LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY LUT
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Degree Programme in Industrial Engineering and Management

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COLLABORATIVE ECOSYSTEMS IN THE DECARBONIZATION OF CITIES: MAIN DRIVERS, BARRIERS AND REQUIREMENTS

Master's Thesis

Examiners: Professor Timo Kärri
Post-Doctoral Researcher Sini-Kaisu Kinnunen

ABSTRACT

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Title: Collaborative Ecosystems in The Decarbonization of Cities: Main Drivers, Barriers and Requirements

Year: 2021 **Place:** Helsinki

Master's thesis
Lappeenranta-Lahti University of Technology LUT
School of Engineering Science
Degree Programme in Industrial Engineering and Management
79 pages, 12 figures, 11 tables and 1 appendix
Examiners: Professor Timo Kärri, Post-Doctoral Researcher Sini-Kaisu Kinnunen

Keywords: decarbonization, carbon-neutral city, business ecosystem, ecosystem, drivers, barriers, requirements, public sector ecosystem, sustainability, collaboration

International climate policies are aiming for an equilibrium of carbon emissions and sinks. Most of the emission reductions need to be done rapidly by the year 2030. Cities have declared ambitious carbon-neutrality targets and need others from the private and third sectors to collaborate in order to reach the targets. The ecosystem approach is studied as a dynamic structure, which is both collaborative and competitive, to solve complex issues such as the decarbonization of cities.

The purpose of the thesis is to study the various drivers, barriers, and requirements for ecosystems that are aiming to decarbonize cities. The study is conducted by reviewing the topic from the perspective of ecosystems literature, decarbonization literature, and interviews within selected Finnish cities. In addition, the study aims to provide guidelines for successful ecosystems in city decarbonization. The main research method used is semi-structured interviews in eight Finnish cities. The goal was to include a diverse mix of respondents from cities of different sizes and locations. Furthermore, city representatives in the study have different roles in the city organizations, such as development manager, environmental planner, director and mayor.

Identified drivers for decarbonization ecosystems are business value, innovations or, for example, knowledge creation, and sharing. These all can bring economic benefits for cities, such as new jobs, cost-efficiency and new business opportunities. However, scarcity of resources in both available time and money is the most considerable barrier that cities face in their ecosystems for decarbonization. Other barriers arise from communication, which affiliates with building of trust and the alignment of interests between ecosystem participants. The ecosystem participants should be diverse, complement each other's capabilities and should have something concrete to contribute to the ecosystem. In addition, in the transformation to carbon-neutral cities, the city-specific strengths should be considered and the collaboration to support those should be facilitated.

TIIVISTELMÄ

Tekijä: Vilma Saari

Työn nimi: Yhteistyö ekosysteemeissä kaupunkien hiilineutraaliustavoitteissa: ajurit haasteet ja edellytykset

Vuosi: 2021 **Paikka:** Helsinki

Diplomityö
Lappeenrannan-Lahden teknillinen yliopisto LUT, Tuotantotalous
79 sivua, 12 kuvaa, 11 taulukkoa ja 1 liite
Tarkastajat: Professori Timo Kärri, Tutkijatohtori Sini-Kaisu Kinnunen

Hakusanat: dekarbonisointi, hiilineutraali kaupunki, liiketoiminta ekosysteemi, ekosysteemi, ajurit, esteet, vaatimukset, julkinen sektori ekosysteemissä, kestävä kehitys, yhteistyö

Kansainvälinen ilmastopolitiikka pyrkii hiilipäästöjen ja hiilinielujen tasapainoon, eli hiilineutraaliuteen. Suurin työ päästöjen vähentämisessä täytyy tehdä nopeasti, vuoteen 2030 mennessä. Kaupungit ovat julistaneet kunnianhimoisia hiilineutraaliustavoitteita, mutta tarvitsevat yhteistyötä yksityiseltä ja kolmannelta sektorilta niihin päästäkseen. Kaupunkien hiilineutralisointi on monimutkainen ja laaja ongelma, ja ekosysteemit ovat yksi mahdollinen ratkaisu vastaavien ongelmien lähestymisessä. Ekosysteemi on dynaaminen yhteistyön muoto, joka sisältää sekä yhteistyön että kilpailun ominaisuuksia.

Työn tarkoituksena on tutkia ajureita, haasteita ja vaatimuksia kaupungin hiilineutraaliuteen tähtääville ekosysteemeille. Aihetta tutkitaan kirjallisuuskatsauksena ekosysteemiteorioista ja hiilineutraaleista kaupungeista, sekä suomalaisiin kaupunkeihin kohdistuneiden haastattelujen pohjalta. Lisäksi tutkimus muodostaa ohjenuoria kaupungin hiilineutraaliuteen tähtääville ekosysteemeille. Haastattelut toteutettiin teemahaastatteluina kahdeksassa suomalaisessa kaupungissa. Tavoitteena oli saada monipuolinen otos vastaajia erikokoisista ja eri puolella Suomea sijaitsevista kaupungeista. Lisäksi haastatellut edustivat erilaisia rooleja kaupungeissa, tehtävänimikkeinään mm. kehitysjohtaja, ympäristösuunnittelija, johtaja ja pormestari.

Pääajurit kaupungin hiilineutraaliuteen tähtäävissä ekosysteemeissä ovat liiketoimintahyödyt, innovaatiot, ja esimerkiksi tiedon keruu ja jakaminen. Nämä kaikki voivat tuoda elinkeinollista hyötyä kaupungeille, esimerkiksi uusien työpaikkojen, kustannustehokkuuden ja uusien liiketoimintamahdollisuuksien muodossa. Resurssien vähyys ajan ja kustannuksien osalta on kuitenkin suurin este, joka kaupungeilla on ekosysteemeihin osallistumisessa. Muita haasteita nousee esimerkiksi viestinnässä, joka on tärkeää luottamuksen rakentamisessa ja yhteisten intressien sovittamisessa. Ekosysteemin jäsenien pitäisi olla monimuotoisia, toisiaan tukevia osapuolia, ja jokaisella pitäisi olla jotakin konkreettista annettavaa ekosysteemille. Lisäksi alueellisten vahvuuksien tunnistaminen ja hyödyntäminen hiilineutraaliuteen tähtäävissä ekosysteemeissä on oleellista.

ACKNOWLEDGEMENTS

Writing these forewords means that my studies have come to an end after six exciting and eventful years. From that, I would like to thank LUT University and all the friends I got to meet in Lappeenranta.

I would like to thank my thesis supervisors Timo and Sini-Kaisu, for the valuable feedback and guidance, and my thesis instructor Fredrik for the interesting thesis topic and support during the process of writing this thesis. Also, I would like to thank my employer and colleagues for allowing me to complete my studies while working. In addition, I would like to thank all the interviewed persons from cities for the interesting conversations and the time spent on my thesis.

Finally, I would like to thank you, mom, dad and sister Katri, for always encouraging me with my studies and reminding me what is important in life. Also, thank you Teemu, for your constant support and cheering during the process.

Helsinki, May 26th, 2021
Vilma Saari

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1 INTRODUCTION

This beginning chapter explores the background and motivation for the thesis. In addition, the research questions are formulated and the overall progress for the study is described.

1.1 Background

A few of the significant challenges humanity is facing are climate change, depletion of natural resources, and population growth (Rauland *et al*., 2015). These have global effects and consequences, such as extreme weather conditions, rising sea levels, drought, and biodiversity loss (IPCC, 2018; European Parliment, 2019). To overcome these challenges, international climate policy is aiming for an equilibrium of carbon emissions and sinks, in other words, net zero emissions by 2050. This target is based on the Paris agreement of limiting the temperature rise to under 2 degrees and pursuing efforts to limit the temperature rise to 1.5 degrees above the pre-industrial level (UNFCCC, 2015). To reach these targets, up to 80% of current emissions should be reduced by 2050, and the most significant effort in reducing emissions must be done rapidly, before the year 2030 (Barker and Crawford-brown, 2014; IPCC, 2018).

To understand what should be addressed in reaching the Paris agreement, in 2015, the United Nations formed 17 goals for a sustainable future. Goal 11, "*Sustainable cities and communities",* focuses merely on cities. Globally, cities play a crucial role in addressing climate change and accelerating urbanization. (United Nations, 2021) The European Union has initiated a mission for 100 European cities to be carbon-neutral by 2030, which is part of a larger strategy for climate-neutral Europe by 2050 (European Commission, 2020). In Finland, the national target for carbon-neutrality is 2035 (Koljonen *et al*., 2020). Cities act as centers for innovation and wealth, and therefore the solutions to the climate risks are likely to be found in cities (Mi *et al*., 2018).

Since decarbonization is a present global issue requiring attention and rapid actions, it is vital to assess how cities can reach the targets set to them during a relatively short time period. Research shows that networks that include governmental, nonprofit and business organizations are essential in facing complex collective action problems regarding, for example, social and environmental problems (Clarke and Fuller, 2010; Mitterlechner, 2018). Decarbonizing the

world economy is a global matter that requires collaboration between nations, industries and organizations. A city cannot become carbon-neutral on its own, and reaching the target requires collaboration across various sectors (Rosenzweig *et al*., 2015). A human-made ecosystem is a collaborative concept that can drive change in addressing such social and environmental problems (Deloitte, 2015).

Over the last decade, the concept of *ecosystem* has entered the vocabulary of different industry sectors from financial services to manufacturing, and similarly to public services' vocabulary and policy planning (Valkokari *et al*., 2014; Deloitte, 2015). The ecosystem concept is often used to describe the complex interdependencies and relationships between different actors for achieving mutual effectiveness and survival (Iansiti and Levien, 2004). Interdependencies among businesses have increased, and competition is happening increasingly between collaboration networks and business ecosystems rather than individual firms. The business ecosystem is a well descriptive expression of a modern business environment (Peltoniemi and Vuori, 2004; Salminen and Halme, 2017).

Businesses and regions should find a way to develop internationally competitive products and services in complex and difficult-to-forecast environments, which are affected by megatrends like climate change that set up boundaries for possible growth (Salminen and Halme, 2017). In a research conducted by the Finnish government, ecosystems are seen as catalysts for sustainable growth (Laasonen *et al*., 2019). Different network concepts seem to appear in trends, and due to the recent popularity of ecosystems, it has replaced some of the previously called *clusters*. Therefore the future of business is seen to have more ecosystems than previously. (Valkokari *et al*., 2014) Some other terms similar to ecosystems are, for example, *clusters, inter-organizational networks* and *value networks*. This thesis focuses on the ecosystem perspective, because the topic of the thesis is the decarbonization of cities, which is a complex issue and requires collective impact from multiple actors across sectors. The purpose is to explore the use of human-made ecosystems in cities' decarbonization plans.

1.2 Objective and Research Questions

This study aims to analyze the current use of collaboration frameworks, especially in the form of ecosystems, in cities' path towards carbon-neutrality. In this thesis, the word *ecosystem* refers to a cooperative system between multiple actors and not to natural ecosystems. The definition for ecosystem is further presented in chapter 2 and the definition for carbon-neutrality in chapter 3.

The objective is to determine the requirements for a city to join an established ecosystem or create an ecosystem for its carbon-neutrality goals and identify the main drivers for a city to be part of such an ecosystem. Also, the possible barriers such as challenges, risks and limitations are studied. Finally, the study aims to provide some guidelines for successful ecosystem projects in carbon-neutral cities based on the findings. The research questions and their respective targets are presented in Table 1:

Table 1 Research questions and targets

	Research question	**Target**
1.1	*What are the drivers for a city to join an established ecosystem or create an ecosystem with multiple actors in a city's decarbonization project?*	Recognized drivers for collaboration in ecosystems for carbon-neutral city
1.2	*What are the perceived barriers and requirements in cities' use of collaboration in city decarbonization?*	Recognized barriers and requirements for collaboration in ecosystems for carbon-neutral city
2	*What should be considered in a city's decarbonization ecosystem with multiple actors?*	Guidelines for successful ecosystems in city's carbon-neutral initiatives

Cities are chosen as a target group for this study due to their interesting position as catalysts for sustainable economies and global decarbonization. Urbanization is expected to accelerate in the future, which emphasizes the role of urban areas in solving of the climate crisis. However,

reaching carbon-neutrality in a city is not possible without the necessary impact from companies and organizations, other public authorities and citizens.

1.3 Methods and data

The research questions are answered by reviewing literature and conducting a qualitative research within selected Finnish municipalities. This approach allows to find out the underlying drivers, barriers and necessary requirements for cities to use collaboration with multiple actors in their sustainability targets. In addition, the study aims to gain an understanding of the current state of city decarbonization ecosystems and provide guidelines based on the research. The developed guidelines are targeted for cities and organizations collaborating or interested in collaborating in ecosystems for achieving a city's decarbonization targets. These guidelines aim to support the formation of ecosystems and inform what should be considered.

The literature sources used in the study are scientific articles, books, reports and other internet sources such as current news and statistics. The methodology and collected data are further introduced in chapter 4.

1.4 Structure of the thesis

This thesis consists of seven chapters and respective subchapters. The primary literature on both ecosystems and the decarbonization of cities concepts are presented and brought together in later chapters.

Firstly, in chapter 2, different ecosystem views and their shared characteristics are discussed, and a comparison to other collaboration network theories is introduced. In addition, chapter 2 includes the public sector's perspective in ecosystems and the drivers, barriers and requirements for collaboration in ecosystems. In chapter 3, the definition for a carbon-neutral system is introduced, and drivers and barriers for the decarbonization of cities are analyzed. In addition, chapter 3 includes an overview of collaboration in the decarbonization of cities. After constructing understanding of the topic from a theoretical perspective, the used methodology and interview results are introduced in chapters 4 and 5. Lastly, discussions and conclusions

from empirical and theoretical findings are presented to conclude answers to the research questions. Furthermore, suggestions for future research are recommended.

In Table 2, the structure of the thesis is presented with each chapter's initial input and conclusive output.

Table 2 Input-Output model of the thesis

Input	Chapter	Output
Background	**1. Introduction**	Purpose of the study, objective and research questions
Different ecosystem views and theories on collaboration	**2. Collaboration in ecosystems**	Drivers, barriers and requirements from collaboration in ecosystems
Theory of carbon-neutral city	**3. Decarbonization of cities**	Drivers, barriers and requirements for decarbonization of cities and overview of the decarbonization of cities in Finland
Research methods	**4. Research design**	Selected cities and interview framework
Data from interviews	**5. Results of the interviews**	Cities' answers for research questions
Theoretical and empirical findings from previous chapters	**6. Analysis and discussion**	Comparison of interview results to collected theory, answers for research questions formulated
Answers to the research questions and guidelines based on the research	**7. Conclusions**	Conclusions of the study, Answers for research questions, Recommendations for future study

2 COLLABORATION IN ECOSYSTEMS

This chapter explores the ecosystems theory and pursues to find shared characteristics from different ecosystem views. The role of the public sector as a part of an ecosystem is explored, and the drivers, barriers and requirements, especially in ecosystems where the public sector is also present, are described.

2.1 Ecosystem views

The concept of an ecosystem derives from biology. Nature and its organisms are seen as ecosystems or ecological systems, with all the species co-evolving and interacting with each other. Although this thesis considers business and organizational ecosystems rather than biological, the analogy of biological ecosystem actually supports in understanding the business network more deeply. According to Iansiti and Levien (2004): *"Like business networks, evolved biological ecosystems, from the Atlantic Ocean to the Amazon are essentially communities of entities with differing interests bound together as a collective whole"*. Similarly to the biological ecosystems, business ecosystems consist of many single entities creating a collective whole, and the business is influenced by the complex connections and interests in its ecosystem (Iansiti and Levien, 2004; Moore, 2006). Conversely, the analogy of biological ecosystems is correspondingly criticized as it may cause confusion in the overuse of the nature metaphor (Hyrynsalmi, 2014). Metaphors can make it easier to understand abstract concepts, and the business world widely uses metaphors derived from, e.g., military, sports and machinery. Nevertheless, influential metaphors could also mislead as much as they inform. (Deloitte, 2015)

The concept of ecosystems has gained distinction during recent years within research and businesses, especially in the field of business strategy, and its nature has been adapted to several different sub-groups, the significant streams being: *business ecosystem*, which focuses on the focal firm and its network; *innovation ecosystem*, which emphases new value proposition and innovation; and *knowledge ecosystem*, which centers on knowledge generation (Aarikka-Stenroos and Ritala, 2017; Jacobides, Cennamo and Gawer, 2018). Some other streams in ecosystems literature that are not further discussed in this thesis are, for example: *platform ecosystem, service ecosystem, start-up ecosystem, software ecosystem* and *industrial ecosystems*.

