosystem. As a result, legislative, economic and technological aspects are identified as the most critical sources of risks, as they create a lot of uncertainties in the circular economy ecosystem. Through early identification, these risks can be successfully mitigated. Moreover, the results of the research revealed the beneficial sides of the circular economy implementation. They are mainly related to the development of the region in terms of economic and social aspects, as well as enhanced sustainability profile.

ACKNOWLEDGEMENTS

I would like to thank my supervisors Katrina Lintukangas and Veli Matti Virolainen for their supportive guidance and motivation during the research process. Also, I wish to thank professor Anni-Kaisa Kähkönen for her help. A big thanks goes to a team of UIR project, especially WP7 and all the interviewees for sharing their knowledge and opinions.

Finally, I would like to express my gratitude to my family for all the support during my long way to the point where I am now and for encouragement in difficult periods of my study. Also, I would like to give a big thanks to my friends for their endless inspiration.

Lappeenranta, 16.04.2019

Evgeniya Tsytsyna

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1 INTRODUCTION

Sustainable development of cities has become one of the most discussed topics nowadays. Since the ecological and environmental consequences of the world economies' development have raised worries, the ideas of how to reduce the environmental impact have been under active discussions. Cities have become locations accumulating industries, organizations, and citizens, where each player has a role, acting individually and mutually, simultaneously affecting other players. According to statistics of the World Bank, 55% of the population lives nowadays in urban areas, and this number is continuously growing. In turn, cities are responsible for 70% of the greenhouse gas emissions globally, consuming 2/3 of energy in the world. (World Bank, 2018a) In addition to that, annual generation of the world municipal solid waste has increased from 1.3 billion tonnes in 2012 to 2.01 billion tonnes in 2018, which in 2018 equals to 0.74 kilograms in a day per person. With this tendency, it is expected to grow 3.40 billion tones by 2050. (World Bank, 2018b) Hence, the linear model of production and consumption, which was a common way of the world's development, has shown evidence of inapplicability for the future and does not appear to be sustainable. These facts conclude the necessity to a shift towards another way of urban development, applying a sustainable development.

The concept of sustainable development has gone through an evolution since the 1980s when the World Commission on Environment and Development defined the term as an activity that "meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987, 37) Taking into consideration the latest views, the population growth today, scarcity of resources and economic development of the modern world, these factors put the future of the next generations in danger. In contrast, sustainable development is being discussed to be an idea of "peaceful coexistence between economic development and the environment". Encouraging sustainability in cities and other smaller geographic areas might be considered as "a new pathway towards global growth and livability”. (Portney, 2015) A circular economy has been discussed as one of the possible ways of sustainable development of urban areas, where it is possible to create an ecosystem, which is a “co-operative system, where actors involved, utilize each other waste materials and energy flows and create ecosystem properties like interaction and symbiosis” (Kurhonen, 2001b, 31). In that sense, the possibility to follow the sustainable way of development through a circular economy ecosystem makes the topic attractive to study as a research field.

1.1 Aim and research questions of the thesis

This master’s thesis is conducted as a part of Urban Infra Revolution (UIR) project. The project is searching for solutions to make urban construction development more sustainably. It aims to involve sustainability and the circular economy in the urban construction scheme. Particularly, UIR focuses on CO2-emission reduction during cement production by substituting the cement used in construction industries with biofiber-reinforced geocomposites. It is possible as a result of local industrial side-streams, including ashes, green liquor dreg, tailings, construction waste that will be used for geocomposites. These resources are large in volume in the South Karelia region and still, are not widely used. The project aims to close the material loop to achieve a circular economy in the city of Lappeenranta. Lappeenranta is a European medium-size city with a population of 73 000, it targets to reduce CO2 emissions by 80% till 2030, and then finally to 0% till 2050. (UIA, 2018a)

Similarly to Lappeenranta, such projects related to the circular economy have been launched in seven other European cities. They are the following ones:

- Antwerp (Belgium), population 521, 946, duration 01.01.2018 – 31.12.2020

- Heraklion (Greece), population 173,993, duration 01.03.2018 – 28.02.2021
- Kerkrade (The Netherlands), population 114,522, duration 01.11.2017 – 31.10.2020
- Ljubljana (Slovenia), population 288,307, duration 01.11.2017 – 31.10.2020
- Maribor (Slovenia), population 111,550, duration 01.12.2017 – 31.11.2020
- Sevran (France), population 50,374, duration 01.03.2018 – 28.02.2021
- Velez-Malaga (Spain), population 78,890, duration 01.04.2018 – 31.03.2021

Each of the city projects has its own aim, and ecosystems differ from one city to another, but the main idea remains similar for all of them: “innovative solutions for sustainable urban development”. (UIA, 2018b)

Concerning the project of circular economy implementation in Lappeenranta and South Karelia region, there are certain gaps that are available for research. Due to strict regulations in the construction field and innovative product, there are certain risks that the region might face. Obviously, the project and the city of Lappeenranta are expecting positive results, though the possible benefits for the city need analysis. This creates possibilities for a deeper study and research for the master’s thesis.

Research on different ecosystems has been evolving during the years. As the term “ecosystem” originates from biology, in this perspective it has been studied the most. In the business field, business ecosystems and industrial ecosystems have gotten attention. In the academic literature, the research regarding circular economy ecosystems has not been well established yet. The circular economy ecosystem is a relatively new phenomenon, which has started to be researched in recent years. Figure 1 shows the evolution of publications on different kinds of ecosystems.

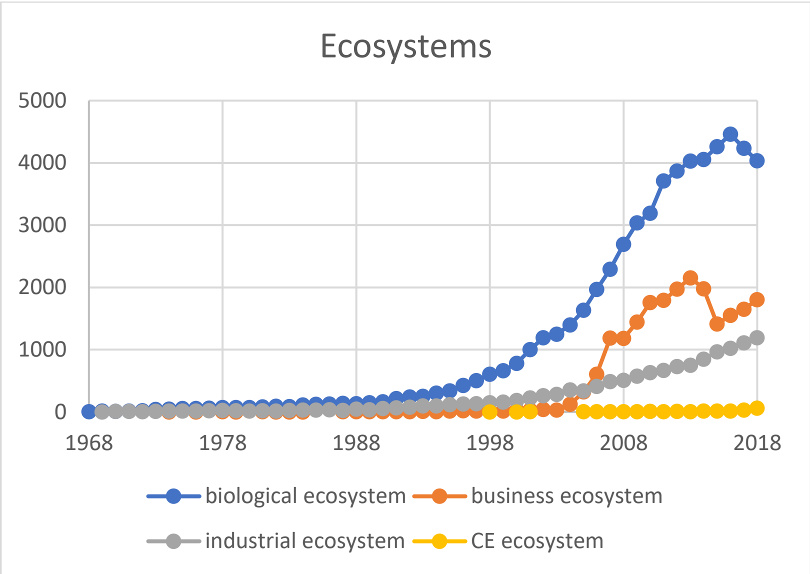

Figure 1. Number of publications on different kinds of ecosystems (Scopus)

Thus, the sphere of the circular economy in ecosystems is an attractive field to study.

The purpose of this master's thesis is to answer the following main research question:

RQ1: What are the risks and benefits of the circular economy within geopolymer ecosystem for South Karelia region?

There are two sub-questions, supporting the main question. They are the following ones:

RQ1.1: What are the characteristics of the circular economy ecosystem of South Karelia region?

RQ1.2: What is the structure of geopolymer ecosystem of South Karelia region?

The aim of this research is to define how the geopolymer ecosystem might benefit from the circular economy, and what are the potential risks that are involved in developing the circular economy ecosystem.

The conceptual framework used in the thesis is represented in Figure 2. The main term of the study is the circular economy, which is shown in the center of the picture. It is located inside an ecosystem, which limits the boundaries of the circular economy and creates an environment for it. Two aspects are being studied in the master's thesis, they are risks and benefits that are linked to the circular economy and are also related to the ecosystem. Risks and benefits come from five elements: political, economic, social, technical and environmental aspects of the circular economy within the ecosystem.

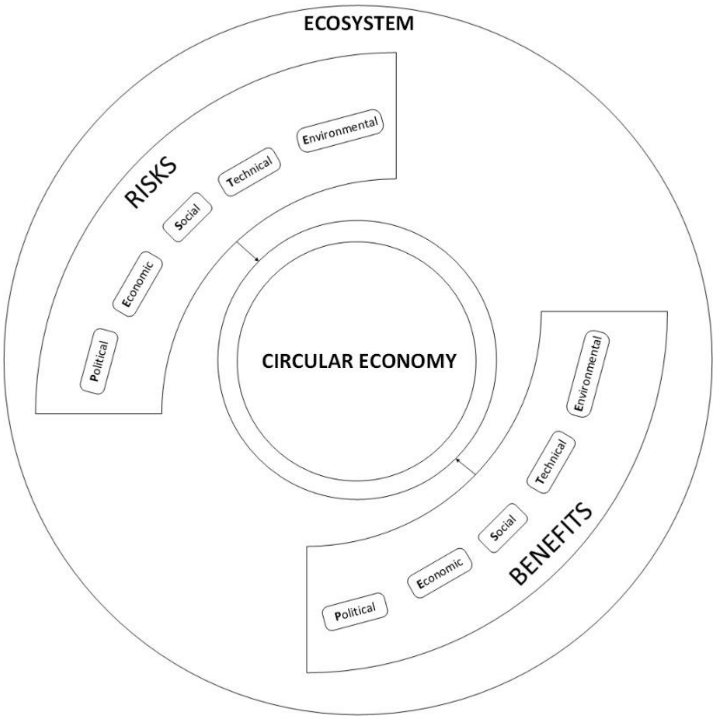

Figure 2. The conceptual framework of the master's thesis

The central concept of the circular economy refers to an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized" (European Commission, 2015). An ecosystem that creates the environment for the circular economy is defined by Aminoff et al. (2017, 530) as "co-evolving, dynamic and potentially self-organizing configurations, in which actors integrate resources and co-create circular value flows in interaction with each other". Particularly, risks and benefits are being studied within the boundaries of the circular economy ecosystem.

1.2 Methodology

In this master's thesis is based on qualitative research. The context within which the phenomenon is being studied is not excluded and is part of the research. The phenomenon is the circular economy, while the context is the geopolymer ecosystem in the South Karelia region. This type of research strategy is also able to answer "what?" research questions, which is relevant in this study. (Saunders et al., 2009) The data about the phenomenon under research is rather limited and unstructured. The study aims to find new insights about the problem in addition to the existing points of view, which makes exploratory approach the most relevant, as it implies the flexibility of the research. Also, the data available for the research is rather unstructured and unstandardized, which would make it hard to make any quantitative analysis, in contrast, qualitative analysis is more applicable in this case, as it allows to interpret and understand unstructured empirical data. (Eriksson and Kovalainen, 2008) Thus, to answer the research questions, qualitative methods are being used. The executing of the study is divided into three stages.

The first stage encompasses the theoretical study of the research question. In this phase, the main concepts are being defined by the literature, and risks and benefits are identified from the literature as well. The second stage includes an empirical study of the circular economy ecosystem of South Karelia region. At this phase, primary data is being collected from the ecosystem's participants. To gain primary data, semi-structured interviews are conducted with the participants of the geopolymer ecosystem. The structure of the interviews can be found in Appendix 1. In total, nine semi-structured interviews are conducted with six actors of the ecosystem. A semi-structured interview implies a set of "themes and questions to be covered", which may slightly "vary from interview to interview depending on the flow of conversation". (Saunders et al., 2009, 320) The description of the interviews conducted for this master's thesis is presented in Table 1. Four interviews are conducted with the university researchers: associate professor, two post-doctoral researchers, and one doctoral student. Two interviews are focused on the materials providers, namely side-streams' generators. Another two interviews are conducted with the material and technology developers. Finally, one interview is meant to be with the organization, responsible for the coordination of all the parts of the ecosystem. It should be noted that one of the interviews was a group interview, as two persons were interviewed together. The flow of this interview differed from the other discussions, as the participants could add more ideas to each other's answers and discuss the problems during the interview. All the chosen interviewees have relevant experience and knowledge about the local circular economy related to their professional field, which allows gathering opinions from different perspectives.

Table 1. Description of interviews

Interviewee	**Title**	**Interview length**
A	Post-doctoral researcher	36 min
B	Post-doctoral researcher	21 min
C	Associate professor	32 min
D	Doctoral student	39 min
E	Business Service Director	32 min
F, G	Advisor, development services Manager, business services	62 min
H	Development engineer	26 min
J	Director of Minerals Processing	54 min
K	Head of the side stream research programme	20 min

The interviews include a general question on the role of an organization in the ecosystem, twelve main questions regarding the risks and benefits of the circular economy within the ecosystem and two additional questions. The interviews last on average about 35 minutes, though some of them are shorter or longer. They are conducted in English, and are transcribed afterward. The interviews are organized according to the main themes in relation to PESTE framework that is described below in more details, which makes it easy to analyze the information.

Each aspect of PESTE model is analyzed separately in the interviews. Every interview is analyzed to find keywords, which can be coded. Based on these codes, categories in every aspect are being created so that similar ideas of risks and benefits of the circular economy ecosystem are put into one category.

Aspects of the interviews are derived according to the PESTEL framework, which stands for six aspects, applied in the research. They are the following ones:

- Political
- Economic
- Socio-cultural
- Technological
- Environmental
- Legal

It helps to identify what factors have an impact in a particular situation. (Dockalikova and Klozikova, 2014) *Political* heading stands for the decisions made by governments through political systems, ideology, a governmental policy which have an impact on business. *Economic* part includes the whole range of economic factors, particularly including the welfare of customer base, industrial growth in the region, employment rate, investments, possible future profits. *Socio-cultural* aspect deals with human behavior. It might encompass demographics, characteristics of cultural groups, trends in preferences and beliefs of certain groups. *Technological* heading considers research and development field of a particular area. It may include available technological properties, patents, customer acceptance. (Fifield, 2012) *Environmental* aspect might consider such procedures as waste management, environmental protection, awareness of climate change. Finally, *Legal* factor might be considered as part of the political aspect, though it has more focus on laws and regulations and juridical aspects. (Dockalikova and Klozikova, 2014) In this study legal factor is not considered separately and is studied under the political aspect.

In this case, the framework is named PESTE, and initial categories are formed according to the framework.

The third stage of the master's thesis finalizes the results of the findings from the literature and the interviews and answers the research questions. Primary data is supplemented with secondary data and discussed in a perspective of supportive ideas that are not yet taken into consideration. Altogether, the process of data collection and analysis is visualized in Figure 3.

