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ABSTRACT

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Abstract

The prevailing linear economic model is reaching the end of its life cycle as the continuous population and economic growth are endangering the access to vital resources. Urbanization has created significant concentrations of population, where the diminished supply of resources realizes. This positions urban areas to a focal role in developing a more sustainable economic model. Circular economy is an emerging economic model promising decoupling of economic growth from resource usage by increasing resource efficiency and circulating the resources. The city of Turku actively invests in the development of circular economy and pursuits to advance the opportunities of other cities to join the cause. This study will draw a picture of the current systemic circular state of Turku and analyze it through the Urban nexus framework. The method of the study is an inductive case study primarily based on expert interviews. The discussion verifies enablers of circular economy and evaluates the future development potential of circular economy generally and in the city of Turku. Based on the application of the Urban nexus framework and empirical date, an urban system circular transition management plan is proposed as a result of the study.

Key words	circular economy, urban studies, futures research, sustainable development
Further information	

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Tiivistelmä

Vallitseva lineaarinen talousmalli on saapumassa elinkaarensa loppuvaiheeseen jatkuvan väestön- ja talouskasvun ylittäessä ympäristön kantokyvyn ja vaarantaessa elintärkeiden resurssien saatavuuden. Kaupungistuminen on luonut merkittäviä väestökeskittymiä, joissa resurssien heikentynyt saatavuus realisoituu, mikä asettaa kaupungit keskeiseen rooliin kestävämmän talousmallin kehittäjänä. Kiertotalous on nouseva talousmalli, jonka lupauksena on erottaa toisistaan talouskasvu ja resurssien kasvava tarve tehostamalla resurssien käyttöä ja kiertoa. Turun kaupunki panostaa kiertotalouden kehittämiseen aktiivisesti ja pyrkii toimillaan edistämään myös muiden kaupunkien edellytyksiä kiertotalouden kehittämiseen. Tämä tutkimus tekee katsauksen kiertotalouden edistämisen nykytilanteeseen Turun kaupungissa ja analysoi sitä systemaattisesti Urban nexus-viitekehyksen kautta tavoitteenaan todentaa kiertotalouden mahdollistajia ja arvioida kierotalouden tulevaisuuden näkymiä sekä Turun kaupungissa että yleisesti. Tutkimuksen tuloksena esitetään Urban nexus- viitekehykseen sekä empiiriseen tutkimusaineistoon perustuva kaupunkiympäristön kiertotaloussiirtymän johtamissuunnitelma.

Asiasanat	kiertotalous, kaupunkitutkimus, tulevaisuuden tutkimus, kestävä kehitys, ympäristö
Muita tietoja	

UNIVERSITY OF TURKU
Turku School of Economics

URBAN CIRCULAR TRANSITION

Case study – City of Turku: the current systemic circular state and future development potential for 2030

Master´s Thesis
in Futures Studies

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The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

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1 INTRODUCTION

1.1 Increasing unsustainability calls for paradigm change

We are currently living under an increasing understanding of the unsustainability of our lifestyles. The exponential growth of material wealth surrounding us is a produce of economic growth of the past decades, which, according to a growing amount of research evidence, our environment cannot sustain. Global warming, resource scarcity and biodiversity loss are commonly acknowledged as the greatest threats of this century. We experience it through the scarcity of resources like water, clean air and fertile land, that are even presently a reality in many regions worldwide. (Prendeville et al. 2018, 171; Hezri 2018, 14; Lehmann 2018, 47). Additionally, at the end of the resource life cycle exists the global waste generation, that is estimated to be between 7-10 tn. annually. Of this, only 30% is recycled and the majority is still landfilled, which indicates high stress to environment and significant resource loss to economy (Zeller et al. 2018, 84).

The current linear production and consumption paradigm is no longer adequate due to inefficiency inherent in its resource use, which calls for transition towards more resource efficient model of circularity (Ghisellini et al. 2016, 11). In recent years, circular economy (CE) has emerged as one of the buzzwords for sustainable development. The interest towards CE and has been increasing worldwide due to the promises of a more sustainable future invested in it. CE is claimed to contain a solution to simultaneous growth and increased sustainability by decoupling growth and material usage to diminish resource scarcity. Additionally, it is considered of being a central tool in altering our consumption patterns to mitigate climate change (Ghisellini et al. 2016, 11, 26).

When it comes to the subject of CE, the academic community seems to agree on one thing: the research concerning it is merely on its early stages (Kircherr 2017, 12: Prendeville et al. 2018 171). This notion is shared by numerous practitioners of circularity, even leaders of the development of the concept (Korhonen et al. 2018, 545). However, the lack of research evidence does not hinder established organizations like World Mayor Council on Climate Change, ICLEI – Local Governments for sustainability, G40 Climate Leadership Group and Ellen MacArthur Foundation advocating and promoting the advancement of CE as the new paradigm for more sustainable future (Prendeville et al. 2018, 272).

Practical applications of CE are currently being introduced in increasing amounts in various domains of society. Circular principles seem to be at least roughly known by the actors in public and private sectors and partly understood by the citizens. The ideology of CE mimics the circulation flows of natural resources, where the waste of one process is always a resource for another (Marin & DeMeulder 2018, 1311). In the modern world CE stands for more efficient circulation of resources and materials in the industrialized and

built environment with the aim of decreasing the amount of waste to zero. The essence of CE lies in the design of a novel economic pattern, that allows efficient resource use, optimal resource exchange and circulation through interaction between producers, users and components. (Ghisellini et al. 2016, 18, 26).

1.2 Cities as the domain of circular transition

Population growth and urbanization are constantly intensifying megatrends with estimations of 70 percentage of the global population of 9,6 billion living in cities by the year 2050 (WHO 2013, cf. GIZ – ICLEI 2014, 5). Cities are economic growth engines with generating up to 85% of the global GDP. Consequently, they are major clusters of resource consumption and contributors of environmental stress, as they consume more than 70% of total energy and produce more than 70% of the total greenhouse gas emissions. (Boyd & Pablo 2016, cf. Wang et al. 2018, 877; WEF 2018, 3). With the largest cities of the world reporting 25 million populations and increasing (World Atlas 2019), the significance of urban ecosystems in mitigating climate change related issues is further growing in importance. The demand for improved and stronger infrastructures providing safety of resource supply, simultaneously sustaining the environmental limitations poses a focal challenge for the urban futures (GIZ-ICLEI 2014, 5). In consequence, the perceived impact and importance of CE in urban context has started to appear as subject of considerable interest. Some cities, like Amsterdam and London, have already been acclaimed as pioneers of CE. Additionally, there are numerous cities that have started to show interest towards the phenomena or carried out some circular projects.

The New Urban Agenda of United Nations (UN 2016) calls for an urban circular transition, which means a systemic paradigm change from linear consumption culture to circular economy in cities. This is not a novel ideology, since the term circular city has been associated with ecological urban planning consisting of transportation, infrastructure, governance and participation of citizen since the 90´s. Urban metabolism is a metaphor used in depicting a city as a body of organisms hosting processes where resource flows enter the system, undergo transformations in the process and finally exit the system (Hezri 2016, 12). Circular city has during the last three decades evolved from concerning separate domains of resource and activity to concern the system and connecting circularity to urban metabolism through efficient reduction, reuse and recycling of resources (Boeri et al. 2019, 74). Lately, CE has emerged as the new tool to reach the paradigm of sustainability.

Although there are several notions about urban circular transition, there is a lack of concrete descriptions and evidence of the means and actions through which the process occurs. According to Hobson and Lynch (2018, 20-22), to proceed and succeed, circular

transition requires radical ideas, concrete examples and inspirational stories from practitioners combined with further research and analysis from academic community. Prendeville et al. (2018, 171) identify a lack of consensus of the meaning and even significance of circularity in cities and a further demand to research the impact and potential practices of urban CE. Urban environments are extremely complex, and it is difficult to determine and attain the optimal level of sustainability and find the suitable combination of initiatives. Petit-Boix and Leipold (2018, 1278) suggest it would be desirable for academia to provide research about CE to support the decision-making processes of cities in transition towards more sustainable ecosystems. Velenturf et al. (2018, 1409-1410) emphasize that circular city needs to be a comprehensive approach spreading to all the stakeholders and domains of action. In order to achieve systemic transition, fundamental change is required in all governmental and policy levels to inflict the change throughout society.

The establishment of a systemic understanding is essential in changing the paradigm from linear to circular. Kircherr et al. (2017, 221) indicate that a systemic shift is required in the transition process towards actual circularity, even if the concept is most commonly identified through resource efficiency relating mnemonic 4R of reducing, reusing, recovering and recycling. WEF (2018, 20) describes the roles of actors in the systemic approach by claiming that the role of the government is to provide policy incentives and the private sector is responsible in creating circular business models, whereas civil society advocates the change. Research institutions provide research and analysis for other parties to develop their approaches and the individuals can advance the cause by adapting their consumption patterns. Low ownership of stakeholders of different levels will most probably lead to failure of the endeavour.

The successful advancement of circular transition is a combination of participation, commitment and innovation. Smol et al. (2018, 1035) identify drivers of circular transition to be the increase in public awareness and involvement, which coexists with the commitment of the government and policy makers. In building successful urban CE, there exists a fundamental requirement for governance and political commitment, building of futures understanding through scenarios and visions, experimental culture, mapping of resources and participation of diverse set of stakeholders. Jones and Comfort (2018a, 1729) and Prendeville et al. (2018, 171, 185-186) argue that in order for circular transition to succeed, both public and private sector actors need to be actively involved in the development of circular operational models.

Cities increasingly identify themselves as hotspots of circular economy, which can be considered constructive, since they are the major consumers of limited resources and thus a crucial party in finding solutions to the environmental pressures and resource constraints Petit-Boix & Leipold 2018, 1278; Wang et al. 2017, 877; Hezri 2018, 22). Scientists of urban studies and policy makers show an increasing commitment on mitigating the threats climate change inflicts on water, food and energy security through more sustainable

system creation (Lehmann 2018, 47). Cities are the domain, where the threats of climate change are potentially most prevalent and scale up due to the large population (Prendeville et al. 2018, 171). Infrastructural issues like increasing population density, energy demand peaks, waste management, traffic congestion, polluted water and air and social factors like poverty and lack of identity are some of the most prevalent risks of urban areas, which call for more resilient systems. This places cities in a prime position to be experiment fields of new, innovative technological and systemic solutions. (Boeri et al. 2019, 73). Notwithstanding, urban areas are also characterized by sufficient volume of resources and people to form an efficient market. Additionally, cities obtain significant power in altering the behavior of the residents through urban planning, governance and advocacy. Cities themselves have the focal role in determining not only their future resilience, but the survival of the planet, since they have the capacity of decision making that enables them to increase innovative resource use and improved productivity combined with economic efficiency and social challenge mitigation. (Hezri 2018, 22; Zeller et al 2018, 84).

1.3 Research questions

In addition to challenges in the definition of CE, there exists a lack of research concerning the implementation of CE initiatives. According to Marin and DeMeulder (2018, 1312) in the context of CE research, the systemic transition of a city has so far not been mapped or thoroughly examined, which forms an interesting research gap and study domain. Furthermore, in this subject I am able combine my academic major of futures studies and minor in sustainable development to be utilized in a concrete setting to form a wider picture of a current situation of a development that has significant potential to affect the future. The motivation for the theme of this research was finalized as Finland Futures Research Centre assigned me to map the CE actors of the region on mandate of the city of Turku.

City of Turku in South West Finland is a municipality of 185000 inhabitants that is actively seeking circular solutions to relieve the pressures of increased sustainability demands. The empirical study explores the current state of circularity in Turku and the discussion assesses its circular development against the factors contributing to the development of circularity and its goals of transforming traditional linear ecosystems to circular ones. The research questions, through which the study is conducted are as following:

1) What is the current systemic state of urban circularity in the city of Turku?
2) Which focal factors contribute to the urban circular transition?
3) How will the circular transition proceed during the next decade?

The research questions were formed by the theory and items especially highlighted in the case study material. The first is the general research question the empirical study was originally based upon. The second question is focused on the theory and attempts to highlight the essential factors contributing to the development of circularity. The third research question ties the research to futures studies and aims to anticipate the future development potential of circularity.

The structure of this study is the following: in the literature review section, I will first introduce the phenomena of CE with the general principles and the focal applications in the urban domain. I will then convey a comprehensive outlook of the current stage of academic research with regards to urban circular economy and give some practical examples of concrete circular actions that have been initiated in cities worldwide. I will give an outlook to the urban enablers, barriers and identified strategies of CE after which I will give an overview of the wider futures studies approach on the situation that linear economic model has inflicted on us. Finally, I will present the systemic nature of the cities and a few systems thinking principles in order to build the groundwork for presenting the theoretical framework of Urban nexus used in this study. The framework consists of two parts: the elements, actors and strategies of CE in urban environment which are completed with the practical application modes and areas. Advancing to methodology section I will begin by introducing the origins of the study, after which the methodology and proceeding of the study will explained in detail. I chose to explore the local circularity of Turku in its real-life context through a case study, since the objective was not to find answers per se, but to strive to understand the situation through a multitude of expert interviews and engage in a reasoned discussion about the subject, that is broad and requires a formation of systemic understanding (Yin 2014, 13; Marin & DeMeulder 2018, 1313).

The results of the empirical research will first give an overview of the circular state of Turku. It will then proceed to examine the local circularity through the thematic urban sectors detailed in the methodology section in order to systemically assess the state of the city´s circular transition. After presenting the results of the empirical research I will advance to discussion, where I will first construct the systemic connections of the thematic sectors explored in the study. I will then progress to reflect the empirical data through the Urban nexus framework, usage of which is designed to methodically review the data in order to reveal hidden connections and challenge me to critically assess the situation and find focal factors that can be generalized to contribute to the urban circular transition. I will then anticipate the possible development paths circularity in Turku and in general may obtain during the next decade. Ultimately, I will conclude my paper with the theoretical and practical contributions of the study and suggestions for further research.

2 LITERATURE REVIEW

This chapter presents some relevant pieces of academic research of CE in urban transition context. It constructs to the themes of the research questions by first defining CE and evaluating the current urban circular transition discourse. It proceeds to explore enablers, barriers and strategies for circular transition and gives an overview of the future expectations and anticipations there exist for CE. The final subchapter of this literature review will build upon systems thinking to create the theoretical framework for this research, through which the empirical case study will be analyzed. The Urban nexus framework highlights the objectives, elements, actors and strategies of the urban ecosystem and draws an overview of the practical application modes and areas.

2.1 The current systemic state of urban circular economy

2.1.1 The roots and definition of circular economy

Circular economy is considered to be an emerging concept, but it has been under development for decades. According to Prendevill et. al (2018, 273) the roots of CE lie in environmental economics, ecology and systems thinking. Kalmykova et al. (2018, 194) draw the origins of CE to the Bouldings "spaceman" economy in 1960´s, which entailed circulation of materials. Similarly did the succeeding closed system of cradle-to-cradle from Stahel and Reday-Mulvey on 1980´s and the resource efficiency promoting steady-state-economy of Daly in 1990´s. In addition to this, Korhonen et al. (2018, 545) identify CE having resemblance and adjoining principles with i.e industrial eco-systems and symbioses, product- service systems, cleaner production, resilient social-ecological systems, biomimicry, the performance economy, natural capitalism and finally with the concept of zero emissions, thus connecting it in a system of multiple disciplines and concepts linked to one another.

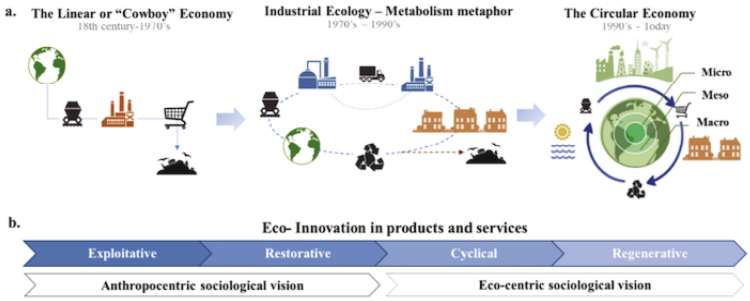

Fig. 6. Proposed circular economy knowledge map. Based on Ayres (1989), Boulding (1966), Chertow and Ehrenfeld (2012), Hofstra and Huisingh (2014), Pearce and Turner (1990), Pope Francis (2015) and Yuan et al. (2006).