2.1.1 Business ecosystem

James Moore (1996) presented the business ecosystem concept to organizational management literature in the 1990s. He reasoned that a business ecosystem is *"an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world"* (Moore, 1996). Thus, companies should be seen as parts of an ecosystem, a larger network of companies and stakeholders who work together to meet the customer needs. Instead of being part of a specific industry, companies should be part of a cooperation ecosystem in which companies can cooperate, compete and co-create. The combination of cooperation and competition was coined as coopetition (Moore, 1996, 2006). This coopetition ecosystem consists of different stakeholders in the system, for example, industrial players, competitors, suppliers, customers, owners and others who are part of the same economic area and coexist and co-evolve together (Moore, 1993; Iansiti and Levien, 2004). Moore's business ecosystem structure is illustrated in Figure 1 below:

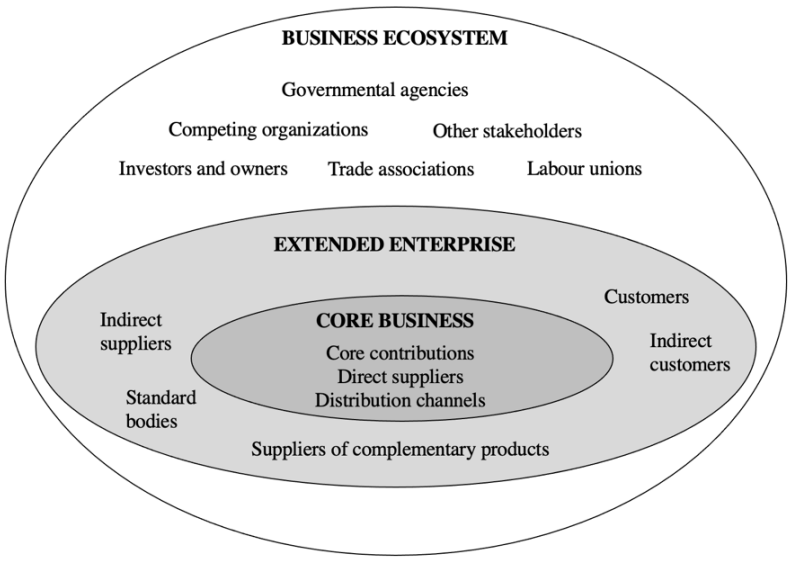


Figure 1 Structure of a business ecosystem (adapted from Moore, 1996)

Moore's business ecosystem consists of the core business, extended enterprise and surrounding business ecosystem (Moore, 1996). The core business are seen as ecosystem managers, a

"keystone firm" that provides stability to the network (Iansiti and Levien, 2004). Business ecosystems are especially embraced in the technology sector. For example, Apple envisioned its products and services as an ecosystem that provides a unified experience to its customers. Similarly, Facebook builds its 'developer ecosystem'. (Deloitte, 2015) An additional technology sector example of an established business ecosystem is Google's global ecosystem, which is built around the focal company Google, and businesses that complement to Google's platform gain additional value from belonging to the ecosystem. In conclusion, a business ecosystem allows its participants to create value that a firm could not create by its own (Clarysse *et al.*, 2014).

2.1.2 Innovation ecosystem

Where the business ecosystem's target is on creating value, an innovation ecosystem focuses on creating value with innovations, and participants are actors and institutions who enable the innovation creation (Aarikka-Stenroos and Ritala, 2017). Like business ecosystems, innovation ecosystems allow firms to create value that would be impossible to create alone (Adner, 2006). Innovation ecosystems include innovation policymakers, local intermediators and, for example, funding organizations (Valkokari, 2015). The emphasis is on understanding how the different actors can cooperate to create and commercialize innovations that are beneficial to the end customer, and gain growth for the ecosystem participants (Adner, 2006). The innovation ecosystem concept is intended for capturing the link between the core product and its components, and its complementary products and services, which together can add value to the end customers (Jacobides, Cennamo and Gawer, 2018).

2.1.3 Knowledge ecosystem

Knowledge ecosystem literature suggests that a knowledge ecosystem benefits from distributed location and enables collective learning within the ecosystem. Knowledge ecosystems typically have firms, universities and research organizations involved, and these knowledge generators have a positive impact to the focal organization's innovation performance (Phelps, Heidl and Wadhwa, 2012; Clarysse *et al.*, 2014). The knowledge ecosystem has diverse organizational forms, and the research produced in the knowledge ecosystem acts as a catalyst for technical

innovation in different R&D collaborations. While comparing to the business ecosystem, where the key player is often a large company, in a knowledge ecosystem the key player is often a university or other public research organization (Clarysse *et al*., 2014). One example of knowledge ecosystems are different open-source communities (Valkokari, 2015).

2.1.4 Layered ecosystem for collective impact

While these views on ecosystems differ, they all involve complementary innovations, knowledge or products from different industries (Jacobides, Cennamo and Gawer, 2018). Similarities across the ecosystems make setting the border between them occasionally difficult. The same actor can be involved in different ecosystems with the same or a different role, and, thus, there is interconnectivity between ecosystem participants and platforms in ecosystems (Valkokari, 2015).

Though there are significant differences between knowledge and business ecosystems, starting from their leading organization and purpose, it is likely that new knowledge and innovation created in a knowledge ecosystem, typically led by a research organization, could be commercialized in a global business ecosystem, led by a large enterprise (Clarysse *et al*., 2014). Valkokari (2015) considers that innovation, business and knowledge ecosystems are all *"dynamic, changing, and also changeable through ecosystem orchestration"*. She argues that much like in biological ecosystems, organizational ecosystems collaborate and co-evolve together, resulting into a larger combined ecosystem. Innovation ecosystems combine the new knowledge gathered from research institutes in knowledge ecosystems and uses it on value creation for business in business ecosystems. (Valkokari, 2015)

This layered idea of ecosystems overlapping and interacting with each other is presented in Figure 2.

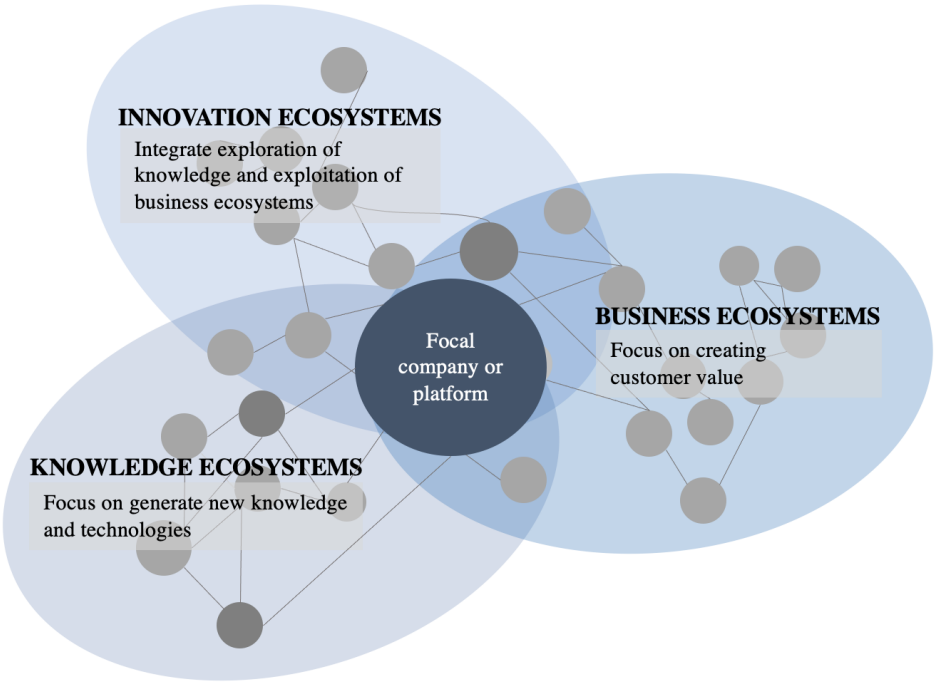


Figure 2 Interconnected ecosystem (adapted from Valkokari, 2015)

This interconnected ecosystem view is needed when you wish to make systemic change that relies on all the three ecosystem views (Ahola *et al*., 2020). Systemic change refers to *"a simultaneous reform of operational models, structures and their interactions, which are used to create the prerequisites for future welfare and sustainable development"* (Sitra, 2021). In order to make a systemic change, there is a need for collective impact in the system.

The concept of collective impact is based on the premise that social problems occur and continue due to a complex combination of actions by players in all sectors. Henceforth, the problem can only be solved by the coordinated efforts of those players. (Kramer and Pfitzer, 2016)

The movement towards collective impact requires that companies turn to governments, Non-Governmental Organizations (NGOs) and community members to work together for the common social problems (Kramer and Pfitzer, 2016). From a business perspective, the aim is to pursue financial success while also benefiting society. The way forward is to initiate "collective impact" efforts and involve all stakeholders in the business ecosystem (Kramer and Pfitzer, 2016). One example of this kind of ecosystem approach is the Global Food Safety

Initiative (GFSI), an NGO that includes members from the world's largest food producers, distributors, and retailers, all aiming to address challenges among global food safety collaboratively. Some of the members compete fiercely with each other in their markets but at the same time collaborate for creation and sharing of standards and improving food safety. (Deloitte, 2015)

The value creation in an ecosystem can be, e.g., knowledge generation within participants or even shared building or manufacturing operations. The unique feature of an ecosystem is the *"co-specializations to exploit the multilateral interdependencies and multilateral complementarities among its multiple actors",* which means that each participant's capabilities in an ecosystem complement other participant's specializations. (Ma and Hou, 2020) This approach to ecosystems is also described as "Ecosystem as a structure" (Adner, 2017). Adner (2017) describes that an ecosystem "*starts with a value proposition and seeks to identify the set of actors that need to interact in order for the proposition to come about"*.

2.2 Shared elements of an ecosystem

Whether the purpose of the ecosystem is to achieve value in business, innovations, knowledge creation or something else, all ecosystems seem to have common attributes. These characteristics are the ecosystem structure, complexity, lifecycle and adaptivity, and inter-dependency. These are further examined in the following.

Ecosystem structure. An ecosystem is a group of actors, combined from a focal firm which sets up and manages the ecosystem, and participants who join the established ecosystem. In an ecosystem, the focal firm and other participants are working towards the same vision of value creation and with mutually agreed governance mechanisms. (Ma and Hou, 2020) Most studies in ecosystems especially highlight the importance of the leader or the hub of the ecosystem, whether it is a "keystone organization" (Iansiti and Levien, 2004), or "focal firm" (Moore, 1993), in creation and regulation of the ecosystem. The ecosystem leader should set the system-level target and consider ecosystem specific interfaces and governance for the ecosystem to succeed (Jacobides, Cennamo and Gawer, 2018). The primary reason for the demand for an ecosystem is often that the focal firm has a challenging vision for value creation that could not

be achieved without the participation of others with multidimensional complementarities (Ma and Hou, 2020). The consideration between creating an ecosystem, or joining an already established one, is for an actor to consider whether they can survive without joining the already established ecosystem. If not, they should consider are they able to lead an ecosystem. One important question is also whether an actor should join multiple different ecosystems. (Ma and Hou, 2020)

Complexity. Ecosystems are not linear processes but complex systems that have uncertain development paths. Complexity in ecosystems means that the ecosystem should be self-sustaining and adapting because of its co-evolutionary and self-organizational qualities. (Peltoniemi and Vuori, 2004; Kaihovaara *et al*., 2017)

Lifecycle and adaptivity. Ecosystems are born, grow and die or renew themselves. Furthermore, ecosystems have the ability to adapt to the changes of its surroundings, and this adaptivity is one of the attributes that enable an ecosystem to foster in the long term. (Kaihovaara *et al*., 2017)

Inter-dependency. Even though every participant in an ecosystem has their own interests, they depend on the ecosystem's other participants. In other words, the ecosystem is more than the sum of its parts, and its success is beneficial for all its participants. On the other hand, one's failure in ecosystem affects also other members of the ecosystem. (Kaihovaara *et al*., 2017; Mäntymäki and Salmela, 2017)

2.3 Governance of an ecosystem

Ecosystems differ from other business constellations, like markets and hierarchical supply chains, with their modularity in multilateral complementarities and lack of hierarchy between the ecosystem participants (Jacobides, Cennamo and Gawer, 2018). The governance of the ecosystem is non-hierarchical, allowing autonomous organizations to work in an efficient and agile way and take on new opportunities (Ahola *et al*., 2020). Opposing to traditional markets, the ecosystem approach is functional when there is a need for coordination but not for authority (Jacobides, Cennamo and Gawer, 2018).

Ecosystem governance defines how the power is distributed inside the ecosystem. Ma and Hou (2020) suggest that the governance of ecosystem participants could be analyzed with four key attributes: *openness, formalness, interconnectedness* and *exclusivity*. Openness is measured with the barriers of entry. If an ecosystem has low or no barriers of entry – it is widely open for all to join and exit freely. On the other hand, the ecosystem can also be a selectively closed system where only invited members can join. An open ecosystem might foster diversity in participants and scaled benefits, but a closed ecosystem might better represent the strategic intention and desired multilateral complementarities among participants (Ma and Hou, 2020). Therefore, the ideal openness of an ecosystem is based on the individual's desired value creation and nature of the ecosystem. Formalness relates to whether the participation is binding according to a contract or possible equity. Interconnectedness stands for the number of interconnections between participants. Finally, exclusivity refers to whether the ecosystem participation requires exclusive participation, where it is not recommended or even allowed to join another ecosystem. (Ma and Hou, 2020)

2.4 Public sector as a member of an ecosystem

Research in social innovations in the public sector suggests that, when designing innovation that satisfies public needs, or aiming to solve complex large-scale problems, it requires collaboration among different stakeholders (Crosby, Hart and Torfing, 2017; Parahoo and Al-Nakeeb, 2019). Scholars have encouraged governments to embrace the paradigm of co-innovation and co-creation in delivering public value (Parahoo and Al-Nakeeb, 2019). This paradigm requires investing in the education of public managers to prepare them for solving wicked problems through collaborative innovation (Crosby, Hart and Torfing, 2017). Even though companies have a central role in creating innovations, especially complex issues require systemic innovations that are often created by collaboration between companies, and the public and third sectors (Kaihovaara *et al*., 2017). Interactions inside the innovation ecosystem between public institutions and citizens and between public institutions and partners are recognized as key players in creating social innovation (Parahoo and Al-Nakeeb, 2019).

The public sector has an essential role in building and developing business and innovation ecosystems (Laasonen *et al*., 2019). According to a report by the Finnish Prime Minister's Office, current public services that are aimed for enterprises should be transformed to '*ecosystemic'* services that focus on finding a common vision and building trust between different actors. This task requires active facilitation of networks and constant communication with companies and research institutes. (Kaihovaara *et al*., 2017) For the public sector, taking care of the regional facilitation and creating possibilities for interaction among different organizations with events and roundtable meetings is a natural role in ecosystem development (Ketola, 2019). The role for public sector in an ecosystem is about enabling development and an overall environment for companies. The public sector shouldn't control or plan the ecosystem development, but they can create the platform for open collaboration and act as an enabler, coordinator or funder. However, the public sector can also take an active role in ecosystem and its orchestration, but often this task fits better to a private or third sector actor who knows the specific business area well. (Salminen and Halme, 2017; Laasonen *et al*., 2019)

2.5 Motives and limitations for collaboration in ecosystems

What are the reasons for the public and private sector to be part of an ecosystem, and what kind of barriers are there? This subchapter aims to define different motives for collaboration and list challenges and risks that have been discovered in ecosystems. Also, the requirements for an effective ecosystem are defined.