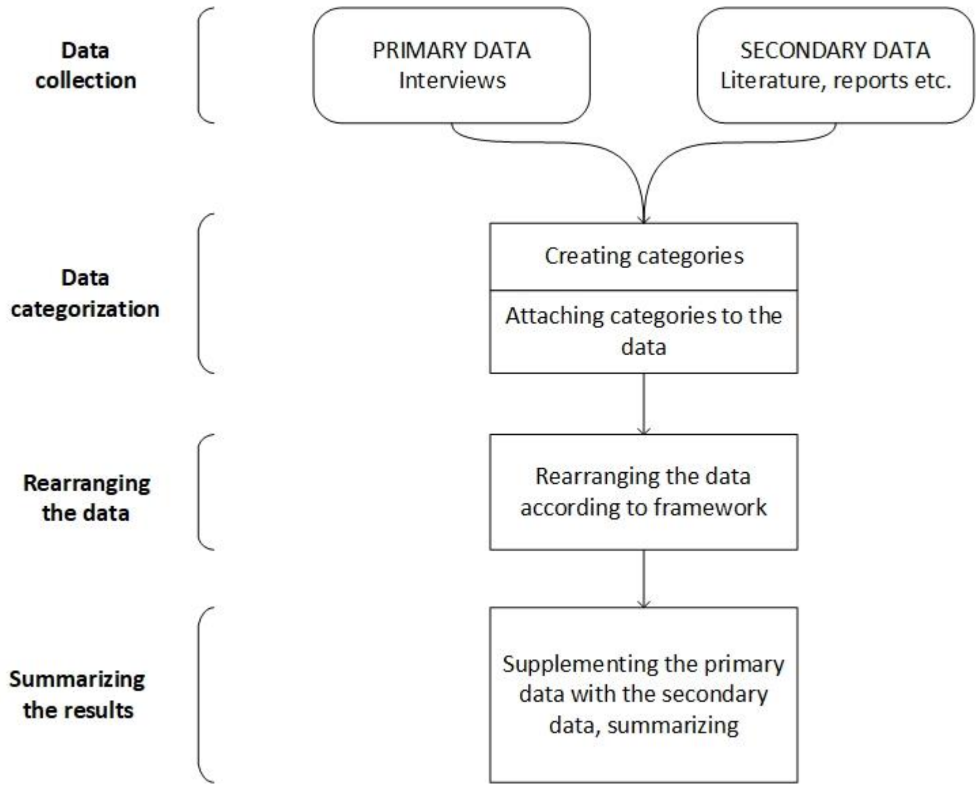

Figure 3. Data collection and analysis

1.3 Structure of the thesis

The master's thesis has two parts. Firstly, the theoretical part describes the main concepts related to the topic. This part includes discussion on the circular economy and its principles and ecosystems together with different types of ecosystems. This order allows coming to the circular economy type of ecosystems, which is the central term of the master’s thesis. Then, this chapter is followed by the theoretical findings of the risks and benefits of the circular economy ecosystem. They are organized according to PESTE framework in order to be comparable with the empirical findings.

The second part of the master’s thesis is the empirical part. It starts with the description of the circular economy ecosystem of South Karelia region. This part discusses the ecosystem’s characteristics and structure. After that, risks and benefits of the circular economy within geopolymer ecosystem are being discussed. This part is organized according to PESTE framework similar to the theoretical findings. Significant factors that were identified from the interviews are discussed in chapter 5.3. Discussion part includes a comparison of what the literature review and interviews revealed. Finally, the master’s thesis has a conclusion, where the research questions are answered and the main summaries are concluded. Limitations and suggestions for further research are also discussed in conclusion.

2 TOWARDS CIRCULAR ECONOMY ECOSYSTEM

The circular economy is a topic that has been actively discussed by researchers. The number of publications has been increasing for the last decade. Figure 4 and 5 illustrate the rise in interest in this topic. Following the timeline between 1974 and 2018, the amount of publications of articles related to the circular economy has started to rise at the beginning of the 2000s, with a sharp increase in 2016. Similarly, publications in the related field of a business ecosystem have gained a lot of interest in the 2000s. Though in 2014 it has slightly dropped, this area of publications has started to gain a lot of attention again after 2014. Altogether, both of these research topics have started to be researched very actively in the latest years.

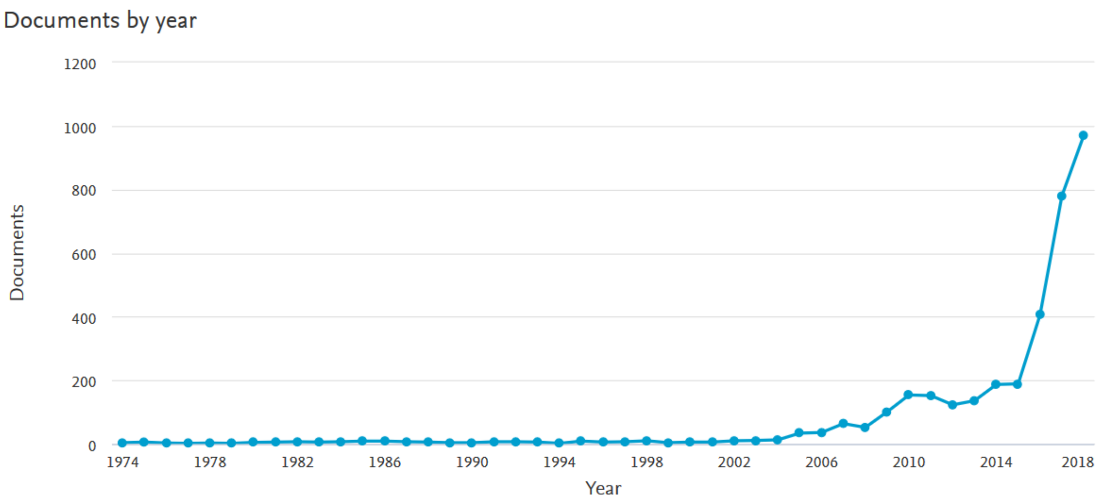

Figure 4. Documents published between 1974 and 2018 ("circular economy")

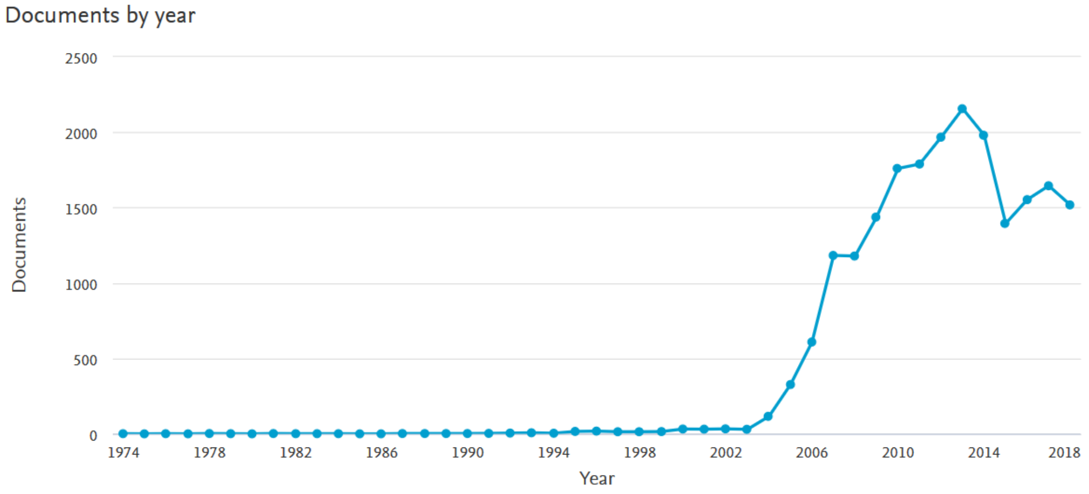

Figure 5. Documents published between 1974 and 2018 ("business ecosystem")

Researchers from various countries contributed to the topic of research. Though, considering the origin of articles, the United States has published the most significant number of documents, followed by China and the United Kingdom (Figure 6).

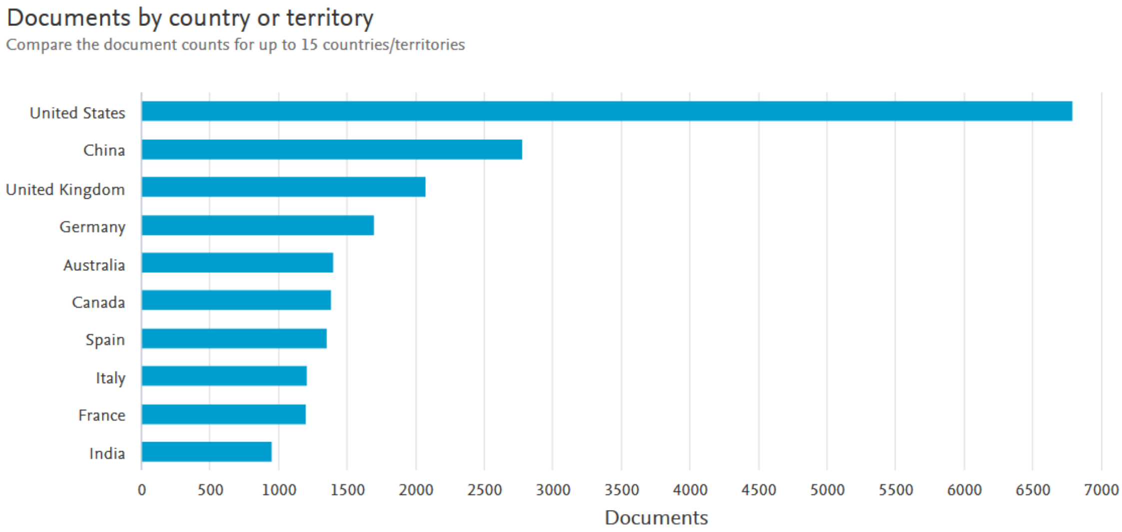

Figure 6. Publications by country 1974 - 2018

After a general search with keywords of "circular economy" and "business ecosystem", the approach was limited to the purposes of the research. A narrower limitation for the search of articles was chosen, namely limitation of subject areas, language, document types, and keywords have been applied (Table 2).

Table 2. Literature search limitations

<table>
<tr><td>Subject areas</td><td colspan="3">Business, management and accounting, decision sciences, engineering, computer science, social sciences, and environmental sciences.</td></tr>
<tr><td>Language</td><td colspan="3">English</td></tr>
<tr><td>Document types</td><td colspan="3">Book and book chapters are excluded</td></tr>
<tr><td rowspan="8">Keywords</td><td rowspan="3">“circular economy”</td><td rowspan="8">AND</td><td>"business"</td></tr>
<tr><td>"purchasing"</td></tr>
<tr><td>"risks and benefits"</td></tr>
<tr><td rowspan="3">“industrial ecosystem”</td><td>"procurement"</td></tr>
<tr><td>"supply"</td></tr>
<tr><td>"supply chain"</td></tr>
<tr><td rowspan="2">“business ecosystem"</td><td>"supplier relation"</td></tr>
<tr><td>"supplier"</td></tr>
</table>

The initial total results of the search have extracted 549 documents in total. After deleting the duplicates this amount has decreased to 371 documents. After reviewing the articles, 25 of them were kept for the preliminary literature review.

Additionally, articles related to the risks and benefits of a circular economy ecosystem were reviewed. After the search, 10 more articles were reviewed and added for the literature review in the field of risks and benefits of the circular economy ecosystem.

2.1 Concept of the circular economy

In the literature, the roots of the idea of the circular economy can be found in the work of Kenneth E. Boulding (1966), when the researcher identified closed and open systems. Boulding (1966) pointed out the difference between such systems. The author presented the world as spaceship earth and argued about the identification of communities that extends over time from the past into the future. Interestingly, Boulding (1966, 2) pointed out the most probable difficulty to identify closed systems, as there are "no inputs from outside and no outputs to the outside, indeed, there is no outside at all" for such systems.

A shift from a traditional linear system, which is open-ended, to understanding a circular economy with its closed-loop approach has started in 1990. Pearce and Turner (1990) in their work have illustrated how the loop of resources can be closed. The linear process of production and consumption according to Pearce and Turner (1990), creates outgoing wastes at each stage. Waste (W) comes from resources (R), production (P) and consumer goods (C) (Figure 7).

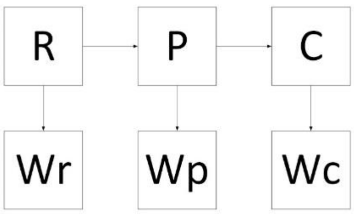

Figure 7. Linear system (Pearce and Turner, 1990)

In contrast, circular economy (Figure 8) is explained to be a closed system, where the flows of waste coming out at every stage are either recycled (r) or assimilated (A) by the environment. In turn, assimilative capacity is a capability of the environment to absorb waste. In case the waste amount can be assimilated by the environment, afterward, it will be returned to the economic system as a resource, and will create a positive effect on the utility (U). Alternatively, disposed waste in excess of the assimilative capacity result in pollution and damage to the environment and lead to negative amenity to the utility.

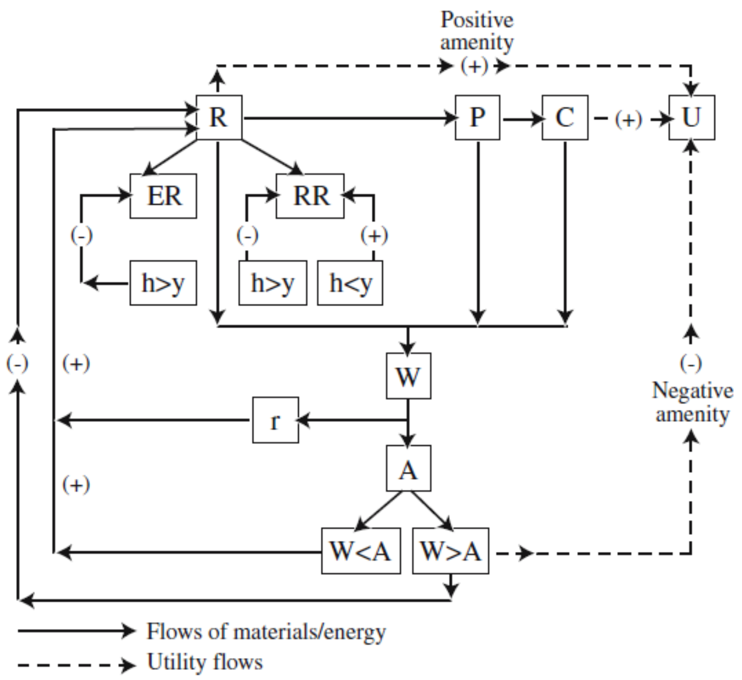

Figure 8. The circular economy (Pearce and Turner, 1990)
P – production, C – consumption, C – consumer goods, U – utility, W – waste,
r – recycling, A – assimilative capacity, ER – exhaustible resources,
RR – recyclable resources, h – harvest, y - yield

For the waste to become a resource again, it is vital to define whether it is a source for biological cycles or technical cycles. McDonough and Braungart (2002) separated these two flows of wastes. Biological nutrients are those wastes that can go into organic metabolism and literally go back into nature thanks to microorganisms. After the metabolism, it can be perceived as a natural resource that can be again used as a raw material for production. Technical nutrients are those materials, whose quality can be circulated after the first use of the product. Depending on the origins of the material, when it is looped, it might proceed via technical cycle or biological cycle. (McDonough and Braungart, 2002)

On a global scale, the idea of circularity underlies the concept of the circular economy. It is also paired with the field of industrial ecology or eco-industrial development, which integrates manufacturing and disposal activities to be industrial ecosystem similarly to a biological ecosystem. Industrial ecology focuses on the "healthy economy and environmental management". Again, there is the same idea applied in industrial development: 'natural resources – transformation into manufactured products – byproducts of manufacturing used as resources for other industries'. (Geng and Doberstein, 2008, 232) One of the most modern definitions provided by Ellen Macarthur Foundation (2013, 22) identifies the circular economy as "industrial economy that is restorative by intention". It restores both nutrients: biological and technological, through the economic system.