Figure 1 The development process of circular economy drawn by Prieto-Sandoval et al. (2018, 609).

Defining the circular economy has proven to be a complex task. To illustrate the variety of definitions Kircherr et al. (2017, 221) identifies over 100 various definitions for it and Leer van der et al. (2018, 299) argues that the concept is almost as widely defined as it is used. The complexity arises from the pursuit to define the central principles of CE, which Petit-Boix and Leipold (2018, 1271) argue to remain consequently ambiguous and lacking consensus. Instead of appearing as a coherent definition, CE can according to Marin and DeMeulder (2018, 1310) be described to be an evolving umbrella term consisting of multiple, situationally determined definitions to advance sustainability. Generally speaking, CE is considered as a way to transform the current linear economic model to a more sustainable, resource efficient model mitigating the negative impact of consumption to the environment. Prendeville et al. (2018 172 - 185) argue CE to be a concept, that is "over-hyped, scarcely investigated and therefore as yet ill defined". Contrary to that, Korhonen et al. (2018, 544, 547) suggests that attempts to find universal definition might actually prove harmful to the concept by excluding some interests. Accordingly, CE is a dynamic and adaptive concept and it should be enabled to develop without artificial restraints through the systems it interacts with.

Albeit the complexity of the theme, numerous models have been created to illustrate and attempt to explain CE. Yuan et al. (2006, 5-6) define tree levels of society where CE can be operationalized: micro level represents businesses, meso level depicts the networks formed by various actors and macro level renders cities and urban areas. Prieto-Sandoval et al. (2017, 609) introduce a simplified circular model, where resources are transformed in these three identified levels to a novel use after extracting and recycling them.

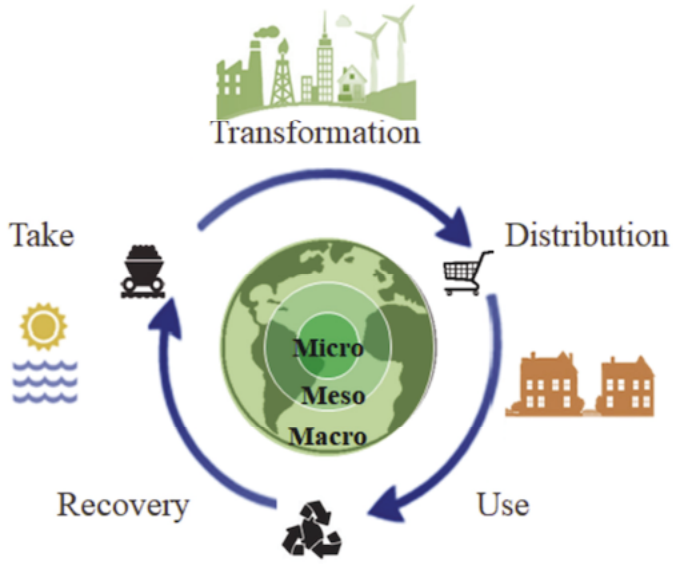

Fig. 5. Circular economy cycle.

Figure 2 A simplified example of the circular economy cycle (Prieto-Sandoval et al 2017, 609)

A basic, product related version of CE definition encourages to consider strategies of recovery and recycling throughout the life cycle of a product, which according to Wang et al. (2018, 876) can be summarized in 3R, as in reduction of material usage, reuse (containing the notion of reparation and refurbishment of products) and recycling of the raw-materials at the end of the product life cycle. WEF (2018, 9) extends the definition of CE to contain upstream and downstream circularity, of which the former is concerned with efficient management of resources before use and the latter preserving the value of resources after use. In a wider context CE is illustrated to be an economic and industrial system where resources are kept alive as long and efficiently as possible through repair and reuse. At the end of their life cycle the resources are recovered, recycled and remanufactured to serve again in a new cycle. Kalmykova et al. (2018, 194) invests essential importance in restoring the natural resources, minimizing the value loss and maximizing the value creation in each stage of the resource life cycle. A more systemic and environment-related definition from Pietro-Sandoval et al. (cf. Marin & DeMeulder 2018, 1310) claims that CE is an economic system changing the relationship between human society and nature. The goal of this system is to facilitate sustainable development by preventing the resource depletion and to form loops where energy and materials circulate in all levels from consumers to businesses and urban systems. The system is based on regenerative and cyclical environmental innovations and realized through novel ways of legislation, production and consumption.

As the term transition often linked in the concept of CE reveals, it is unconstructive to concentrate too much on detached definitions of the concept, but to evaluate it on wider contexts as phenomena. This literature review proceeds accordingly to evaluate the phenomena mainly through the transition of paradigm from linear to circular.

2.1.2 Evaluating circular economy

The circular transition visions draw an image of socio-technical future radically different from the system today. The general discourse of CE is loaded with expectations, such as potential of perfect material flow and production circles to renew the industry, a solution for decoupling economic growth from environmental damage and shifting consumers to users or prosumers to co-create the services. CE is expected to be regenerative and produce minimal amount of waste, use energy extracted from completely renewable sources and eliminate the usage of toxic chemicals. Furthermore, it is expected that the transition will be enabled by redesign of superior products, systems and operation models. These expectations are often criticized to be too optimistic and to require critical interrogation, which can be corroborated by the general deficiency of research on the subject. However, a counterclaim is presented by Lazarevic and Valve (2017, 60, 63-64) that optimistic expectations and positive future images carry power to initiate action and highlight the current defects in systems, thus creating awareness and innovative atmosphere towards change.

A critique towards CE is that the economic growth paradigm remains often unquestioned in general CE discourse. According to Marin and DeMeulder (2018, 1311) and Prendeville (2018, 173-174) the co-existence of the constant growth paradigm and CE has been contested by claiming that true circularity should disengage from the growth and concentrate on systemic level resource usage reduction. Additionally, there exists a debate over the substantial economic benefits speculated to inherent in CE and their relevance for attaining the goal of more sustainable way of life. The promotion of CE appears to offer a win-win situation for the environment and for the economy, but often fails to indicate how exactly that will be possible in practice. The current narrative seems to concentrate on business benefits leaving the wider impact of CE in the framework of urban sustainability improvement unclear. According to authors, the current research does not give strong evidence of economic decoupling of increased growth and decreased environmental stress, although there exists some cases it has been achieved.

In promoting the opportunities presented by CE it is also worth considering, that there are environmental risks and operational obstacles in the formation of the resource cycles. Petit-Boix and Leipold (2018, 1271) remind that materials tend to degrade in quality during the processes and restoring the materials is known to be energy consuming. They

emphasize that materials cannot be circulated indefinitely without major efficiency losses. CE has also been criticized by Lazarevic and Valve (2018, 63-64) of being too idealized to work in reality and consisting of partial approaches. Furthermore, they remind the goal of achieving perfect circle and resource efficiency ought to be balanced with energy usage, cost, consumer choice, safety and welfare. In fact, consumer selection and choice will probably be one significant factor determining the success of circular transition. A major indication of this are the emerging concepts of sharing economy and collaborative consumption that are generally identified as part of the circular economy. The understanding of the consumer behavior towards various forms of circularity is still developing, but it seems those forms where consumer experiences greater benefits with less cost are more easily accepted. Similarly, new challenges like informal economy arise from new operational forms.

An issue of debate concerning CE is whether social factors should be incorporated in the concept or is CE a merely economic and technological approach to sustainability. Prendeville et al (2018, 173-174, 187) argue, that as urban sustainability consists of the livability of a given area and requires participation of citizens, the concept on urban CE should contain areas beyond technology and infrastructure. Additionally, Marin and DeMeulder (2018, 1312) have criticized the Ellen MacArthur Foundation model of circular cycles of biology and technology for not integrating the social factors.

A lack of research exists in implementation of CE and knowledge of its spatial practice. Marin and DeMeulder (2018, 1312) claim that an interdisciplinary research combining technical approach with economic, environmental and social aspects would be essential in promoting the implementation of circularity. Additionally, Mohtar and Daher (2019, 110) argue that a complex and multifaceted phenomenon such as CE requires deep rooted and wide interdisciplinary approach in order to be understood and assessed. Jones and Comfort (2018b, 1729) corroborate, that the lack of commonly approved indicators is a challenge for the advancement of the circular transition, which has led various institutions to develop measurable scales and indicators to support the development of CE.

2.1.3 Cities as circular economy research context

As acknowledged in the introduction, circular economy and its urban applications are a concept of novel academic and practical debate. Petit-Boix and Leipold (2018, 1270) identify a concrete demand for urban areas to enhance their sustainability, which is also recognized in many policies around the world that actively promote CE even if the impact in achieving the set goals for sustainability remains largely unknown. This calls for strategies to assess the environmental impacts of circularity. With circularity, the transition is most often the key verb to portray the paradigm change from linear to circular. Ruggieri

et al. (2016, 1164) claim, that the transition towards circular economy follows the logic of reconstructing new value chains in networks of actors to replace those that have proven to be obsolete. The transition requires an extensive interplay of innovative actors and concepts, especially in the implementation phase, where a radical chance is often needed.

There seems to exist a gap between the research and practical application of CE in the cities. Marin and DeMeulder (2018, 1311) argue, that in order to transition to sustainable cities through circular economy, the concept needs to be environmentally, socially and economically explored and defined in more detail it presently is. Prendeville et al. (2018, 176) point out, that the implementation of urban area CE in existing literature is insufficiently covered but brings about the notion, that the CE objectives have regardless of that been adopted by several cities. Korhonen et al. (2018, 551) point out, that circular economy academic research is fragmented, and mainly takes place in applied context, but that should not be used as an excuse to avoid developing the concept. Kalmykova et al. (2018, 196 – 197) acknowledges, that there are numerous implementations of CE initiatives underway and introduces a CE Implementation Database, which contains cases from variety of actors, including businesses, government, NGOs and academia. The database contains implementations from various stages of the loop, for example materials sourcing, design, manufacturing, distribution and sales, consumption and use, collection and disposal, recycling and recovery, remanufacture and finally circular inputs, which stand for materials that last multiple lifecycles. However, this database is practically orientated, and the impact of initiatives has necessarily not been scientifically assessed.

Cities are facing numerous insecurities with regards to resources and constraints in their infrastructure, which may have serious consequences even in short term, if the supply security is compromised. Van der Leer et al. (2018, 229-300) argue that integrated circularity and its effects on improved resource self-sufficiency may have fundamental effects on improving the resilience of a city. According to Lehmann (2018, 47) systemic inefficiencies, such as shortages in affordable housing, transportation challenges, environmental degradation, water supply and sanitation, energy supply and food security pose serious situations and threats in urban settlements urban sustainability measures the resilience and livability of the city, that reaches far beyond the minimal goal of sufficient infrastructure. Prendeville et al. (2018, 187) claims that minimizing the loss of resources by closing the loops according to circular economy principles in partnership with all the stakeholders, the city will be able to improve its resilience. Consequently, its preparedness for future challenges created by climate change and the supply security of the critical resources will improve.

2.1.4 Urban circular initiatives

The number of urban circular initiatives is in a constant increase. United Nations (2016, 13) acknowledges circular economy in its New Urban Agenda as a tool to facilitate ecosystem conservation, resilience and restoration in the emergence of climate change and resource depletion. Following to this agenda, there are numerous countries and cities worldwide, that have engaged themselves in circular experiments. The following figure is by no means extensive representation of the constantly increasing amounts of urban circular initiatives, but it gives some examples of the cities that are publicly seeking circular transition in order to improve their sustainability and further development of the interplay of the environment and society.

Source: (Preston & Lehne, 2017)

Figure 3 Global map of urban circular initiatives (Preston and Lehne 2017, cf. WEF 2018, 10)

Internationally, the approaches in striving for circular transition vary. In China, CE is a result of national policy strategy to design more efficient environmental and waste policies. Wang et al. (2018, 876) and Fang et al. (2017, 31) claim that the implementation reflects the local political paradigm being run authoritatively in top-down direction. The transition towards circular economy in China began 12 year ago and is intended to extend to all societal levels in addition to industry. Fang et al. (2017, 30) corroborate, that the role of CE in China has been significant in speeding up urban transition towards low

carbon society. CE has enabled simultaneous resource savings and carbon footprint (CFP) reductions over the course of CE initiatives in Chinese cities. Japan is advancing CE by engaging public sector as well as corporations and civil society in collaboration towards transition. Ruggieri et al. (2016, 18) suggest the strategy of Europe is characterized more through bottom up approach, where environmental organizations play a key role with NGO´s and civil society. As a contrast, Petit-Boix and Leipold (2018, 1271) point out that CE has been appointed as the core theme of European Commission major European action plan, through which cities are being encouraged for making strategies for urban scale circularity advancements.

The urban implementation of CE has seen interesting initiatives over the last few years. Ruggieri et al. (2016, 26) identify waste sector being especially active with introducing zero waste index and increasing recycling rates but also evidencing numerous challenges in the transition of the down circle. As part of decelerating the down cycle, reuse and repair actions have been supported with success in for example Oslo, Tiana, Eskilstuna, Nijmegen and Austin. Lehmann (2018, 41) introduces Linköping having achieved meaningful results in waste to energy- process with producing biogas from municipal waste management system. Petit-Boix and Leipold (2018, 1271) identify Ghent, Amsterdam and Barcelona as cities that are already engaged in urban planning CE through district redesign initiatives.

Prendeville et al. (2018, 172 - 185) have mapped 6 cities they claim to actually be in circular transition. CE has been adopted by several cities like Amsterdam, where CE is written in the sustainability agenda of the city and implementation of new concepts and policies begins with experimentations. Rotterdam has listed CE as a tool to reach its goal in forming a strong economy and focuses in long term pragmatic planning of policies. Glasgow similarly has a business-driven approach with importance in engaging stakeholders and creation of Green Business network to connect and support businesses in CE innovation. Haarlemmermeer perceives CE as a tool to design novel living environments and stresses the importance of involving the quadruple helix (businesses, government, institutions ja citizens) to the creation of this new paradigm. The Hague policy makers show interest towards CE, however, they lack the information and understanding of proceeding at this point, calling inspiration from other cities. Barcelona shows strong CE initiative in proceeding to build city blocks self-sufficient with regards to energy and efficiently linked in water and waste infrastructures. Jones and Comfort (2018a, 186) introduce the London circular transition agenda, that sets strong focus in its leading sectors, the built environment, textiles, food, plastics and electrical and electronic equipment, with its strong financial, digital and media sectors as well as academic institutions acting as enables for the transition. Cross cutting themes identified in London are finance, policy, communication and collaboration, procurement and market development, innovation, business support and demonstration. According to Marin and DeMeulder (2018, 1316)

there has even been an attempt to build a completely new city for the principles of circularity in United Arab Emirates. Building of the city of Masdar was an ambitious project that started as early as in 2008, but it has not yet realized. The reasons for failure are identified to be the isolated location of the city which did not attract residents regardless of its superior environmental values and systems.

2.2 Focal factors contributing to the urban circular transition

2.2.1 Enablers of urban circular transition

The significance of the role of the city governance and public sector is a frequently assessed topic. Prendeville et al. (2018, 271, 185-186) impose a significant responsibility for the governance, policy makers and urban planners over leading transition towards more sustainable cities. They claim that municipalities perceive CE being positive per se, but when it comes to investments in infrastructures enabling circularity, the superficial interest does not intensify to the level of engagement and implementation. WEF (2018, 22-23) reminds cities that in addition for it being their responsibility, it is also in their long-term best interest to harness their own agenda and engage citizens and private sector to contribute to circular transition. CE is concentrated in resources, which flow in the forms of materials in circular economy through different sectors and thus require collaboration. Cities role, according to WEF, is to act as an enabler in developing this network of value chain-based partnerships and creating infrastructure for ensuring the materials stay in circulation as long as possible. Systemic transition needs strong local advocates and enablers. Without the grounded support of the city governance it is improbable that a successful transition from linear to circular economy can be obtained. Additionally, the city is responsible for the critical infrastructures and resource flows of energy, water, waste, traffic and buildings which are essential to circularity. Without setting them in a central role of the transition, it is unlikely that urban area will achieve circularity.