2.5.1 Drivers for collaboration in ecosystems

The previously described ecosystem views provided understanding of some of the different value creation targets in ecosystems. These were new innovations, business value and knowledge creation. These targets can certainly be drivers for collaborating in ecosystems, but, there are other drivers as well.

The overall intention of collaboration is that all parties can contribute and benefit from the cooperation (Smith and Thomasson, 2018). Abreu and Camarinha-Matos (2008) have modelled some common collaboration benefits for different collaborative networks, and identified

different collaboration variables and their associated advantages. Table 3 presents these variables and an example advantage from their work:

Table 3 Collaboration benefits (Abreu and Camarinha-Matos, 2008)

Target goal of collaboration	Example advantage
Share and reduce costs	Financial stability
Share risks	Sharing knowledge reduces the uncertainty in the decision-making process
Decrease the dependence level in relation to the third party	Collaboration enables the creation of privileged links to other firms and can reduce the dependency for others' products, services and, for example, raw material
Increase the innovation capability	Increase the capacity of generating new ideas with extended resources and experiences
Defend a position in the market	Increased negotiation power in relation to those that are outside the collaboration
Increase flexibility	Share of skills and core competences
Increase agility	Improved process agility allows quicker reactions to business opportunities
Increase specialization	Collaboration lets companies to concentrate on their critical mechanisms
Establish of proper regulations	Increase common culture of trust with definition of rules
Sharing of social responsibilities	Develop social responsibility and reinforce common values

These defined benefits from Table 3 are applicable in different collaborative networks (Abreu and Camarinha-Matos, 2008). Thus, they are also valid when discussing collaboration in ecosystems and the potential benefits for ecosystem actors.

Ecosystems can provide a competitive advantage in both national and international levels (Salminen and Halme, 2017). For the public sector, regional ecosystems can have a significant impact to the region's economic well-being and labor markets and bring new growth

opportunities locally and nationally. Ecosystems can also create scalable solutions that have export potential and can result in national GDP rise. (Ahola *et al*., 2020)

2.5.2 Barriers in collaborating in ecosystems

According to Smith (2013), as a business ecosystem environment is both cooperative and competitive, it holds both opportunities and risks for its participants. General risks of business ecosystems relate to the complexity of the relationship management between actors and the leader of the ecosystem. The dominating actors can cause an imbalance in the ecosystem and take full advantage of the resources and value. There is a risk that the leader might attract someone else to the ecosystem that threatens current participants. Potential risks can also be rapid changes in the business ecosystem, mergers in industry and conflicts between actors. (Smith, 2013) Adner (2006) discusses a risk of interdependency in innovation ecosystems: for example, other ecosystem members might be dependent on another member's progress, and when one is late, the ecosystem is collectively late with the innovation process.

Scholars have identified that one of the main characteristics for successful and long-term business relations is trust (Kumar, 1996; Huang and Wilkinson, 2013). A culture of trust is necessary for establishing collaboration among different actors (Smith and Thomasson, 2018). Trust can be a significant concern in participating in ecosystems, since there is a risk that confidentially shared knowledge or innovations are leaked outside the ecosystem (Ma and Hou, 2020).

Some other identified difficulties in establishing collaboration are *resources*; how resources are owned and shared between members; *rewards*, is there a standard definition or model for possible benefits and intellectual property creation; *commitments*, how do members act in the collaboration and do they stay even when faced with difficulties; and finally, *responsibilities*, is the responsibility shared among the members (Wolff and Solutions, 2005). Participants should consider the risk of losing intellectual property rights if those are not agreed upon beforehand (Smith, 2013). All these possible issues should be addressed before initiating the collaboration.

Particularly for the public sector, difficulties may arise from, for example, the resources and funding of different investments within the ecosystem (Ahola *et al*., 2020). Even though it was agreed that finding a leading business organization for the ecosystem is essential, in the public sector's ecosystem projects it has sometimes been difficult to find motivated and committed companies to initiate ecosystem work. Therefore the creation of public ecosystems in Finland has been more publicly and politically driven. (Laasonen *et al*., 2019)

2.5.3 Requirements for successful collaboration in ecosystems

According to a report about the role of the public sector in developing innovation environments and ecosystems in Finland (Laasonen *et al*., 2019), the following steps should be considered in ecosystems where the public sector is involved: common goals and structures that support collaboration, sufficient diversity of ecosystem actors, critical mass and benefits from clustering, and facilitating of collaboration and a reliable key stone firm. In addition, the funding from the public and private sector should be aligned and the public sector should have political consistency in the ecosystem.

Some general pre-conditions for collaboration are to have a mutual agreement and vision for the collaboration, knowledge of each other's abilities, shared understanding of the progress and sharing of the responsibility and resources (Camarinha-Matos and Afsarmanesh, 2008). Participants must come together with a joint approach and vision, decide how the progress is measured, and all participants should communicate often in a structured way in order to build trust between different participants (Kramer and Pfitzer, 2016). Sharing interests and goals for the ecosystem also incents participants to nurture, sustain and protect the ecosystem collectively (Deloitte, 2015).

Every ecosystem member brings their own additional value to the ecosystem which complements other members' abilities, and each ecosystem actor should have a well-justified place within the ecosystem, and be able to contribute and benefit from the ecosystem (Kramer and Pfitzer, 2016; Laasonen *et al*., 2019). The sufficient diversity also refers to multilateral complementarities, ecosystem participants should complete each other's specializations

(Adner, 2017; Ma and Hou, 2020). The diversity of ecosystem participants is seen central to the system's health (Deloitte, 2015).

Critical mass and clustering are essential to business ecosystem's characteristics of simultaneous cooperation and competition. The critical mass of partners and customers fosters competition between companies within the ecosystem, which supports its development and growth, especially when discussing of business ecosystems (Moore, 1996). Public sector-based ecosystems don't scale to commercial innovations without the presence of a keystone firm, and the roles of public and private sector actors should complete each other in order for the ecosystem to succeed and grow into a business or innovation ecosystem (Laasonen *et al*., 2019). The public sector should consider what political support a business ecosystem requires and be consistent in order to reach goals in national and regional collaboration. In addition, participating in ecosystem should be well resourced (Laasonen *et al*., 2019; Ahola *et al*., 2020). The role of international funding in ecosystems where public sector is involved, such as from EU research and development programs, has increased (Laasonen *et al*., 2019).

2.6 Other network theories compared to ecosystems

Business ecosystem is not the only concept used to describe a group of inter-connected organizations. In the following, some of the other widespread concepts to define such collaboration are described and compared. The selected other concepts are *inter-organizational networks, value networks* and *clusters*.

Inter-organizational networks, or business networks focus on collaborative inter-relationships between organizations. Because of the wide variety of different collaborations, formulation of the exact definition for the inter-organizational network is difficult (Mäntymäki and Salmela, 2017). Inter-organizational collaboration is a cooperation between three or more independent organizations. Drivers for starting such collaboration can be competitive advantage received from working in alliances rather than in isolation (Mitterlechner, 2018). In inter-organizational networks the relationships between companies are seen mainly collaborative, whereas in ecosystems, the ties can be both collaborative and competitive. Furthermore, inter-organizational collaborations differ from ecosystem structure by its evolution. Evolution is seen

as results from formally governed negotiations, whereas in ecosystems transformation depends on customer and innovation needs (Mäntymäki and Salmela, 2017).

The concept of clusters is often actively discussed with the concept of ecosystem (Valkokari, 2015). Porter (1990) presented that clustering is a phenomenon where relationships between companies are linked to their geographic location, and therefore a cluster is a concentration of linked industries located to a single region (Porter, 1990). Porter (2000) discusses that clusters, or *"geographical concentrations of interconnected companies"*, are a regional feature that reveal the role of location as a competitive advantage (Porter, 2000). Participants in clusters are: " - *interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate"* (Porter, 2000). Most known example clusters can be found in the Silicon Valley and Wall Street. Regionality and emphasis on competition distinguish clusters from ecosystems (Dedehayir, Mäkinen and Roland Ortt, 2018).

Value network is an interconnected network of direct and indirect actors, that create value to customers by exchanging information and services. The relationships between different actors in value network are often flexible and require agility. (Lusch, Vargo and Tanniru, 2010) Compared to ecosystems, value networks don't focus on co-evolutionary processes between organizations (Dedehayir, Mäkinen and Roland Ortt, 2018). Compared to clusters, value networks don't emphasize geographical location and, much like ecosystems, value networks can be both global and local (Peltoniemi, 2004).

Ecosystems differ from these different terms in their dynamic view on connections between people and their more diverse concept that includes both collaborative and competitive relationships (Mäntymäki and Salmela, 2017). This study focuses on ecosystems, because they are seen more powerful than traditional networks due to their openness, dynamic nature, interconnectedness and -dependencies (Kaihovaara *et al*., 2017). Ecosystems are also seen powerful in addressing complex issues: they allow its participants to achieve something that is beyond their effective scope and capabilities (Deloitte, 2015). As this study focuses on

decarbonizing cities, which is a complex task in solving climate change, the ecosystem approach is suitable.

However, it should be noted that all these perspectives can be seen as alternatives to addressing a phenomenon in relationships in business (Mäntymäki and Salmela, 2017). For analyzing systems and understanding of the connections between different organizations, these concepts are beneficial. Researchers and managers should select the concept that best fits to explain their problem (Peltoniemi, 2004; Mäntymäki and Salmela, 2017).

2.7 Summary

A business ecosystem can at the same time have influences from innovation and knowledge ecosystems and form a layered ecosystem model that includes interconnected ecosystems (Valkokari, 2015). This interconnected model between different ecosystems is useful especially when addressing complex issues, that require participation from multiple different actors (Kramer and Pfitzer, 2016; Ahola *et al*., 2020). Public sector's participation is essential especially in these kinds of complex issues, and in solving social problems. Finnish government has suggested that traditional business services should be transformed more to '*ecosystemic'* way of working, and collaboration in ecosystems should be encouraged (Kaihovaara *et al*., 2017).

Identified drivers, barriers and requirements of collaborating in ecosystems, from the literature perspective, are presented below in Table 4. According to literature, it is important to have a common goal and strategy for the collaboration and every ecosystem participant should have a justified place in the ecosystem (Abreu and Camarinha-Matos, 2008; Kramer and Pfitzer, 2016; Laasonen *et al*., 2019). Constant communication among actors improves building of trust, which is essential for successful collaboration (Kumar, 1996). Drivers, barriers and requirements can differ between specific ecosystems based on their structure and vision.

Table 4 Ecosystem: drivers, barriers, requirements

Drivers	Barriers	Requirements
• Competitive advantage • Create value that would be impossible to create alone • New innovations • Collective learning • Complex, large-scale problems • Sharing of responsibility and risks • Sharing of resources	• Trust • Value alignment • Interdependence • Rapid changes in ecosystem participants • Commitment • Finding a reliable focal company	• Focal company, lead • Communication • Mutual vision • Structures that support collaboration • Resources • Diversity of ecosystem actors • Critical mass and benefits from clustering

3 DECARBONIZATION OF CITIES

This chapter provides a literature review of the decarbonization of cities. The wicked problem of climate change is addressed, and decarbonizing cities is presented as part of its solution. This chapter aims to define the drivers and barriers for cities in their road towards carbon-neutrality and the requirements in cities' decarbonization plans. The exploration starts with a definition of a carbon-neutral system and the decarbonization of cities. Lastly, the importance of collaboration in decarbonization of cities is examined.

3.1 Carbon-neutral system

The rise of carbon-neutrality emerged during time of exceptionally high public awareness of climate change in late 2010s. The word *"carbon-neutral"* was even considered as the Phrase of the Year in 2007 (Dhanda, 2014). Online carbon footprint calculators emerged for companies and individuals, and companies began to decrease their emissions. The rapid rise of the concept has brought up issues in its guidance and calculation methods (Rauland *et al*., 2015). Increasing interest for carbon-neutrality among the general public has also driven growth for cities pursuing the carbon-neutral status (Kennedy and Sgouridis, 2011).

Carbon-neutrality stands for the balance of carbon dioxide (CO_2) inputs and outputs of a system, resulting in zero net carbon emissions (Rauland *et al*., 2015). For example, a product, a service or in the context of this thesis, a city or an urban area, can be in a carbon neutral state. This carbon-neutral system is achieved by reducing carbon emissions as much as possible and offsetting the unavoidable emissions. The process for reaching carbon-neutrality is first to measure the current emissions, then reduce the emissions as much as possible, and finally offset the remaining emissions (Rauland *et al*., 2015). This process is illustrated in Figure 3.

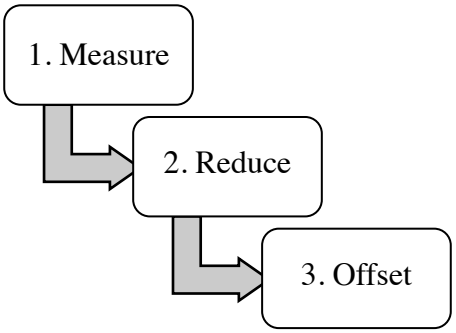


Figure 3 Process for carbon-neutrality (Rauland et al., 2015)

Carbon offsetting means compensating the remaining emissions, that cannot be reduced from the atmosphere. Carbon offsetting arrangements can be, for example, forest projects or wind farms, with a purpose to deliver carbon emission reductions to organizations or individuals. (Hyams and Fawcett, 2013) In practice, these offsetting arrangements refer to absorbing carbon to carbon sinks that are any systems that can absorb more carbon that emit. For example, soil, forests and oceans are the main natural carbon sinks. Currently, there is no artificial method for carbon-absorbing, but search for new technologies is ongoing (European Parliment, 2019). Carbon offset is often bought from a third party offering offset services, where the desired amount of carbon is reduced from the atmosphere with methods listed above (Dhanda, 2014). Another way to reduce emissions is to offset the emissions made in one sector by reducing them somewhere else, for example, by investing into renewable energy or to other clean technologies (European Parliment, 2019).

By definition, carbon-neutral holds only the balance of carbon dioxide emissions, but with current discussions on climate change and roadmaps to carbon-neutrality, also other greenhouse emissions are included (European Parliment, 2019; Koljonen *et al*., 2020). Different greenhouse gases included in carbon-neutrality calculations are converted to CO_2 - equivalents for correct measurements (Koljonen *et al*., 2020). Some other definitions that are used for carbon-neutrality are *net zero, zero carbon, carbon zero, low carbon, carbon-free* and *climate neutral* (Rauland *et al*., 2015; United Nations, 2019). The process by which countries, organizations and other entities aim to achieve carbon-neutrality is called *decarbonization* (IPCC, 2018).

Calculating carbon emissions is often divided into production-based accounting and consumption-based accounting (Rauland *et al*., 2015; Harris *et al*., 2020). *Production-based*

accounting (PBA) includes emissions related to households' and companies' economic activities, regardless of where the activity occurs. Conversely, *consumption-based accounting* (CBA) includes all the upstream emissions from the production of consumed products and services regardless of where they are produced. (Dahal and Niemelä, 2017; Harris *et al*., 2020) The third option is to use *territorial accounting*, which means taking into account only the emissions that are produced inside the city borders. Cities often use either territorial accounting or PBA (Dahal and Niemelä, 2017).

Focusing merely on production or territorial-based accounting, significant amounts of emissions consumed inside a city, but produced outside of its borders, are left out from accounting (Dahal and Niemelä, 2017). In addition, focusing on PBA can lead to the outsourcing of carbon-intensive activities (Harris *et al*., 2020). Lack of guidance and common metrics for carbon accounting can result in different definitions of carbon-neutrality. For example, two cities in different levels of emission reductions can both say to be carbon-neutral, depending on the calculation. Comparing cities' climate actions remains challenging due to these various calculation methods (Dahal and Niemelä, 2017). To follow and compare ambitious targets of carbon-neutrality, there should be a carefully defined accounting framework available (Kennedy and Sgouridis, 2011).

3.2 Decarbonization of cities

Cities affect the issue of climate change negatively by overconsuming resources and adding waste and carbon emissions to the environment. Cities only cover about 3% of Earth's surface but are currently producing 70% of its greenhouse emissions. In addition, the population in cities is expected to grow fast due to increasing urbanization. In Europe, it is estimated that up to 85% of the population lives in cities by 2050. (Rauland *et al*., 2015; European Commission, 2020) Urban areas populate around 55% of the world's population globally, and the percentage is expected to rise to 70% by 2050 (CDP, 2019; Harris *et al*., 2020).