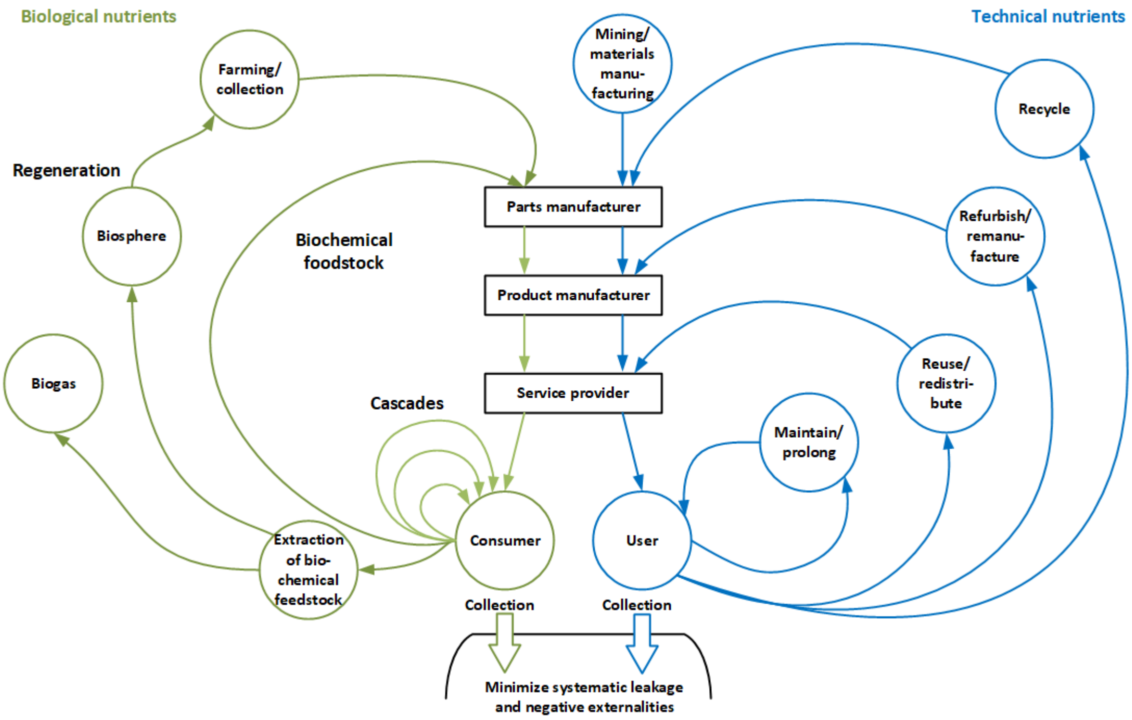

Figure 9. The circular economy (Macarthur, 2013)

Biological cycles (on the left side) and technical cycles (on the right side) create cascades (Figure 9). Biological nutrients might be a subject for biochemical extraction, when biomass is converted into valuable chemicals of fuel or anaerobic digestion that produces biogas, as a resource of energy, and solid residual, as a soil fertilizer. All in all, the nutrients are restored in a biosphere and again are proceeded in farming to plant agriculture products. Technical nutrients are extracted from mining and further manufacturing. During the life cycle when it has been used by a user, it can be maintained to prolong the product's lifecycle. Another option is to reuse a product. Then it will be used again in the same quality, or it might be used for another purpose. The product could be also refurbished, which means that components are replaced or repaired, and minor changes are made. Remanufacturing would allow building a new product out of the parts of the ones, which requires disassembly and recovery. Eventually, material recycling could be done to extract the functioning components to convert them into increased or reduced functionality products. Cascading allows to put "materials and components into different uses after end-of-life across different value streams and extracting, over time, stored energy and material 'coherence'. Along the cascade, this material order declines". (Macarthur, 2013, 25)

The circular economy can be perceived on different scales (Wells and Seitz, 2005; Zhijun and Nailing, 2007; Ghisellini et al., 2016). Three levels of implementation represent the scale and typical evolution of circular economy practices (Figure 10).

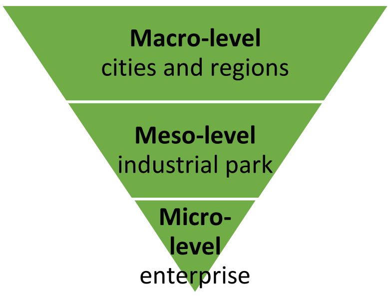

Figure 10. Levels of circular economy implementation (adapted from Feng and Yan, 2007; Ghisellini et al., 2016)

Micro-level refers to internal looping of materials and energy at a manufacturing site. Enterprises adopt eco-design to reduce the quantity of raw materials and minimize the polluting effect of a product, benefiting from material efficiency. (Wells and Seitz, 2005; Feng and Yan, 2007) Frequently this as the first stage for further expansion of the circular economy (Ghisellini et al., 2016). At an enterprise level, companies choose a product design strategy, supporting the idea of closing the loops. Depending on the materials' type, (1) design for a technological cycle, (2) design for a biological cycle, (3) design for disassembly and reassembly might be applied (Bocken et al., 2016). Design for a technological cycle implies that products are service-oriented rather than consumption-oriented, and they are designed in a way that after their initial use, they could be recycled into new products or materials for further use. Design for the biological cycle is targeted for consumption-oriented products, which are being designed with safe materials to be decomposed in nature to initiate a new cycle. Disassembly and reassemble design contributes to both previously discussed designs, as it assures that parts are easy to reassemble and also to separate biological and technological cycles.

Meso-level is frequently discussed as industrial park level or industrial symbiosis. It means that circulation of materials is achieved by sharing infrastructure, regional integration, information and waste exchange. (Feng and Yan, 2007; Ghisellini et al., 2016) "Industrial symbiosis" benefits from business collaboration within a certain geographical area, where businesses exchange by-products while sharing municipal services and circulating the local waste streams (Bocken et al., 2016). The mechanism that transforms industrial systems at the meso-level towards circular economy systems is a disruptive business model (co)-innovation. As critical elements of the disruptive business model (co)-innovation, "value creation innovation, new proposition innovation, and value capture innovation", as well as a "co-creation" meaning collaboration in resource usage and commitment, are discussed to extend circular economy in this kind of network. (Aminoff et al., 2017)

Macro-level circular economy implementation promotes eco-cities and zero wastes in cities and provinces achieving such a recycling rate that would fully reuse or recycle all the municipal and industrial wastes. This type of circular economy also involves a social aspect, which means infrastructure for citizens, for example, car sharing practices. Ideally, the macro-level circular economy should lead to disconnection of environmental impact and economic growth. (Ghisellini et al., 2016)

The circular economy is, therefore, a complex concept that has different layers of implementation depending on a scale being studied. It is an antithesis of the linear economy but paired with such fields as industrial economy, eco-industrial development, circularity, looping, and closing loops, cascading. De Jesus and Mendonça (2018, 76) have given a complex definition of circular economy, identifying it as “a multidimensional, dynamic, integrative approach, promoting a reformed socio-technical template for carrying out economic development, in an environmentally sustainable way, by re-matching, re-balancing and re-wiring industrial processes and consumption habits into a new usage-production closed-loop system”. This is an approach that follows sustainable principles.

Circularity and closing the material loop approach is also discussed in supply chain management. The closed-loop supply chain is often studied together with sustainable supply chains, but it is focusing on reverse flows of a supply chain and it is named as a reverse supply chain system. In fact, it reflects the cascading function of a system, which was discussed previously. The closed-loop supply chain aims to optimize the return flows in such a way that the network would benefit out of it by forwarding them in the manufacturing planning. (Kalverkamp and Young, 2019)

2.2 Principles of the circular economy

The circular economy has certain principles that are used to implement the initiatives. In its core, it is basing on 3R principles, which are Reduction, Reusing and Recycling. Reduction implies minimization of all the resources and energy consumption needed for manufacturing, and waste generated. It can be achieved by improving the efficiency of production. (Feng and Yan, 2007; Ghisellini et al., 2016; Su et al., 2013) The production efficiency – so-called eco-efficiency – meaning economic and environmentally-oriented sustainability of production processes (Ghisellini et al., 2016). Next, the principle of reusing aims to prolong the endurance by using it again after the first consumption at another facility. It is also applicable for by-products and wastes that are suggested to be used as a resource for other manufacturing sites or industries. Finally, recycling refers to the reprocessing of products, by-products, and wastes into new products in a way that would reduce the amount of virgin materials needed for production, supported by the reduced environmental impact caused by less waste generation. (Feng and Yan, 2007; Ghisellini et al., 2016; Su et al., 2013).

A broader view of circular economy encompasses 6R principles, that are based on previously discussed 3R principles, supported by three additional ones, which are Recover, Redesign, and Remanufacturing (Govindan and Hasanagic, 2018). Recovery is characterized by a collection of the products after they have been used to disassemble, sort and clean for further utilization. Redesign principle is an activity to design the products in a way that would use recovered materials, parts and components from the previous phase. Remanufacturing means recovering the used products to their original condition by reusing parts to avoid losing the like-new functionality of the product. (Jawahir and Bradley, 2016)

Another approach focusing more on the restoration of a system proposes the other three principles (MacArthur, 2013; Ghisellini et al., 2016). First one suggests “design out of wastes”, which stresses the role of the design stage to be able to easily disassemble and reuse products after use. The second one refers to strict differentiation of biological and technical nutrients in order to be able to safely return the biological ingredients into the biosphere, or reuse technical nutrients, because they are unsuitable for the biosphere. The third principle defines the source of energy used, which should be renewable to minimize resource dependency. (Macarthur, 2013) This approach is based on the original 3R principles in its core, including Reduce, Reuse, Recycle initiatives, discussed above, but the features suggested by Macarthur Foundation (2013) add more opportunities to apply the 3R principles. For example, the design of a product might be made for easier recycling or minimization of resources and energy used while manufacturing refers to the reduction of energy consumption during the production phase.

To summarize, all principles discussed in this chapter have a common sense of making a life cycle of products and material flows longer. They provide options on how to make it longer and how to loop a circle of material flow and create cascades of the circular economy.

2.3 Concept of an ecosystem

A term of an ecosystem has its origins in biology. Nevertheless, an ecosystem in the world of business has a similar idea as a biological ecosystem. (Moore, 1996) The author argues that business ecosystems "develop like biological ecosystems". Biological ecosystems have organisms that somehow communicate with each other. They are situated in an environment. Similarly to biological ecosystems, an organism can be considered as a department, business unit, a process or business. As biological ecosystem is defined as "community of organisms, interacting with each other, plus the environment in which they live and with which they interact", business ecosystems are "economic communities supported by a foundation of interacting organizations and individuals – the organisms of the business world". (Moore, 1996) Similarly, Geng and Côté (2007, 332) have also introduced an ecosystem parallel to the biological ecosystem, which is defined as "the complex organization of biological interactions and the nonliving surroundings". In addition to that, parallel to an ecological ecosystem, there might be an industrial ecosystem. It does not only have a relation to the biological ecosystem, but it can also be inside an ecological system. (Geng and Côté, 2007) Similar to biological symbiosis, where mutualism can be observed, for instance when symbiosis is beneficial for each side (or organisms in biology), in a more complex way it appears in industrial symbiosis. (Chertow and Ehrenfeld, 2012) In contrast to the biological ecosystem, in man-created ecosystems to attract, select and retain the members, the intentional organization does these functions. (Valkokari, 2015)

An ecosystem in a perspective of industrial ecology has been discussed in a form of the industrial ecosystem and industrial symbiosis, industrial parks, eco-parks, which have a focus on sustainability and optimization of resources. (Tsujimoto et al., 2017) Such ecosystems establish relationships among companies involved through waste/by-product exchange. They are often organized in a cluster form that has a competitive advantage at the level of a region. (Valkokari, 2015) Geographical proximity facilitates the exchange of materials and by-products, logistics, trust, and collaboration. Knowledge and information sharing and frequent close interactions might even create local norms of behavior inside an industrial symbiosis. (Patala et al., 2014) In a more sustainability-oriented approach, business ecosystem or a network implies a number of firms that are considered as members of a network, which aims to utilize a company's by-products as another company's feedstock. In literature, such a phenomenon is also known as industrial symbiosis (Chertow and Ehrenfeld, 2012).

In a broader perspective, ecosystems have a set of characteristics, identified from the literature (Table 3).

Table 3. Characteristics of an ecosystem

Characteristics of an ecosystem	Valkokari 2015	Patala et al. 2014	Kurhonen 2001	Zhu and Ruth 2013	Sacirovic et al. 2018	Geng and Côté 2007
Closing loops by exchange of wastes and by-products	x	x	x	x	x	x
Eco-innovations and shared environmental goals		x	x	x	x	x
Collaboration between industries and establishing relations	x	x	x	x	x	x
Knowledge and information sharing		x		x		
Utilities' sharing (water, energy, wastewater treatment)		x	x			x
Clustering, geographical proximity	x	x	x	x		
Economic gains and competitive advantage	x	x	x	x	x	
Diversity			x	x	x	x
Resilience				x		x

Exchange of wastes and by-products and closing the material loops is a key idea of an ecosystem. Materials are exchanged between firms involved in an ecosystem and between industries inside it. (Patala et al., 2014; Valkokari, 2015) In other words, this principle is also called a “roundput” or “cyclical flow of materials” or “cascading“ (Kurhonen, 2001, 33). It follows the aim to act as a natural cycle, where similarly to nature, wastes and by-products are forwarded into the internal cycles through exchange with actors of the ecosystem. This would close a loop of resources needed for different firms. (Geng and Côté, 2007; Sacirovic et al., 2018; Zhu and Ruth, 2013)

An industrial ecosystem’s actors *share similar environmental goals* and sustainable strategies that facilitate *eco-innovations*. They are aiming at environmental goals, such as decrease of virgin materials and energy utilization, supported by the reduction of emission and pollution from the system. Environmental impact is also measured by material and energy efficiency, which companies are trying to maximize. Industrial ecosystems are trying to reach excellence in environmental protection paired with economic benefits. (Geng and Côté, 2007; Kurhonen, 2001; Patala et al., 2014; Sacirovic et al., 2018; Zhu and Ruth, 2013)

Establishing relations among companies is the focus of a symbiosis (Valkokari, 2015). It can be also called a "symbiotic collaboration" that is based on cooperative management (Patala et al., 2014, 168). This cooperation basis between actors improves decision-making process with partners. Closer relationships, in fact, might cause more dependency, thus, it might complicate the possibility to switch between suppliers. (Zhu and Ruth, 2013) In ecosystems, relationships are maintained in a self-organizing manner, avoiding the top-down approach, and those who would not need to cooperate in the traditional economy would start these cooperation relationships in the ecosystem (Geng and Côté, 2007; Sacirovic et al., 2018).