Regulation and policies are the key determinants in guiding consumers and businesses towards CE implementation. Prieto-Sandoval et al. (2017, 611) suggest that policies may support towards decreasing resource demand, encourage in reusing, repairing, renovating and applying sharing economy. Ideally, policies and incentives would be designed to support innovation. Ellen MacArthur Foundation (2019, 5) states that the city governments hold an unique position to lead the circular transition with their power of involving and motivating stakeholders from public and private sectors using the variety of policies and support they possess. Furthermore, Ruggieri et al. (2016, 1164) point out that the policymakers can stimulate this development by addressing fiscal and financial incentives

towards innovation and production that aims towards increased environmental sustainability. Velenturf et al. (2018, 1408 - 1415) identify adequate monitoring and reporting of the flows, tax breaks to promote reuse and repair, extended producer and user responsibility of the products and their end of life recovery, mandatory recycling systems, and product standards and bans as further enabling factors.

World Economic Forum (2018, 4, 11) elevates the importance of procurement processes of the cities. Their paper state, that a determined development of procurement criteria to favor circularity could result a new market standard of economically viable and simultaneously sustainable business models. Establishment of circular procurement policies could, according to WEF, begin with identification of priority sectors to concentrate in, definition of the prioritized targets, setting time frames for the sectors to be at a given level of circularity and development of methods for circular approach. Additionally, explicit criteria for implementing life-cycle impact assessment would be vital to advance circular procurement.

Interorganizational co-operational structures are a vital enabler of circular transition. De Mattos and de Albuquerque (2018, 4630-4631) argue a precondition for successful CE to be that actors co-operate, solve collective problems and create mutual economic benefits in addition to environmental and social sustainability. Local councils and city governance play a key role in forming regulation towards demanding and delivering incentives of innovating more sustainable solutions. Government partners engagement in circular transition is focal in all levels in order to legitimate it as the new paradigm. The participation of academia is vital, since the core strength of academia is creating the systemic view of situation. According to Ellen McArthur Foundation (2013, 61) business models play a significant role in circular economy development, but they cannot evolve without the support of policy makers, knowledge institutions and other strong advocates. Giezen (2018, 3500) claims that in order to succeed, circular transition requires interaction between different organizations and systems. However, this is not always easy to achieve, because while the strategic level of organizations may accept the necessity of this interaction and change in culture, the operational levels often prefer to hold on to their existing routines.

2.2.2 Barriers to urban circular transition

There exists multiple identified barriers to urban circular transition, which can be categorized in financial, social, institutional and technical categories. WEF (2018, 21) identifies the deeply rooted linear mindset as one of the key barriers to overcome. Combined with the lack of the awareness it may well form the roots of the resistance to change. To overcome these barriers, cities can involve and expose stakeholders to new experiences and

opportunities by piloting new initiatives in their own operations and scale up the models that have been proven to succeed. Subsidies or tax breaks may encourage circular action. Similarly, the removal of subsidies from non-renewal energy and other environmentally unsustainable resource usage will motivate shifts in business models and behavior patterns.

Measuring the impact of circularity still remains as a barrier, even if numerous indicators and models are being developed to overcome it. Jones and Comfort (2018b, 1729 - 1732) indicate that convincing businesses to abandon their linear business models will require evidence of profitability. Economic growth potential needs to similarly be proven before mainstreaming of CE will materialize. Prendeville et al. (2018, 271, 185-186) identify challenges in altering consumer behavior in large scale due to the developed world lifestyle being based on the paradigm of owning. Ghisellini et al. (2016, 16) claim weak governance structures and ambiguous goals to be a serious barrier of CE transition initiatives, whereas fostering public awareness of circularity and creating visibility and transparency to the CE advances the development. Citizen participation is a crucial element and calls strategies from the governance to foster inclusion. The successful transition to circular economy requires involvement of all the actors of a society and their ability to cooperatively and innovatively interact in creating circular solution to replace linear.

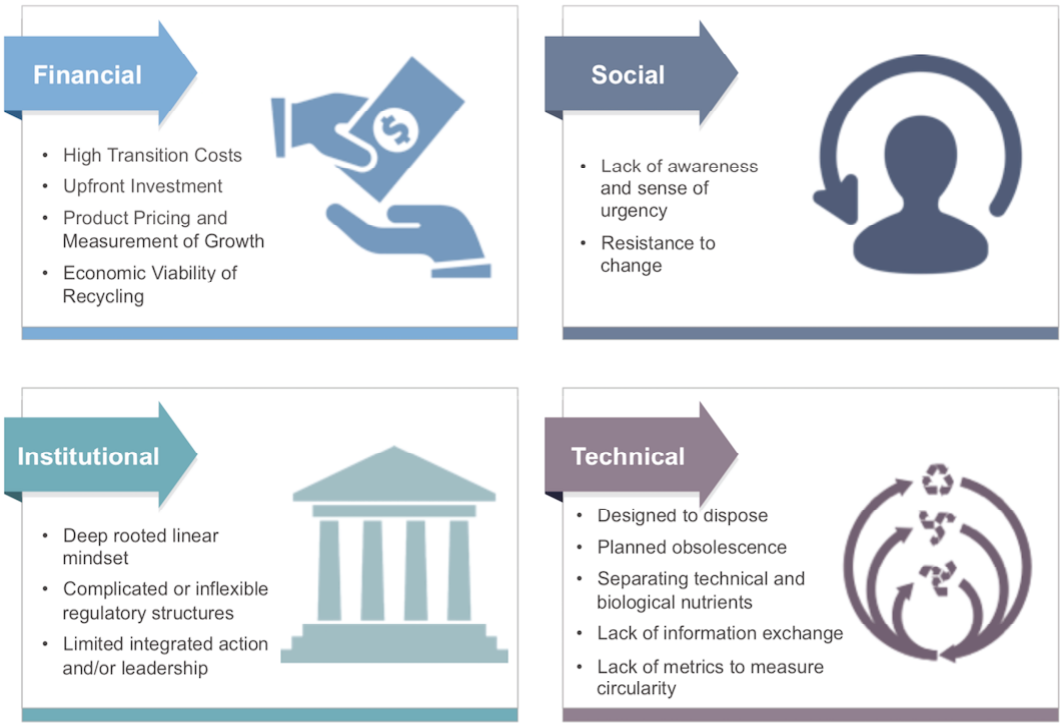

Figure 4 Barriers for urban circular transition (WEF 2018, 19)

2.2.3 Strategies for urban circular transition

In order to operationalize circularity, numerous authors have attempted to build strategies for circular transition. Jones and Comfort (2018a, 184) recognize systemic complexity in "creating a circular city is a complex journey involving many organizations, companies, technologies and resources" and proceed to identify four stages for the circular city transition. First stage is to identify the sectors with strong political support, followed by the second stage of mapping existing material flows (energy, water, biomass, chemicals, metals, minerals etc.) Third stage consists of selecting the appropriate strategies and in the fourth stage a further detailed analysis carried out in order to select the pilot projects.

An attempt towards building a systemic strategy is made by Boeri et al. (2019, 77) who identify a strategy for circular transition to begin with an analysis of the local context with its resources, stakeholders, energy, environmental conditions, economy, etc. Forming a guideline for citizen participation, identifying innovation opportunities and building local circular ecosystem by involving focal stakeholders follow the analysis. Creation of scenarios and value chain propositions, finding technological solutions to realize them and planning the implementation are critical phases prior to generating action, evaluation and replication. Elements of transition process and key actions in urban environment include re-usage of public space, reduction in use of materials and land, building less, sharing and reusing of existing goods and solutions, maintenance of existing goods to ensure longevity, energy recovery, establishment of a set of reliable performance and impact indicators and monitored processes.

Vandenbroeck (cf. Marin & DeMeulder 2018, 1324) proposes 4 approaches and frameworks for cities and defines them through transition drivers. A technocratic agenda focuses on technological drivers and solutions, business driven agenda in innovation and circular business models, a holistic agenda acknowledges cultural and multi-scale solutions in focusing restoration of ecological cycles and activist agenda democratizes flows and brings about social aspects. Velenturf et al. (2018, 1415-1416) propose, that a practical strategy towards circular economy requires integration of the environmental, economic and social values, metrics and models with support to secondary resource markets. In this strategy, novel supporting policies enabling innovations throughout the sectors and adoption of the systemic view to the analysis of CE are necessary. Special importance lays on the governance collaboration across society and integration of research with policy and legislation development.

WEF (2018, 10) highlights the CE principles and attempts to build on the ideal of a closed loop, where all technical and biological materials form and infinite cycle. Renewable energy, value generation through resources, flexible and modular design to increase adaptability, innovative business models, regional logistics systems and positive contribution to ecosystem are considered to be essential to circular urban system. Prieto-

Sandoval et al. (2017, 611) in turn suggest that CE should be a multi-level approach aiming to sustainable development including the following elements: The recirculation of energy and resources, minimization of resource consumption, waste recovery and a close relationship to societal innovation. Van der Leer at al. (2018, 298-299) remind that as the cities are widely recognized for being the main hubs of consumption and therefore main contributors for production, it places them in crucial position in advancing global circular transition. This requires ways to integrate CE into urban planning practice and policy making of the cities. Jones and Comfort (2018a, 183-184) identify modular and flexible built environment, localized, resilient and renewable energy solution, bio-economy system where nutrients are circulated back to the soil, general focus on partnerships, local production and circular solutions within the urban area business communities as pathways of building the circular city.

The importance and potential of specific applications and sectors in implementation strategies of CE is highlighted by some authors. Hobson and Lynch (2018, 16) identify sharing economy as the focal element of circular economy in all sectors, since it implies the products are mere means to create services and thus circulate and are used multifold during their lifetime in comparison to privately purchased products. Sharing economy alters the way of consumption and parts consumers from the paradigm of owning. Zeller et al. (2018, 84) draw the importance of waste flows as resource with enormous CE potential. Even though waste and recycling are themes found in the agenda of each city aspiring for circular transition, it is estimated, that 70% of the waste is neither reused, nor recycled, which forms an extensive volume flow and a constantly growing stock of resources to utilize.

2.2.4 Local solutions essential for circular action

Most of the contemporary cities are currently experiencing transition towards circularity or at least pressures for building more sustainable structures and systems. Boeri et al. (2019, 74) recognize some cities for actively seeking solutions and others that choose to adapt to change through business models and citizen activism. Marin and DeMeulder (2018, 1311) identify that transition towards sustainable cities poses a number of systemic challenges, different ones for each city in transition. Lehmann (2018, 53) suggests it might be beneficial to learn about other cities transitional solutions towards CE, but as each city forms its unique system its circular system differs substantially from the solutions of other cities and thus demands for local solutions.

Locality forms an essential feature for CE, because cities are characterized by physical proximity, which entails numerous opportunities in terms of resources, actors, and networks. It also contributes to the sufficient scale of functioning markets and presence of

potential customers. An inherent notion of CE is that the excess transportation of goods should not create emissions, therefore circular business models would preferably be in local or national scale. Zeller et al. (2018, 84) claim large cities to have adequate synergies and sufficient market size for this type of local business models. Furthermore, according to Prieto-Sandoval et al. (2017, 611) the geographic proximity has been determined as a focal component in successful CE symbiosis cases through ease of sharing resources, reduction on transportation cost and greater collective benefits. Proximity, combined with organizational culture of working in interconnected manner, form a supply side determinant closely linked with organizational innovational capacity which is essential to forming circular symbiosis and ecological innovation.

The growth within-scenario, which means future production will have good chance of happening locally as the resources are recycled and reused in the location of usage has also been met with criticism. Lazarevic and Valve (2017, 64-65) argue that whereas this for Europe could mean a renewal of industries and thus employment lost to Asian locations during the last decades of globalized production, it will require significant structural re-adjustments and political change, which, although potentially possible, contains some major obstacles. In a world where transportation is currently so inexpensive the waste is transported to developing countries to be landfilled, it is probable that recycled materials will not automatically be remanufactured locally if economically more viable options exist elsewhere. They remind that even circular economy is an economy, where the cost often proves to be the most relevant factor.

2.3 The role of circular transition in creation of future sustainability

2.3.1 The predictions of scientists proving to be true

Scientists, futurists among them, have for decades been raising awareness about the finite resources and planetary boundaries of the earth. A focal work of the field, the limits to growth from the Club of Rome in 1972 presented 12 futures scenarios of how the natural resource usage and population growth are intertwined and what possible outcomes might the approach of the limits reveal. The decades after that have proved the direction of development to be true and the stress the growing humankind has caused for the environment has intensified. However, there also exists positive development for example through improved technological solutions, that have, in some fields, diminished the relative stress of our actions towards environment. The negative outcomes of total

consumption and growth have so far exceeded the positive outcomes of technology and is expected to continue if a radical change is not urgently enforced. (Meadows et al 2005, 10-20).

Today, we are witnessing intensified indicators of the climate change. It begins to be evident, even for the most persistent climate change denialists, that the current systems of construction, transportation, energy, food and goods production need to be systemically changed to preserve the livability of the earth. The report Global Warming of 1,5 °C by Intergovernmental Panel of Climate Change (IPCC 2018, 4-10) estimated, that the climate has already warmed by 1 degree on average and the warming will continue. Additionally, it represented a wide array of risks the warming has already inflicted in global ecosystems and even wider range of threats the continued warming poses for environment and humans. These reflect to the wide spectrum of human lives, including food and water supply, health, security, livelihoods and economic growth. The directive of the report is to limit the climate warming to 1,5 degrees, since the risks will escalate exponentially with the higher degree of warming. The challenge in limiting the warming are the current supporting systems of human population, that need to be systematically challenged and changed in order to lower the degree of carbon dioxide emitted to environment.

Circular economy entails several tools that are currently considered, developed and investigated as solutions for systemic change towards more sustainable production paradigms. IPCC report Climate Change and Land (2019, 19-35) identifies several pathways to enable the adaptation and mitigation of the effects of global warming, that are consistent with the principles of CE. Example include land use in terms of zoning and landscape planning, standards for sustainable production, efficient management of agricultural systems to avoid farm land degradation, systemic solutions to food system including dietary selections and reduction of loss and waste, co-operation through the technological, biophysical, financial and socio-economical systems, development and usage of novel energy sources.

One of the essential determinants on whether CE will advance and turn our lifestyles towards more sustainable will lay in the economical profitability development of the paradigm. It will probably not be determined solely through the profitability of the novel circular systems but also through the expected reverse profitability development of the prevailing linear systems. One of the primary drivers are the investors and financers and their willingness to support environmental causes. According to Sitra (2019c), a currently growing trend in investments is impact investing, which aims at preventing and solving environmental and social issues. If this trend will advance to the level where environmentally harmful operations fail to attain financing, it might be a key factor contributing to the decreased profitability of linear economy models, that do not consider the environmental sustainability.

2.3.2 The sixth wave

Several futurists have over the past decades attempted to make sense and explain the societal and economic development cycles through fluctuating waves. The discussion is based on the work of Nikolai Kondratieff, who presented a wave theory originally in the beginning of the 20th century, according to which the economy consists of periods of growth following a crisis which leads to stagnation prior to new period of growth. The dynamics behind the waves lie in technological development which creates new economic growth potential and crisis which is faced at the exhaustion growth profitability of the existing technology. (Wilenius & Kurki 2012, 7, 12).