The distribution of emission sources varies between cities, but most of the emissions originate from building heating, electricity and road transport (Dahal and Niemelä, 2017; SYKE, 2018). The distribution of emission sources in Finnish municipalities is presented in Figure 4 below.

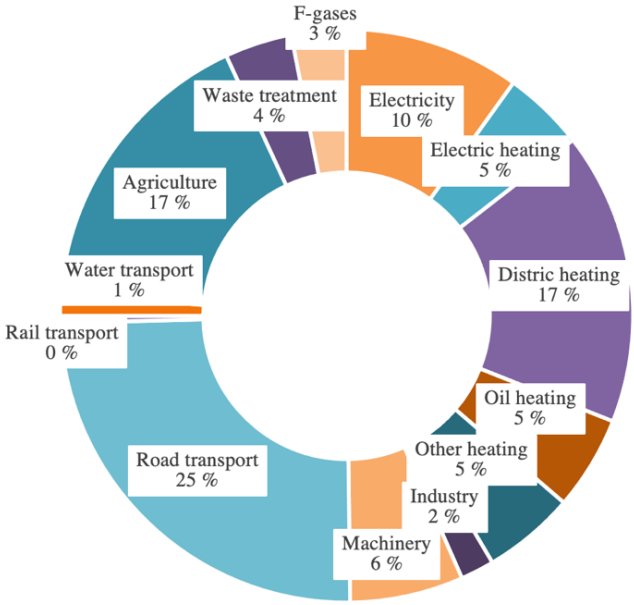


Figure 4 Emission Distribution, Finland (Syke, 2018)

However, cities also play a key role in solving these challenges because they have infrastructure for producing and accelerating innovation, and local decision-making units to foster environmental regulations (Rauland *et al*., 2015). The decarbonization of cities might also be enough to affect global-scale carbon-neutrality due to their overall contribution to current emissions (Barber, 2017). Reaching the Paris agreement target requires reducing most of the current carbon emissions, which requires all cities in the developed world to cut down their emissions (Kennedy and Sgouridis, 2011).

Besides being key players in both causing the problem and solving it, cities are vulnerable to the consequences of climate change. The impacts of climate change have already been experienced in cities and by citizens (Rosenzweig *et al*., 2015). Depending on the city's geographical location, climate change has increased risks of different extreme weather conditions, such as floods, extreme heat and drought. These extreme weather events impact the city's infrastructure and management systems of energy, waste and water. (Rauland *et al*., 2015) For coastal cities, sea level rise is a substantial risk with climate change (IPCC, 2018). By 2050, 800 million people are expected to live in cities, where there is risk for more than 0.5 m sea level rise (C40, 2021). For example, the UK government has already had thousands of homes

affected, and faced on average £1.5 billion per year of economic loss in the last two decades due to floods (Shahbaz *et al*., 2020). In Finland, the effects of climate change are, for example, increased temperatures especially during winter seasons, increased rain, and sea-level rise in the Baltic sea. These provide challenges especially to the health of nature's biodiversity and quality of life. (Ilmasto-opas, 2017) Supposed that current climate agreements and emission plans are followed worldwide in the future, there will be fewer negative impacts to the intensity and frequency of extreme weather events, resources, biodiversity, food security, tourism and carbon removal – and the adaptation of natural and human systems to global warming is less difficult (IPCC, 2018).

In order to hinder climate change and the previously mentioned challenges, the global economy must rapidly change and evolve to one that is not dependent on fossil fuels and find alternatives and more efficient ways to utilize resources (IPCC, 2018). The challenge and need for change also provide opportunities for new businesses to arise, especially in the industries that play a prominent role in current emissions production (Frost & Sullivan, 2015). These evident industries are, for example, energy systems, construction, public transport and agriculture (European Commission, 2020). The economic wellbeing is expected to grow, even though societies transform to low carbon societies (Koljonen *et al*., 2020). The future's carbon-neutral cities could utilize the information and communication technology industry (ICT) in its smart-city solutions, sustainable energy in its energy systems, sustainable transport as part of a solution for reducing city emissions, and buildings could have an important role also as carbon sinks. By diving into the current megatrends within climate crisis, there are also business opportunities. (Frost & Sullivan, 2015) Fostering climate solutions in businesses can benefit the city economy as well as the goal of carbon-neutrality. These and other drivers for carbon-neutrality are discussed in the next subchapter 3.2.1. In the following chapters, the barriers and requirements for city decarbonization are studied.

3.2.1 Drivers for the decarbonization of cities

Environmental disaster risk reduction and adaptation to climate change are vital for cities (Rosenzweig *et al*., 2015). Globally the impacts of climate change are increasing, and although the changes will not occur at the same rate and consistency in all cities, it is the uncertainty of the climate system that is certain. Climate disasters could be intensified in cities due to the increasing urbanization, infrastructure systems and economic activities. (Rosenzweig *et al*., 2015)

The emissions trading system and climate policies act as an incentive for pursuing carbon-neutrality. The EU's emission trading system (ETC) is one of the central systems on which the EU pursues to combat climate change. ETC incentivizes the biggest polluters to decrease their emissions by creating a price for greenhouse gas emissions. (European Commission, 2021) In addition to the international systems, climate and energy policies implemented in the national level are key drivers for local policymaking in cities. Improving renewable energy policies is necessary to achieve climate change mitigation. (Dahal, Niemelä and Juhola, 2018)

It has often been assumed that current economic growth cannot keep up with the strict climate targets, because, historically, carbon emissions have increased through economic growth. Still, recent studies suggest that with ambitious climate policies and increased efficiency there can be economic growth even during the decarbonization era. (Drummond *et al*., 2021) Better environmental quality is beneficial not only to the quality of life of humans and animals, but also for higher economic growth (Shahbaz *et al*., 2020). This economic growth is also often considered as a primary driver for reducing the carbon emissions (Shahbaz *et al*., 2020). During the last decades, the improvements in cost and performance of low-carbon products and services have increased their competitiveness compared to the fossil-fuel options. Research and innovation investments for sustainable technologies could create lasting economic growth and more jobs (Fragkiadakis, Fragkos and Paroussos, 2020).

Achieving carbon-neutrality comes with various new business solutions, which create numerous new jobs in sectors that need sustainable growth (CDP, 2016; United Nations, 2019). Some of the megatrends that act as drivers towards carbon-neutrality are climate change, future

of energy, smart is the new green, future of mobility, urbanization and future infrastructure development. These megatrends can create significant business opportunities in cleantech, especially in core market areas in Finland: transportation, energy systems, buildings, industrial processes, and water and waste management. (Frost & Sullivan, 2015) These core market areas have a possibility for significant impact on the road for carbon-neutrality due to their current impact on the environment. In transportation, the globally expected amount of vehicles will increase by approximately 900 million by 2050, and in the energy sector, the share of renewable energy is expected to cover up to 80% of the global energy mix in 2050 (Frost & Sullivan, 2015; European Commission, 2020). In addition, construction plays a vital role in achieving sustainability of urban areas. Buildings cover almost 40% of energy-related global CO_2 emissions (Adams, Burrows and Richardson, 2019). During the next 20 years, 60% of the world's buildings are expected to be built or rebuilt in urban areas (Frost & Sullivan, 2015). Rebuilding is especially challenging in Europe, where currently about 35% of buildings are 50 years or older. The majority of this building stock is not compiled with achieving carbon reduction targets and needs energy-efficient renovation. (Adams, Burrows and Richardson, 2019) Sustainable building materials and smart energy management in buildings provide a solution for reducing construction carbon footprint and new business opportunities. Other business opportunities arise from, for example, the use of automation and advanced hardware and software systems that can result in higher levels of efficiency in industrial processes (Frost & Sullivan, 2015). The megatrends, main market areas and business opportunities within them are presented below in Table 5.

Table 5 Megatrends, markets and business opportunities (based on Frost & Sullivan, 2015)

Megatrend	Market area	Business opportunity examples
Future of mobility	Transportation	• Electrification of vehicles - eMobility • Autonomous driving • Mobility as a Service
Future of energy	Energy systems	• Smart grids • Renewable energy market • Prosumer market (consumers that produce some of the energy themselves) • Energy storage • Biofuels
Future infrastructure development	Buildings	• Sustainable construction materials • Smart technology buildings
Smart is the new green	Industrial processes	• Smart factory: wireless sensor networks and big data analytics platforms for automated factory operations • 3D printing • Online platforms and crowdsourcing
Smart is the new green, urbanization	Water and waste management	• Smart water technologies • Solid recoverable fuel technologies that extract recyclable waste

Circular economy, which refers to the economic model of promoting sharing, renting and recycling of goods, and consuming services rather than owning and producing more products, is also a key solution for achieving carbon-neutrality. Circular use of resources cuts down emissions and saves our world's scarce natural resources, and can bring new business models

and economic growth as well. (Drummond *et al*., 2021) Other business models for carbon-neutrality could be developed in ICT and in smart city solutions. The ICT-sector could provide tools to smart-city solutions, which can help city organizations in managing theri carbon-neutral initiatives better by using intelligent data collected from different sectors (European Commission, 2020). One of these kinds of solutions is, for example, Climateview, which helps cities with scientific modelling and providing insights to a city's emission causes and impact measurements and, thus, enabling informative decision-making around the city's emissions (Climateview, 2021).

One of the most critical stakeholders in the city's carbon-neutrality program is its citizens. Citizens are political actors, users, producers, consumers and owners of different functions in a city (European Commission, 2020). The citizen approach is vital when discussing the wellbeing benefits of systemic change towards carbon-neutrality; these are, for example, improved air quality, healthier lifestyles and the creation of jobs (Rosenzweig *et al*., 2015; European Commission, 2020). Environmental Kuznets Curve (EKC) hypothesis suggests that people with better income and environmental education will also demand better quality for the environment in the long run, which would suggest that GDP growth would result automatically in growth of climate friendly activities. However, the evidence for the EKC hypothesis is mixed, and higher income is not the only factor for a more sustainable economy. A study conducted in the UK suggests that the financial sector is in a significant position to support sustainable solutions in addition to the general economic growth. (Shahbaz *et al*., 2020)

Planning roadmaps and actions towards decarbonization is correspondingly an image question, and cities as public authorities aren't indifferent to their public images. A citizen can push sustainable agenda by voting, not only by elections but also by deciding where to live. Foot-voting can take place from many reasons, and motives could be, for example, better governed destination, lower taxes or nicer weather (*The Economist*, 2019). As more and more cities promote their values and sustainable actions, people can decide where to live and pay their taxes to also based on the city's ambition towards the environment. Successful climate branding in cities can add to the city's attractiveness as a good place for living, working and travel (*Hiilineutraalisuomi.Fi*, 2021).

In Figure 5, the identified main drivers for the decarbonization of cities are summarized. These include the mitigation of extreme weather events in cities, the effect of climate policies, stronger economy from sustainable businesses, citizen wellbeing and city's image as an environmentally friendly city.

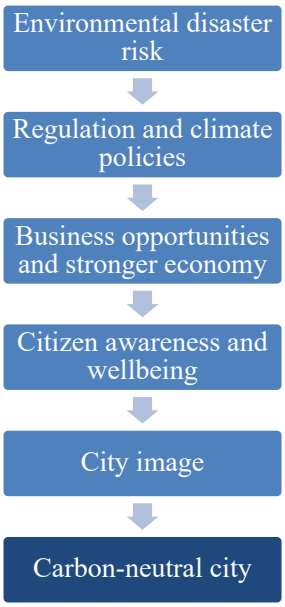


Figure 5 Drivers for the decarbonization of cities

3.2.2 Barriers for the decarbonization of cities

The European Union has identified five main barriers for cities in their mission to become carbon-neutral: innovation management, governance models, economic support, urban planning and digital technologies (European Commission, 2020). These barriers and ways to turn them to enablers of carbon-neutrality are presented below in Table 6.

Table 6 Barriers of the decarbonization of cities (based on European Commission, 2020)

Barrier	Description	Enabler
Innovation management	Innovation must be in the center on creating carbon-neutral city: not only technological innovations are to be considered but also others, such as social and organizational innovation.	Cities should enable testing of new ideas and solutions and catalyze innovation across different sectors and silos.
Governance model	Systematic transition to carbon-neutrality requires a change into city's traditional and hierarchical governance model.	The city administration should, instead of siloed way of working, be more co-creating and co-developing with its stakeholders and pursue to find synergies.
Economical support	Climate innovations need a supporting funding solution.	Cities should combine finance streams from international, national, and local resources for supporting climate innovations.
Urban planning	Urban projects are siloed and don't necessarily use resources efficiently	Common perspective and integrated planning on how to build urban systems
Smart technologies and data	Digital technologies are not in use at scale	Digital technology can enable carbon-neutrality by improving efficient use of resources and decision making – including emission modelling. This requires the deployment of digital infrastructure at scale across the city ecosystem.

For the barriers introduced in Table 6 to be transformed as enablers of decarbonization, cities are required to focus on their governance systems and finance streams to support testing of new ideas and integration of stakeholders in urban planning (European Commission, 2020). Barber (2017) identifies two obstacles for cities in solving climate change and becoming climate neutral: scarcity of resources to take on new responsibilities and the absence of autonomy and jurisdiction in cities. These relate to the barriers of economic support and city governance model. Furthermore, attention to digital technologies should be given, as it can be a significant factor in efficient use of resources and decision making (European Commission, 2020).

Globally, trust in governments and media is low: according to 2017 Edelman Trust Barometer, 53% of global citizens believed that the current system is not working and does not give hope for the future (Mendiluce, 2018). In addition to the previously mentioned barriers, socioeconomic and political barriers also remain in the decarbonization work as they remain in any other public sector's work (Mendiluce, 2018).

Moreover, circular economy and decarbonization require new skills and knowledge. To overcome the knowledge cap in transition from a linear economy to circular, there is need to up- and reskill workers from different industries and to support research and innovation in sustainable solutions (Drummond *et al*., 2021).

3.3 Use of collaboration and ecosystems in the decarbonization of cities

The international pressure on tackling impacts of climate change is demanding all over the world. In order to achieve this transition to a sustainable future and keeping the global warming in just 1.5 degrees, it is impossible to solve the challenges by only one organization. How much can innovation, political and economic changes improve resilience, adaptation to inevitable impacts and reduce the current emissions? According to IPCC (2019), coordination and monitoring policy actions across sectors are essential for sustainable development.

In order to achieve effective action, public-private partnerships and multiple funding possibilities are needed (Rosenzweig *et al*., 2015). For cities to achieve carbon-neutrality, they should work with multiple businesses, co-create solutions to cut down emissions and fund

initiatives, as well as hear unique insights from actors in civil society, NGOs and academia (CDP, 2019). Cities' climate change work that utilizes co-generated action plans in inclusive and transparent way with interdisciplinary stakeholders enhances relevance, flexibility and legitimacy. In addition, access to not only municipal funding but also external financial resources is necessary in funding climate change solutions (Rosenzweig *et al*., 2015). Business opportunities regarding climate change require building of strong relationships between industries that previously did not need to interact with each other (Frost & Sullivan, 2015). Carbon-neutral initiatives are driven by government and cities, businesses and consumers. Public authorities can impact with regulation, companies with innovation, and consumers have the ability to raise awareness and change behaviors of other consumers (Frost & Sullivan, 2015). The different stakeholders identified in city's decarbonization are presented in Figure 6.