Sharing of knowledge and information – non-material resources - encourages changes in cultures in organizations and improves the innovativeness of companies. Frequent interactions and sharing can also form a certain set of shared norms that would influence business behavior inside the ecosystem. (Patala et al., 2014). Also, information sharing positively influence the connectedness of an ecosystem and trust (Kurhonen, 2001).

Utility's sharing is an example of additional collaboration between firms and industries. They can cooperatively utilize water, energy, wastewater treatment, together with some services, which will ease and decrease in price the utilization. (Geng and Côté, 2007; Kurhonen, 2001; Patala et al., 2014)

Clustering refers to finding a competitive advantage at the level of a region. It highlights the idea of locality and regionalism. (Valkokari, 2015) In ecosystem inputs and outputs that are circulated frequently originate from the local sites, based in relatively close *geographical proximity*, which enables to ease transportation and exchange, as well as facilitates trust and collaboration. (Patala et al., 2014; Zhu and Ruth, 2013) Kurhonen (2001, 34) defines it as “locality” that targets to use materials and energy coming from the local sources according to the sustainable point of view, so that waste flows and energy are used as valuable for the region resources.

Economic gains are highlighted as a characteristic of an ecosystem, as financial benefits and financial performance are one of the aspects that would keep the industrial ecosystem alive and motivate the actors to innovate. In fact, one of the targets of such an ecosystem is not only to minimize environmental impact but also to increase the economic effect for firms. (Kurhonen, 2001; Patala et al., 2014; Sacirovic et al., 2018; Valkokari, 2015; Zhu and Ruth, 2013) Additionally, this strategic decision to participate in the ecosystem should be a source for *competitive advantage* for every organization (Kurhonen, 2001; Patala et al., 2014; Valkokari, 2015).

Diversity encompasses the diversity of actors involved in the economic system, diversity of inputs and outputs, diversity in cooperation. A range of businesses is usually involved in ecosystems, exchanging various materials. The diversity of material flows allows to create multiple possible inputs and outputs, e.g. material and energy flow that enhance the sustainability of the relationships. In turn, the diversity of companies involved creates stability, because there is always a backup company. The diversity of organizations implies also large companies and SMEs, private and public organizations, which makes cooperation more complete. (Geng and Côté, 2007; Kurhonen, 2001) Diversity and resilience are characteristics that are paired with each other. Diversity also brings redundancy and creates lower dependency among firms. (Sacirovic et al., 2018; Zhu and Ruth, 2013)

Resilience means flexibility and adaptability of an industrial ecosystem in a changing environment. Resilience is decreased by the inter-dependency of organizations. In case a disruption happens to one of the firms that others are highly dependent, the damage to the whole industrial symbiosis is large. In contrast, redundancy, caused by the diversity of actors, cooperations and material exchange, encourages to involve more players, decreasing thereby dependency and enhancing resilience. (Geng and Côté, 2007; Zhu and Ruth, 2013)

2.4 Types of ecosystems

When discussing an ecosystem, different types of ecosystems have been identified, having a focus on a specific characteristic of those described previously. Generally, the above-discussed characteristics of ecosystems might have a more important role or less important role in an ecosystem, which depends on which type of ecosystem it belongs to. The characteristics of different types of ecosystems are collected in Table 4. General characteristics in the first column represent all of the features that were discussed in the previous chapter. They belong to an ecosystem on a general level, though not all of them are necessarily present in a specific type of an ecosystem. Next columns have the most typical characteristics of each type of ecosystem. The characteristic in green color is the main feature of a particular type of ecosystem.

Table 4. Characteristics of different types of ecosystems

Characteristics of ecosystem	**General characteristics**	**Business ecosystem**	**Industrial ecosystem**	**Knowledge ecosystem**	**Innovation ecosystem**	**Circular economy ecosystem**
Closing loops by exchange of wastes and by-products	x		**X**			**X**
Eco-innovations and shared environmental goals	x				**X**	x
Collaboration between industries and establishing relations	x	x	x	x	x	x
Knowledge and information sharing	x			**X**		
Utilities' sharing (water, energy, wastewater treatment)	x					
Geographical proximity, clustering	x			x	x	
Economic gains and competitive advantage	x	**X**	x			
Diversity	x	x	x	x	x	
Resilience	x					

Valkokari (2015) has distinguished three types of ecosystems: business ecosystems, innovation ecosystem and knowledge ecosystem (Figure 11).

Business ecosystems highlight economic outcomes when creating customer value. It is described as a network that is based on a variety of players creating several layers. They have different commitment. (Valkokari, 2015) Particularly, there are “keystone” players of an ecosystem, which means that it has a role of a leader in the ecosystem. Such “keystones” are able to retain the other organizations within the ecosystem. Additionally, they are supported by “niche players” that are focused on a certain specialization and generate innovations in their narrow field. (Harland et al., 2014, 723-724) All in all, such business ecosystems aim to get economic gains.

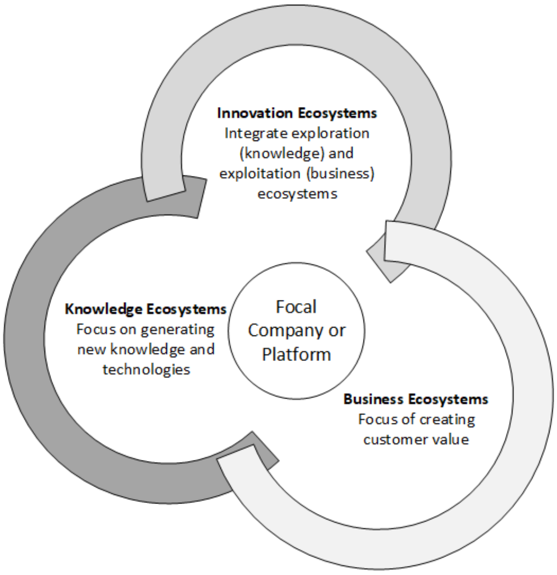

Figure 11. Business, Innovation and Knowledge ecosystem (Valkokari, 2015)

Knowledge and innovation ecosystems have a common feature, which is the geographical proximity of actors or clustering. Locality eases the interactions between organizations and collaborations. Knowledge ecosystems focus on new knowledge creation. Collaboratively such ecosystems create new knowledge. Frequently research organizations and developers have a financial network supporting the main knowledge-creating actors. All together they create synergies through knowledge exchange. Innovation ecosystems also require the support of various organizations, not only technically advanced developers. These other supporting companies are innovation brokers and funding organizations, innovation policymakers. Innovation ecosystems can integrate the knowledge created by business ecosystems and the needs of business ecosystems by creating innovations. (Valkokari, 2015)

Industrial ecosystems that are discussed parallel to business ecosystems differ from them in a way that they do not focus that much on economic gains as business ecosystems do, but more concentrate on the exchange of materials and by-products, building collaboration on this basis. (Valkokari, 2015)

Aminoff et al. (2017) introduce a circular economy ecosystem. It is defined as "co-evolving, dynamic and potentially self-organizing configurations, in which actors integrate resources and co-create circular value flows in interaction with each other." (Aminoff et al., 2017, 530) This idea is a meso-level concept of circular economy implementation according to Ghisellini et al. (2016) It creates value circles by different actors that are required to bring a product back to the system. The concept implies principles of the regenerative and restorative system. Eco-innovations and rethinking of partnerships provide collaboration between companies creating an ecosystem, where different partners can close the loop of materials.

Though, all the characteristics identified are reflected in every ecosystem, each type of ecosystem has its main focus and additional features that are more typical for specific types of ecosystems. It shoult be noted that such characteristics as *Utilities' sharing (water, energy, wastewater treatment*) and *Resilience* are not mentioned in any particular kind of ecosystem, though they play a role on a more general level when describing ecosystems. They might be present in any type of ecosystem, but they are usually not the main focus of the ecosystems.

3 RISKS AND BENEFITS OF A CIRCULAR ECONOMY ECOSYSTEM

The circular economy ecosystem is a relatively new phenomenon, which has been observed as real-world examples by researchers. The cases have been widely discussed in a positive manner by the researchers, emphasizing usually the positive environmental and ecological outcomes, though benefits from the perspective of other fields are presented as well. Implementation of principles of circular economy and the creation of an ecosystem based on circular economy creates uncertainty, as the cases are rather unique and there is not much practical experience available in this field. That is why the novelty of the circular economy ecosystem case leads to the necessity of risk identification in various fields.

As the risk identification in the field is a crucial task to reveal the potential of the circular economy, one can obtain it by applying PESTE framework. It is a beneficial tool for the need of a broad identification of risks and benefits, encompassing different fields. This tool is used to derive risks that are not under control of an organization but can be mitigated. (Forbes et al., 2007; HM Treasury, 2004) By PESTE framework, the topic can be analyzed from five different perspectives: (1) political, (2) economic, (3) social, (4) technological, (5) environmental.

3.1 Risks of a circular economy ecosystem

Generally, a risk can be defined as “a probability or threat of damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action”. (Business dictionary, 2018a) Particularly, in terms of risks related to circular economy ecosystem, they are considered to be threats of negative outcomes of circular economy activities within the ecosystem that can be avoided by proper risk management. Researchers have discussed different ideas on the risks caused by the circular economy ecosystem, which are grouped together and presented in Table 5. In this chapter, risks will be discussed according to PESTE framework.

Political risks come mainly from governmental authorities responsible for making decisions as well as legal restrictions, including laws and regulations. Particularly, a chance that regulatory system might become a barrier to develop and implement the initiatives towards circular economy into action, should be considered as a risk. Velenturf et al. (2018) argue that in fact the regulatory system is too much focused on waste, and it should better pay more attention to the whole cycle of production and value resources, including the wastes, but not limited to the wastes, as it simply restricts the use of the waste streams. Similarly, Aid et al. (2017, 89) conclude the fact that “excessive environmental legislation can, at times, prevent environmentally beneficial activities”. It is obvious that the regulation that might occur to be too restrictive, is supposed to limit the possibility of any leakage of hazardous materials and support safety, nevertheless, it sometimes limits too much any possible actions with these materials.

Furthermore, the circular economy and environmental law might not have enough guidance and information for handling the wastes and side-streams and loop them back to the production. Basically, for the actors of the circular economy ecosystem, there might be not enough clear regulations on how to handle the wastes to be able to use them in the cycle of production (Aid et al., 2017). Another aspect that makes this kind of economy incomparable and hard to evaluate is the absence of a standard circular economy indicator system. Only industry-specific indicators are being used instead. (Masi et al., 2017) This makes it more difficult to measure the performance and make accurate decisions at any stage inside the ecosystem.

Table 5. Risks of a circular economy ecosystem

PESTE	RISKS	Authors	
Political	Regulatory system becomes a barrier to develop and implement the ideas into action	Velenturf, A., et al. 2018	Aid, G., et al., 2017
	CE and environmental law does not have enough guidance and information	Aid, G., et al., 2017	Masi, D., et al., 2017
	Regulations on handling by-products and wastes encourage to avoid using them	Aid, G., et al., 2017	Masi, D., et al., 2017
	Difficult to secure supply from waste owners such as public organizations that are required to publically procure their contracting services several times per decade	Aid, G., et al., 2017	
Economic	Risk of arising financial problems to finance synergy partnership between companies	Aid, G., et al., 2017	
	Restrictive market conditions	Aid, G., et al., 2017	
	Needed volume and quality of resource materials cannot be reached to achieve viable economies of scale	Aid, G., et al., 2017	Masi, D., et al., 2017
	Costs are too high	Masi, D., et al., 2017	Petit-Boix, A., Leipold, S., 2018
	Availability of funding	Masi, D., et al., 2017	
	Over-investment in new infrastructure that utilizes more resources in its construction than it will ever save over its lifetime	Jesus, D.A., Mendonca, S., 2018	
Social	Lack of trust between actors	Aid, G., et al., 2017	
	Overdependency on other actors	Aid, G., et al., 2017	
Techno-logical	New technologies not used before might be a threat in terms of safety for consumers	Bilitewski, B., 2012	
	Technology is not suitable or very limited for the specific symbiosis.	Masi, D., et al., 2017	
	Technical challenge to reach the needed quality	Masi, D., et al., 2017	
Environ-mental	Not identified from the literature		

The legislative field might also create a risk that regulations on handling by-products and wastes encourage to avoid using them. For example, even for non-hazardous materials, there are quite strict requirements in terms of transportation and administration, when they are classified as by-products and wastes. Furthermore, classification as wastes and by-products frequently lead to much more bureaucratic procedures that are time-consuming. (Aid et al., 2017) Another possible barrier that a circular economy ecosystem might face is hidden support of primary material producers by subsidies or lower taxation rates that discourage the actors of an ecosystem from circular economy initiatives (Aid et al., 2017; Masi et al., 2017).

In more specific cases, difficulties might arise, when supplies of materials proceed from such waste owners as public organizations, because by regulations they are required to make their procurement of contracting services publicly a few times per decade. Therefore, it is hard to secure the supply of waste streams from such suppliers, and there is a risk of another barrier that might happen in a circular economy ecosystem. (Aid et al., 2017)

Economic risks are significant factors to be considered and studied further as they might endanger the success of the whole ecosystem, in case the circular economy is not economically reasonable for the ecosystem's inhabitants. Firstly, there is a risk of arising financial problems to finance companies' internal economies and win-win partnership for the actors. In case symbiotic activities are not possible to be financed, they become unsustainable. Restrictive market conditions might be a reason for such a financial problem to arise in a project. (Aid et al., 2017)

Secondly, the total costs might be underestimated and appear to be too high eventually. Not only such projects require significant upfront investments and even become dependent on governmental funding (Masi et al., 2017), but also operational spendings, including transportation, waste handling costs, additional administrative costs, maintenance costs and other transaction costs (Aid et al., 2017). As the investments for such projects are high, possible unfavorable situations related to the economic field might be risky. The risk to be considered is an investment in new infrastructure, which will eventually use more resources in establishing it, than ever generate during its lifecycle. (De Jesus and Mendonça, 2018) Moreover, this type of collaboration requires very accurate and precise management, which additionally creates higher expenses of qualified and experienced management. Hence, customized technology needed for a certain circular economy ecosystem and maintenance of this technology undoubtedly leads to higher expenses in this case. (Masi et al., 2017)

Regardless of the fact that the transactions of resources for circular economy needed in an ecosystem might be well-arranged, it can be difficult to reach a proper quantity of them to be reasonable to handle them in a circulating way. Consistency in quantity and quality, as well as the timing of transportation, are essential to be able to reach economies of scale, otherwise, there is a risk that these materials would be economically unattractive compared to more traditional but less expensive virgin materials. (Aid et al., 2017; Masi et al., 2017)

Social risks in a circular economy ecosystem refer to the influence on the ecosystem’s citizens and local social groups, as well as problems arising inside the companies operating in the ecosystem. As actors of the ecosystem include a social aspect, communication both inside an organization and inside the ecosystem might affect the success of the circular economy ecosystem. Particularly, tight collaboration inside the ecosystem would significantly suffer in case of lack of trust between actors. In other words, mistrust of joint targets, of beliefs in an unfair division of returns on investments is a probable risk for the whole ecosystem. Moreover, this situation might be a barrier to the desired synergy effect, which is possible only when actors are willing to share the knowledge and information, they have in order to reach common goals. All of these barriers might be a reason for a company’s reluctance to change when neither the management nor employees are motivated to make changes in their operations and processes. In addition to that, very tight collaboration and partnership between a small number of companies might create a risk of overdependency on particular actors, which does not allow to develop the circular economy ecosystem in the most effective way. (Aid et al., 2017)

Technological risks come from the novelty of circular economy products and lack of experience to handle the wastes and side-streams. Bilitewski (2012) has emphasized a threat in terms of safety for consumers. There is a risk that new unsafe products might enter the market. For example, such circular economy products may contain heavy metals, which are dangerous for consumers' health and might lead to unforeseen safety and health issues.