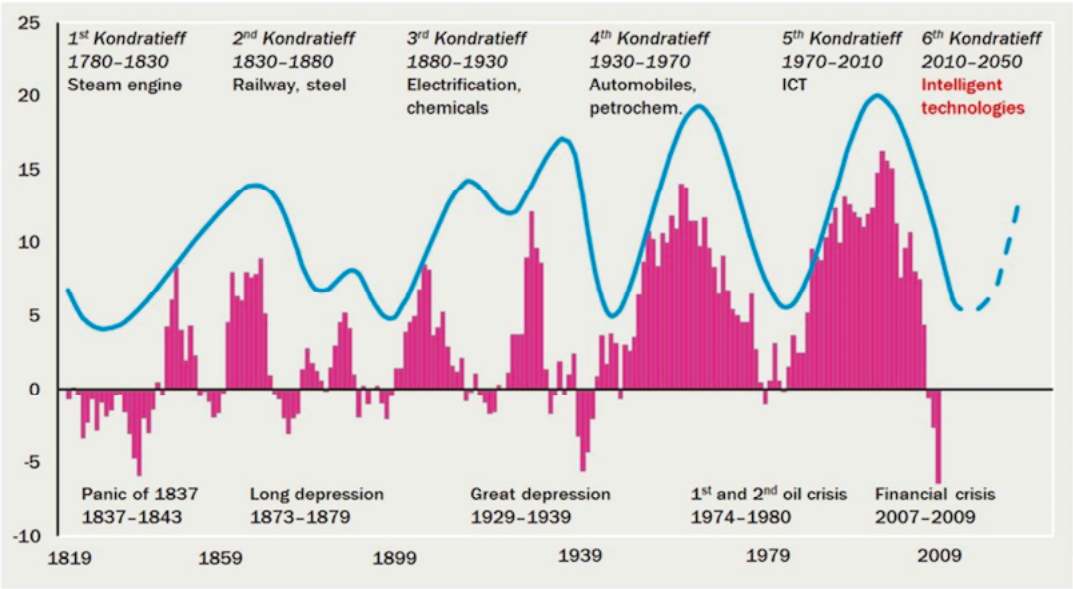

Figure 5 Combination of Kondratieff wave theory and Standard & Poors 500 equity index presenting the economic fluctuation (Wilenius & Kurki 2012, 8)

At present, we are finding ourselves in the first decades of the sixth wave, Wilenius (2017, 36) argues to have initiated from the financial crisis of 2008. The sixth wave is distinguished by the increase in environmental pressures for the paradigm of growth, tension in materials supply, constraints for the increasing fossil-based energy production which have primarily been caused by the rapid growth of the fourth and the fifth wave that ended in financial crisis as the expected growth in value was not met in reality. The sixth wave marks the beginning of the increased and action seeking understanding of the limits of the growth presented by the club of Rome in the 70s. In practical terms this means intensifying research and development of products, processes and models that

increase the level of resource efficiency to replace material intensive, non-recyclable solutions. (Wilenius 2017, 41-47).

Circular economy is a practical way for the economy to approach the demands sixth wave inflicts to the society. The development of prominent circular solutions is enabled by the increased availability and ability to process information as well as advanced technological solutions which make it possible use renewable energy and recycle resources in a more efficient manner. The technologies showing potential for the improving sustainability of the sixth wave include for example numerous ways to extract energy from renewable sources, cleantech solutions, green nanotechnology, biotechnology and increased resource productivity (Wilenius & Kurki 2012, 80 – 94), of which most are circular in nature.

According to Wilenius and Kurki (2012, 12-13) the role of society and culture in inflicting the change and innovation it focal. Technological and societal change are often interlinked, which indicates circularity has more potential for the sustainability for the society than mere change in production logic of goods. Sixth wave will optimally mark a change in society through decentralization of the power dynamics, which would direct more of the actual influence for the individuals (Wilenius 2017, 43). This influence is visible today through the power of opinion rapidly expanding through social media discussion and is a powerful medium in distribution of awareness and initiating action.

The ultimate challenge of the sixth wave is, that the systems created during the previous two waves remain strong and the total consumption and environmental stress is still in the increase even with the new emerging technologies. The innovation, investment and action of novel environmentally more sustainable solutions needs to be scaled up rapidly to replace the old material intensive and fossil-based system. (Wilenius & Kurki 2012, 95-96).

2.4 Theoretical framework

2.4.1 Cities as systems

Theoretical framework of this study builds upon the practice of systems thinking evolving in the specific context of urban ecosystem and forming a framework of Urban nexus, which strives to portray the urban system with its objectives, elements, actors and strategies. According to Meadows (2008, 188 – 194) fundamental principles of systems thinking there does not exist any independent systems, but all systems are linked to one another. Considering a city as a system, we are actually dealing with a set of subsystems

operating as a city level system, which again forms a subsystem to the national and global systems. System behavior originates from system structure, but often the least obvious parts of it. Most of the interconnections of the systems operate through information flows and can thus be affected through communication. There exists places to intervene the system to create change, which can often be found from parameters used, stocks and flows of resources and physical systems, delays or system changes, information flows, rules, (self) organization principles, goals and purpose of the system, paradigms and attempts to overcome the paradigms. All systems need to be managed for resilience in addition to productivity and stability, because there are always limits to both growth and resilience. These are the critical general systemic aspects considered in this study.

The systemic nature of cities and its effects on circular transition can be interpreted from multiple perspectives. Boeri et al. (2016, 75) suggest that a systemic perspective in cities is a comprehensive approach of aspects, such as plurality of stakeholders interacting and creating a governance structure in a new level that includes urban metabolism, circular economy, resources, society and culture. Pomponi and Moncaster (cf. Marin & De Meulder 2018, 1312) point out, that interdisciplinary research combining technical, social, economic and environmental perspectives is essential in advancing multi-dimensional circularity. Keeping in mind the systems implications, van der Leer et al. (2018, 298) present the essentiality to find ways to integrate urban planning and CE approach, since urban areas are the focal domains of consumption and thus key players, when it comes to successful global transition towards more sustainable production. Simultaneously, McLaren and Duncan (2015, 2-3) remind that metropolitan areas are vulnerable in their infrastructural capacities in facing scarcity of resources, climate change and biodiversity loss. Cities as systems are places of interlinked challenges caused by economic, social and environmental factors. However, all of these challenges can also be considered as opportunities with good planning and governance, which understands cities as drivers of global society in equitable sharing of global resources.

2.4.2 Urban nexus

During the first decades of 21st century, the scientists have recognized the demand for a holistic and systemic approach to explore and understand urban environments and enhance their sustainable infrastructural planning (GIZ & ICLEI 2014, 33). Lehmann (2018, 48, 50) argues that different entities of cities tend to operate in their own isolated silos and disregard potential synergies, which leads to wasteful trade-offs in resource consumption. Traditionally, the problems facing interdependent sectors of food, water and energy have been attempted to be resolved within the silo of the given sector, which neglects numerous potential and beneficial interconnections between systems. GIZ and ICLEI

(2014, 5) confirm that the prevailing urban governance practices, where resources are managed separately from each other in their own departments have been identified to cause fragmented city infrastructures and loss in resource efficiency. Daher and Mohtar (2015, 748) confirm the importance of an integrated approach.

As the understanding of the interconnections of urban material flows such as energy, water and food has increased, the models presenting urban nexus have arisen as an interplay of different authors and scientists. Daher and Mohtar (2015, 749) introduce the Urban nexus model, that was originally initiated by World Economic Forum annual meeting in 2008. World Economic Forum 2011 and Bonn Conference continued the work towards defining the nexus approach, that was also encouraged for by the United Nations Sustainable Development Goals. Lehmann (2018, 49-50) corroborates the influence of major international actors among the initiators and supporters of the Urban nexus development project, which completed its second development phase in 2018. Among them were United Nation's Economic and Social Commission for the Asia-Pacific (UN ESCAP), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and International Council for Local Environmental Initiatives (ICLEI). Allouche et al. (cf. Lehmann 2018, 52) identify a number of different approaches to the Urban nexus, a model that demonstrates the relationships within critical urban infrastructures. Lehmann (2018, 54) reminds the concept is still emerging and calls for more clarification and testing. Additional research is especially required in identifying alternatives to linear production and consumption patterns and decreasing harmful impact of urban planning to the resource usage. Further conceptualizing of interdependencies among the urban nexus will also be necessary.

Urban nexus attempts to design and display a holistic approach to describe the key interactions and inter-dependencies of city as a system and its sub-systems in order to increase sustainability in urban development. Lehmann (2018, 47) and GIZ – ICLEI (2014, 4) describe the overall aim of the model to transform urban planning to integrate infrastructural systems with resource management processes in order to increase the efficiency of resource use and reduce the harmful effects on environment and society. Hezri (2016, 5) argues that the model is solutions-orientated and attempts to avoid silo solutions, where a seemingly solved problem in one domain may cause further challenges in the others. Furthermore, according to GIZ- ICLEI (2014, 6) the approach is designed to guide and participate stakeholders to identify and build potential synergies between sectors, departments and technologies in order to optimize resource usage and improve performance and quality. Gold and Bass (2010 564 - 566) describe it as an interrelated complex system intersecting the essential urban infrastructure elements of water, food, energy and waste. According to Bizikova et al. (cf. Lehmann 2018, 48), the interdependence among these sectors is so strong, that any strategy focusing on only one part without considering the others contains high risk. In addition to these vital infrastructural sectors, Stringer et al. (2018, 904-908) point out, that the Urban nexus model should not be limited

to water, food and energy, but encompass other urban aspects such as land usage, mineral collection, material flows and climate change concerns. In addition to environmental concerns, nexus approach is combined with resilience thinking, more equitable and just access to resources and in finding ways to combine more favorable social and ecological outcomes.

Urban nexus attempts to form a systemic framework, through which the sustainability improving urban actions can be planned and executed. According to GIZ and ICLEI (2014, 33-36, 44) it encompasses all urban aspects and scales from resources and systems to services and facilities attempting to break silos and alter social behaviors. It operates in all phases of development, laying special significance in the planning period of identification, innovation and design and upscaling towards mainstreaming the solutions. It combines several innovation areas and identifies that innovations often develop in the interfaces of different disciplines. The overall goal is to improve the systemic performance of the given urban area.

Figure 6 Urban nexus elements, actors and strategies (Hezri 2016, 25)

Urban nexus -model bases on participation of stakeholders to initiate transition and connect the city systems to transformative global development patterns though identifying and considering megatrends, which coexist closely with the assessment of systemic risks. Hezri (2016, 25-26) claims Urban nexus is designed to apply systems thinking in placing importance in understanding and highlighting linkages between resources,

elements, human and ecological systems. Technology and innovation are harnessed in e.g tracking data of resources and flows. Finding synergies across sectors and actors combined with learning in various levels develops the operations and efficiency of the nexus performance.

Urban nexus identifies several necessary practical tools, activities and enabling factors in order to proceed in the quest of more sustainable practices. Hezri (2016, 26-28) describes Urban nexus through creating a system of analyzing resource inputs and outputs and engagement in resource modelling being practices aimed at creation of quantifiable information to support the resource efficiency goals. Co-operation with knowledge institutions is advised in order to support the process. Co-operation of foresight professionals and urban planners is sought after in the activity of understanding past stresses and identifying future risks. An analytical mapping of interconnected resources and their operating systems is required to clarify system trade-offs and explore synergies in order to maximize potential efficiencies. Scaling policy response and technological choice stands for developing instruments that increase resource productivity, decrease resource demand or use waste as resource. Peer- to peer learning is a vital progress marker in identifying and applying pathways to reduce the usage of resources. Finally financing, implementing and monitoring tools are designed for active adaptation and continuous performance improvement.

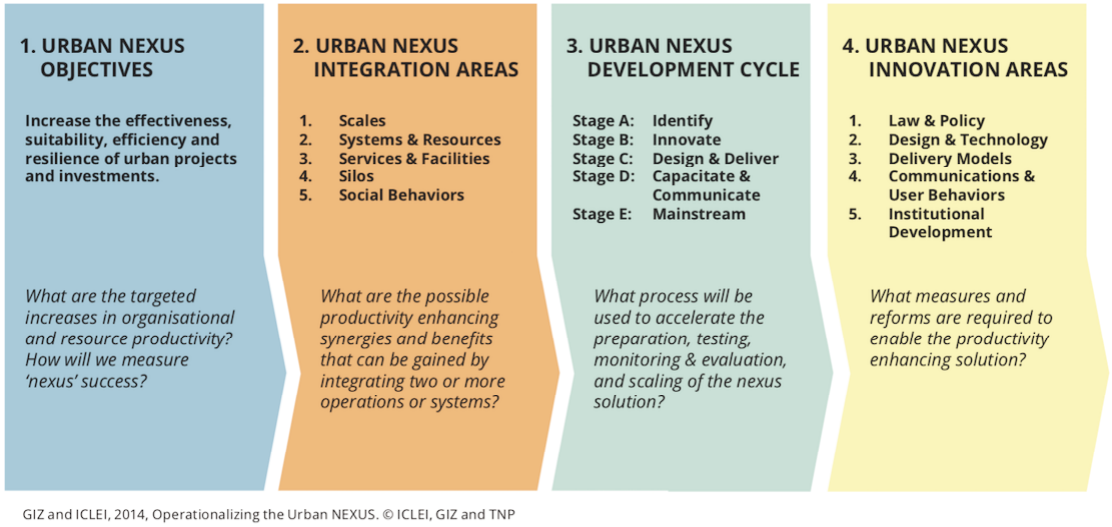

Figure 7 A description of practical application modes and areas of Urban nexus (GIZ and ICLEI 2014, 28).

In the operationalizing of the Urban nexus system, the existence of advocators who understand the system and initiate action is at utmost importance. GIZ and ICLEI (2014, 27-30) argue this to require relevant objectives, through which the urban projects measure e.g. resilience, sustainability and resource efficiency. The areas where Urban nexus is

integrated needs to be assessed to understand their structure, the systems and resources as well as uncover the silos where the decisions are currently made. Sustainable development requires multidimensional innovation, that encompasses from policy and legislation to the design, production and delivery processes and alters consumer behaviors and institutional culture. Finally, having acknowledged the domains, the process of developing more sustainable practices has been described in a cycle beginning with identification of possibilities and potential, innovating design of business or operational model and finally mainstreaming those solutions that gain positive feedback in the pilot phase.

For the purposes of this paper, the Urban nexus serves as a context and theoretical framework, against which the current systemic state of the circular transition of the city of Turku will be reflected and analyzed. The theoretical framework is based, as explained in detail above, to the implications of systems theory in urban context. Having now defined circular economy, urban circular transition and the potential role of circular economy in futures sustainability through an outlook of the academic research of the subject, this paper will proceed to the methodology chapter of this study.

3 METHODOLOGY

This chapter will present and justify the method used in the study, an inductive case study research. It will explain the origins of the study, the method selected, the sub methods utilized, and the manner results are presented and analyzed. Additionally, this chapter will offer an assessment of the credibility of the study combined with ethical considerations of the process.

3.1 Method of the study

3.1.1 Origins of the study

The empirical material used in this case study was originally collected on the assignment of the city of Turku to serve a purpose of mapping the CE actors of the region. I was asked to conduct this research project in autumn 2018 in order to assess the feasibility of Turku region to successfully contribute to the work of ICLEI Green Circular Cities Coalition, it was invited to engage in.

ICLEI stands for International Council of Local Environmental Initiatives. It is a global network consisting of over 1750 local and regional governments in more than 100 countries, who are committed to advancing sustainable development. ICLEI – Local Governments for sustainability operates to promote sustainability and drive local action through 5 pathways: low emission development, nature-based development, resilient development, equitable and people-centered development and circular development. (ICLEI 2019). As part of the Circular development pathway, ICLEI decided in autumn 2018 to invite 12 cities from Europe, China, Korea and Japan to form Green Circular Cities Coalition (GCCC) to initiate circular co-operation between cities, upscale and accelerate circular transition (ICLEI 2018, 1,11).

In order to successfully contribute to GCCC co-operation, the City of Turku and Finland Futures Research Centre at the University of Turku agreed on a joint research project in the form of a feasibility study. The aim of the study was to analyze circularity of Turku and identify the current and potential future actors of circular transition. I conducted this research between November 2018 and March 2019 and the report of the research "ICLEI Green Circular Cities Coalition: feasibility study to build an active network of circular economy actors in Turku region" was published in September 2019. My co-author in the study, Juha Kaskinen was primarily in a supportive role and participated in the planning phase, discussion and the structuring of the study.

In addition to its original purpose, the research opened up an interesting view on the state of current systemic circular development of Turku region and the futures potential with regards to circular transition. Similarly, it presented an interesting international co-operational system ICLEI has built for initiating change towards increased sustainability (GIZ & ICLEI 2014, 28), which led me to consider the material from a wider perspective. This Masters´ Thesis is based on the empirical material collected for the ICLEI GCCC feasibility study. However, in this thesis the material is considered, examined and analyzed through the perspective of urban nexus elements and their interplay in enabling circular transition.