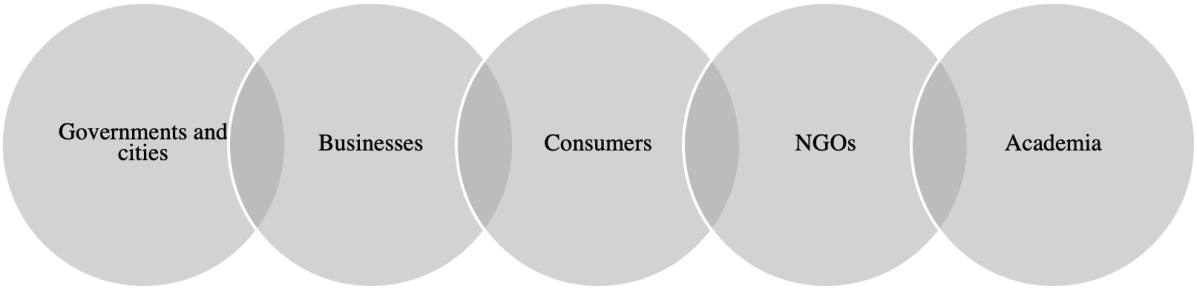


Figure 6 Stakeholders in the decarbonization of cities

To achieve functional collaboration, it's important to clearly understand the city's climate goals and the essential factors affecting those. Precise planning, choosing of the partners from the private sector and from research institutes and other organizations that can support in city's climate targets, and formulating governance of the selected partners results in impactful cooperation (CDP, 2019). Collaboration is beneficial not only to the environment but also economically. Cities that collaborate in their climate targets are studied to be more ambitious, seize more economic opportunities, and attract more investments than cities that don't collaborate (CDP, 2016). Areas of collaborating between cities and businesses are knowledge sharing, business development, planning policy, project implementation and financing, most important of these being knowledge sharing. Cities can enable knowledge generation and knowledge sharing in cities by bringing together different stakeholders, and thus learn best

practices, coordinate action and deliver more significant impacts on climate with a lower cost. (CDP, 2016)

Instead of pursuing overall carbon-neutrality by collaboration, working together in more specific topics could be beneficial as well. According to a report by Deloitte, in the future, there may be, for example, mobility ecosystems pursuing to change mobility from personally owned vehicles to shared mobility and, for example, autonomous driving. This kind of mobility ecosystem would " *include city planners, technology and energy players, public transportation providers, regulators, infrastructure and construction players, insurance companies, and peer-to-peer networks —collaborating, adapting, and responding to one another's moves, and once again transforming and improving our lives* " (Deloitte, 2015).

3.4 Overview of the decarbonization of cities in Finland

The Finnish government has agreed that Finland should be carbon-neutral by 2035 and be carbon negative afterwards. This should be done by advancing emission reduction actions and strengthening Finland's carbon sinks (Koljonen *et al*., 2020). A carbon negative system absorbs more carbon into carbon sinks than it emits carbon (Koljonen *et al*., 2020)

Finnish cities have ambitious targets towards carbon-neutrality and act as forerunners in national climate mitigation (Deloitte, 2018). Some municipalities in Finland are part of networks for enhancing knowledge sharing and goal formulation for carbon-neutrality and resource wisdom. These networks are for example: Hinku, Fisu and Circwaste. The Hinku-network consists of 70 Finnish municipalities (in 2021), which all are committed to a common target of being 80% carbon-neutral by 2030. (Hinku, 2021) Fisu, Finnish sustainable communities, is a similar network, that supports its member municipalities in achieving carbon-neutrality by 2050 (Fisu, 2020). Circwaste, is a program promoting circular economy, waste and material efficiency in Finland and has currently 10 municipalities committed to reducing their total waste to the level of year 2000 (Syke, 2020).

Some Finnish municipalities are part of several networks at the same time, and all of these different networks provide knowledge sharing for their participants. Some of the collaboration

forums are international, such as the Covenant of Mayors of European Cities, which involves thousands of EU governments to voluntarily commit to mutual climate and energy objects (Covenant of Mayors for Climate & Energy, 2021). Diverse city-to-city collaborations create a significant opportunity for policymakers to learn from others in climate mitigation and adaptation (Mi *et al*., 2018).

3.5 Summary

Carbon-neutrality refers to an equilibrium of carbon emissions and sinks, resulting in net-zero emissions (Rauland *et al*., 2015; UNFCCC, 2015). There are different methods for emissions accounting available, and the lack of standard metrics brings difficulties in defining a carbon-neutral city (Dahal and Niemelä, 2017).

Drivers for the decarbonization of cities arise from climate change and mitigation of the environmental risks occurring with climate change (IPCC, 2018). Cities might even be more affected by the consequences of climate change due to urbanization, infrastructure systems and economic activities (Rosenzweig *et al*., 2015). Business opportunities in sustainable solutions can bring well-performing companies in regions and affect national GDP growth (CDP, 2016; United Nations, 2019). From the citizen perspective, pursuing carbon-neutrality can provide cleaner air and new jobs (Rosenzweig *et al*., 2015). Promoting sustainable values has a positive impact on city image and can positively affect in the form of new inhabitants, companies, and tourism in the city.

Barriers that cities have in their decarbonization plans are in their governance system, resources, and technologies (European Commission, 2020). Many cities have created ambitious strategies to address climate change; however, it can't be done in isolation but in cooperation with other actors. Dialogue between the private and public sector can result in impactful insights and joint advocacy and campaigns to address the possible systemic barriers limiting climate action in cities. (CDP, 2019) Achieving carbon-neutrality also requires securing of knowledge gaps when transitioning to new solutions and circular economy (Drummond *et al*., 2021).

The identified drivers, barriers and requirements for the decarbonization of cities are collected in Table 7 below.

Table 7 Decarbonization of cities: drivers, barriers, requirements

Drivers	Barriers	Requirements
• Mitigation of environmental risks • Climate policies • Business opportunities and a stronger economy • Citizen wellbeing • Image	• Innovation management • Governance models and jurisdiction • Economical support • Urban planning • Digital technologies • Scarcity of resources	• Resources • Collaboration between public, private and third sectors • Filling of knowledge gaps for new solutions

4 RESEARCH DESIGN

After discussing the main theoretical background regarding the thesis topic, the study proceeds to the empirical part. Chapter 4 introduces the research methods, interviewees and interview framework used to find answers for the research questions. Furthermore, this chapter includes the presentation of the selected cities and the criteria for choosing research participants.

4.1 Research methods

The research method used for this study is semi-structured interviews. The semi-structured method ensures that information collected from interviews is comparable and allows flexibility with the line of questioning. The interview framework was formulated with open-ended questions, which ensured that participants could answer openly from their perspective and experience in their own words. The structure of the interview followed the purpose of the research. (Galletta, 2012)

The research was conducted within a short time period. Researching the literature started in December 2020, and all interviews were completed during February and March 2021. The interviews were recorded and afterwards transcribed. Because interviews were held in Finnish, the answers and questions have been translated from the original language to English. The notes from all interviews were collected to a combined Excel document, where the answers were compared and further analyzed. All participants were asked for permission for using the recording of the interview for the research purpose. The overall research process and schedule is presented in Figure 7.

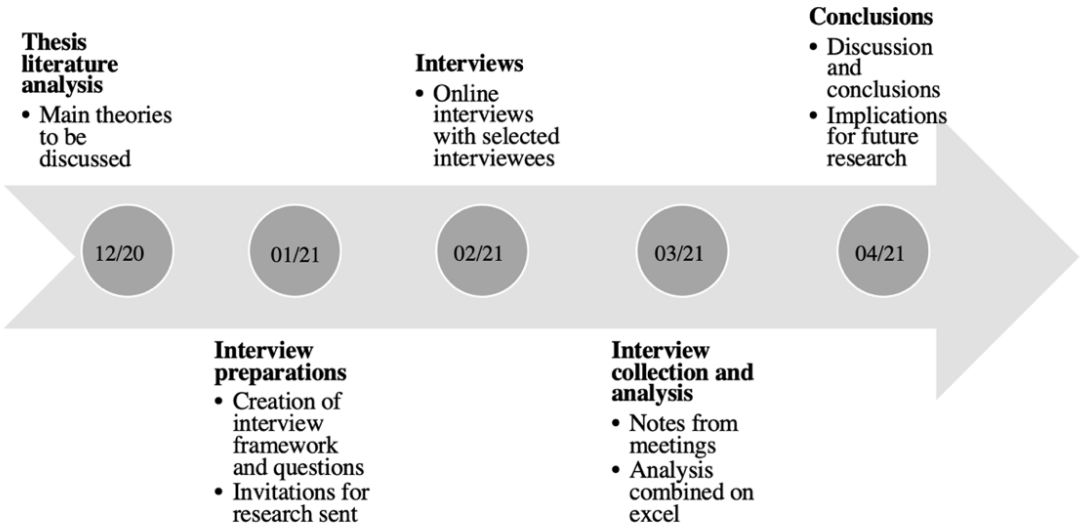


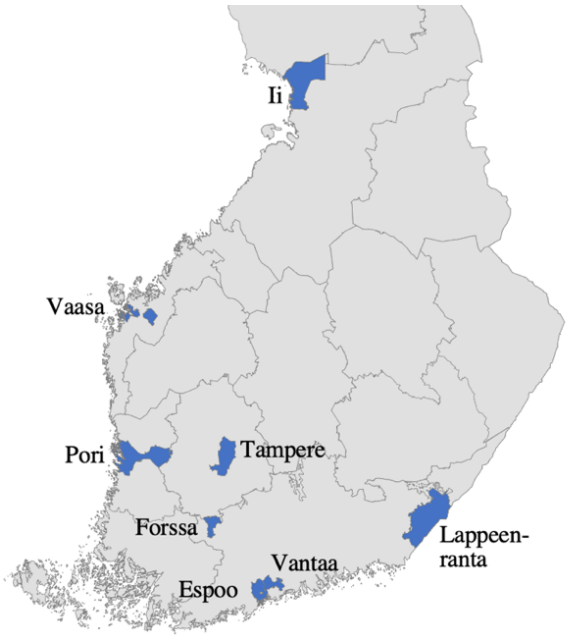
Figure 7 Research process

4.2 Data collection

The data collection aimed to gain an overall understanding of current collaboration activities within carbon-neutral initiatives in urban areas in Finland. The study aimed to find out, for example, do cities utilize ecosystems on their path towards carbon-neutrality and why. Furthermore, the study investigated how is the use of collaboration perceived, and what kind of challenges cities might have in collaboration.

The criteria for choosing the research participants were to have comparable answers from a diverse mix of cities in Finland. The original objective was to have interviews from 7-12 cities, and invitations to participate to the study were sent to 15 city representatives. The reached sample size was eight cities. The studied cities have different ambitions towards city's carbon-neutrality, and they were in different phases of reaching the target. Furthermore, the selected cities are geographically evenly distributed in Finland and are of different sizes regarding their population. The smallest municipality is Ii with its nearly 10 000 inhabitants, and the largest city Espoo, from the capital area, which inhabits approximately 290 000 people (Tilastokeskus, 2021). This distribution in location and population is presented in Figure 8. Even though some

of the selected cities are not defined as cities but municipalities, all interviewed municipalities are discussed as cities in the context of this thesis.



City	Population
Espoo	292 796
Tampere	241 009
Vantaa	237 231
Pori	83 684
Lappeenranta	72 662
Vaasa	67 551
Forssa	16 800
Ii	9 848
(Tilastokeskus, 2021)	

Figure 8 Selected cities: location and population

The chosen interviewees were contacted because they are the first contact points in the city's carbon-neutral program, are a city representative in an ecosystem for city's carbon-neutrality or are in other ways part of the city's environmental expertise or management. Thus, the interviewee roles varied from each other, and the interviews included views ranging from, for example, a mayor and environmental planner. The total number of respondents was 10 from eight interviews, which included six individual interviews and two group interviews. All interviews were conducted online via Microsoft Teams. The Table 8 shows the date, role, number of respondents and duration of the interview in each city.

Table 8 Interviewed cities in Finland

City	Date	Role in the city	Interviewees	Duration (min)
A	March 2021	Development manager	1	37
B	February 2021	Environmental manager	1	63
C	February 2021	Mayor	1	60
D	February 2021	Development manager	1	35
E	February 2021	Director Project manager	2	79
F	February 2021	Development manager	2	60
G	February 2021	Director	1	52
H	March 2021	Environmental planner	1	46
Total of the respondent roles: 4 development managers, 2 directors, 1 environmental planner, 1 environmental manager, 1 project manager and 1 mayor.				

The themes discussed in the interviews were the status of carbon-neutral city; ecosystem and collaboration in city's carbon-neutral programs; requirements for participating in an ecosystem; and challenges, risks and limitations for collaboration in carbon-neutral city program. The main questions are presented in the Table 9 below, and the complete interview framework is found in the appendix.

Table 9 Interview themes and main questions

Theme 1: Carbon-neutral city
- What are the reasons for your city to pursue carbon-neutrality? - How are carbon-neutral goals organized in your city?
Theme 2: Ecosystem
- Is your city part of an ecosystem? (in carbon-neutral city targets) - What kind of participants are in your ecosystem? With whom do you collaborate in environmental matters?
Theme 3: Collaboration drivers
- What are the drivers to start working in ecosystems in carbon-neutral initiatives? - What are the three most important reasons or desired outcomes to utilize ecosystem-based cooperation in achieving carbon-neutrality in city?
Theme 4: Requirements
- What requirements are needed from the city, in order to take part in cooperation or create an ecosystem with other actors? (in carbon-neutral city targets) - What requirements are needed from other participants, in order to take part in cooperation in same ecosystem with city? (in carbon-neutral city targets)
Theme 5: Challenges, risks and limitations
- What kind of challenges have already come up in cooperation? (Carbon-neutral city) - What kind of risks are perceived in the cooperation? - What factors limit opportunities to act?

The purpose for these interview questions was to find answers for the selected research questions and understand the overall status of decarbonization in cities. Also, a sub-question on the specific importance of an ICT-vendor in a city's ecosystem was asked from respondents. The relevance for ICT-sector was brought up in order to study how important the ICT industry is seen in achieving decarbonization in cities. Due to the study's limitations, it was not possible to ask the perspective for all possible ecosystem participants separately.

4.3 Reliability

The reliability of the study is ensured by providing a complete description of the research process in this research methods chapter. Furthermore, all interviews followed the same structure. The interviews were conducted with the same interview framework and interviewees could answer openly to the questions. The main questions were provided before the interview by e-mail. This enabled respondents to have a look at the questions in advance and also possibly collect material around the topic. During the interviews, the interviewer shared a PowerPoint presentation on the screen, which had the name of each theme that was discussed at the moment. This visual reminder made sure that no research areas were left out from the conversation as well as ensured the concentration on each topic in question since it was not possible to see the next theme in advance. The specific questions were asked separately from notes. Recording and transcribing of the interviews ensured that everything was taken into account from the discussions.

5 RESULTS FROM THE INTERVIEWS

This chapter presents the results from the semi-structured interviews. The overall contents of the interviews are discussed before they are combined with the collected theory. The results are presented in a similar order as the interview structure and main themes.

5.1 Carbon-neutral city

All of the cities' decarbonization targets were initially set by national road maps for 'carbon-neutral city' or 'resource-wise city'. Afterwards, many cities have set their own more ambitious goals and aim for carbon-neutrality even within this decade. Most of the cities interviewed are aiming to be carbon-neutral by 2030, which is in line with the Finnish government's goal of carbon-neutral Finland by 2035. Some cities have differing targets from the year of 2030: one had a goal of being 80% carbon-neutral by 2020 and has already succeeded in that, one aims to be carbon-neutral during the 2020s, and one has the target on the year 2050. Most of these targets include offsetting the rest of the emissions that cannot be further reduced. Often, the amount reserved for offset is 20% of the emissions compared to the year 1990.

Updating these target years and achieving carbon-neutrality first has started to feel like a competition: "*many municipalities have updated their goal since the beginning, and it feels almost like a competition now of who offers the lowest number. I wouldn't mind if there weren't a target year at all. I feel its actions first". – Environmental manager, B.*

Cities have already done a significant amount of work to reach the target. There are detailed roadmaps planned that include steps for each city unit on what actions are needed to reach the target. Depending on the calculation, city C could already be carbon-negative with the help of strong carbon sinks in wind power and forests.