Taking into consideration the complexity of the technology required for circular economy production and making the wastes suitable for looping and putting them back into the production cycle, it requires accurate pre-processing of the materials before they can be used in another process, which creates another barrier. There is a risk that the available technology is only suitable for a particular symbiosis and is very limited to the exact materials. The solution should be customized for certain specifications and needs of a circular economy ecosystem, which includes the type of by-products available, their quantity and quality, and production activities planned for the circular economy ecosystem. (Aid et al., 2017) It might be a "bottleneck for further environmental and industrial symbiosis improvements" (Masi et al., 2017, 11).

The literature review did not reveal any *environmental risks* discussed by researchers, as in most cases circular economies are discussed as beneficial for the environment situation. That is why in this research environmental risks will be studied according to the results of the empirical study only.

3.2 Benefits of a circular economy ecosystem

In contrast to risks, circular economy ecosystems also create benefits in various aspects. A benefit is usually perceived as “desirable and measurable outcome or result from an action, investment, project, resource, or technology” (Business dictionary, 2018b). In the case of the circular economy ecosystem, the benefits of it would be positive results of joint efforts of all the participants to close the loop of resources. Benefits of the circular economy ecosystem from different perspectives have been discussed by researchers and they are represented in Table 6. In this chapter benefits of a circular economy, ecosystem will be discussed according to PESTE framework.

To start with, no benefits related to *political and legislative sphere* have been revealed in the literature review. The political and legislative field is hard to link to the positive effects of the circular economy ecosystem. Most probably this is the reason why researchers did not pay much attention to it in this perspective. Thus, in this thesis political and legislative benefits will be only studied based on the results of empirical study.

Economic benefits are stimulating the circular economy ecosystems to develop further and become more innovative. Companies taking part in the circular economy ecosystem, are becoming more innovative, and they can benefit from entering new business markets via innovations in the circular economy. It is stated that this kind of innovativeness that affects product design, business models, the design of supply chain and materials’ choice, becomes one of the sources for competitive advantage. (Aid et al., 2017; Lieder and Rashid, 2016; Macarthur, 2013) In addition to that, participation in the circular economy projects creates a responsible image for companies. A new business image and green label, gained in a circular economy ecosystem, help to open new business opportunities. (Korhonen et al., 2018)

Table 6. Benefits of a circular economy ecosystem

PESTE	Benefits	Authors			
Political	Not identified from the literature				
Economic	New business markets and competitive advantage	Aid, G., et al., 2017	Macarthur, E., 2013	Lieder, M., Rashid, A., 2016	
	Reduced externalities (of materials and products)	Macarthur, E., 2013			
	CE initiative encourages further innovation and growth in the region	Macarthur, E., 2013	Sacirovic, S., et al., 2018		
	Net savings on costs	Macarthur, E., 2013	Korhonen, J., et al., 2018		
	Reduced dependency on resource markets	Macarthur, E., 2013	Korhonen, J., et al., 2018		
	Attractiveness for new businesses and entrepreneurs to the area	Aid, G., et al., 2017	Korhonen, J., et al., 2018		
	Increased taxes on income communities	Sacirovic, S., et al., 2018			
	Increased value of property in the region	Sacirovic, S., et al., 2018			
	Profit opportunities for developers	Sacirovic, S., et al., 2018	Lieder, M., Rashid, A., 2016	Korhonen, J., et al., 2018	
Social	Employment growth	Macarthur, E., 2013	Korhonen, J., et al., 2018		
	Wider choice for consumers and improved service quality	Sacirovic, S., et al., 2018	Macarthur, E., 2013		
	Improved health and safety in the community	Sacirovic, S., et al., 2018			
	Improved quality of life in the region and sense of community	Sacirovic, S., et al., 2018	Korhonen, J., et al., 2018		
Techno-logical	Not identified from the literature				
Environ-mental	Reduced emissions and contamination	Velenturf, A., et al. 2018	Sacirovic, S., et al., 2018	Lieder, M., Rashid, A., 2016	Korhonen, J., et al., 2018
	Enhanced sustainability profile	Aid, G., et al., 2017	Sacirovic, S., et al., 2018	Korhonen, J., et al., 2018	
	Contribution to climate change mitigation	Macarthur, E., 2013			
	Slowing down the resource depletion	Macarthur, E., 2013	Korhonen, J., et al., 2018		

Based on the definition and principles of the circular economy, it reduces the amount of materials used in production processes. It allows minimizing dependency on resource markets. Resource markets independence refers to the raw materials extracted from nonrenewable sources, as well as energy from unsustainable sources used for manufacturing needs. Circular economy allows the ecosystem to decouple the growth and resource depletion because the resources' value is utilized several times. (Korhonen et al., 2018; Macarthur, 2013) Moreover, reduced materials' usage has also a positive impact on purchasing costs. It is clear that costs are proved to be reduced by the circular economy for several reasons. These benefits are mainly decreased resource and energy costs, waste and emissions costs, originating from tax benefits. (Korhonen et al., 2018; Macarthur, 2013) Particularly, a waste tax is possible to decrease, as it is set for every tone of landfilled wastes. It means when wastes are utilized in another way, they do not go to landfill and the waste tax should not be paid. This is a positive influence for manufacturers, as well as a good motivation to make the production of waste an alternative focus of the business. (Keskisaari and Kärki, 2018)

The region where the circular economy ecosystem is operating can benefit economically as well. Such projects attract new businesses and entrepreneurs to the area (Aid et al., 2017) because it is considered to be a profit opportunity for developers and new investors (Sacirovic et al., 2018). The benefits for the local area are clear, as they do not only speed up the economic development of the region, and have an operational impact, but also influence strategically and become a source for growth and innovations. (Macarthur, 2013) Sacirovic et al. (2018a) have also pointed out such additional benefits as increased taxes on income coming to the local budget, resulting from the increased number of taxpayers, and the increased value of property in the region, which impacts local welfare as well.

As a result of this economic development, the population of the region can benefit in terms of *social aspects*. First of all, development of new businesses and growth of economy discussed above, would create more job opportunities in the region and attract new specialists (Korhonen et al., 2018; Macarthur, 2013). Particularly, the recycling industry and waste management create a large number of jobs and it might even rise more in a circular economy in the future. Also, a shift towards job growth in service field is more likely to happen, as there will be an increased need for reverse cycle services. (Macarthur, 2013) Secondly, consumers of circular economy products benefit from a wider choice of environmentally friendly products and higher quality of services (Macarthur, 2013; Sacirovic et al., 2018). All of these aspects positively influence the community regarding a healthier and safer environment for living and creates a sense of community with shared values and goals. Considering all the aspect stated above, the circular economy ecosystem makes the quality of life better in the region. (Korhonen, 2001; Sacirovic et al., 2018)

Finally, justifying the main goals of the circular economy ecosystem, it creates significant benefits for the *environment.* It is obvious that the use of wastes and side-streams instead of new raw materials weakens the pressure on the ecology when landfill wastes are reduced, and decreases pollution and contamination into nature, as well as carbon dioxide (CO2) emission. (Korhonen, 2001; Lieder and Rashid, 2016; Sacirovic et al., 2018; Velenturf et al., 2018) As a result, the circular economy ecosystems have an effect on climate change mitigation (Macarthur, 2013). Ecosystems based on the circular economy create benefits coupled with sustainability profile. Both internally, including actors within the ecosystems, and externally, including other influenced parties, for example, citizens of the region, initiatives towards circular economy implementation make a substantial change in terms of reduction of negative environmental influence. (Aid et al., 2017; Korhonen et al., 2018; Sacirovic et al., 2018)

4 SOUTH KARELIA CIRCULAR ECONOMY ECOSYSTEM

The circular economy within geopolymer ecosystem in South Karelia region is the main phenomenon studied in this master's thesis. The implementation of the circular economy in the region is part of the UIR project and it is based on the idea of concrete production with a material replacing cement, using geopolymer materials. Utilization of different materials that are considered as wastes or side-streams from local factories is the purpose of geopolymer manufacturing in this project. Side-stream materials that are possible options for geocomposite production are available locally and are being continuously generated (Table 7). The main available material is flotation sand, which is the most generated side-stream from the mining industry. Green liquor sludge comes from pulp mills and the quantities of this side-stream are also significant. Ashes and fiber reject are side-streams of the forest industry.

Table 7. Local materials available for geopolymer manufacturing (Keskisaari and Kärki, 2018)

Material	Quantity (tones/year)
Flotation sand	143 000
Green liquor sludge	31 500
Ashes	19 200
Fiber reject	3 100

The main goal of the ecosystem is to be able to convert the local side-streams into materials that can be recycled by a new material creation and manufacturing technology development. The new geocomposite that is being developed is aimed to reduce the environmental pressure by replacing the traditional cement with geopolymer binder, as well as achieving the higher technical performance of the geocomposite because of fiber additive. Geopolymer materials are known to be highly resistant to the aggressive environment and high temperatures while having very low CO_2 emissions level. (Korniejenko, 2018)

The project is also developing a method, in which the geocomposite material will be used for construction purposes. For the purposes of the project, additive manufacturing is considered to be the best option for construction, as it is a much more sustainable method that also increases freedom in architectural design. (Nematollahi et al., 2017) This technology has already been used for construction purposes in other pilot projects. For example, a company Apis Cor has printed a house made of geopolymer concrete in Irkutsk (Russia) – Figure 12.

Figure 12. 3D printed house by Apis Cor (Apis Cor, 2018)

Hence, an additive device is needed to be developed and tested for additive manufacturing in terms of the local geocomposite construction with the local recipe of the material. Finally, after acceptance of the material and technology, the innovation should be implemented and the joint work of all the participants would result in a circular economy ecosystem. The main activities are visualized in Figure 13.

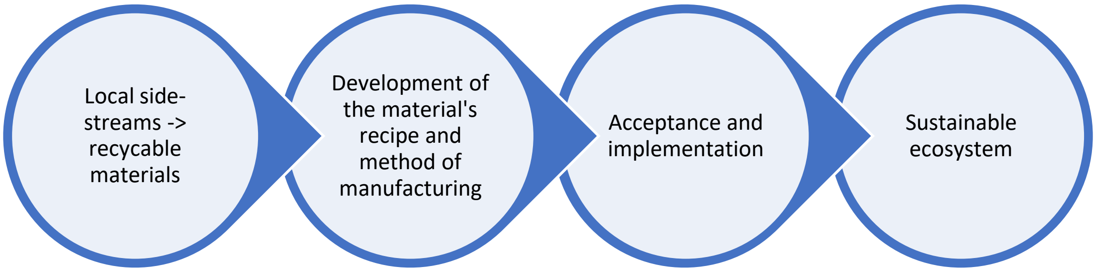

Figure 13. Main implementation activities (adapted from Korniejenko, 2018)

Successful implementation of the technology and well-organized sourcing from the local manufacturers would create a circular economy ecosystem. Side-streams from companies would be recycled and used as resources for geocomposite manufacturing, which would close the material loop. Sustainability of the ecosystem would be additionally supported by an innovative production method and longer life cycle of the ready-made geocomposite products.

4.1 Structure of circular economy ecosystem in South Karelia region

The circular economy ecosystem within geocomposite manufacturing is possible to create if all the functions and activities are allocated among the participants. Organizations have different functions, some of them are very unique and some of them are working on common problems for the circular economy jointly. During the interviews, organizations were discussing what roles they have in the ecosystem and what is their interest. They mentioned what resources and capabilities they possess and how they can be applied in the circular economy. Based on the discussion with the interviewees and literature the author has formed four groups of the functions in the local circular economy ecosystem. They are the following ones:

- Knowledge creation and sharing
- Materials supply
- Technology, design, and production
- Coordination and implementation

According to the identified roles, organizations can be allocated to these four main functions (Table 8).

Table 8. Roles of the circular economy ecosystem's actors

Partners	**Knowledge creation and sharing**	**Materials supply**	**Technology, design, and production**	**Coordination and implementation**
Apila Group Ltd.				
UPM-Kymmene Oyj				
LUT University				
FIMATEC				
Outotec (Finland) Ltd.				
Imatra Region Development Company				
Nordkalk Corporation				
Design Reform Ltd.				
Metsäliitto Cooperative				
Stora Enso International Oy				
Saimaa University of Applied Sciences				
Totaldesign Ltd.				
City of Lappeenranta				

The first function is knowledge creation and sharing. The circular economy ecosystem requires organizations that are responsible for the information and knowledge creation. Research at the field of circular economy, business models and legislation is important for the future implementation of the innovative product into the market reality. The success of the ecosystem and synergy effect depends on the knowledge sharing between the actors and the ability to collaborate within the network. It is also essential to be able to have an effect on the current legislation to be able to get the final product into the market. All in all, knowledge creation and sharing is associated with a number of organizations involved in the ecosystem.

The second function is the supply of materials, namely sides-streams for geopolymer production. A number of side-stream sources are considered as materials’ providers in South Karelia region and the nearest regions for geocomposite production (Table 9). Ashes, fiber reject, flotation sand, green liquor sludge, and construction wastes are the main materials available locally.

Ashes are the side-streams generated by the forest industry. They are produced by burning of wood and bark. Ashes are either collected from the bottom of a boiler – bottom ash, or from the flue gases – fly ash. Fiber reject is rejected material from the pulping process. It might be pieces of wood that are not desired in wood handling. Flotation sand is a side-stream from calcite and wollastonite quarry. It is a rejected material after crushing the mined stones from the quarry, it can be of bigger particles – coarse fraction, and of smaller particles – fine fraction. Green liquor sludge is a side-stream generated by pulp mills and it is usually landfilled after being removed from a process as it does not have any application. Construction wastes are coming in the form of a heterogeneous flow containing sand, pieces of brick and tiles from demolition. (Keskisaari and Kärki, 2018)

The recipe of the geocomposite material should be developed in a way that it fits the required criteria for construction purposes and sustainability profile. In addition to that, to reach the viable volume of side-streams, it might be beneficial to combine them from a number of sources to increase the amount of materials available for geocomposite production. This is the reason for a large number of side-stream sources from both, very local factories and farther locations, taken into consideration in the material development.