3.1.2 A multi-method case study

Gillham (2000, 2-24) describes case study an inductive multi-method approach, that is especially efficient in researching phenomena of which there is a lack of previous research knowledge. Inductiveness stands for the situation, where the existing information does not give researcher material to make theoretical a priori notions or hypotheses. It also gives the research question room to be broad in the beginning and a chance to formulate over the process. Multi-method approach means that the material of the study will build up by using various sub-methods. Case study is characterized through its subjectivity and participation, which places the researcher and her own interpretation of the evidence in a central role. The method of collecting and assessing data appears in a form of a research database, which contains the evidence, notes, observations and other sources in such order it can be used to legitimize the origins of the information, ie. used as an "audit trail". USC (2019) suggests case study to be especially beneficial if it can reveal a phenomenon, that has not previously been exposed to research or if an exploratory case offers a new direction to futures research.

I chose case study as my research method, since there was next to none existing material about the circular economy scene of the city of Turku. The research was designed to be instrumental, i.e. to find insights to an existing situation with a possibility on generalization of results (Stake 2000, 347-438 cf. Silverman 2009, 156). My original task was to map the circular economy actors of Turku region, but the collected evidence opened up a much deeper and more profound view of the systemic state of the circular transition of Turku, which led me to formulate my research questions more towards the systemic view of the topic, to highlight the most influential enabling factors through them and explore the future potentials of the system.

Case study offers a possibility for a multi method approach, where multiple different methods are combined to collect relevant information. I selected this approach and my multi-method study consisted of horizon scanning and semi-structured interviews.

Horizon scanning is a systematic data finding and collection system, where relevant information of the subject is searched and analyzed. (ENAP 2019). The system is often used in futures studies in order to find background information to construct futures images and scenarios and find development paths. In this study I used it to construct an understanding about the subject, its applications and future expectations. Additionally, I used the method to find preliminary information to construct the interview questions and background information for the data collected in the interviews.

The focal part of collecting research material were the semi-structured interviews, which I chose to commit because I wanted to collect in-depth information and insights from a relatively small number of experts of the field (Gillham 2000, 62). Interviews were constructed in a same inductive and exploratory manner as the research itself. Albeit my original intentions I was not able to form framework or hypothesis of the local network based on publicly available information. This was due to the lack and incoherence of publicly available information and my personal lack of knowledge and connections to the circular economy actors and operations of Turku region.

The principal system of colleting, analyzing and storing data in a case study is a research database. The material in my research database consists of academic and other theme related articles, horizon scanning material, notes taken during the 35 interviews, my personal notes and ideas, a list of some 700 local circular economy actors, their fields of action as well as the written and published report "ICLEI Green Circular Cities Coalition: feasibility study to build an active network of circular economy actors in Turku region". The list of interviews and sources of the empirical research are illustrated in Appendix 1.

3.1.3 Sampling and interviews

The sampling method of the interviewees of the empirical research followed the principles of non-probability sampling, where the sample of the research was selected non-randomly (Research Methodology, 2019). This is justified with the specified knowledge required from the participants. A two-phase sampling was conducted through first engaging in purposive sampling, where interviewees were selected on the premises of them being known and focal actors of local circular economy. Purposive sampling covered approximately 10 of the interviewees, the rest were selected through snowball sampling, where the primary interviewees were asked to nominate other potential interviewees who would have significant information to contribute to the research. In practice, the method of selecting interviewees was to first identify and nominate some central actors in co-operation with the principal of the study, the city of Turku. After that, I asked the

purposively selected focal actors, who they considered to be other relevant actors in the local circular economy scene, thus engaging in snowball selection and accumulation of data.

With this method, I was able collect and identify approximately 70 persons, of which I ended up interviewing a half. The number of interviews was not predetermined, I decided it during the process based on the development of my research database material amount, quality and representativeness. Approximately 15 interviews were conducted over skype or telephone and the rest in person. There exists a clear positive distinction between the depth and scope of information that was approachable through personal contact in comparison to telephone/skype. Similarly, the quality of information I was able to collect improved towards the latter interviews as my own personal understanding of the scene expanded.

My original questions, in addition to background mapping questions, for the interviewees were the following:

- What is the circular economy related know-how you/your principal/employer possess?
- List the circular economy initiatives, projects etc, you are involved with or you have planned for the future?
- What is the significance of circular economy in the strategy of you/your principal/employer?
- On your view, who are focal circular economy actors in Turku region and what expertise they possess?
- Who are you/your principal/employer in co-operation with when it comes to circular economy?
- Which challenges do you identify for the advancement of circular economy in Turku?
- In what sectors do you consider Turku to have realistic potential for circular development over the next decade?

Mostly, the interviewees, being experts of the field possessing a lot on insights, explained me much more, wider and in-depth details than I asked for. Confirming the claim of Gillham (2000, 65), the semi-structured interview style proved to be a rich source of information. In addition to being informational, the process was enlightening, exiting and ended up giving me material to build an understanding towards the systemic view of the circular transition of Turku. This is also the precondition that directed me towards an attempt to analyze the circular transition in the city of Turku through Urban nexus framework.

3.1.4 Results and analysis

The results and discussion chapters of this thesis respond to the three research questions taking a somewhat diverse approach towards each individual question. The results of the case study chapter present an image of the current state of the circular system. The first part of discussion will intensify the systemic considerations as a response to the first research question of the current systemic state of the system on circularity in Turku. Results of the empirical study were divided according to the 6 thematic sectors identified by ICLEI (2018, 5). The structure was originated by the interest of the principal of the research, city of Turku. As the results formed a logical coherence, they are presented similarly in this thesis.

Figure 8 Six thematic sectors and circularity enablers ICLEI determined for the work of GCCC (ICLEI 2018, 5).

Urban planning and governance represent the mapping of urban planning to identify systemic potentials and opportunities to affect local decision and policy making. Green public procurement aims in using the municipality's significant purchase power in setting an example and primarily choosing suppliers, who engage in circular activities. Industrial symbiosis represent municipality´s means of supporting individual companies ja

networks towards increased circularity. Municipal resource management stands for waste collection and recovery to recycled materials, products or energy. Buildings and construction are major industries to which municipalities have a strong influence potential through their urban planning practices. The final theme is water-food-energy nexus, which represents the critical urban infrastructures and actually forms the base of the Urban nexus model (ICLEI 2018, 3-4).

The enablers mentioned in the figure above represent the view ICLEI has taken towards circular economy. Six verbs beginning with letter R illustrate actions that are considered circular economy related. Reuse, recycle, recover, remanufacture, repair and redesign give a broad set of actions which are included and approved as part of attempts to develop circularity. I adopted this broadmindedness from ICLEI to guide my case study – the recognition of various circular activities was extensive.

The themes ICLEI has selected as their GCCC thematic sectors are strongly related to Urban nexus, which directed me towards selecting it as the theoretical framework of this study. The theoretical framework is the tool used in this thesis to analyze the results of the empirical study and respond to the second research question of focal factors, that contribute to the development towards the urban circular economy. This research question is assessed as second of the discussion chapter.

The third research question of the future of the circularity will be anticipated in the latter part of the discussion chapter. According to the principles of futures studies, the future cannot be predicted. However, as the future is also not predetermined, our past and current collective actions influence the future outcomes. (Bell 2003, 162-164). The anticipation of the future development is based on the modes and levels of action engaged in the present and the coming years.

3.2 Credibility of the research

The credibility and trustworthiness of a qualitative research is assessed through several aspects. A framework by Lincoln and Cuba (cf. Sage publications 2010, 343) identifies the following conditions for measuring the soundness of a study:

1) whether the research findings are true and internally consistent for the subject of the study
2) whether the results are externally valid, applicable to other settings or generalizable
3) whether the results are consistent if the research is repeated with the similar participants under similar circumstances
4) to which extent the personal perspectives and biases of the researcher have conducted to the results.

With regards the of first condition of internal consistence and third condition of repeatability, the results of the empirical study build an image of the state of the local circular economy as it is perceived by the interviewees. This suggests a sufficient level of internal consistency and repeatability of the results. The discussion, where the results are analyzed through the systemic framework build the structure for external validation. Whereas the unique details of the urban system of Turku cannot be generalized to other cities, the systemic level connections between the elements and application areas of urban nexus circularity aim at confirming the theory and thus applicability in other similar settings. The nature of the research is extensive, which simultaneously indicates that the phenomena depicted would benefit from a more thorough investigation.

What comes to the personal perspectives and biases of the researcher, there are some limitations that deserve to be evaluated in consideration of the credibility. During the study I admired the dedication of practitioners on their commitment to action even if the impacts of CE are not fully known. The determination of action and knowledge creation among the practitioners appears to be strong. Naturally the practitioners have their set of plans and theoretical calculations but as it is typical with novel technologies, there exists insecurities and unknowns that have to be hypothesized to advance. Being a case study involving a subjective view of researcher, I feel obligated to state, that the results of the study and discussion are based on optimism towards the practice and opportunities of CE rather than criticism towards them. I have pursued towards critical evaluation of the circular system. However, I strongly perceive, that criticism should be provided in conjunction with constructiveness, which has probably hindered me from criticality in matters where I have lacked the experience and understanding to offer constructiveness. Additionally, I have written my paper with the aspiration it would give an encouraging image for the CE practitioners and researchers alike. Moreover, I sincerely wish that academic research would support the cause by finding concrete solutions and tools for the practitioners to use, since the academia was identified in the literature review as the entity who has the ability to form a wider picture to advance the cause.

University of Turku is committed to conducting ethical research and using the methods and principles according to the guidelines of scientific community according to Finnish Advisory Board on Research Integrity (2012, 29-30) responsible conduct of research. According to those principles, this study has been conducted with sincere aim to carefully plan the research, collect, handle and interpret material and report the results in order to find accurate and significant conclusions. The collection of material was open and the people participating the study were informed the grounds for conducting the study and to which purpose the results were planned to use. Each participant gave their information freely and informed. An improvement to the process would have been to make written confidentiality agreements with the interviewees as opposed to verbal. Another improvement would have been to record all interviews instead of taking notes during them, which

would also have allowed me to concentrate on the interviewee instead of writing during the interview. A valuable contribution to the realization of this study has been the previous work done by other researchers, which was meticulously acknowledged in the referencing. All parties of the research have mutually agreed on their rights, responsibilities and obligations concerning the research and relevant commitments shared and reported.

The following chapter proceeds to the empirical part of this paper, which examines the city of Turku from a local system perspective. To supplement the understanding of urban circular transition build throughout the first chapter, this paper now proceeds to empirical exploration of a city striving development towards urban circular transition.

4 RESULTS OF THE CASE STUDY

This chapter presents a narrative of the case study exploring the circular state of the city of Turku. It will first give a general overview of the circular development state of Turku and then proceed to give specific systemic examples through the 6 thematic sectors presented in chapter 3.1.4. and complement it with an additional theme that stood out during the case study process; data, research and education. This chapter does not contain references, but the content of this chapter is published by Silvonen and Kaskinen (2019) and based on the research database which, in headline level is presented in the Appendix 1.

4.1 State of the circular transition of the city of Turku

Turku is a city of approximately 185 000 inhabitants located in the southwest coast of Finland. It has set an ambitious target of climate neutrality by 2029, as it celebrates its 800 years of existence. Turku is surrounded by smaller cities and municipalities, that combined form the region of Proper Finland with approximately 480 000 inhabitants. This study is generally based on Turku, but as the city co-operates widely with the other municipalities of the region and they are an integral part of the urban nexus of Turku in many infrastructural aspects, I have been flexible in including them in the study and thus use the notion of Turku region.

General overview of the state of circular economy in the Turku region revealed approximately 700 actors, who contribute to or are verifiably planning to include CE in their operations. The identified actors consist of public officers, elected representatives, public bodies, public construction projects, trade ombudsmen, research and education representatives, regional and statewide actors, circular economy related projects, networks, strategic bodies and corporations of the city of Turku and private companies. Regarding the actors, the case study was, on my opinion, successful in mapping comprehensively the relevant municipality related and public actors. Concerning private companies, the study was mostly able to map the actors who are in co-operation with the interviewed public institutions. It is probable that a greater number out of the 22000 private companies on Turku region are active in circular economy than was covered in this study.

The city of Turku and Finland Proper have produced a roadmap for circularity in 2017, which consisted of three thematical sectors: food and agricultural circles, technical circles and transportation. These, combined with the cross sectional themes of the roadmap: public procurement, service economy and development of chemistry knowledge can be seen to have constructed an interesting foundation to this study, since most of the operators were well aware of this roadmap and thus it formed a foundation of the local understanding about CE. Additionally, the local understanding of CE has been enhanced by the

categorization SITRA has conducted on the subject, where CE is divided in five business/operational development areas: extending the product life cycle, product as a service, sharing platforms, renewability, resource efficiency and recycling. These two categorizations combined conducted significantly in the manner, circularity is understood and operationalized in the Turku region. Overall, the description and definition of circularity used in this study was broad. I accepted the ways on conducting circularity that were presented by the interviewees with sufficient reasonings of the relationship to CE.

4.2 Urban spatial planning and governance

City governance and urban spatial planning are in a focal role in determining the overall atmosphere and framework the municipality has towards environmental sustainability and CE as a part of it. They are the bodies responsible of the top-down direction of the approach, but also possess the power of setting an example. Furthermore, they are responsible of finding the ways of using the existing resources and directing the development in the most sustainable and productive way, which positions them as key actors of circular transition.

Urban spatial planning of Turku consists of master planning, which covers the land use planning and town planning that giving specific detailed guidelines to different properties, blocks and areas. In addition, green area, street and traffic planning are part of the functions of urban spatial planning.

The land use poses an interesting theme for CE in the city of Turku. It appears in the form of old industrial areas that are surrounding the center of the city, thus placing them as very attractive properties for residential housing production. The central location is also favorable with regards to public transportation and traffic planning, because the proximity of the city center provides public transportation more efficiency without expanding the length of the routes. However, being brownfield areas, the land masses will require at least partial purification and changing before circulating these areas from industrial to residential use, which connects urban planners to the business operators who are developing land purification and innovating new ways to use land masses. The mildly contaminated land masses can be circulated in local infrastructure construction, but the more severely contaminated masses need to be purified before circulation. According to an interviewee working for the urban spatial planning department, the cost of the purification of contaminated masses is difficult to determine in advance, which poses insecurity in terms of budget and thus often delays the processes.

Additionally, the condensation of the urban structure is actively taking place in the central areas of Turku through additional construction to those properties that have space. In this form of circular economy housing is being built in areas with existing

infrastructure, thus decreasing the need to zone completely new areas. Condensing the structure indefinitely with the cost of green area is however not in accordance with CE principles, but the structure and density need to be optimized to provide livable environments.

Town planning is the next step following master planning, giving concrete building guidelines and specifications. Town planners are thus in central role of advancing CE by making the instructions concerning land use purpose, permitted building area, heights and materials of the buildings, protection values of the surrounding nature, other buildings and green areas. In this process, the city constructions officials have a strong influence over private contractors, who in turn are motivated to develop their methods towards circularity to fulfill the new building regulations. In Turku, there is a pilot residential area of Skanssi, where circular economy solutions have been applied in for example energy, materials, sharing platforms for vehicles, increasing the green area and building a novel style storm water recovery system. According to the urban spatial planning department employee of Turku municipality, the piloted actions proven successful are planned to be augmented in the construction of future residential areas.

The city of Turku drives three spearhead projects in the field of urban planning during this election term of city government (2017-2021). Each of these projects are of large scale and have points of reference with circular economy. City Centre Development project (Keskustan kehittäminen), aims in creating a vision of a robust and dynamic city centre and implementing action in order to achieve it. The project emphasizes green area development together with walking and biking area creation, the renaissance of downtown as living area and decreasing the need to use of private cars in the central areas of the city. The Science Park project (Turun Tiedepuisto) is carried out in close cooperation with the local academic and educational institutions. It concentrates in creating intelligent and resource aware working areas for corporations and hence, for the citizens employed by them. Utilizing the solutions provided by digitalization, smart solutions and thus increasing the utilization rate of the office space the project brings about circularity in using working space. The Turku Science Park area is also situated and linked closely to the city centre and residential areas by efficient public transportation routes. To the wider economic and working area it is connected with adjoining train station that offers direct link to Helsinki. Easy access to public transportation is designed to diminish the demand to use private transportation. Finally, Smart and Wise Turku project concentrates on utilization of data and creating new operational models for municipality´s services in participation with citizens. The encompassed areas of the project are carbon neutrality and resource wise solutions, management of services and customers, security, urban planning, traffic and transportation. In addition to this, prevention of citizen exclusion by inventing and supporting inclusive models of operation is a major goal.