Urbanization brings challenges for the larger cities: *"Emissions wise, emissions per inhabitant have decreased compared to year 1990, but the total of emissions haven't yet decreased, because due to urbanization our population is constantly increasing, and this makes it difficult to compare the progress. But I would say we are on the right track." – Development manager, A.*

However, the detailed plans and roadmaps themselves don't have effect if the planned actions aren't taken into use in everyday work: "*Currently the status of the program is quite bad, road map lives its own life and practical efforts are different" - Environmental manager, B.*

5.2 Drivers for carbon-neutrality

According to the respondents, the reasons for targeting carbon-neutrality by 2029-2050 are the city's image, positive pressure from the government, the EU and corporations, and also general opinion on valuing climate work important. Cities have a strong economic wellbeing interest in mind and see, for example, investments in wind power valuable to the region also in a form of new jobs: *"It is important to combine the environmental goals and economical goals – this is the key to success" (Mayor, C).* Energy and environment will be in higher focus in the future, and the change to low-carbon economy is seen inevitable. Cities also see themselves as possible catalysts for the change and also wish to ensure a financially secured city in the future as well.

When asked if there is pressure to act towards carbon-neutrality, the cities do not perceive to have significant pressure, at least not negative pressure. Respondent from city B felt that there actually should be more pressure from the government and legislation. Respondents described that the pressure to act is more of positive pressure and an overall mutual understanding of valuing the climate. Cities also recognize their responsibility for building the future's sustainable economies. Respondent from city H says that most Finnish people live in cities, and cities have the opportunities to coordinate work within the city to align its climate goals. Cities have the needed networks, tools, and methods to directly impact, for example, land use or traffic planning. In addition, changes in the corporate world affect cities' climate work as well – globally, investment companies are stating that they don't want to invest in polluting companies anymore. According to city E, this adds to the positive pressure to promote sustainability in cities as well.

All cities said to have a strong support from the city management and carbon-neutrality is part of the city strategy. The road map for carbon neutrality or resource wisdom has a set of action points planned for each unit in the city. These action items are discussed and usually also

reported to the city management. By respondents in city F, it was seen important that environmental work is part of the everyday work inside the city organization, and it should be managed like any other work in the city. In city E, the environmental policy is combined directly with the city's industrial policy, which was felt as an advantage, and this combination allows easier collaboration with industries regarding their sustainability actions.

Cities mentioned that the importance of having the environmental targets included in the city's strategy has increased compared to previous decades. Cities B, C and G highlighted the role of the head of the city has in playing the strategy to action. City leaders and the mayor have a crucial role in the operative work and taking the city's targets forward. They are responsible for supervising the work and making sure the right resources and attention are where they are supposed to be. The head of the city also has an important task in inspiring the people working within the city organization to go to a carbon-neutral direction.

The main drivers for pursuing carbon-neutrality identified from the interviews were:

- Achieving carbon-neutrality
- Concern about climate and realisation that something needs to be done
- Image (it is perceived trending to target carbon-neutrality)
- New jobs and sustainable growth from carbon-neutral programs
- Economic wellbeing
- General opinion on valuing the environment

The general atmosphere and acuteness of the climate crisis are the most significant drivers to pursuing carbon-neutrality in cities. In addition to the ecological perspective, economic benefits in the form of well-being and new jobs are important. Moreover, the city's image benefits from promoting sustainable values and decarbonization projects.

5.3 Ecosystems and collaboration between organizations

Some of the respondents felt the word ecosystem is strange because they were more familiar with concepts like networks and clusters, when discussing about cooperation between different actors towards a mutual goal. Some found the word 'ecosystem' even annoying since it's

borrowed from nature and sounds like greenwashing. The purpose was to find out about the city's collaboration use in carbon-neutral city context, and therefore the initial conflict with theoretical terms discussed during the interview was insignificant. However, some of the cities knew precisely what the word ecosystem means in this context and had in place several ecosystems that are also named as ecosystems.

The nature metaphor of ecosystems was discussed. The mayor from city C began to describe an ecosystem with its correlation to an ecological ecosystem, because an ecosystem involves entities and areas that live well because of the other entities and areas. The respondent continued that the ecosystem for carbon-neutrality could be described in a way that it consists of researchers that provide fact-based information, companies that have different business interests, a municipality with infrastructure services and, lastly, the government that provides the legislation.

Generally, cities are part of multiple ecosystems: with other municipalities, businesses and research organizations. From business collaborations, the most discussed areas in the interviews were the energy sector, manufacturing and traffic. Also, international ecosystems are important, and from those cities can get information and great ideas from other countries' cities. Municipal networks that are collectively aiming for carbon-neutrality are, for example, HINKU forum, FISU network, and the Covenant of Mayors for Climate & Energy. The role of different research organizations, such as The Finnish Innovation Fund Sitra and VTT, Technical Research Centre in Finland, was highlighted.

The method of working is cooperating with different partners in different ecosystems or other cooperation units. Respondent from city A described their city's project of building a new city district; just alone in this one, there are eight different ecosystems in place that all include businesses from the area. City A identified ecosystems that are built, for example, around transport biogas, plastic recycling, smart city projects and circular economy.

Collaboration with businesses might vary depending on their size. Some cities have organized different climate partnerships, where it's possible for the city to provide information to businesses and especially smaller companies can create their own emission reduction goals with

the city's help. Large companies look for business opportunities within climate change and decarbonization, and cities want to participate in the conversation also with large companies.

"*Ecosystem needs businesspeople, technical knowhow, project management abilities, participants from close by and far away, participants that stay for the long run and some just for the next sprint" - Director, G*

Figure 9 lists different ecosystem partners that the interviewees recognized when they were asked: "*What kind of participants are in your ecosystem?"* and *"With whom do you collaborate in environmental matters?"*. Cities identified important stakeholders that are involved in the same ecosystems from area of research, businesses, organizations, and other cities and, of course, citizens. Cities that have a local university emphasized the importance of close collaboration with the university. Ecosystem participants can be other municipalities and cities (nationally and internationally), small and large businesses, consulting firms, research institutes, universities, and ministries.

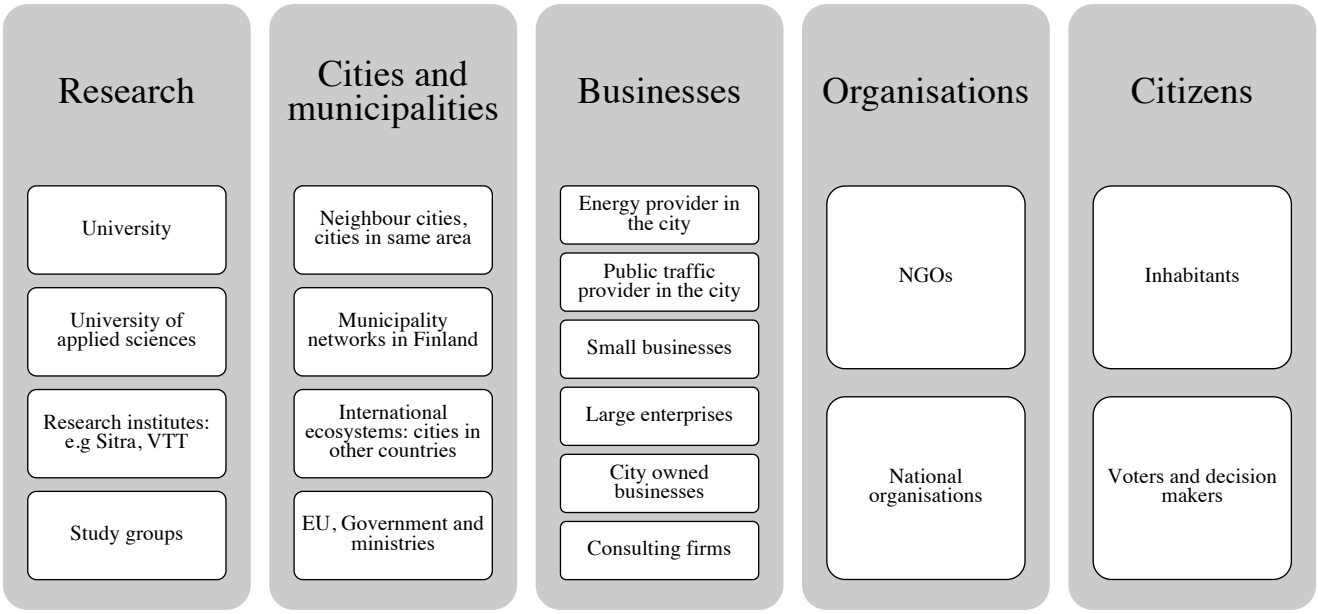


Figure 9 What kind of participants are in your ecosystem?

The energy provider in the city is in a central role in cities' decarbonization because the energy sector is accountable for most of the emissions in a city. All respondents mentioned

collaboration with the energy company. Some cities have their own city-owned energy company, but some collaborate with the private company in the area:

"Most of our emissions come from district heating. We don't have our own energy company, but we do have collaboration with [a private energy company], and jointly we have agreed to give up the use of coal totally by 2025" - Development manager, A

City C noted that current economic discussion focuses more on technology and how technology can help, but it is also important to focus on the people. Reaching the climate target only by technology is not possible, there is also a need to change people's behavior.

5.4 Ecosystem governance

According to the respondents, ecosystem management depends on the type of collaboration and what kind of participants are involved. Typically, the interviewed cities don't have agreements between the participants, and collaboration is considered very open. Usually, there is a leader, but who is in charge depends on the project. An ecosystem can be research institute-driven, company-driven or city-driven. Collaboration can have a steering group, which has a representative of each of the participant organizations, and which openly discusses the common targets and actions.

"In this world situation, I have to admit that the city is not the one creating and managing ecosystems. We need the outside sparrers and project leaders. Even though we have great people working here, we just don't have the resources and time anymore for carrying out projects outside of the city's internal development. Usually, the people that represent the city in an ecosystem are experts giving their expertise, but not the ones leading the project"- Director, G

It was seen important that every member of an ecosystem has something concrete to bring to the table and every participant inside an ecosystem should have a reason for being part, as well as specific expertise. In city F, they had noticed that the narrower the purpose for an ecosystem the better results were received. For example, first, they had an ecosystem for sustainable

transport, but afterwards, they created an ecosystem for sustainable last-mile transport. This was clearer for all the participants, and everyone knew if they could contribute to the ecosystem.

5.5 Drivers for the use of ecosystems and collaboration in decarbonization

All cities considered collaboration in a city's decarbonization important because a city can't become carbon-neutral without others. The city organization is responsible for only around 10-20% of the city's emissions, depending on its size, and the rest comes from elsewhere inside the city. Citizens and companies are necessary actors in city decarbonization, making it definitely important to work with the local organizations. From national and international organizations, cities can gain important knowledge and ideas from elsewhere and also share their own experiences. Respondent from city F said that its actually very easy to collaborate in climate matters, because everyone is involved in environmental issues. Therefore, cities are not competing against each other: if the temperature rises on one side of Finland, it rises the same amount on the other side as well.

Cities are concerned about their industry's well-being, and respondents (cities A, C, D and E) considered that climate activities can bring many new business models and growth to the area. This economic wellbeing in the area was seen as central for cities' decarbonization. Cities want to have businesses that can also perform well in the future.

When considering collaboration with the private sector, an agreement for collaboration was also seen as a commitment from the companies. Respondent from City B said there is a possibility that a company wouldn't want to stay in the region, and in order to make them stay, it is seen essential to try to listen and collaborate with the company.

Respondents were asked to list the three most important reasons for utilizing collaboration or collaboration in ecosystems in the city's decarbonization plan. Answers were analyzed by comparing and linking the similar answers together, in order to gain an understanding of the most important reasons. The most common reason was naturally to achieve the carbon-neutrality; another frequent answer was the economic benefits gained from pursuing carbon-neutrality together with others. These economic benefits that respondents saw as main drivers

were new jobs, cost-efficiency and new business opportunities. Similar to economic benefits and resource sharing, knowledge sharing among partners was emphasized. Answers for the listed main drivers are presented below in Figure 10, in order from the most mentioned to the least mentioned. The area of each answer in the square represents its percentage share of the total answers of the total square.

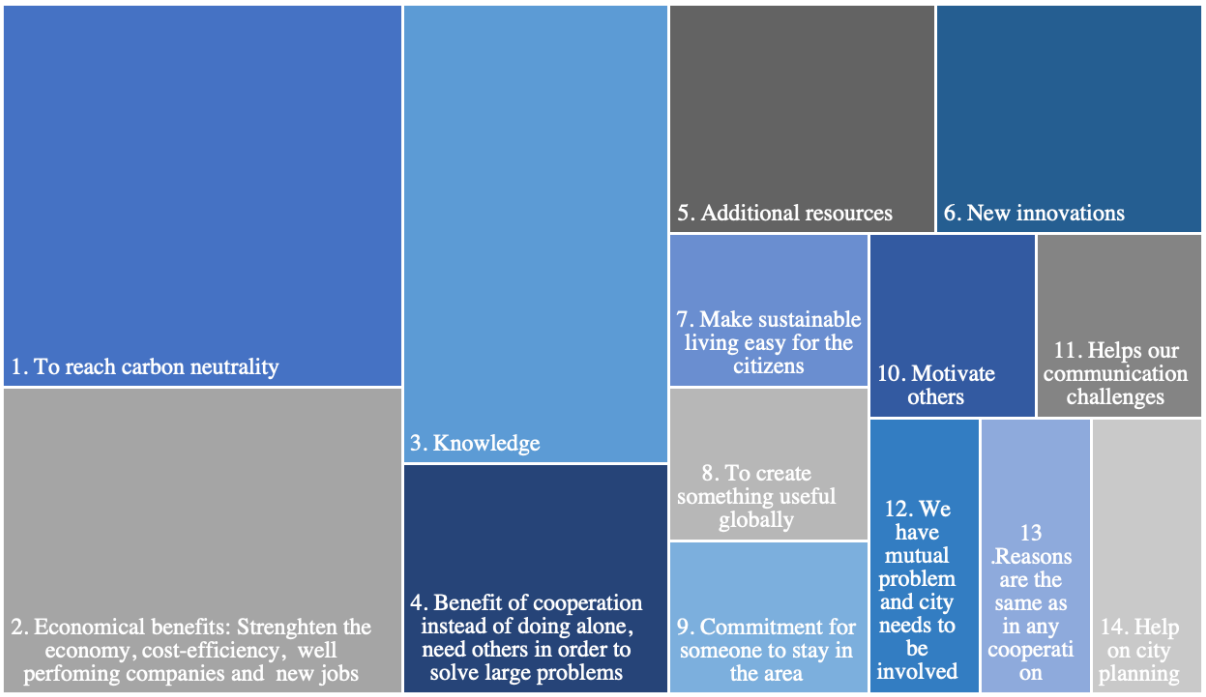


Figure 10 Main drivers for collaboration in ecosystems in decarbonization of cities

The city organization can only function inside its borders, but businesses can scale up and take innovations that are built inside the city to the world. This perspective was brought up in city

D, where collaboration between a university and companies was highlighted as a possibility for creation of global innovations. Universities can listen to businesses on what kind of expertise is currently needed and businesses can employ the graduates with the desired skillset and knowledge. The respondent saw that it's essential that we don't only pursue our own city's climate goals further when there is possibility to do something that can also be beneficial elsewhere and globally. Internationality was seen as a possibility to broaden the city network and also improving of the city's communication challenges.

The targeted benefits can also be universal and not dependent on the goal of decarbonization. As the development manager from city F said, *"the targeted benefits and reasons for collaboration are the same as in any cooperation, although there is an additional bonus of saving the world"*.

Some of the interviews (cities A and H) also included a brief conversation on how Covid-19 has impacted their work during 2020 and 2021. Respondents felt that the rapid change to remote working and online tools have actually improved ecosystem work in cities. It's easier to participate in meetings nationally and internationally and to plan development work together with different organizations online at the same time. EU recovery funding shows some promising opportunities for cities and businesses. In a way, working in ecosystems towards a common goal was considered even more topical now than previously.

5.6 Requirements for a city and other ecosystem members

What is needed from the different actors that wish to be part of an ecosystem together with a city, and how do city representatives see their own pre-requirements to join or create an ecosystem? Respondents felt that most of the requirements for collaboration are the same for both the city and the other actors. All actors need to have the right attitude and belief for the topic and to be ready for concrete actions. Openness and commitment to mutual rules were seen as necessary in cities' ecosystems.