Table 9. Local sources of materials

Classification	Company/mill	Side-stream
Ashes	Hanasaari	Ash
	Helen Helsinki (Hanasaari)	Fly ash (coal)
	Kaukaan Voima	Fly ash (biomass power plant)
	Metsä Group (Metsä Board) Simpele	Fly ash (peat + biomass)
	Metsä Group (Metsä Fibre) Joutseno	Ash (gasification of bark on CaCO3 bed)
	Metsä Group (Metsä Fibre) Lappeenrannan saha	Ash (combustion of bark)
	Stora Enso Anjalankoski	Bottom ash (co-incineration)
	Stora Enso Anjalankoski	Fly ash (co-incineration)
	Stora Enso Imatra	Ash (bark combustion)
	UPM Pellos, Kristiina	Ash
Fiber reject	UPM Kaipola	Deinking flotation reject foam
Flotation sand	Nordkalk Lappeenranta	Tailings, coarse fraction (from carbonate mine)
	Nordkalk Lappeenranta	Tailings, fine fraction (from carbonate mine)
Green liquor sludge	Stora Enso Imatra	Green liquor dregs
	UPM Kaipola	Mixed sludge (deinking sludge + biowaste + fiber waste)
	UPM Kaukas	Coating sludge
	UPM Kaukas	Green liquor dregs
Other	-	Construction waste
	Metsä Group (Metsä Fibre) Joutseno	Lime / slaked lime (CaO / Ca(OH)2)
	Metsä Group (Metsä Fibre) Joutseno	Lime kiln dust
	Nordkalk Lappeenranta	Thickening pilot underflow (from carbonate mine)
	Ovako Steel	Steel slag
	Stora Enso Imatra	CaCO3 (from chemical recovery cycle)

Technology, design, and production is the third function. Considering the technology development phase, it includes two main aspects: geopolymer material development aspect and production aspect. Material development requires, firstly, the recipe development and testing, and after that, the technology of the geopolymer material manufacturing. After the stage when the material is ready to be used for manufacturing, production technology should be ready as well, particularly additive manufacturing technique should be customized for the geocomposite material and the design requirements. Companies responsible for these functions have a role of material creation and assessment, design of the geocomposite products and manufacturing of the products, using additive manufacturing method.

Finally, the fourth function is coordination and implementation. The geocomposite construction should find an application in the ecosystem. Implementation of the innovative products should be obviously discussed with the purchasing organization that is planning to use the new technology in the local region. The organization has a role of coordinator, as it can influence all the participants of the ecosystem, acting as a central organization.

4.2 Characteristics of the circular economy ecosystem in South Karelia region

The idea of the circular economy in the South Karelian region relates to meso-level circular economy implementation and creation of the ecosystem, achieving waste exchange between local manufacturing companies by utilizing regionally available side-streams. It will affect not only the largest companies and its economies but also the citizens of the region.

Characteristics of ecosystems discussed in the second chapter of this thesis can be found in the local ecosystem as well. The project is based on the idea of closing the material loop, it is a tool that is used to achieve both aims: environmental goals, particularly reduction of CO_2 emissions and creation of more sustainable material, and new use of local side-streams and wastes (UIA, 2018a). The goals of the project place this characteristic at the top level, which means that this is the central attribute of the ecosystem.

Other qualities of ecosystems can be also found in the South Karelia ecosystem. All the participants are sharing similar goals, which are related to eco-innovations. Collaboratively organizations from different industries are trying to create a circular economy locally. Companies share knowledge and achieved results among the ecosystem’s participants. Parties providing the resources for future material production are located in the near proximity (Figure 14), which should ease the transportation of the materials if needed.

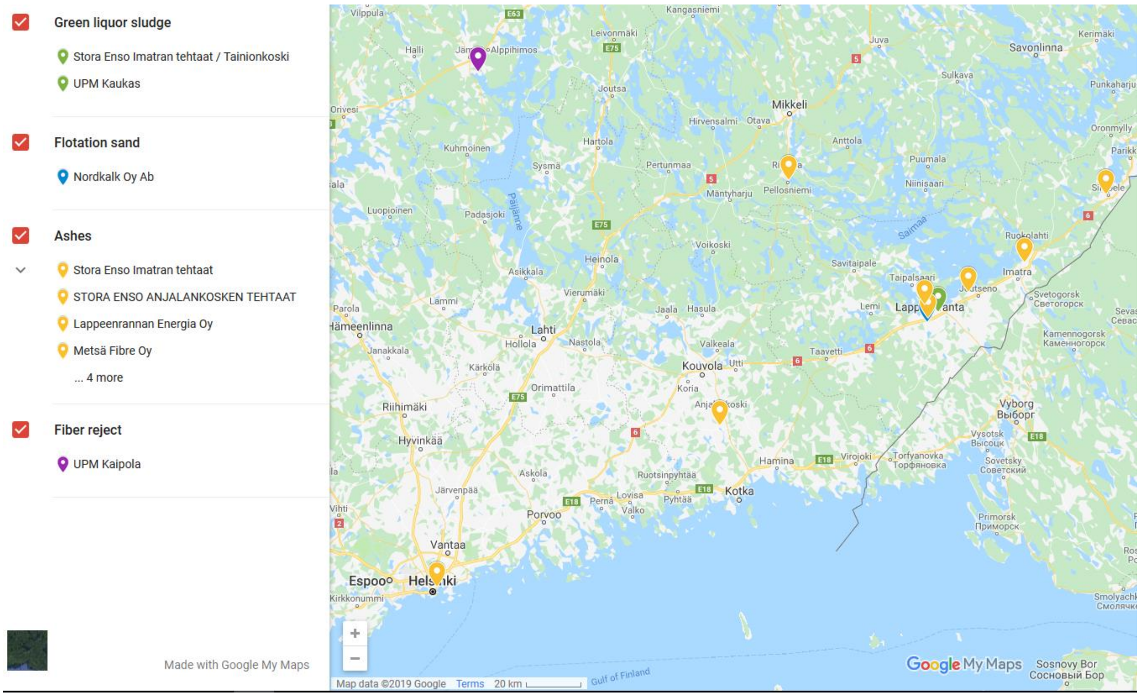

Figure 14. Location of side-streams' sources

The exact material recipe is still in the phase of development, and different options and mixtures are under evaluation and tests to reach the highest quality properties and sustainability goals, that is why the ecosystem cannot be fully formed at the moment, because the sources of side-streams are being considered from various geographical locations, though most of the alternatives are the local industrial companies, which are interested to make use of the rejected flows, or side-streams, or wastes that they generate. Different industries and research institutions are working on eco-innovations for common purposes.

Such characteristic as diversity can definitely be noticeable in the ecosystem, as such a diversified spectrum of industries is taking place, providing the materials, knowledge, and ideas, developing the method and technology, and compiling the possible applications of the final products.

The characteristics of the local ecosystem discussed above make it possible to conclude that the local ecosystem has good qualities of an ecosystem. The qualities of the ecosystem could fit it into the classification of the business ecosystem, as a very wide range of organizations collaborates a lot. Nevertheless, economic gains of the ecosystem are not the central aspect, as it is not yet clear what kind of materials and what kind of material flows are needed for the ecosystem and it is hard to estimate the potential expenses and economic gains. South Karelia ecosystem also has characteristics of an industrial ecosystem, as it has the exchange of the materials in the heart of the processes, though the element of shared environmental goals would be missing from this type of ecosystem. Knowledge and innovation ecosystems can also fit the local ecosystem in terms of innovativeness of the developed material, but such aspect as closing the material loop and material exchange would not fit into those two types of ecosystems. Finally, a high priority of the environmental goals and looping the material flows via tight collaboration between actors allow to class South Karelia geopolymer ecosystem as a circular economy ecosystem, which was defined earlier by Aminoff et al. (2017).

5 RISKS AND BENEFITS OF THE CIRCULAR ECONOMY WITHIN GEOPOLYMER ECOSYSTEM

Geopolymer ecosystem has not been established yet, and a lot of research and development are being conducted at the current stage, which will identify what ingredients work the best for the final products and what the ecosystem should consist of. There is still no clear view of the structure of the ecosystem and what actors are missing at the moment. The whole idea of the circular economy ecosystem is considered to be new and rather challenging for the participants, though, according to the results of the interviews, it is believed to be very beneficial in the future. There is a big number of actors participating in the project to launch the circular economy, and the participants have discussed some risks and benefits that they believe might have an effect. The following chapters discuss risks and benefits considered during the interviews with the actors of the geopolymer ecosystem according to PESTE framework.

5.1 Risks of the circular economy within geopolymer ecosystem

Risks related to the *political sphere* are mostly reflected in the legal challenges that the circular economy products might face when entering the market. Hence, one of the most frequently discussed risks is that regulations and laws are very tight to get a new product into the market. Not only the number of standards and regulations is very large and all of them should be taken into consideration when dealing with circular economy products, but also active communications with authorities are essential to get the product through, as this is how the legislation can be modified in order to get the circular economy products approved legally. The risk with the current legislation is that the process of approval might take a long time. The difficulty of circular economy products implies the fact that they should be safe for the users, that is the materials used for the production should be proven not to be hazardous and not to be harmful to the end-users. A lot of tests and pilots are required and long legislative procedures are considered to be a risk of extension of the period of starting the pilots and getting the results. It was emphasized that legal approval and officially getting product status requires a lot of efforts and time. These resources should be allocated to be able to successfully introduce a circular economy product to the market.

In addition to that, waste utilization and side-streams' usage are not encouraged by the legislation. Classified as side-streams and wastes materials have additional challenges to get legal approval. This will affect the challenging process of legal approval and might lead to even longer approval period. This is another risk, discussed by participants of the circular economy ecosystem.

Moreover, there has been a lot of *economic risks* mentioned by the interviewees. Most of them are caused by the expensiveness of the resources and technology that are considered to be used. The ingredients that should be used are mainly the side-streams and wastes from the local industries. Nevertheless, is has been mentioned that there is a risk that the price of these side-streams could be increased by the manufacturers. Another price increasing risk is the costly activator needed for material production. Of course, it depends on the final recipe decision, but the activator is considered to have a significant influence on the price of the final product. These factors would lead to an increase in the final product's price, which might be confronted by the unwillingness to pay extra when there are alternative less expensive options.

"People are not yet so willing to pay more to get more environmentally friendly products." Interviewee B

Furthermore, the new technology for manufacturing would include a lot of processes. Particularly, the necessity of very vast pre-treatment procedures would significantly increase the final product's price. The pre-treatment procedures might be needed, because of heterogeneity of the side-streams coming out from factories. To be able to proceed with the materials, this might require expensive pre-treatment work. This would heavily rise the product's price and question its attractiveness, especially compared to the existing alternative traditional concrete, which is less expensive. This idea might lead to another risk that the market is not yet ready for such a circular economy product. The market of traditional concrete is very mature and developed, and the risk that there is not enough market for geopolymer concrete. Additionally, the technology for additive manufacturing is very unique and not wide-spread. It hasn't yet found the market for construction purposes. The big risk is that the market is not ready for this kind of business.

Even though the circular economy ecosystem has a unique idea of geocomposite production, there are a few other organizations developing geopolymers. Also, 3D printing is spreading among construction companies, even though it has not been yet a very popular solution. Taking into consideration the long period of legal approval and fulfilling the requirements, there is a risk that competitors can enter the market faster. Competition from material and technology developers are considered to be another risk for the local circular economy ecosystem.

The locality of the circular economy ecosystem also brings some risks. Side-streams are available locally from the industries in the region. Despite the fact that the volumes of the side-streams are rather big and they are being continuously generated, there is a risk that this amount would not be enough for a big scale geocomposite production in the future. This is of course not a current risk, but possible future risk. Also, since this is a local circular economy ecosystem and the geopolymer production is considered to be utilizing the local side-streams, there is a very location-specific availability of side-streams, which should affect the recipe of the geopolymer.

In addition to the economic risks discussed above, the risk of market resistance to the new product has been highlighted by the interviewees. As mentioned before, the industry of conventional concrete has a very established position in the market of traditional concrete, which has been actively used by construction companies. Geocomposite would be a substitute for the concrete, which the industry might not accept. The risk is that a very old and developed sector of the conventional concrete industry, which already has large producers and reliable customers, would try to resist and prevent the new product to enter the market. Another problem would be that the construction industry is not familiar with the geocomposite and it would be hard to find the application in other industries and get acceptance from them.

A circular economy ecosystem requires a big number of actors to fill the needs of the ecosystem as a whole. Geopolymer ecosystem also encompasses a very large spectrum of organizations, including private companies and educational institutions. This becomes a source of *social risks* in the circular economy ecosystem. Some of them share some functions, some of them are more actively participating, some of them are more independent. Being a member of such a circular economy project means having common goals and sharing interests. However, companies and organizations have their own business or research interest and their own point of view. They are ambitious to some extent. There is a risk of not getting enough alignment of personal and shared goals between the participants, which would block the development of the circular economy. Lack of trust and lack of cooperation is a related risk as well. Communication and coordination of a big number of players are challenging.

“There is always risks that when you have many stakeholders at the same table that someone gets very greedy and they start blocking the whole development.”

Interviewee J

Moreover, *technological risks* take place in the circular economy ecosystem. Technological risks, first of all, are existing due to some limitations. As it was already mentioned earlier, locality of the circular economy ecosystem implies the utilization of local side-streams. In a technological point of view, this creates limitations on the materials that might be used for the recipe development and future geopolymer production. That is why, interviewees have questioned the ability to find a recipe that would work with the local side-streams, like tailings and ashes. The risk is a part of the material development phase, which raises questions of possibility to create geopolymer out of the locally available side-streams. Another limitation is the applicability of 3D printers that are considered to be a beneficial solution for construction. The challenge that exists at the moment is how the available 3D printers could create more complicated shapes, as at the moment technologically they can only create rather straight walls. There might be a risk that the project partners do not have the best technology that is available on the market, or even aware of the best available technology.

In the technological point of view, there is definitely a need for more research and development both in the recipe development and additive manufacturing technology development. It is not yet clear what recipe would work the best and how the technology will work after the geocomposite will be produced. A lot of testing and piloting is needed before the technology can be actually applied for production and geopolymer concrete can be used for construction purposes. This leads to the risk of arising problems when applying the technology on a bigger scale. Even with successful results of smaller-scale tests and pilots, when shifting to big scale production the ecosystem might face unexpected challenges and problems. Altogether, the novelty of all the elements creates a lot of technological risks.