The traffic planning department of Turku has introduced electric busses and a bicycle sharing system. A new, more resource efficient skeletal structure of public transportation is currently being designed to circulate passenger flows more efficiently and enable better public transportation coverage to lower the demand of private vehicle usage. In addition to that, there are projects based on developing light transport logistics to cover the city centre instead of heavy vehicles. A sharing platform of privately-owned parking spaces is also preliminary being discussed for the coming years.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential in urban spatial planning during the following 10 years of time. The collection of their views concerning urban special planning is listed in the following table.

Table 1 Challenges and circular potential of urban spatial planning

Challenges of circular transition	Circular transition potential
Long time perspective. Existing structures pose restrictions to circular solution implementation of today. The anticipation of the whole life cycle a building or area is challenging in the design phase, because the future development cannot be predicted with certainty Theoretical understanding of a potential CE solutions exists but not necessarily practical solutions in the markets Urban planning requires more in depth information and concrete operational models to efficiently advance circular solutions. Private traffic is a deeply rooted cultural and habitual norm, which difficult to change even with development of public transportation Economical boundaries of developing public transportation to more scarcely populated areas means private cars will remain as important part of the transportation system	Regional development areas built as testbeds and example setting areas of circular economy solutions. A residential and business area based solely in circular principles could be realized to one of the brownfield areas City could open up pop up spaces for businesses and create flexible use of existing spaces Further development of a car free, flexible public transport orientated city centre City could enable and support a car sharing service Anticipatory urban planning in order to maximize the utilization rate and circulation of existing building stock Development of city structure in order to diminish the emissions of transportation and energy solutions.

The city governance plays a central role in advocating and enabling of circular transition. The highest authority of the city of Turku is the city council consisting of 67 representatives elected by the citizens. City government operates with their mandate. Government officials prepare and city boards develop the proposals for the city government, which has the authority to meet the decisions independently of direct them further to the assessment of city council.

A new climate plan setting carbon neutrality by 2029 as a primary goal of the climate politics of the city was accepted by the city council of Turku in June 2018. The plan stated circular economy as an important tool ja attainable paradigm in order to achieve the ambitious climate goals. The governance has so far been a significant supporter of CE development through the corporations, city of Turku has an ownership in. Of these corporations, many have been pioneers in the development of CE solutions, which also implicates that a major part of the local infrastructure has already developed towards circularity. The city governance participates citizens to decision making and action through for example Turku Future Forums, which invites citizens to discuss and contribute to upcoming development projects prior to the decision making.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning city governance is listed in the following table.

Table 2 Challenges and circular potential of city governance

Challenges of circular transition	Circular transition potential
The lack of sufficient resources in comparison to the demand of action required. Getting concrete directives, instructions and plan of action to the operational level of city organization. Some actions to advance circularity require changes in national policies, which is above the power of the city representatives to rule.	Creating joint agenda, goals and models for circular transition. The potential benefit is multifold in comparison to resources required. Focus on optimization, how to attain the best solution with existing resources? Educating city employees to make practical resource wise solutions. Making the interface between public and private sectors more visible and concrete. More active participation of corporations, communities, citizens and academia to the climate action and circular transition. Intensifying communication and understanding of CE and feeling of responsibility amongst corporations, communities, citizens and academia about circularity to participate more potential actors.

4.3 Green/circular public procurement and green supply chain

Public procurement forms a direct link to city governance, being positioned directly under it as a department of municipal administration. It exercises the purchase power of the municipality and thus possesses substantial power over the suppliers of the city. The importance and potential impact of public procurement is high, since the net worth of public sector annual purchases in Finland is 35 billion euros, which amounts for 17% of the GDP. Public procurement contracts are usually long and large in volume, which entails the motivating factor for private companies to develop circular economy model into their production. This also suggests that the effect of intensifying CE criteria in public procurement demands would not be limited to the public procurement, but CE products would also be more widely available for private consumers, increasing the level of overall systemic circularity.

City of Turku has a dualistic situation when it comes to public procurement. The city is the sole or partial owner in approximately 60 corporations, that are providing mainly infrastructure related service to the region of Turku. Many of these companies are local pioneers in circular solutions, because they have, with the mandate of the municipality, developed circular economy in their fields of operation in the past years. The climate plan accepted in 2018 by the city council obligates all city owned companies to emphasize climate, environment and life cycle impact. Furthermore, in their future operations they are obligated to advance CE solutions and decrease the use of natural resources in their procurement and investments. As a contrast, with the procurement external from the municipality owned infrastructural services, the procurement department of the city seems to suffer from the public tendering legislation, which is considered rigid and does not easily allow environmental factors to play a significant role in the quality ratings. Presently, there still exits a lack of information about the true environmental impact of many products and services, which makes it even more difficult to determine criteria for green public procurement. The lack of resources for developing green procurement was identified by an interviewee. The workload and the pressure at the department drives procurement officials to remain in the known procedures whereas development and assessment of new criteria would require significantly more time resources.

In addition to procurement, city of Turku makes investments. A recent example of how the pressure for climate awareness also comes through external sources is the Turku Urban Infrastructure financing agreement, which Turku entered with European Investment Bank in January 2019. The central criteria of the agreement were the proven energy efficiency and the climate effects of the projects financed.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning public procurement is listed in the following table.

Table 3 Challenges and circular potential public procurement

Challenges of circular transition	Circular transition potential
The assessment and measurement systems of CE impacts in a city are not sufficiently developed Insufficient available information about product and service carbon footprint (CFP) Rigid procurement legislation Several circular concepts exist on theoretical or demo level, but only few in the markets in such scale it is sufficient for a large customer as a city	Development of CFP as the measurement system of public procurement and thus the base of international politics and legislation Turku could pilot the CFP in its public procurement, promote it and augment its experience in the ICLEI GCCC network. Centralized public procurement with other cities though national operators Federation of Municipalities (Kuntaliitto) could be the active party to demand a reform to the procurement legislation to advance climate criteria consideration in public procurement. Benefits given for those service providers who use ecological solutions.

4.4 Circular industrial park (industrial symbiosis)

There exist 22 000 companies in Turku region, which positions private sector operators in a significant role in determining the pace and overall success of the circular transition. Through this case study, 300 of them were identified to have engaged in CE development with the public stakeholders interviewed. The companies found through this study represent the private entities systemically working in circular economy with public sector. The type of actors that stood out among the companies were small handicraft businesses actively using a side stream or recycling materials in their production, large companies investing heavily in circular production, data and programming related companies, agricultural enterprises and companies recycling their waste and using renewable energy on their production facilities. It is also possible and even probable, there are more companies that work in private CE networks and collaboration, but they remained undetected in this study.

Due to the limitations of resources of this study, there was no chance to thoroughly engage in business examples. Instead, I explored a more systemic example of how the city governance can positively influence the CE innovation on private companies. As

previously mentioned, the city of Turku is a sole or partial owner of several companies providing infrastructural services. One of them is Turku Science Park Oy (TScP), which operates under the name Turku Business Region various themes to support business development in Turku region. Turku Business Region has divided its operations according to the 5 spearhead industries of the region, descriptively calling them Maritime, Tech, Health, Experience and Clean. Of these, Clean employs a team of experts in the fields of sustainability, chemistry and circularity to support circular business innovation. A concrete example of Clean teams' efforts to circular development is the Smart Chemistry Park, which is a consortium of chemistry field businesses operating under the same roof providing services in planning and implementing circular operations through e.g. material chemistry solutions. Another example are the plans of building the Blue Industry Park, a new business area to host maritime and its supporting companies according to principle of wise resource usage, including CE solutions.

According to the CE experts of Turku Business Region who probably have the best view of the local private sector, the larger companies of the region are well aware of circular economy and circular development is already integrated in their strategies. Efficient production always entails circular thinking, even if it is traditionally considered as cost efficiency rather than environmental thinking. Smaller companies have less resources to innovate, research and adjust their operations and production to meet circularity, which means they need more support to circularize their operations. As a contrast, some of the smaller companies have been founded on circular principles alone, which is a good representation of the employment potential CE has.

City of Turku also forms network of public operators that co-operates in various projects and business development. The network includes city officials, businesses, researchers and educational bodies. It extends through all the layers of the city by developing new circular solutions for the citizens and initiatives combining public and private sectors.

The local universities have a growing body of research relating to CE and they have research teams cooperating closely with businesses. According to a researcher interviewed, the co-operation with companies enables such research conditions for circular solution experimentation and development, which would not be possible with university resources alone. Consequently, an efficient co-operation is highly beneficial for the development and assessment of the solutions. Turku University of Applied Science has a strong practical application in teaching CE through business models and business cases, which is conducted in co-operation with local businesses.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning industrial symbiosis is listed in the following table.

Table 4 Challenges and circular potential of industrial symbiosis

Challenges of circular transition	Circular transition potential
Many material flows are too small or insecure for investing in high volume production. This can be an opportunity for smaller businesses. The design phase of CE products requires more attention and understanding Lack of qualified people to advance circular business and product development Lack of analytic services provided to industry It is difficult to gain information about businesses and their circular solutions, because they are often considered as trade secrets.	Creation of industry vision, that systematically participates all companies in CE transition. Ship building and maritime industry are interesting and significant fields of advancing CE in the Turku region. Optimization of the business logistics There exists a lot of partial solutions that would require integration to create comprehensive CE cycles Advancing service and sharing economies and bio-based solutions SMEs need inspiring examples of how CE can work in their own scale.

4.5 Municipal resource management

Waste is widely considered as a resource in CE, but the collection, management and recovery of materials form a complex task for the municipalities. One of the founding principles of CE is to consider the reuse and recycling of materials in the design phase of a product to enable smooth repair, recovery and recycling. For municipal resource management of today, it is obvious, that the principle has not yet been realized and most of the waste needs to be sorted and material separated without inbuilt qualities or design for that. Waste collection is a critical part of municipal infrastructure, and organizing it belongs to the responsibilities of the municipality. In Turku, this task is outsourced to a company Lounais-Suomen Jätehuolto Oy (LSJH) that is partly owned by the city of Turku. The other owners are the smaller municipalities surrounding the city of Turku, which makes Municipal Resource Management a joint venture of 17 actors to attain enough volume for making it cost-effective.

At present, 1-2% of the total waste in Turku region is landfilled. Of the remaining 98-99% the recyclable waste is recycled, and the rest is used in energy production. This represents a significantly higher ratio between recycled and landfilled waste than global average. The future objective is to increase the proportion of recovered and recycled waste

and decrease the one used in energy production, because incineration of waste always generates more emissions and loss of materials than recycling. However, it was indicated by an interviewee that it is not probable to reach 0-waste ideal. In addition, with proper, modern incineration technologies energy use of waste can be sustained, naturally after the recyclable materials are properly recycled prior to that. A new designed to be ecological waste incineration plant is being built by 2021 in Salo, 50 km from Turku, where the unrecyclable proportion of the waste of Turku region will be incinerated and circulated it into energy.

LSJH upholds 12 waste centers and sorting stations, where citizens can deliver products to be recycled. The central waste treatment facility in Turku, called Topinpuisto, hosts a physical center for CE and a platform in which it cooperates with a network of private and public sector operators with the goal of developing circular solutions and making circular economy transparent for wider public. According to circular specialist, the waste treatment facility plans open a platform for consumers to give their old products to be renewed by local entrepreneurs, who repair and remanufacture second-hand products from existing old ones. The objective of this, in addition to supporting local small entrepreneurship and craftmanship, is to accustom citizens to circularity by showing that all materials contain value.

With regards to specific waste flows, Turku has been active in textile recycling development and is pursuing a textile recycling plant to be stationed in the region. Preliminary smaller testing plant has been operational for some years and practical research has been conducted through several multi-stakeholder projects. European Union has ordered ta separate recycling of textiles to be arranged by 2025. Will the current plans proceed, Turku has potential to be among the central actors of textile recycling in Europe. A textile recycling plant would potentially have high enough volume to process all the recyclable textiles collected from Finland and possibly from the wider Baltic region as well.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning municipal resource management is listed in the following table.

Table 5 Challenges and circular potential of municipal resource mgt

Challenges of circular transition	Circular transition potential
The total amount of waste increases although the relative amount decreases The volume of the waste sorting depends upon the awareness and action of consumers and easiness of the sorting system	Securing the stationing of the textile recycling plant in Turku Region Further development and visibility of Topinpuisto CE park and platform Situating waste collection units closer to consumers providing easier access Recycling of ships and cars More efficient collection, recycling and reuse of packaging materials Policy related support for "products as service" business model and corporations that use recycled materials

4.6 Buildings and construction

Approximately 1/3 of the greenhouse gas emissions is generated by buildings and construction, which makes them an essential theme of CE. The relationship of buildings and construction with urban planning is direct, thus the decisions of the city officials have substantial influence over this theme.

Considering the buildings, significant circular opportunities lie in two separate stages of their life cycle. In the new buildings, the emphasis is on the design and construction of circularly progressive and environmentally sustainable buildings. In the existing building stock, the focus is on the usage ways and rates and lengthening of their life cycles by maintenance and renovation. Additionally, the circulation of materials of demolished buildings that reach their end of life belongs to this stage. Combined, these two aspects form the life cycle of buildings, which is increasingly considered in the city of Turku.

In construction of new buildings, the special attention is invested in the design that enables the buildings to be multi-functional, modular, easily adjustable for various purposes and of built of high-quality durable materials. In addition to durability, the materials used should be recyclable at the end of life of the building. The solutions for circular buildings are still emerging, but a significant advance is being expected, as the Ministry of Environment is preparing a document for evaluating the carbon footprint of buildings

and building materials. The objective is that a comprehensive set of instructions for building in an environmentally sound manner would exist by 2025. Special importance is laid on the energy solution, which should be extremely energy efficient and accommodate the potential for using solely renewable energy. Additionally, the energy used during the construction period is critical when calculating the lifetime energy consumption of a given building. A novel method in Turku region that has recently gained interest through the first realized projects, is storing energy to the ground. The energy stored may for example be solar or loss energy that is collected and conducted to the ground storage through energy pillars. The ground stores energy efficiently and the heat can be extracted from the ground and be used on demand basis. The city of Turku construction department is currently preparing to scale up the circular building standards, after they have received positive and encouraging experiences from the residential test bed area of Skanssi.

Considering the existing buildings, appropriate maintenance and renovations are a vital part of their circular transition. A major part of the building related emissions is caused by energy production, that is used in heating the properties. Renovations of the existing buildings, that were built when oil heating was the paradigm, are often enforced by modernizing the energy system and improving insulation, which decreases the energy consumption and thus the environmental footprint of the building. Furthermore, energy renovations are often made to enable the usage of renewable energy, which links the operation directly to circularity.

Another aspect of circularity of existing buildings can be considered through utilization rate, where increase of utilization rate of a given building decreases the demand for new buildings. Not only the rate of usage, but also the time of usage is a relevant circularity advancing aspect. With improved maintenance and sufficient renovations, the life of a building can be considerably prolonged. On some buildings, i.e. log houses and industrial halls, movability may also allow more usage opportunities over the life cycle of the building. The city of Turku has identified these leverage points in their approach to circular economy of buildings and has conducted initiatives in realizing the circular potential. In this aspect, there is also often potential for immediate financial savings. The personal view of the director of the urban planning department of Turku was, that as long as renovating old has the same of lower cost than building new, it should always be preferred. Unfortunately, the quality of some of the buildings built between 1960-1990 is proved to be so poor, that renovations would in fact cost more than building new and still the circular quality of them would be inferior to new construction.