From a city perspective, before a city can be part of an ecosystem, there needs to be a commitment for the climate targets and leadership to support the targets. City representatives

highlighted the importance of resourcing the time used in ecosystems. If a city wants to be active and gain a lot from being part of an ecosystem, then there needs to be enough time to put effort into it. Respondent from city G said that a city can't, for example, pay for some company's product development, because the spending of city money is done with taxpayer's money and everything a city does needs to be well reasoned and equal for all. According to city F, ecosystem work should be open per se, because the city's work and information are always public information, and there needs to be a specific reason for something not to be open.

For collaboration partners, the interviewees felt that there needs to be the same vision of improving citizens' and the environment's wellbeing (cities A, F, G). Interviewees from city F phrased the desired values as it does not matter if a partner disagrees in something, but at least they should be on an ethically sustainable basis, and maybe not feel strongly against the climate goals since then it would not make sense to cooperate for achieving the climate goals.

The different identified requirements for other ecosystem partners and cities themselves, and mutual requirements for everyone, are illustrated in Figure 11.

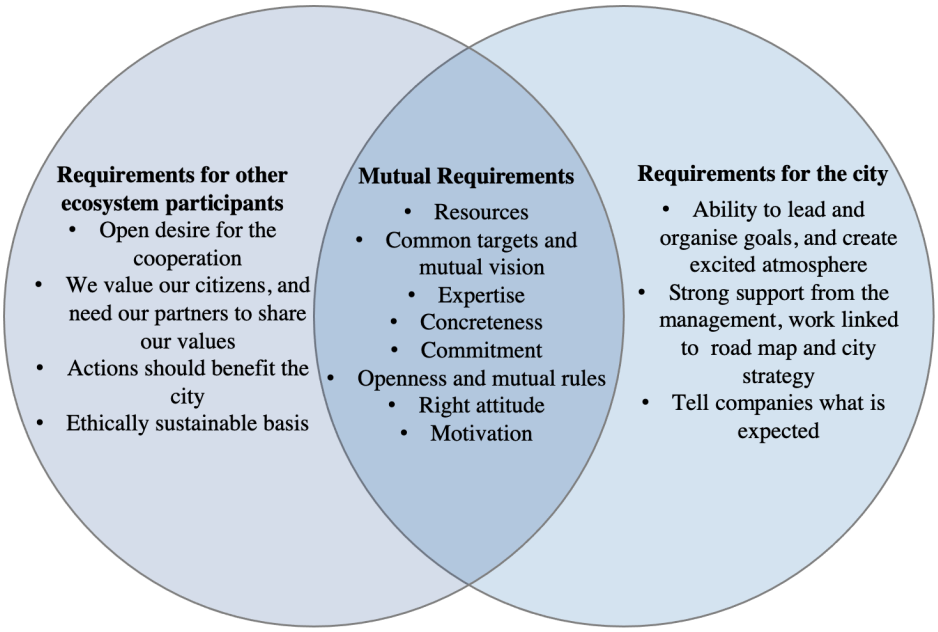


Figure 11 Ecosystem requirements

In the ecosystems that a city representative is leading, there should be ability to lead and create an exciting atmosphere for the participants, according to a respondent from city D. All cities

considered concreteness as an important requirement for both the city and other actors, and it should be clear what is expected and how everyone can contribute.

Interviewees were also asked about the relevance of an ICT-vendor as a part of city decarbonization ecosystems. In the interviews, an ICT-vendor, such as a data platform or telecommunications provider, was seen central in a carbon-neutral ecosystem, although not more important than other partners in regards of the collective whole. Different data indicators can help in following the city's progress and help companies and citizens in their decision making or carbon footprint calculations. According to respondent from city D, digitalization has a lot to do with other sectors, for example, enabling of taking energy efficiency further. Some of the respondents highlighted that ICT-vendors can be an important help for cities on their path towards carbon-neutrality, but they also need to be responsible on their own emissions, and, for example, excess heat from data centers should be collected to energy systems (cities B, H).

5.7 Challenges, risks and limitations

Challenges, risks and limitations in the use of ecosystems and collaboration for city's carbon-neutral city goals relate to all actors as well as the city's own internal challenges with resources and bureaucracy.

Image, branding and communications can be challenging*: "Maybe for us as a city it has been difficult to brand ourselves as a good area for companies that are interested in, for example, renewable energy" (Director, E)* Even though a lot of actions are made towards a more sustainable direction, the efforts that are made might not always be visible outside the city organization. Respondents felt that it is challenging to communicate the city's climate actions for citizens and sometimes also within the city organization. If the goals are placed into global metrics of environmental goals, the climate work within city organization was seen more justified (city H).

Also, when discussing about the image and collaboration, respondent from city F brought up a risk that if a city works together with someone who then does something illegal or, for example,

gives out a discriminating statement, it also influences the city's image. The second risk that was identified related to the image was that a city might experience setbacks from media if they do something experimental with public money and fail (city D).

Communication is an important key in any collaboration. Respondents felt that it is important to have constant communication, especially if the focus of the ecosystem shifts to something than what was initially planned. The importance of good communication was seen as crucial also in agreeing on mutual goals. Aligning different interests gets more difficult the more different participants are in an ecosystem, but it is mandatory to get the work forward. Interviewee from city H said that the communication challenges rise up even when you think you have been clear and communicated well, there are always people that don't understand or don't ask if something is unclear to them. Collaborations are based on trust, and if trust is broken then it can be difficult to continue working together. The respondents identified a risk of a partner leaving during a project or agreement breaks in other way (cities B, H). Collaboration is always voluntary, so a partner leaving is a potential risk.

Continuous collaboration can also depend on the size of the partner. Respondent from city A discussed that it can sometimes be economically unstable to collaborate with a small business if it's about a program that lasts for a longer time period.

Many respondents brought up that commitment inside an ecosystem is a challenge. For some reason, others are more active than others, even though all want to be involved. Respondent from city B felt that it's difficult to get companies involved and interested in collaboration for city's climate targets, because smaller companies don't have enough resources to work together, and larger companies are not interested because there is not enough concrete benefit for them. If there is a concrete cooperation target with business, there is usually also business secrets. Some don't want to give out information, and this can create asymmetrical cooperation inside the ecosystem (City F). For business secrets, interviewees mentioned that as public authorities, cities are great at keeping business secrets. These information risks were also discussed in the form of data property (City G). Ecosystems usually include information about its participants, depending on the purpose of the ecosystem. Data and information sharing were seen as a risk. If the city borrows its data to building of products, and it is then combined with different

organizations' data, there might come some limitations and cyber security risks. The discussions on the data property have to be very explicit if it's taken into use outside the city organization.

A city as a public organization has its own legislation and methods to follow that can make collaboration with businesses sometimes difficult. Respondents from cities D and G felt that its sometimes difficult to support the companies and interact with them because the public sector can't give financial support to private companies and it is crucial to stay equal to everyone. Respondents noted that cities as public organizations have to ask for bids on every procurement publicly. This makes it challenging to buy services when there isn't really much of competition to choose from:

> *"Sometimes purchase laws that municipalities have to obey can hinder innovativeness. In this case, these networks and ecosystems come to place because in this scenario we are not buying anything; instead, we are partners and can enable innovation work and open testing" - Director, G*

Interviewees recognized some political risks. There is a risk that carbon-neutrality is seen as only the Green Party's mission and doesn't somehow involve other political parties or doesn't fit to other political agendas, even though respondents felt that carbon-neutrality fits to everybody's agenda because the climate crisis is equal to everyone (cities E, H). Respondent from city H recognized a potential lack of common language and definitions between people, which can create confrontation and polarization, especially in a political landscape. This political landscape in which cities function was brought up also in the form of new elections. With new elections coming up, there is a risk in the shift of political power and the limited resources that cities have for environmental work might be even more limited afterwards, if other political parties don't see climate matters as part of their agenda. In the end, politicians are the ones that decide the city's resources and funding. Political risk was also pointed out when discussing about investments made into new wind power plants since not everyone feels the same way about wind power (City E).

Even though all of the cities said to have a support from city management, they don't have separate resources to work with in carbon-neutral road map. This limitation of money and time is the biggest challenge in both limiting city organization's own emissions and also in participating to different ecosystems with the region's companies and other organizations. Participating in an ecosystem is not only the time it takes to take part in the meetings but also time used for studying and discussions on the topic outside the meetings (cities A, F, H). Respondent from city C felt that there is not enough money and time to have multiple innovative new projects going on at the same time, especially in a small city. All interviewees mentioned the scarcity of the city's own resources as a challenge or limitation in ecosystem work.

"Resources, just yesterday we decided that we can't participate in a project together with other municipalities because there is not simply a person, we could reserve for it"- Environmental planner H

Also, limitations of time from businesses side were mentioned as a challenging factor because every time that is used in working in ecosystems, is away also from the company's time (city D). From city perspective it's important to show why its beneficial to spend time on mutual targets, even though they might not show in the next financial quarter in a company.

The nature of the city organization itself can also be a limiting factor. Respondents from cities E and H said that it would improve a lot of things inside the city organization if they were able to share information better. Inside the city there might be different ideas on what the climate goals should be, or even if different units agree on the goals, there might be different ideas of how to get there.

The answers from interviews were organized with the affinity diagram method, where answers were grouped with similarities and then given a header name for categorization. For example, trust was mentioned for both challenges and risks and therefore selected as combining area name. It was seen as challenging to build trust between ecosystem participants, and there is a risk that trust breaks. Trust breaking also correlates to the commitment between actors and possible agreement breaks. Challenges, risks and limitations which were recognized during interviews and presented in this chapter are collected below in Table 10.

Table 10 Challenges, risks and limitations

Area	Challenges	Risks	Limitations
Commitment	Commitment to agreed work and active participation from all	Agreement breaks	
Trust	Building of trust	Trust breaks	
Businesses' motivation	Difficult to get interested businesses to join	Collaboration with small businesses can be economically unstable	
Aligning of interests	Aligning of interests		
Justification	Justification for the work		
Image	Branding	Image risks	
Politics	Political views on environmental matters	Shift in political power	Regulation and political goals
Bureaucracy	Purchase laws How to support companies as public sector		Bureaucracy and city management
Communication	Communication, same style of communication established for the key players		Lack of common language or definitions can create confrontation and polarization
Information	Openness of information	Data privacy and cyber security	
Scarcity of resources	Resources: time and money		Resources: time and money

Most of the attributes that were discussed in the interviews relate to potential challenges and risks that have been already experienced or are seen as potential risks. The limitations that cities have for participating in ecosystems with multiple actors relate to their scarcity of resources and public sector bureaucracy.

6 ANALYSIS AND DISCUSSION

In this chapter, the empirical and theoretical findings are brought together to form insights into the research and answer the research questions. Identified drivers, barriers and limitations are classified in political, economic, social, technological and environmental factors. Furthermore, the guidelines for successful ecosystems where a city organization is involved are formulated.

6.1 Insights of the research

Figure 12 groups drivers, barriers and requirements collected from both empirical and theoretical findings from previous chapters. Drivers are the targeted benefits and motivation for the use of ecosystems in cities' decarbonization; barriers refer to the challenges, risks and limitations that cities have in ecosystems, and finally, requirements are the required attributes and assets for all ecosystem participants. The findings are divided into a PESTE analysis, which includes five areas: political, economic, social, technological and environmental findings. PESTE is selected for analysis because cities function in a complex and broad environment, and there are drivers, barriers and requirements identified in all of the mentioned areas. PESTE analysis is a useful tool for current state analysis of a macro environment (Johnson, Scholes and Whittington, 2007).

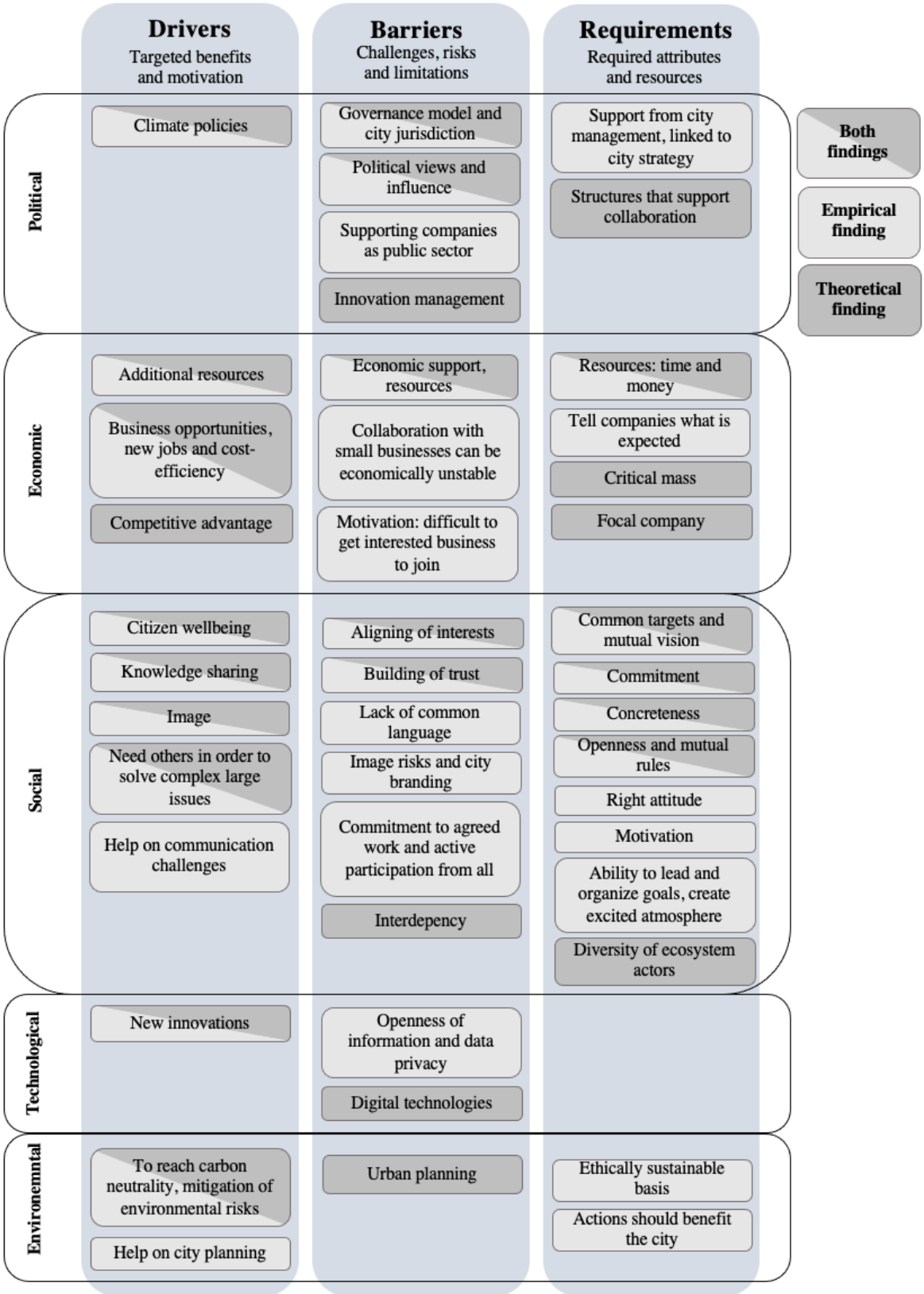


Figure 12 Empirical and theoretical findings in PESTE analysis

From Figure 12, we can conclude that the findings found from both empirical and theoretical data are strongly supported. The main drivers for cities to use ecosystems in decarbonization are the different ecosystem value propositions: knowledge sharing, business value and new innovations. A further driver is a collective action of solving a complex and large-scale issue of carbon-neutrality, which requires collaboration between multiple actors. Also, the positive image and of course mitigating climate change consequences are seen as important drivers. The main barriers are political views, the governance model of cities and scarcity of resources. In addition, more general collaboration issues were recognized in building of trust and aligning of interests. The main requirements for city's decarbonization ecosystems are resources, mutual vision between the ecosystem members, commitment to the ecosystem, concreteness, openness and mutual rules.

The drivers, barriers, and requirements are further discussed in chapters 6.1.1-6.1.5 from political, economic, social, technological, and environmental perspectives.

6.1.1 Political factors

A lot of cities' challenges lay in their political and bureaucratic operating environment. The governance model and city jurisdiction can be a hindering factor when discussing of, for example, innovation ecosystems in cities (European Commission, 2020).