"Everything changes when you go from the lab scale to the pilot and then to the real life." Interviewee H

The circular economy ecosystem’s partners have also mentioned *environmental risks*. They are related to the harmfulness of the materials used for the production of geopolymer. The first risk in this field is that some materials might be toxic or might negatively affect the safety of the final product, which will not be safe for the user. Another environmental risk includes possible leakages of materials being used to the surroundings or groundwater. Also, dry materials are considered to be risky in terms of environmental safety, as they can dust in the air during the works with them or during transportation. Finally, as the products that will be produced are aimed to be sustainable, it should be taken into consideration that the sustainability of the material varies depending on the quantity and kinds of input materials. For example, dependent on the quantity of alkali used, geopolymer might be more sustainable or less sustainable.

To summarize, the risks mentioned by the interviewees are rather challenging and it is important to take them into consideration on the early stages of the circular economy implementation. All the risks discussed in the interviews are illustrated in Table 10. It is visible from the table that *economic* and *technological* spheres have the most significant number of risks mentioned during interviews. Economic side and challenges on the market seem to have a big influence on the ecosystem. Technological risks are mainly caused by the novelty of all the elements in the circular economy, which creates uncertainty and, therefore, risks in technical aspects. Also, it should be noted that even though *legislative* risks are not very high in number, they were mentioned by the interviewees in a very similar way many times. This fact made the author conclude that legislative risks are very critical for the circular economy ecosystem and they require a lot of attention.

Table 10. Risks of the circular economy within geopolymer ecosystem

PESTE	RISKS
Political + Legislative	Regulations and laws are tight to get new products into the market
	Classification of the materials as wastes and side-streams creates new obstacles to use them for production
	Legal approval of new materials and products requires a lot of resources (both financial and time)
Economic	Possible increase of the price for side-streams used in the recipe
	Initial high price of the ingredients in the recipe and the final products
	Additional investments needed in the pretreatment processes for bigger volumes
	Market is not ready for this kind of business
	Resistance from the industry of conventional concrete
	Competition from the similar product developers
	Volumes of the side-streams available might be not enough for production
	Location-specific availability of side-streams and their price
	Lack of application in other industries and acceptance from them
Social	Big number and variety of actors are not easy to communicate and collaborate
	Lack of alignment of personal and shared goals of the participants
	Problems of getting social acceptance of the new products
Techno-logical	Limited applicability of 3D printers
	The project partners do not have the best technology that is available on the market
	Development of a recipe is limited to the side-streams available locally
	Problems when applying the technology on a bigger scale
	More R&D is needed before technology will be ready (both recipe development and additive manufacturing)
	Novelty of all the elements creates a lot of technological risks
Environ-mental	Safety issues when working with liquid and powder materials
	Possibly hazardous materials used
	Leakage of materials being used
	Sustainability of the product depends on the ingredients used

5.2 Benefits of the circular economy within geopolymer ecosystem

Benefits of the circular economy ecosystem discussed by the interviewees have been mainly emphasizing the future advantages and positive outcomes that will be available because of the circular economy ecosystem's functioning. Starting from the *political and legislative field*, successful implementation of the circular economy products and establishing the ecosystem, based on the circular economy, will mean legislative approval of side-stream usage for the production. This will make it possible to improve the existing legislation to make the whole process of getting a product status for circular economy products easier in the future, and more circular economies could be launched in Finland in the future. Establishing the local circular economy ecosystem would be an input for legislation improvements for the future circular economies globally.

The circular economy ecosystem is believed to be very beneficial in the *economic point of view* for regional development. The circular economy will create new businesses in the area and new companies will come to the region. Moreover, the circular economy will support the local companies and create new opportunities and new forms of cooperation for organizations involved in the ecosystem, which will help them to grow and develop. Participants of the circular economy ecosystem might also get a reputation of a "green and more sustainable" company, which is of course very beneficial in terms of increased loyalty and, as a result, higher sales. Another aspect of economic benefits refers to the local manufacturers generating side-streams that will be used for geopolymer. For them, this will also be an economic benefit because their side-streams will be taken into production covering the costs of storing them instead.

The properties of the circular economy's products can bring economic benefits as well. Particularly, the geocomposite is known to be more durable than traditional concrete. In this case, buildings made out of it will have to be renovated after a longer period of time, which means that fewer costs are associated with maintenance of geocomposite structures. Also, unique properties of the geocomposite, such as fire-resistance, durability, printability, recyclability, sustainability, are justifying a higher price of the geocomposite, compared to the conventional concrete. The properties of the geocomposite make the material more attractive in comparison to the characteristics of the conventional concrete. Another source of the economic benefit comes from the construction process associated with geocomposite. The material dries faster than traditional cement, which allows making the construction process faster and more economically wise. Eventually, in spite of the fact that the material might be more expensive than the traditional alternative, its characteristics can bring more economic benefits in the future.

The circular economy ecosystem would have a positive impact on the *social sphere*. New businesses and companies coming to the region and local developing companies will be able to offer new job opportunities for local specialists. This will positively affect the employment situation in the area. Additionally, the circular economy in a region will be a good attraction for citizens to stay or even come to the region, because of better employment situation and sustainability of the region and opportunity to feel personal involvement in an environment-related project. Nowadays more people choose the more sustainable and environmentally friendly way of living.

“A lot of people want to get away from city life and a polluted lifestyle to come to a much more safe environment and much cleaner environment.” Interviewee D

That is why the circular economy might be an attractive factor to stay or become a citizen of such a region, to be a part of a circular economy culture.

“*People will think I am part of the solution, not part of the problem.”*

Interviewee C

On the other hand, the culture of a more sustainable living creates a strong message to the rest of society to change the behavior, which is another social benefit of the circular economy ecosystem. Part that is the most visible for the citizens is the city's architecture. With the help of additive manufacturing, it is possible to create new shapes of buildings, which will be more esthetic. This will attract the citizens as well and grow the interest of the new technologies used to create such forms.

This new kind of technology and material development will be a big step in the research in technology development. One can consider the achieved results as *technological benefits,* as the outcomes of the current research will be a good base for future research in this field. Knowledge of the input materials, environmental advantages and disadvantages of different recipes, ingredients and activators will be beneficial for further research in this field. Particularly, in material development, the properties of the geopolymer have already been studied. For example, it is known to be more durable, fire resistant, fast drying, printable, recyclable. In the technological point of view, such properties of the circular economy product are very beneficial.

Furthermore, another advantage of technology development in that the circular economy might be an impulse for small local companies. As mentioned before, the ecosystem creates a very organized collaboration between companies, and smaller technology development companies might benefit in a way that they will be able to get support in the ecosystem to develop the technology. In addition to that, it is possible that the technology would be applicable in other industries. It was mentioned that even the conventional concrete industry might get some ideas out of the material development to create a greener concrete. Altogether, the technology development in the circular economy is considered to boost the related fields of technology and material development in the future.

"*It's a technology, once it's fully developed and produced, it could be a benefit to the industry, it's a benefit to the research world, it's a benefit to concrete industry as a whole, because they could also adapt it to their industry and also produce a type of concrete." Interviewee D*

Finally, the circular economy ecosystem would have significant benefits for the *environment.* As the main idea of the circular economy, the material flows will be looped, which means that the materials will be circulated and, as the resources for production, side-streams from local manufacturing will be utilized. This creates the first environmental benefit of the new implication of the side-streams. They will not be considered as a reject from the industries, instead, they will be used purposefully as materials for a new material's production. This creates a loop effect. Consequently, the new implication of side-streams reduces the amount of natural resources being used, as they are replaced by the recycled side-streams. From the environmental point of view, production of the new kind of material reduces energy consumption and water consumption, compared to conventional concrete production. This will also decrease the emissions of CO2 and environmental impact. As the circular economy product itself will be more sustainable, will have a longer life cycle and will be easier to recycle, it will be highly beneficial for the environment.

Overall, the interview participants were assessing the situation of the circular economy in the ecosystem in a positive manner. Various benefits have been mentioned during the interviews. Benefits that were highlighted by the interviewees are demonstrated in Table 11. Mostly the region is benefitting from the circular economy ecosystem in terms of economic and social development, which does not affect the environment in a negative way, but alternatively has a positive impact on the sustainability profile. Additionally, results in the technology and recipe development might be a good base for further research in a similar sphere of geopolymer production or circular economy implementation in a general view.

Table 11. Benefits of the circular economy within geopolymer ecosystem

PESTE	BENEFITS
Political + Legislative	Improving legislation for the circular economy products
	Easier process of approval for similar circular economy products in the future
Economic	New opportunities for new companies in the ecosystem
	Properties of the product will justify the higher price
	New forms of cooperation and new opportunities for companies involved in the project
	Beneficial influence of increased reputation for the companies
	Money savings in the long run because of better product's properties
	Cost-efficient use of side-streams for companies instead of storing them
Social	It might create new jobs
	It might attract or retain people to stay in this region
	Esthetic forms of new buildings
	Personal participation in an environment-related project
	Strong message to people to change the behavior
Techno-logical	Results will be beneficial for future research and technology development
	Beneficial properties of the new material
	Impulse and ideas for conventional concrete industry to evolve
	Impulse for local technology development companies
	Future application in other industries
Environ-mental	New implication of the side-streams
	Less materials will go to landfill
	Reduction in the use of natural resources
	Reduction in CO2 emissions
	Advantages of the new materials: easier to recycle, longer life cycle, more sustainable

5.3 The most influential factors for the circular economy ecosystem

Apart from the risks and benefits discussed by the circular economy partners from different perspectives, there are some factors that are believed to be the most meaningful in the circular economy of the geopolymer ecosystem. These factors are those that might influence in the most dramatic way. One of such factors, which is the most unwanted one, is the risk of failure to develop the material and any business out of it, and eventually, this would mean a failure of the project realization. This is the most unfavorable result that any party is willing to avoid because this result would mean a waste of financial resources invested in it, waste of time of all the actors and inability to achieve any of the goals of the project. This risk drives every actor of the ecosystem to work more actively and avoid such an unfavorable result.

“The biggest risk is that everybody is wasting their time and nothing new is developed. No new material, no new business, and it just doesn’t work – that is the biggest risk.” Interviewee B

Secondly, a significant factor was named to be the locality of the side-streams. The volumes of the side-streams that are considered to be used are limited locally. Even though some of them are being continuously generated and stored, there is an anxiety that in the future this amount might be not enough for massive production of geopolymer products. As it was discussed previously, the idea of the circular economy ecosystem implies local side-streams’ utilization. Therefore, local availability of the side-streams suitable for the geopolymer production purposes should be confirmed. Otherwise, transportation of the missing materials from distant locations would increase the costs and the price of the geopolymer. Another economic risk considered as a very serious one is the necessity of very vast pre-treatment procedures that would significantly increase the final product’s price. The pre-treatment procedures might be needed, because of heterogeneity of the side-streams coming out from factories. To be able to proceed with the materials, this might require expensive pre-treatment work, which would heavily rise the product’s price and question its attractiveness.

Thirdly, the economic attractiveness of the circular economy is believed to be questionable for private companies involved in the ecosystem. Companies should see the business potential of the circular economy, even if it is considered to be later in the future. They need to see a reason to invest their time and money into the material and technology development not only from the environmental perspective and enthusiasm but also from the economically reasonable business opportunities. This would keep the high interest of the companies in the circular economy ecosystem, and it will put the project in the high priority list, as it is considered to be promising for companies.

Fourthly, the question of acceptance of the circular economy products is recognized as a very serious one. Even if the final product meets all the legal criteria and is fully accepted by the legislation, it doesn't necessarily mean social acceptance. The new product should gain social trust and comfort to be used in daily life. If people do not feel comfortable to use it, there is no social acceptance and it is believed to be a significant risk for such circular economy product. Particularly, the success of the geocomposite's acceptance is also discussed in relation with the acceptance from the conventional concrete industry, which might be a powerful tool for the future expansion of the geocomposite materials into the market. In turn, the idea of scaling the concept of the circular economy up to other locations, producing another kind of products, encourages the local companies. In case of successful implementation of the circular economy at the local level, parties are interested to expand the idea of the circular economy to other places, which is one of the options of the business potential discussed above.

At the same time, the fact that there will be a new implication of the side-streams is one of the most appealing drivers for the ecosystem's actors, supported by the volumes of side-streams already being stored and continuously being generated. The idea that the product will be the circular economy product and it will be more environmentally friendly because of the materials it is made of, and also, because of its sustainable properties, is reflected as the companies' enthusiasm to find a more sustainable way of doing business as well as their personal commitment to the environmental targets. Enthusiasm to start such environmental innovations also spreads this kind of ideas to other business and becomes a global idea. This might be also visible from the demand, as more customers are willing to pay extra for sustainable products. There is a clear need for a more sustainable solution in the construction industry.

"The beauty of the project is that we are looking at the local realities, and the possibilities to copy or take this concept to somewhere else to other reality so that the volumes and the business opportunities can be multiplied."

Interviewee E

Another strong side of the ecosystem is the variety of stakeholders that are involved. Private companies, research organizations, waste-stream producers, coordinators, each partner has a specific role in the ecosystem, but all of them share common goals. Also, such a diverse entity of stakeholders create a very rich platform for experience sharing, as professionals from different spheres are actively involved. Nevertheless, at the moment there are missing elements in the ecosystem: geopolymer producer and civil construction organization. Geopolymer producer is the new business that is aimed to be created when everything will be arranged for geopolymer production, including the recipe and technology of the material. The civil construction company was mentioned to be a missing element in the ecosystem, as the product is targeted for construction purposes, and it is believed that there might be not enough expertise of the construction works.

Even though, the legislation was discussed to be a barrier to get the circular economy product in to the market, because of a big number of regulations it should comply with, legal difficulties to work with the side-streams and a very long-lasting period of getting a product status of the final product, there are certain shifts in the legislation, encouraging such environmental initiative. For example, the EU Waste Framework Directive (Directive 2008/98/EC) states that 70% of the construction and demolition wastes are to be re-used and recycled by 2020. This might give an impression that the legislative side is rather controversial, as there are incentives to recycle more materials, but on the other hand, it works as a barrier towards the circular economy products implementation. In fact, the legislation has both sides: encouraging to recycle more and restricting the use of side-streams due to safety reasons. Thus, discussion with the legislative authorities is needed for a successful launch of the circular economy products on the market.

5.4 Discussion

Researchers have emphasized some risks and benefits of the circular economy ecosystem, which were discussed in the third part of the thesis. Actors of the circular economy ecosystem of South Karelia region have mentioned some risks and benefits that are similar to those that were discussed in the literature. Nevertheless, there are aspects that should be taken into consideration by the ecosystem's actors, because they might cause warns according to the researchers' point of view.

As political and legislative risks are considered to be a barrier by the ecosystem's actors, a lot of attention is allocated to the discussion with the authorities about the needed changes in the legislation that would ease the use of wastes and side-streams in the production and therefore encourage the circular economies (Aid et al., 2017; Masi et al., 2017; Velenturf et al., 2018). Both, the researchers and the local ecosystem's actors describe the process of the circular economy products' legal acceptance as very time-consuming (Aid et al., 2017), which is why the early communication is essential to succeed in the implementation of the circular economy products. As discussed in the theory part of the thesis, the regulatory system focuses mainly on the wastes and the limitations to using them, which is justified by the necessity to ensure the safety of the final products. However, it is argued that the legislation should consider the whole cycle of production and value resources, including the wastes, but not limited to the wastes. (Aid et al., 2017; Masi et al., 2017) This idea might be a leverage for the actors of the circular economy ecosystem of South Karelia region for the communication with authorities regarding the changes in the legislation. Another possibility for the regional circular economy to make a change in the legislation relates to the lack of guidance and information on how to use the wastes and side-streams further in production processes. This might be a good opportunity for the South Karelia circular economy to give input to the legislation changes.