The city officials in the urban planning department have an important role in determining the framework steering the criteria of the construction and which demands are set concerning space, height of the buildings, green areas, shared areas, building materials and energy solutions. These specifications may be very concrete. Environmental awareness and specific building regulation give urban planners a significant control over the

actions of constructing companies and steer their actions towards circular economy. This is a significant phase, considering the life cycle of a building, since a great deal of life cycle energy consumption can be determined in the construction phase. It was implied in the study, that without concrete regulation, the private construction companies would prefer the most inexpensive solutions to secure the best potential profit. Investments in renewable energy solutions, best possible energy efficiency and durable recyclable materials are to be made in the construction phase, which affects the cost of the property and possibly the markets and profit. However, it entails a strong potential of financial as well as environmental savings over the lifetime of the building.

The city of Turku has conducted an interesting example, which enhanced circularity and created a new innovation in construction business. Approximately 10 years ago, the city of Turku zoned an area of apartment buildings to be built of wooden constructions. The area was very favorably located and thus interesting to building contractors. However, at the time they did not possess the technology for such wooden buildings the area was zoned for. According to an interview with a building department official, a co-operation between city building inspection, private contractors and architects was initiated to find a novel wooden building structure to fit those zoning instructions and create a sustainable structure. Today, this area of Linnanfältti has been partially constructed and serves as an example of the transformative power the municipality has and the support it can offer for relevant causes.

The city itself enforces mainly building of infrastructure, which entails excavation, traffic routes, green and blue areas. A field of circular economy, that is a significant part of excavation and has stood out over the last years in the region of Turku is circulation on land masses. Circulated land masses are processed according to their quality and mostly used in infrastructure development projects.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning buildings and construction is listed in the following table.

Table 6 Challenges and circular potential of buildings and construction

Challenges of circular transition	Circular transition potential
Life cycle assessment requires further development	Unification of databases of construction and usage phases of a building.
Determining of quality criteria is often difficult, which leads to price determining the selected solution	Further development of Skanssi CE pilot area as innovation platform for sustainable traffic, ecological planning and smart community enhancing services.
Construction is a material intensive branch with enormous potential for CE, but it is also conservative and prioritizes cost structure in its projects	Stabilization of land masses with industrial side streams and regional circulation of them
Guiding construction projects requires more understanding on material chemistry and recycling potential of them	Development of sustainable building materials to avoid problems with structural dampness, mold and indoor air quality.
It is challenging to influence the value chain of constructing materials production early enough to be able to affect material development	Increasing the usage of ashes on infrastructure building.
	Solution for using of the sea dredging sediments after piling them in the sea is prohibited.
	Development of life cycle models to guide construction and building management.
	Development of building, infrastructure and space management models to aid simulation and creation of usage scenarios.
	Advancing the cooperation of city and construction companies to develop circularity in buildings further through “stakeholder forum” model.
	Increasing the utilization rate of the existing buildings
	Development of energy storage in new buildings constructed.

4.7 Water-food-energy nexus

Urban nexus framework is based upon the concept of Water-food-energy nexus, since these three streams form the backbone of the urban infrastructure and are critical resource flows that need to be secured. From a perspective of a municipality, their primary security related concern is to secure its residents access to fresh water, food and energy, since disturbances in distribution of them will soon lead to dissatisfaction and conflicts. The three resources are also widely interconnected, since water is essential in food production and can be used to produce and store energy. Energy is needed in food production and water distribution. Food in turn contains a major portion of water and provides energy to citizens and food waste can be transformed into bioenergy. Finland, a wealthy country with small population, strong base of fresh water and well organized and subsidized agriculture has a relatively good standing regarding the security of these flows, but for many urban areas internationally, they pose a serious challenge. Albeit the strong standing with regards to the access to these resources, the city of Turku has developed the circularity further in each of them.

Water related CE in Turku region can be divided in three circular systems; wastewater, pure water and natural waters. Wastewater treatment is one of the success stories of the local circularity as it is not only an environmentally proven, but also economically viable solution. The infrastructure of wastewater purification is built to extract the energy out of wastewater flow with turbines. It is converted to energy with heat pumps feeding it to the local district heating network, where it is used to heat up to 15000 homes around the city. The sludge that wastewater contains is also collected to produce biogas. The wastewater treatment facility is a regional solution for the city of Turku and its surrounding municipalities. It has been estimated that this system produces tenfold the energy it consumes, which proves the economical sustainability of the system.

In the theme of fresh water, Turku has historically been famous of its foul-tasting drinking water. Nowadays Turku utilizes artificial groundwater that is produced by pumping water to infiltration basins, from which it infiltrates through the soil and transforms to groundwater in 3-4 months. Additional energy is collected from the freshwater stream with turbines, that are also used in storm water flows to extract the energy of a flowing water. Several interviewees stated, that the water related circular knowledge Turku has is extraordinary and exportable. There also exist water related initiatives with countries suffering from scarcity of fresh water.

The protection of natural waters is a centric theme of Turku region through Baltic Sea and the efforts to end the contamination of it. With Turku region, the local flows to Baltic Sea originate mostly from fertilizers used in agriculture and there exists a wide base of research, organizations and projects to correct the nutrient cycle from flowing excess nutrients to Baltic Sea and eutrophicate it.

Finland Proper, the region surrounding the city of Turku is a central area of Finnish agriculture and fishing industry. The leading Finnish food industry corporations are located in the region and the University of Turku has a strong research orientation in agriculture and food related CE. There are numerous ongoing projects that concentrate on development of circular food chain, finding novel food raw materials from side streams, circularity of fishing industry, using the low valued small fish as food, finding novel plant-based protein sources etc. The national agricultural institutions like Pro Agria, Luonnonvarakeskus, Suomen Ympäristökeskus and MTK support the circular development of agriculture through their expert services and research projects. According to researchers interviewed, there exists strong future potential for food and agriculture related circular solutions.

The local energy provider, Turku Energia concentrates its investments on utilizing renewable energy sources. The goal for 2020 is to provide half of the total electricity as well as heat extracted from renewable sources. The district heating network has recently been renovated to operate two-way to extract loss heat from its users, to utilize low heat sources, store energy for demand peaks and provide cooling in warm seasons. The electric grid is similarly a two-way solution. In terms of CE, the subject of loss heat combined with energy storing contains endless opportunities to extract energy during the warm season and store it to be used in wintertime. A larger pilot project of energy storage is currently being built in the center of Turku, as the new marketplace parking facility is constructed to collect solar energy and store it to the ground through utilizing energy poles. The energy will be used to defrost the marketplace in the wintertime.

As part of the interviews, I asked the local circular economy advancing actors to identify both challenges to circular transition and themes, in which circularity has realistic potential during the following 10 years of time. The collection of their views concerning water-food-energy nexus is listed in the following table.

Table 7 Challenges and circular potential of water-food-energy nexus

Challenges of circular transition	Circular transition potential
Pure water is one of the globally endangered resources and solutions are needed to secure the access to it for the growing population The existing energy system is built on fossil fuels. The transition to renewable energy sources requires massive changes in attitudes and policy Agriculture is one of the largest industries in inflicting climate change. The consumption of both plant-based food and meat is increasing, which means also the amount of food waste is growing Plant-based side streams have often obstacles like taste and security in using them as food	Wastewater purification know-how of Turku region is exportable and in high demand There are strong food industry actors and strong body of research in the region of Turku Development in utilization of wood and agricultural waste as biogas Further development of the nutritional cycle in agriculture Utilization of the nutritional potential of large masses and mapping the risks of large volume stocks. Further development of bio-based and renewable energy collection Scaling up the electricity and heat storage Advancing the education relating to CE of energy and ground energy storage. Transparency, visualization of energy and participation of individuals in energy collection. Opening a city managed platform for Carbon neutral Turku 2029, where content is provided by the projects relating to CE and environment.

4.8 Data, research and education in CE

In addition to sectors determined by ICLEI and presented in previous sub-chapters, the theme of information emerged in the case study material as an encompassing theme, which is required for advancing the transition. Information is produced, stored and consumed in various forms.

To begin with, recorded data that can be used to measure stocks and flows and allocate sufficient scale solutions is essential to the further development of CE and circular transition. There are numerous actors who collect this data and develop systems of utilizing it, but there exists a strong demand for more development in this sector to mainstream circular solutions. The development of equipment, sensors, RFID tags etc. during the last decade will make it significantly more feasible and cost efficient to collect data and develop circularity, but innovation is further needed in the field. Collection and sharing of data have also enabled the sharing platforms that have in the recent years created sharing economy, which is enabling the CE principles of efficient circulation and high usage rates of products as services in comparison to private use. Platforms are commonly used in sharing of apartments, rides, cars and bicycles but have the potential to expand to all such products, that are expensive or irregularly needed by consumers.

The notion of data can be broadened to cover the intelligence of the organization and ecosystem, which is used to develop sustainable solutions. Data, understanding and creativeness are essential for circular transition. In enabling circular transition and changing the linear paradigm, know-how and expertise are in demand. The cause needs people, who understand the principles and the application opportunities of CE and can implement them in their own field. All the technical Universities of Finland teach CE principles, but there exists a well-founded concern of the lack of interested students and thus the development of broad understanding CE requires. In Turku region, the Turku University of Applied Science is concentrated in practical applications and CE business models, as well as energy and built environment CE solutions. The University of Turku and Åbo Akademi conduct extensive research and give education in chemistry, food and bio-economy and sustainable development. Novia University of Applied Science has research and education on bio-economy and sustainable energy technology in its units in Raasepori and Vaasa. In addition to higher education, there exists second-degree education providing institutions in the region, educating in the fields in which the development of CE solutions is vital. Similarly, there are numerous institutions providing adult education. Unfortunately, it was outside of the scope of this research to investigate the level of CE related education offered and to determine the amount of new, skilled people entering the field of circularity annually. However, the growing existence of professionals and workers understanding and being able to develop and execute CE is vital for the advancement of circular transition and substitution of linear paradigm with circular.

Having now presented the current state of circular transition in the city of Turku, this paper will proceed to assess it through the Urban nexus framework.

5 DISCUSSION

In this chapter, I will proceed to discussion with the aim of responding to the research questions determined in the introduction chapter. I will first build the systemic picture of the circular action in the Turku region through the thematic sectors presented in the results of the study. I will then examine the results of the case study through the lens provided by Urban nexus systemic framework and pursue to highlight systemic intersectoral implications and finding the focal factors that contribute to the urban circular transition. Finally, I will explore the possible future development paths for circular transition over the coming decade based on the collective actions taken so far and the action potential of the coming years.

5.1 The current systemic state of urban circularity in the city of Turku

5.1.1 The interconnections between the urban circular thematic sectors in Turku

The thematic sectors of the case study combined form an interesting system depicting the technical and infrastructural environment of circularity in Turku region. This chapter will build and present a systemic image of the interconnections within sectors and connect them with Urban nexus framework introduced more in detail in chapter 2.4.2.

Urban governance and the public sector departments operating directly under it are the key operators in inflicting change. They also have the overall responsibility of practicing foresight, identifying megatrends and balancing the urban risks and resource flows in order to sustain the security of the region. Governance is the entity, which would optimally possess the overview of the urban nexus and understand the points where change can be initiated. Similarly, the governance is responsible for the scaling policy response and developing a plan for the transition management in order to advance transforming the urban system. The dedication possessed by the governance and city officials is a resource, importance which cannot be played down when it comes to commencing change and development.

In the city of Turku, the climate responsibility governance conveys is in a constant increase. With climate agenda and concrete projects, the governance of Turku is also showing concrete planning and action. Albeit the recognition of municipality of Turku being one of the leading advocators of circular transition, there is strong evidence that there does not exist enough resources to develop sustainable structures and CE solutions in a pace the local CE actors would aspire for. According to numerous interviewees, the

overall awareness and positive atmosphere towards environmentally sustainable operations of the municipality governance has increased significantly over the last 5 years and the level of action has followed. However, there is demand for scaling up action. Urban governance operates mostly through the various departments of public sector and it may engage on multitude of initiatives according to its activeness.

Urban planning is one of the key public sector departments when it comes to determining the infrastructural and technical choices the city makes. It makes long term decisions and faces the consequences of the long- term solutions previous urban planners have made. This brings urban planning department to identify the potential for synergies and trade-offs in its operations constantly. Urban planning department connects the organization of municipality to private sector through various contractors constructing infrastructure, buildings and transportation operators. Urban and town planning departments have a strong influence over the solutions they approve through enforcing building instructions. Through building and construction sectors and transport planning they actually possess the strongest potential for affecting the sustainability of solutions chosen. They also have at least indirect link to water-food-energy nexus and waste management through land use considerations, even if they cannot determine or instruct the specifics of those systems. The three spearhead projects presented in the results of the study formulate a concrete example of operations and values of the municipality of Turku and their implementation represents the style the urban nexus operates locally.

Considering the public procurement though Urban nexus framework, it forms a direct connection between urban governance, private sectors and promotion of circular operational models to advance sustainable development. Reflecting the volume of public procurement to the global system, one can only imagine what would be the effect for circular transition, if the global public procurement would demand circularity from all products and services purchased. Input-output analysis and resource modelling from the Urban nexus framework play an important role in public procurement and they have access to information to assess urban metabolism. Improved synergies and minimized trade-offs are vital results of efficient and silo breaking public procurement development, which proves that public procurement has significant potential to advance guidance of resources towards CE. A wider global, city systems exceeding synergy can be seen in public procurement, if global criteria for environmentally neutral purchases can be created. One suggested alternative presented by the interviewees of this study was the Product Carbon Footprint (PCF), which calculates the product related emissions over its life cycle. Public procurement seems to connect to a national and global system that requires improved legislation and impact assessment for the local systems to follow. However, Turku has independently solved numerous circular procurement issues that belong to its infrastructure thus in its own authority to solve.

It is evident, that the private sector, which this study reflected through the theme industrial symbiosis, forms the most volume to be harnessed to advance sustainable development. To contribute to success of circular transition, it is vital that the participation of businesses in CE is secured. The products and services forming the flows of urban metabolism are mostly originating from corporations, whereas the city is mostly responsible for the infrastructure through which they are flowing. A circular business model specialist mentioned in the interview, that Turku region businesses have strong circular potential and initiative and numerous on them are co-operating with municipality in circular transition seeking projects.

The citizens form the work force of businesses. This means personal values and corporate values have an enormous effect on one another, thus forming the opportunity to create a positive value cycle towards developing circularity. The power of the values of citizens is regularly understood to be through consumer purchase behavior, but it is also significant through the decisions they make in their work domains. An environmentally aware business culture can only form through the personal values of the stakeholders and when a significant enough portion of employees are pro sustainability, the sustainability of the actions of the business increases. Similarly, if the business values give priority to the environmental values, it is to be expected that those values transfer to the private behavior of its personnel as well. Additionally, circular solutions need to prove their profitability to become business paradigm, which is a recognized barrier for CE, but external innovational support and incentives may prove to be beneficial in that development. The city of Turku connects to private sectors through Turku Business Region support but has also numerous of its services provided by private sector operators. The public procurement works widely with the private sector. Even though this study was not able concentrate on the industry, it was able to detect a major number of interconnections and prove the significance of the private sector in determining the potential success of the circular transition.

Considering the thematic sector of municipal resource management, commonly known as waste management and reflecting it back to urban nexus, it forms a stock of resource, that in linear economy was considered as the end of the life of the materials. This is the point where the pressure of circular economy has been the most prevalent so far, and indisputably initiated concrete progress in recovering materials and finding ways to recycle them. A clear connection to water-food- energy nexus is formed through food and plant-based waste, which comes into the waste collection containing nutrients that are vital to be circulated back to nature. Waste collection is another thematic sector where all the stakeholders have a role. Consumers as sorters of used materials and as users of recycled goods, private sector in innovating ways to produce new solutions from recycled materials and municipalities in securing sufficient volumes of resource recovery through their municipal resource management system. Significant challenges have been identified

in finding cost and energy efficient ways to bringing recycled material flows into circulation without compromising quality and safety of the products. In addition to this, the customer choice entails a challenge. There exists suggestions of government subsidies and tax breaks for products manufactured from recycled materials, which is expected to stimulate both production and demand of them. A circularity specialist interviewed called for increased fiscal support for secondary raw material markets in order to attract businesses to use them in their production instead of virgin materials. The role of municipal resource management is vital in assessing and altering urban metabolism. It has the potential of giving feedback to the cycle and thus enable the systemic learning function inherent in the urban nexus.