From the interviews, it was brought up that, for example, purchase laws can make collaboration with companies difficult. Also, politics affect by means of voters and decision-makers in cities, and how for example, investments in wind power are perceived. The role of national and international policies in city decarbonization (Dahal, Niemelä and Juhola, 2018) came up in the empirical part of the study in setting up the target years for decarbonization. These target years in cities were first defined on national level, which in turn is based on the international policies. The respondents felt that having a strong support from city management is important in working towards climate targets. All cities have the decarbonization plan as part of the city strategy, but the participation of city management in implementing the plan to action varies among cities.

6.1.2 Economic factors

Resource sharing an important driver for collaboration (Abreu and Camarinha-Matos, 2008), but resources are also a challenging factor in terms of time management and how the ecosystems are funded (Laasonen *et al*., 2019; European Commission, 2020). The scarcity of resources makes it difficult for cities to pursue their climate goals and forces to prioritize different possible ecosystems with each other. For example, one respondent said that because of resources, they cannot participate in all collaborations as much as they would like to. On the other hand, new business opportunities that come up from collaboration in ecosystems regarding sustainable solutions and carbon-neutrality can bring new jobs and cost-efficiency to the city (CDP, 2016; Ahola *et al*., 2020). Respondents emphasized the importance that well-performing companies have for the region; they bring of course, tax income and employ citizens, but can also, for example, positively affect city image.

Most of the interviewers emphasized different networks among other public organizations like municipal ecosystems or EU Covenant of Mayors that function mainly within the public sector. One interviewee said that there are no resources to be a leader for the ecosystem, but other interviews indicate the leader of the ecosystem depends on the type of ecosystem; some are industry-driven, some research institute-driven and some city-driven. However, in the literature, it was suggested that ecosystems that include business value creation, knowledge creation or innovation formation, the public sector should take a role of an enabler or facilitator rather than the role of the ecosystem leader (Salminen and Halme, 2017). It's also suggested that it would be better for the resilience of the ecosystem if the leader is from the private or third sector rather than the public sector (Salminen and Halme, 2017; Laasonen *et al*., 2019). For the ecosystems that are managed by city officials, interviews supported that a city should have the ability to lead them and create an exciting atmosphere. From theory, it was noticed that it could be difficult for cities to find a strong company leader for the ecosystem (Laasonen *et al*., 2019) and from interviews, one respondent described difficulty in finding motivated companies to join the ecosystems.

From theoretical findings it was suggested that having a critical mass is vital for the success of the ecosystem (Moore, 1996; Laasonen *et al*., 2019). This did not come up in the interviews but can however be an important factor for a successful business ecosystem.

6.1.3 Social factors

Achieving carbon-neutrality is not possible alone (Rosenzweig *et al*., 2015; CDP, 2016). Cities need others to reach the target and achieve systemic change, which is the main driver for the use of collaboration. Openness, mutual rules and common goals are some required attributes in setting up the collaboration (Kramer and Pfitzer, 2016; Laasonen *et al*., 2019). The respondents identified some challenges in aligning the different interests in ecosystems between multiple actors.

A thriving ecosystem should give something to everybody, and if a participant does not get anything concrete out from the ecosystem, then they shouldn't be a part of it in the first place. This concreteness is important for both the city and businesses, and other organizations taking part in the ecosystem. Theoretical findings supported the concreteness also when discussing that all ecosystem participants should have a justified place in the ecosystem (Laasonen *et al*., 2019). In theoretical findings, the importance of multilateral complementarities was highlighted, each participant's expertise should complement to others' (Jacobides, Cennamo and Gawer, 2018; Ma and Hou, 2020). However, the required diversity of ecosystem participants (Laasonen *et al*., 2019) did not come up in the empirical findings.

From empirical findings, constant and clear communication inside an ecosystem was seen as vital. Constant communication enables the building of trust, which is a common challenge in any collaboration (Kumar, 1996; Ma and Hou, 2020). Communication also enhances knowledge sharing and creation, which is one of the main drivers of ecosystems (Clarysse *et al*., 2014; Valkokari, 2015).

From theoretical findings, the inter-dependency between ecosystem members was defined as one of the main attributes of ecosystems (Kaihovaara *et al*., 2017; Mäntymäki and Salmela, 2017). The inter-dependency did not come up in the interviews directly, but the image risk that

was mentioned could be defined as inter-dependency. One respondent said that if someone in the ecosystem does something wrong, it also affects the city's image.

6.1.4 Technological factors

New innovations created in the innovation ecosystems are one of the main drivers for collaboration in ecosystems. Current use of digital technologies in the public sector was seen as a barrier in the theoretical findings (European Commission, 2020), but it did not come up in the empirical part. The ICT sector is seen as a central actor in the city's ecosystems. Different solutions can help cities in their decision making in climate matters (Frost & Sullivan, 2015). In addition, one respondent conversed the importance of clear rules for the city's data use in digital solutions.

The findings did not directly support the importance of a first-mover advantage, which refers to technological leadership and growth gained from new innovations. However, the relevance of innovations in a global scale was brought up, and from empirical findings, it was seen as important to support innovations and the region's companies' growth beyond the city borders.

6.1.5 Environmental factors

As the topic is the decarbonization of cities, the driver for ecosystems in the decarbonization of cities is naturally to achieve carbon-neutrality. However, the main driver for carbon-neutrality is the mitigation of environmental risks of climate change (Rauland *et al*., 2015; IPCC, 2018).

Urban planning was defined as a potential barrier in the theoretical findings (European Commission, 2020). In the empirical part, one respondent noted that collaboration with multiple actors can bring help to city planning, which can be a driver. Utilizing collaboration also in urban planning helps cities to overcome their challenges in this area.

The respondents mentioned collaboration with the energy sector to be particularly vital in decarbonization. However, from the study other crucial sectors in addition to energy systems

are construction, public transport and agriculture (Rauland *et al*., 2015), industrial processes, and water and waste management systems (Frost & Sullivan, 2015).

6.2 Guidelines for successful ecosystems in city decarbonization

The potential guidelines for managing and creating ecosystems for city decarbonization are formulated based on the findings discovered in the previous chapter, aiming to solve the barriers that cities face.

Resources of both time and money were considered to be one of the most significant barriers and limitations that cities have in participating or creating ecosystems. From theoretical findings, combining of different finance streams from the local, national, international and private sector was highlighted in order to take on new responsibilities and support climate innovations (Rosenzweig *et al*., 2015; Barber, 2017; European Commission, 2020).

The diversity of ecosystem members is an important requirement when creating an ecosystem (Laasonen *et al*., 2019). Especially when discussing about achieving carbon-neutrality, the collaboration among multiple different stakeholders is central due to the complex and broad nature of the problem of decarbonization (Deloitte, 2015; Rosenzweig *et al*., 2015; CDP, 2016). In ecosystems, whether it's more of business, innovation or knowledge creation, it is important to gather participants across sectors with different expertise that complements to others' expertise (Ma and Hou, 2020). The interviews described that collaborating in ecosystems is more straightforward when the topic is narrow and precise.

In some cases, it can be difficult to find motivated businesses to join the city in its decarbonization plan (Laasonen *et al*., 2019). And in some cases, the city brand does not reflect its actual climate actions. To solve these and have companies involved and also lead the ecosystems, city organizations should communicate the benefits of collaborating with them and build their image towards sustainability and carbon-neutrality. For companies, these collaborations can bring new business value and innovation creation, not only for the regional markets but also in a global perspective. Together the ecosystems that include the public, the private and the third sector can build future proof societies. This point of view is vital also if

the regional strengths are considered. The ecosystems that aim for regional carbon-neutrality by focusing on a specific sector and issue at a time, should utilize the specific strengths available in the city and facilitate the ecosystems to support that expertise. For example, in knowledge creation, the ecosystem should utilize the local university or other research institutes. Table 11 summarizes suggestions for the collaboration in ecosystems for city's carbon-neutrality.

Table 11 Guidelines for successful ecosystems in city decarbonization

Guideline	Description
Ensure a sufficient amount of resources	Combining of different finance streams and making sure there are enough resources allocated for the ecosystem work
Aim for the diversity of ecosystem members and concreteness of the purpose	Multilateral complementarities among the participants and making sure everyone has something to contribute to the topic
Find common vision and rules	Aligning of interests and finding a common and clear vision, as well as establishing common rules for the ecosystem
Communicate about the city's sustainability actions	Sustainability can have a positive influence in the city image from a company, investments and citizen perspective. Pursuing to build the image of carbon-neutrality so that companies are interested in collaborating, leading the ecosystems and staying in the area
Make use of the regional strengths	Geographical location can bring opportunities, for example, for wind power Universities are important players in knowledge and innovation creation

After all, the purpose of these ecosystems that aim for decarbonization of cities should focus on the actual work of achieving the target. From the interviews, one respondent brought up that it has almost started to feel like a competition, on who says the lowest number for carbon-neutrality, or the overall concept of reaching carbon-neutrality has been incorporated into

politics and moreover to specific political parties. Mitigating the consequences of climate change is vital to everyone, and cities can be the catalysts for a more sustainable future. In the building of the ecosystems for city decarbonization, it's important to keep in mind the actual purpose of the ecosystems and communicate the relevance to the public as well. This might help in the political and social issues and keep the goal of decarbonization not endangered by a change in government or political policy.

7 CONCLUSIONS

The world's ecological ecosystems are at significant risk with the consequences of climate change. The pressure to act is high, and nations, companies and individuals are starting to take action. Cities are aiming for carbon-neutrality, and new innovations to support the goal are being constantly researched. To reach the goal however, cities need to collaborate with multiple stakeholders. Collaboration in ecosystems with industry experts, academia and other organizations could bring the most effective results. It could be said that in order to save our ecological ecosystems, we need to start working in ecosystems.

7.1 Key findings of the research

The object of this study was to analyze the drivers, barriers and requirements in cities' decarbonization ecosystems, and provide some guidelines based on the research. In the following, the research questions are briefly answered.

> *RQ1.1: What are the drivers for a city to join an established ecosystem or create an ecosystem with multiple actors around city's decarbonization project?*

A city cannot achieve carbon-neutrality alone and needs others to succeed in its decarbonization and mitigation of the environmental risks of climate change. The ecosystem approach has an opportunity to create business value, innovations or, for example, knowledge creation and sharing. These all can bring economic benefits and boost the wellbeing of citizens. In addition, decarbonization can create a positive image to the city.

> *RQ1.2: What are the perceived barriers and requirements in cities' use of collaboration in city decarbonization?*

Scarcity of resources in both available time and money is the most considerable barrier that cities face in their ecosystems for decarbonization. Besides being a barrier, resources are also an essential requirement in any ecosystem for both city and other ecosystem members as there needs to be time to invest to the ecosystem. Other barriers arise from communication, which also relates to the building of trust and aligning of interests. Therefore, it's essential to have an

open communication that supports the ecosystem's shared vision and mutual rules. In addition, political views are a challenge in cities' decarbonization as environmental matters can be seen political or that they only belong to a certain party. Also, the governance model of cities can be a hindering factor especially in innovation development. The identified drivers, barriers and requirements for research questions 1.1 and 1.2 are collected in the Figure 12.

RQ2: What should be considered in a city's decarbonization ecosystem with multiple actors?

The ecosystem participants should be diverse, complement to each other's capabilities and should have something concrete to contribute to the ecosystem. The concreteness is easier to establish if the topic of an ecosystem is also clear and narrow. Constant communication builds trust and makes collaboration easier for all the included parties. In addition, in the development of carbon-neutral cities, it should be considered what the specific strengths available in each city are, and the collaboration to support those should be facilitated. The guidelines for building a thriving ecosystem for city decarbonization are collected in Table 11. These suggested guidelines could be beneficial especially for the leader of an ecosystem that is targeting for city decarbonization. Whether the leader is a city organization, a business or an organization from the third sector, the guidelines could provide an idea for the leading and establishing such ecosystems.

7.2 Limitations of the study

The study should not be overgeneralized, due to its limitations in data collection and duration. It should be remembered that since this study includes results from eight cities in Finland, and from 10 respondents in total, the results and observations from the study are estimates, and further research is needed in order to draw extended conclusions on the topic. However, since the target was to have a diverse mix of different cities in Finland, these results provide an understanding of the current decarbonization of cities and use of ecosystems in Finland, and the results could be similar to other countries as well, for example, in the Nordic region.

In addition, even though the respondents were comfortable on presenting their experiences as the city's opinions, they necessarily don't have all the needed information, and answered partly from their personal perspective. Respondents also come from different roles and units from each city, which can affect the results. In fact, the larger the city, the more difficult for the respondent was to answer to all interview questions, because environmental goals are planned in other units, and business collaboration in others, even though the goals align.

Moreover, comparing individual interviews with interviews with two people, in group interviews there was a possibility to complement the ideas from each other and thus have more complete answers.

7.3 Suggestions for future research

This thesis focused merely on cities in Finland and cities' perspective on ecosystems on their path to carbon-neutrality. For a deeper analysis on significance and opportunities of business, innovation and knowledge ecosystems use in decarbonization of cities, research should cover a broader area both geographically and in participant selection. From the geographical viewpoint, further studies could include cities from different countries in Europe. From the participant selection viewpoint, this Finnish study could be extended by researching other ecosystem members, such as companies and the third sector, in city decarbonization ecosystems. Studying the businesses from various sectors, academia and citizens in ecosystems for decarbonization of cities would be interesting and give a more comprehensive idea to the drivers, barriers and requirements of ecosystems in city decarbonization. Business ecosystem was defined to have both competitive and collaborative aspects, but as this study focused on the cities point of view, cities as public authorities did not emphasize the existence of competition within the ecosystem. Studying the ecosystems for city decarbonization from a more business perspective could bring valuable insights also from the competitive side of collaboration in ecosystems.

Furthermore, focusing on specific ecosystems in depth around the topic, such as in traffic, energy or building sector, could provide practical insights into ecosystem governance and success. Also, other ecosystem types such as entrepreneurship or platform ecosystems could be studied related to cities' decarbonization.

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APPENDIX

Appendix 1: Complete interview framework

#	Question
	Theme 1: City's carbon-neutral goals
1	What is the current status of decarbonization goals in your city? *Could you elaborate your goal to be carbon-neutral by 20XX, what actions have already been done and what kind of actions are planned?*
2	What are the reasons for your city to pursue carbon-neutrality? *What are the incentives or pressure that have driven especially towards carbon-neutral city agenda?* *Is there pressure to act, what kind of pressure?*
3	How are carbon-neutral goals organized in your city? *In what way does the city lead participate in environmental matters?* *Is there support from city management, is decarbonization part of city strategy?*
	Theme 2: Ecosystem
4	How do you understand the word 'ecosystem'? (in this case not nature ecosystem)
5	*Brief introduction to ecosystem theory: business, innovation and knowledge ecosystems.* Based on the description introduced briefly before, in your opinion, is your city part of an ecosystem or ecosystems, in regards of its climate – and carbon-neutral goals?
6	What kind of participants are in your ecosystem? With whom do you collaborate in environmental matters?
7	How is the cooperation organized?
	Theme 3: Collaboration drivers
8	What are the drivers to start ecosystem work in carbon-neutral initiatives? *Do you recognize certain incentives or pressure to utilize collaboration?* *What kind of benefits are targeted and possibly already achieved from collaboration?*
9	What are the three most important reasons or desired outcomes to utilize ecosystem-based cooperation in achieving carbon-neutrality in city?
	Theme 4: Requirements: city and other ecosystem participants
10	What requirements are needed from the city in order to take part in cooperation or create an ecosystem with other actors? (carbon-neutral city targets)
11	What requirements are needed from other participants, in order to take part in the same ecosystem with city? (carbon-neutral city targets) *How do you see ICT vendors in the cooperation model that you are involved in?*
	Theme 5: Challenges, risks and limitations

12	What kind of challenges have already come up with collaboration between different actors? (Carbon-neutral city)
13	What kind of risks have limited the start of cooperation in the first place?
14	What factors limit opportunities to act?
	Open question
	What was not asked in your opinion?
	How has Covid-19 affected your city's work in achieving the carbon-neutrality?