Literature review on the political and legislative benefits of the circular economy ecosystem did not reveal any benefits in this field, although the actors of the local circular economy ecosystem consider the possibility to influence the current legislation as very beneficial for the future applicability of the circular economy practices. Experience of the circular economy products' acceptance and changes in the legislation that the circular economy ecosystem might make, will ease the process of approval for similar circular economies in the future. This will encourage to launch more circular economy projects in Finland and globally in the future.

Regarding the economic perspective, expensiveness of the circular economy products has been mentioned many times. In the literature, such elements as a specific technology, operational spendings, transportation costs, waste handling costs, additional administrative costs and maintenance costs are discussed as the reasons for the high price of the circular economy products. (Aid et al., 2017; Masi et al., 2017) Similarly, the price of the geopolymer circular economy ecosystem's products is estimated to be high. The reason for that high price was mentioned to be a big number of processes involved in the process of production. Especially vast pre-treatment procedures were emphasized to be costly and increase the final product's price. Not only the pre-treatment would be expensive, but it might require significant investments in the production sites to be able to provide a certain level of quality of the materials on a big scale. Also, in the local ecosystem, such factor as an increase of the local side-streams' price was highlighted several times as a reason for the risen costs.

In addition to that, the regional ecosystem should take into consideration the need for qualified and experienced employees, which might be also additional costs but they are very necessary for a new type of business. On the one hand, the circular economy requires a lot of investments and it is associated with high costs and a lot of processes involved, on the other hand, it creates a “green label” and an image of a sustainable company for actors involved in the ecosystem. This opens new business opportunities for companies and creates a competitive advantage for them. The actors of the local ecosystem also believe that the properties of the final product will justify the high price of it. Compared to the conventional concrete, such characteristics as durability, fire-resistance, recyclability, sustainability, and easiness to construct were discussed to bring a competitive advantage over the traditional concrete. Also, there is an opportunity to get some benefits related to taxation, particularly, reduced waste tax, as the amount of wastes coming to the landfill will be decreased.

Another aspect related to the locality of the ecosystem brings both risks and benefits. On the one hand, the proximity of the sources of the side-streams and the manufacturing sites allows to ease the communication and decreases the operational costs, including transportation. On the other hand, the region has a limited volume of the side-streams. Even though the volumes are quite big and they are continuously generated, if the production in the circular economy scales up, the ecosystem has to make sure that there are enough of materials for the circular economy in the long run. Also, the locality of the side-streams used in the circular economy puts limitations on the material’s recipe, which is aimed to be produced from the local side-stream flows. This brings challenges at the technological sphere as well. There might be some technological solutions available on the market, but the problem is that they are suitable for a particular symbiosis. Customization for the local reality and locally available side-streams is needed before the technology can be fully applied in any region.

The circular economy ecosystem has also external risks. These risks come from restrictive market conditions, which are related to the conventional concrete industry. As it has been discussed in part 3, the concrete industry is a very old and developed industry with large companies and established relationships with customers from the construction industry. As the circular economy product – geocomposite – is mainly aimed to be used in the construction industry, it was argued that there might be resistance from the conventional concrete industry. One of the solutions of the problem was named to be a collaboration with the conventional concrete industry so that it could partly use the technology in the concrete production to make new kinds of green and more sustainable concrete. This way would also open the possibility to reach new markets and scale up manufacturing.

Despite the expensiveness of the final products and challenges associated with the circular economy, researchers and the circular economy's participants claim that the ecosystem has a positive influence on regional development. Not only it supports the local companies and encourages SMEs to develop, but it also attracts entrepreneurs and new companies to the region, as it is considered to be a new opportunity for them. Consequently, it creates new job opportunities and attracts new specialists to come to work in the region or stay here for a longer period of time. In addition to that, a common trend to be more sustainable in everyday life and a possibility to feel personal involvement in the environment-related project and the green city attracts citizens and creates a good feeling for the community.

Taking into consideration what the researchers have previously studied about the interactions inside ecosystems, the synergy effect that is possible when collaboration between actors is very tight, is achievable only when companies have common goals and share the information between each other. Nevertheless, as the actors of South Karelia ecosystem have emphasized, the number of actors of the ecosystem is big and it makes it difficult to organize effective communication between such a big variety of organizations. Also, the risk comes from the fact that they have their own business or research interest. A lack of alignment of personal and shared goals of the ecosystem's participants was named to be a risk questioning the success of the circular economy ecosystem. One of the reasons for such difficulties discussed in the literature was mentioned to be a belief in the unfair division of returns in the future. This should be discussed on early stages of communication between participants to avoid misunderstanding.

Despite the fact that no technological benefits have been identified form the literature, the actors of South Karelia ecosystem have a positive opinion about the technology being developed in terms of the circular economy ecosystem. The technology is believed to be beneficial for future research in the same field or it might be an impulse for the conventional concrete industry and construction industry. Altogether, the ecosystem's participants see the whole process of technology development as a beneficial base for future research and development. Also, the technology and the final geopolymer product do not cause any warns regarding the safety for consumers, as the actors of South Karelia ecosystem consider the possible safety issues as a high priority and believe that all the necessary tests are made to ensure the safety for users and environment. On the other side, interviewees mentioned that the testing and piloting is usually done on a smaller scale, while they agree that applying a novel technology on a bigger scale might cause unexpected problems even when having successful results of laboratory tests, which causes another technological risk. The aspect of the safety of a new circular economy product was emphasized in the literature as a potential technological risk as well, as the whole circular economy is believed to be very novel and lack of experience might cause this kind of risk.

Considering the environmental effect of the circular economy, both the literature review and the interviews revealed a very strong positive influence of the circular economy on the ecosystem. New implications of the side-streams and wastes are very promising in terms of a decrease of the landfill used for storing the side-streams and wastes, and in terms of natural resources extraction. The researchers and the local ecosystem's partners also mentioned the reduction of emissions, caused by production, and enhanced sustainability profile. Especially, the characteristics of the geocomposite, which were discussed before, can increase sustainability, but it depends particularly on the ingredients used in the recipe. The circular economy creates significant benefits for the environment in many aspects, and there were no risks found from the literature related to the environmental point of view. However, the partners of the local circular economy ecosystem have mentioned a few risks that should be considered in the geopolymer production. Possible harmfulness of the materials is one of them, especially any leakages to the surroundings or water would dramatically affect the environment. Also, possible dry materials can dust in the air, which also causes emissions and is harmful for nature and humans. As mentioned before, the partners claim that all the possible environmental risks are minimized by precise preparations and testing, but this environmental risk should be still taken into consideration.

6 CONCLUSION

This research was meant to answer the research questions that were discussed in the beginning of the master's thesis. This chapter will give the answers to the research questions followed by limitations of the study and suggestions for future research.

6.1 Answers to research questions

The aim of this master's thesis was to study the circular economy within geopolymer ecosystem for South Karelia region. The main research question presented in chapter 1.1 was: "*What are the risks and benefits of the circular economy within geopolymer ecosystem for South Karelia region?"* The empirical study and the literature review revealed a lot of risks and benefits of a circular economy from different perspectives. It is difficult to highlight a particular aspect, which brings the most of the risks or the majority of benefits, as a circular economy is known to be a complex approach (de Jesus and Mendonça, 2018), however, some spheres were more precisely discussed in the literature or during the interviews, which suggests the most influential spheres for the local circular economy ecosystem.

The results of the study indicate that in general legislative, economic and technological risks have a high priority for the local circular economy. These three factors accumulate the majority of the risks discussed both in the literature and in the interviews. Legislative risks are mostly related to the barriers in regulations to apply side-streams as a material for production. Tight legislation and environmental law cause challenges to bring a new product, in which side-stream materials are used during production, into the market. This fact creates a necessity for an active discussion with the authorities towards changes in the regulations, which, in turn, requires a lot of efforts and resources. Legislation in the field of a circular economy is not supportive and it doesn’t have enough guidance for handling side-streams in circular economies (Aid et al., 2017; Masi et al., 2017). Moreover, the economic dimension of the local circular economy brings a lot of concerns in the ecosystem. Due to the novelty of the production technology and high initial investments in pretreatment processes of side-streams, a risk of the expensiveness of the final product arises. Additionally, limitations of the local availability of the side-streams increase the economic risk. Also, there are some economic restrictions that the market brings, such as resistance from the industry of conventional concrete, competition from similar product developers and lack of application in other industries. Such an extensive list of economic risks makes them one of the primary spheres of risks to mitigate in order to secure the success of the circular economy ecosystem. Finally, the novelty of the elements of the circular economy creates high technological risks. The elements include material recipe development, technology for material production development and development of construction technology. These elements require a lot of R&D and piloting, though more technological risk might arise when applying the technologies on a bigger scale.

It should be noted that social and environmental risks didn’t get much attention in the literature and during the interviews, though difficulties in communication and alignment of a big number of stakeholders is one of the internal social risks of the circular economy ecosystem. The geopolymer ecosystem does a lot of research on environmental impact of the side-streams and materials used in the recipe. That is why environmental risks are minimized, though the sustainability of the final product and its safety for the environment and the consumers should be under control to mitigate the environmental risks.

The results of the benefits of the circular economy ecosystem identified in the thesis reveal that such an initiative creates a lot of advantages for the region where it is situated and the local community. In the long term, the region benefits from the circular economy in terms of increased economic development, which is decoupled with an environmental burden as such. Environmental pressure is decreased by new implications of side-streams, decreasing the share of landfilled flows. Moreover, the use of side-streams results into a slowing down of natural resource depletion, as the side-streams available, processed in a particular way are able to replace the natural resources in qualities and quantities for the purposes of geopolymer production. Moreover, economic development of the region is positively influenced by the circular economy, as it boosts the local companies and attracts new business in the region. Thus, the local community is also positively affected by the circular economy by increased job opportunities and raised the interest of the circular economy. In addition to the benefits specifically for the region and local stakeholders, the implementation of the circular economy products into practice would mean a technical shift in the material development and approval from the regulatory side, which is believed to be a great benefit for further circular economy development.

The sub-questions of the research were supporting the main research question and helped to see the picture of the circular economy more extensively. The first sub-question was: "*What are the characteristics of the circular economy ecosystem of South Karelia region?"* The ecosystem's central attribute relates to the aims of closing the material loop and creation of more sustainable material, in other words, it is has a precise focus on eco-innovations. Additionally, geographical proximity plays a role in the ecosystem, as it creates a cluster, in which different organizations located in the same region share knowledge and information, and exchange of material flows is targeted to be performed inside the cluster. Moreover, the circular economy ecosystem has a characteristic of the diversity of actors. The spectrum of industries and types of organizations involved in the circular economy is diversified. As it was discussed in chapter 4.1, organizations have their own roles in the circular economy. Despite the difference of the companies and organizations and their own interest in the ecosystem, they share the general goals of the circular economy and eco-innovations in the region. This brings another characteristic of the circular economy ecosystem – a collaboration between industries and organizations. This set of main characteristics of the circular economy ecosystem confirms the theoretical findings from the literature as a meso-level implementation of circular economy (Ghisellini et al., 2016) and the definition of the circular economy ecosystem suggested by Aminoff et al. (2017), which was discussed in chapter 2.4.

A study of functions and roles of the ecosystem's participants allowed to describe the structure of the ecosystem of South Karelia region. The second sub-question explores: "*What is the structure of geopolymer ecosystem of South Karelia region?"* The answer to this question is based mainly on the empirical study, as the structure of the ecosystem represents the main functions of the ecosystem's actors, which were derived from the empirical study. Geopolymer ecosystem is based at the moment on four main functions: knowledge creation and sharing; supply of materials; technology, design and production; and coordination and implementation. These are the functions divided between the actors of the ecosystem. Nevertheless, additional functions that are necessary for full-value functioning of the circular economy should be added to the structure. These functions include the manufacturer of geopolymer material and a civil construction organization. The geopolymer manufacturer is currently the missing element of the ecosystem, as such an organization will be a new central business in the geopolymer ecosystem. A civil construction organization was mentioned to be a missing element in the ecosystem, as the expertise of construction organization would be beneficial for a product targeted for construction purposes.

Practical implication of the results of the master's thesis is that the results of the study could help to mitigate the risks that might arise in the future of the circular economy development in the South Karelia region and minimize the negative outcomes by foreseeing undesirable outcomes from different perspectives. In contrast, identified benefits are the most intended results affecting the ecosystem's actors and South Karelia region. The findings of the study could be used to focus on the benefits and strengthen their effect. Knowledge of the characteristics and structure of the environment, where the circular economy operates, create additional leverage for risk mitigation and strengthening of benefits for the region.

6.2 Limitations and suggestions for further research

The research has some limitations that should be taken into consideration. Firstly, technological details of geopolymer recipe development and production are excluded from the current research. This was done to focus on the circular economy ecosystem. Secondly, the results of the research are limited by the early stage of the circular economy implementation. At the moment research and development are actively being performed, but it is still an early stage of implementation, as the production of geopolymer has not yet started and the ecosystem is not fully formed. Thus, the results of the study represent the current state of the circular economy ecosystem. Thirdly, results of the empirical part are based on nine interviews conducted internally in the ecosystem, meaning that no external opinion was taken into consideration in this master's thesis. This brings a suggestion for further research to study what risks other circular economy related projects are facing and what benefits they are generating by a circular economy.

This study has a very narrow focus on the circular economy within geopolymer ecosystem of South Karelia region, but some suggestions on a further study regarding a broader view of circular economies' development can be given. Comparison of the current results with other circular economies in Finland and in other countries could be a good option for further research. Also, further exploration of risks and benefits of a circular economy can be continued by quantitative research in this area, providing validation of the qualitative results. To summarize, the study showed that there is a research interest in the field of circular economy ecosystems. As this is a rather new concept, not so much research has been done in this area and not so many cases exist, it is an appealing field of study.

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APPENDICES

Appendix 1. Interview form

What is the role of the company in the circular economy ecosystem?

Main interview questions:

What is the biggest risk in such a project related to circular economy?

What is the most significant benefit in such a project related to circular economy?

What are the risks in launching such circular economy ecosystem related to **political and legislative** point of view?

What are the risks in terms of **economic** perspective?

Do you see any **socio-cultural** risks in launching such products?

Are there any **technological** risks?

What are the risks related to **environmental** field?

What benefits do you see in launching such circular economy ecosystem related to **political and legislative** point of view?

What are the benefits in terms of **economic** perspective?

Do you see any **socio-cultural** benefits in launching such products?

Are there any **technological** benefits when producing circular economy products?

What are the benefits related to **environmental** field?

Additional questions

What are the drivers of creation of circular economy ecosystem?

What barriers do you see?