Buildings and construction are major industries with high resource demand and thus major effect on the proceeding and success of the transition. The industry combines policies with technological development and effectively ties the stakeholders of government and industry together to create public and residential space for citizens. Additionally, buildings and construction have a strong connection to water-food-energy nexus though the notion that buildings are a major consumer on energy and their energy efficiency has major potential in decreasing the overall energy consumption. The connection to waste collection exists through construction waste and waste that comes from the demolition of old buildings. These are mainly not processed through municipal system, but the industry has their own waste collection and circulation system due to the enormous volume and special qualities of the waste. A part of the waste coming from old building demolition is used in infrastructural, eg. road, noise barrier and landscaping projects.

Water-food-energy nexus forms the base to the entire Urban nexus framework through being the essential three infrastructural elements of urban environment and strongly interconnected with one another. They are critical for urban risks and security, because they provide citizens the essentials needed for living. Governance has the priority to secure these basic needs and there are numerous private businesses in the sector as well. The division of water is almost solely taken care of public sector owned company Turun Vesihuolto and private companies mainly use water in their production. The central division of electricity as well as the district heating are taken care by Turku Energia, an infrastructure providing company owned partially by the City of Turku. However, there are numerous businesses offering, mostly renewable energy related solutions directly to consumers. In the city center apartment buildings these are rarely used, but as soon as the houses get more detached outside the center, there exists a domain for heat pumps, geothermal heat, solar power etc. Private companies dominate also the agriculture and food sector.

In addition to interconnections presented between the previous thematic sectors, the information is a cross cutting theme in the system of circularity. Information and data tie the actors of different fields and domains together. A vital resource flow in advancing the circular transition is the flow of information. Information has not, strangely enough, been

directly mentioned in the Urban nexus framework, but through this case study it became clear that information is the most efficient advocator of circular transition. An interviewee named it the crosscutting catalyst of circular transition.Information requires efficient communication, which both are required to break the silos, identify and innovate new circular solutions in order to facilitate systemic urban circular transition.

5.1.2 The current state of circular transition in Turku

Interpreting the results of the empirical study, the consideration of principles of CE appears to be expanding in the municipal organization of Turku. Few of the departments are actively leading circular development in their operations and most of the other departments are seeking ways to apply circular principles. The city of Turku also administers an environmental department that is dedicated in advocating environmental issues, conducting international cooperation and assisting other departments in their CE and environment related incentives. According to recent information, the amount of employees of the department has doubled during 2019. From the actions of the organization of the city, the promotion of the circularity expands directly to the actors cooperating with the city and strategic communities owned by it. Additionally, the municipal organization affects indirectly through the Clean team of Turku Science Park Ltd by advocating circularity in the private sector. The city of Turku also participates its residents, which sets it in the focal position of the advocacy of local circular transition.

The findings of the study reveal a strong dedication among the CE actors in Turku to reach the climate neutrality goals through circular transition. The expectations of the impacts of the phenomena are highest among its advocators. Advocators are often not the same as practitioners, who seem have a more realistic view on the potential impact of the theme. A statement often heard during the interviews was that circular solutions need to entail the potential for economic profitability in order to be scaled up. To support this, contrary to research, that has not found strong evidence of economic decoupling, in the city of Turku, there exits clear evidence, that circular solutions have been proven not only environmentally but also economically feasible. However, the succeeded decoupling of wastewater purification system through circular solution mainly proves that CE principles have the potential to be successful in decoupling, it does not prove that they automatically are. Through this experience, it is evident that the interest towards circularity is increasing in the region.

Simultaneously, proving the arguments of numerous authors, the definition of CE remains broad in the empirical research setting of Turku and there exist concerns about the actual impact potential of the paradigm. According to numerous interviewees, the

dynamicity and adaptivity inherent in the phenomena are considered as positive aspects and allow flexible development of their activities. Sometimes however, this leads to the apparent superficiality of action that is mainly used for PR purposes, but generally it seems the interest of the practitioners is real even if the level of action varies. Noteworthy is a statement from an business circular specialist, who indicated that due to lack of resources and knowledge, most of the practitioners of CE need to begin their actions from a modest level. Often the small initiatives grow depth, width and impact over time as knowledge and networks grow and more resources can be allocated.

In academic literature, there exists a debate of whether the social aspects of sustainability should be included in the definition of CE. The approach in the city of Turku does not directly consider them as part of circularity, but there are numerous identified interfaces between circular initiatives and improved social sustainability. Smart and Wise Turku spearhead project e.g. concentrates on using data to enhance its social services. Similarly, many CE solutions, especially sharing services enable and require people to engage in deeper rooted social activities than the traditional non personal linear model does. Society belongs to the system of CE by forming the base of stakeholders. Circularity has undoubtedly major effects on the society through the people affected by it.

In considering the development phase of CE in Turku by futures studies scale of weak signal growing to a trend and potentially emerging to be a global scale megatrend, it is safe to say CE has passed the weak signal phase and evolved to be an upward trend. Megatrend is a word commonly used to depict strong global developments, and it appears safe to argue that circularity has a long path ahead to become the global paradigm to confront the current linear one. Similar is the situation in Turku. Albeit the effort and dedication shown by the actors, the number of concrete practitioners of CE is still rather low in comparison to the volume of the area. CE is still an emerging consept in most of the sectors and there are profound developments that need to be turned around to support the paradigm of circularity.

Concerning the circular activity in the city of Turku, the case study revealed multifold of incomplete and partial circular initiatives in comparison to circles, that were complete and functioning. In assessing the development process of the circularity through the results of the study, it is constructive to realize that the perfect resource cycles often do not form without intensive iteration, neither are they constant. It was indicated by the expert interviewees, that the first development phases of circularity often produce partial solutions of which the functionable ones will then connect with other partial solutions to form more complete circles. With the partial solutions, the key aspect in determining the success is whether further development is being actively pursued. This process can often be progressed only with other actors, simultaneously creating the network and combining various fields of activity, as pictured in the Urban nexus operationalization model. Partial

solutions thus possess great potential and act as pilots for circular knowledge development and learning. This level of activity is relatively strong in the city of Turku.

5.2 Assessment of the focal factors contributing to the urban circular transition

5.2.1 Urban nexus actors, elements and strategies in Turku

This chapter will concentrate into the circular system of Turku presented in the previous chapters. Urban nexus framework will serve as a tool, through which the results of the study will be analyzed and evaluated in order to find focal factors and the interconnections contributing to the urban circular transition.

Urban nexus framework begins by identifying the stakeholders of urban system. With regards to the stakeholders of the urban nexus of Turku, the city identifies itself strongly through the Quadruple Helix model, where the silos of government, industry, academia and citizens are deliberately attempted to be dissolved to create an open platform of action. In identifying the operators of local circular economy, it became apparent that some aspects of the model are more strongly operationalized than others. Clear connections exist between government, academia and at least part of the industry. Many of these connections are merging through circular economy related projects, where the financing requires participants from several type of actors. Some circularity specialists interviewed criticized the projects often to be superficial in their nature and detached from day to day operations of the given entities. Others gave the projects credit to have the power to create deeper cooperation between different actors of the society, which can enhance the future circular action and breaking of the silos.

The number of active stakeholders taking part in circular economy is on the increase though intensified understanding and interest towards the paradigm. There exists a number of circular economy advocates in government, industry, academia as well as among citizens. The concrete actions they take towards transition, combined with the intensified media coverage of climate change are addressed to stimulate further participants to show interest, grow understanding and join in advancing circularity. Across the interviews, many illustrated there to prevail a situation, where there exits plenty of potential stakeholders, who identify the environmental threat and perceive that solutions need to be created but scaling up the concrete action is pending. However, it was recognized that the situation has evolved in two years and it is evident, the circular action is on the increase. The next few years will be critical to determine the practical development of circular

economy, since Turku is presently, through the ongoing pilot projects in many fields starting to see if CE has means fulfill its potential.

In addition to stakeholders, the Urban nexus model identifies 9 operational elements to support transition; megatrends, systems lens, risks and security, resource flows, synergy, trade-offs, participation, transition and learning. Proceeding to explore the operational elements drawn in the Urban nexus, the identification and seeking to understand the effect of megatrends to local system is one of the essential elements. The case study revealed, that urbanization and climate change with their causes and effects are relatively well understood as drivers of change and as reasons why improved sustainability is needed. Turku has a strong climate related vision and a goal for 2029 and they have selected tools to utilize in order to achieve it. Understanding past stresses and describing future risks refers to a broader action of foresight, which is a core obligation of the city officials and governance in urban development. It should and probably also is utilized in the public and private sectors to create opportunities for demands that are expected to arise in the future. This seems to be the strategy behind current circular development of the region and has not yet exhausted its potential as a source of innovation and action.

Participation is identified as another operational element of the Urban nexus model. City of Turku appears to be quite active in its efforts to participate citizens and private sector as well as initiating research to support its projects. Turku Future Forums and other citizen initiatives combined with Turku Business Region Clean team participating and offering businesses assistance in circular development are strong efforts of participation. However, the level of action and thus impact needs to be scaled up to reach the majority of potential stakeholders. The more aware and invested individuals have successfully participated and contributed to circular transition through their actions, the more the body of the advocates grows and peer- to peer learning escalates. Quite possibly the efforts of the city officials and the example they set in terms of infrastructure, urban planning and building circularity has more participatory power than direct efforts of participation.

Finding synergies and avoiding trade-offs are both elements of Urban nexus, which both promote breaking the silos and initiating close cooperation between different departments and resource systems. There exist strong circular synergies in Turku between water and energy systems, governance and citizens, research institutions and industry. Urban planning has numerous potential synergies with buildings and construction and public procurement has proven synergies with supporting circular infrastructural development. Waste management has potential to scale up synergies with private sector and through efficient communication, a wide set of interorganizational synergies can be found. A circular business specialist interviewed argued that with proper co-operation, Turku has a real chance of being a pioneer of circular economy solution. One key is to avoid trade-offs, like allowing construction companies choose and install the most inexpensive energy systems or use poor quality materials that cause excess economic and environmental cost

in the future. Many trade-offs seem to be based on costs, information and policy. A significant trade off to potentially compromise the advancements of circular transition seems to be the procurement policy that presently does not allow such quality criteria as "produced locally" to minimize logistics related emissions. Notably, the public procurement legislation seems to focus on purchase cost instead of life cycle cost of a product. Exploration of circular synergies and identification of trade-offs is a vital strategy in advancing the circular innovations and thus transition.

Systems lens is another element of Urban nexus. In the pursuit of the circular transition it is highly beneficial to consider that all the elements are interconnected, which indicates that actions in one sector similarly effects the other sectors. Systemic view and the interconnections were acknowledged in some of the research interviews, but it is difficult to assess, how much it is explored in the practical development efforts. However, the questions posed during the interviews about the challenges and realistic potential of CE in the next ten years reveal, that the actors interviewed identified mainly challenges that were systemic in nature, but the opportunities identified were mainly theme related. A recognition of systemic challenges is a good start, but also the opportunities should be considered in systemic level in order to solve the challenges. One concrete action existing widely is the purposeful colliding of representatives of different sectors and actor groups in workshops. It has a high potential for systemic recognition leading in finding synergies and initiating innovation, thus resulting learning, another focal element of the Urban nexus.

In addition to the elements, Urban nexus identifies 6 strategies to create action through the elements previously detailed. Input-output analysis and modelling of resources, understanding past stresses and describing future risks, clarify trade-off and explore synergies, scaling policy response and technology choice, peer-to-peer learning and pathways identification, financing, implementing and monitoring.

The concentration on existing resource flows, which are a focal element of Urban nexus, has been in the core of the circular approach of the city of Turku. Input-output analysis and modelling of resources has led the public operators to improved understanding of systemic circular opportunities and potential. The city has concrete, functioning examples of resource flows, that have been harnessed according to the principles of circularity. One interviewee suggested, it might be beneficial for the cause to make the solutions of water, energy and waste systems even more transparent for the stakeholders to understand, what circularity means in everyday life.

Peer-to-Peer learning and pathways identification resonate to the participation of stakeholders and scaling up the transition, which can be observed for example from the decision makers, who learned through the actions of city owned corporations, that CE economy can be a significant tool for economical savings simultaneously as it is being used for building a sustainable system. Peer-to-peer learning actualizes in every level. Similarly, learning takes place between levels of operators in the joint projects, the city

of Turku is actively taking part of. It was strongly indicated through the interviews that circular transition is a learning process, where existing knowledge needs to be abandoned and novel understanding and action about overall resource efficiency constructed.

Scaling policy response and technology choice reveals the significance of them as an enabler of circular transition. The most glaring and widely recognized example of this study is the policy inhibiting the development of the circular procurement legislation, but there might be other laws as well, that do not presently consider sustainability. As a contrast, the governance of Turku has presented strong positive policy towards sustainability in their climate plan approved in 2018. The enabling capacity of technology is widely recognized in Turku and there are numerous entities providing data related CE services and creating technologies to enable CE applications. In addition to policy, technology and innovation, the Urban nexus stresses that financing, implementing and monitoring are required in transforming the urban system from linear to circular. One challenge recognized by the interviewees in scaling up action is the experienced insufficiency of allocated resources, which can be drawn directly to financing and allocation of working hours.

5.2.2 Operationalizing the urban nexus in Turku

In order to operationalize Urban nexus, the framework identifies four sections, through which the operationalization of sustainable action and CE can be implemented and assessed. The objectives, integration areas, the development cycle and the innovation areas attempt to set guidelines through which the concrete action can be developed.

The first section is concerned with Urban nexus objectives, which is identified to direct the urban projects and investments to meet the priorities of the city. In the case of Turku, the objective set is to attain carbon neutrality by 2029. Development of circular solutions is positioned in a key role of achieving that goal. A challenge strongly identified by numerous interviewees from this section of framework was how to measure the success the operations. City of Turku has attempted to solve the assessment of progress by releasing a climate report, that introduces the concrete operations engaged, the measures taken and planned as well as the achievements and expected future outcomes. This report was presented for the city council of Turku in May 2019 and a similar report of the advancements is planned to be presented annually. The key fields of activities in the report are carbon neutral energy system, sustainable low carbon transportation system, sustainable urban structure, the climate responsibility of public organization of the city and its strategically owned corporations and fortification of carbon sinks. Key activities of the fields contained actions based on CE principles. The progress that the first report conveyed was, that although many operations have been enforced, the commitment to the objectives and

the concrete measures taken will need to be further reinforced. Hitherto, a lack of allocated resources has been limiting the progress. The influences of climate change are expected to be intensified and will thus require stronger understanding of the future development and wider adjustment capacity. (Turun kaupunki 2018, 5-15).

The second section of operationalization of Urban nexus emphasizes the integration areas through acknowledging scales, systems and resources, services and facilities, silos and social behaviors. These areas initially refer to organizations but are directly applicable to people forming them. The integration areas form a field of finding novel synergies that can be gained through integrating two or more urban systems or operations. Based on the case study results, it is apparent, that there exists a certain level of integration between systems, areas and people in the region of Turku. A dominant approach of increasing the level of integration and breaking silos and have been the projects, where a group of actors from various organizations has gathered to solve an existing challenge through circularity. However, an interviewee implicated, that it is often the same set of stakeholders, who run the projects and participate in them. The greater the number of new project participants is, the more potential exists for the synergies. Similarly, the faster the amount of CE practitioners increase. Information if one of the key resources, enabling improved integration of thematic areas.

According to a circular business specialist, businesses seem to find it complex to try to locate existing material side streams for developing CE, because so far, they have not been sufficiently mapped. ELY (Centre of Economic Development, Transport and the Environment) is a national operator that is currently involved in improving the availability and access to that information. They are also targeting businesses by arranging events about the business opportunities of circular economy. This section seems to be the one that is ultimately based on information, the distribution of it and the stakeholder ability to receive and accept it. Furthermore, this is the section where networking and activeness in seeking partners plays a key role. In Turku, the action is supported by Turku Business Region Clean team, but the number of potential business stakeholders is extensive and the majority of them still operate mainly through linear paradigm. Especially the resources of small businesses, most of the private sector is formed from, are limited in engaging in development of circularity.

The third section concerns the Urban nexus development cycle, which begins from identification, followed by innovation, design and delivery, communication and mainstreaming. The actualization of development in this section can be seen as a direct consequence of the success in the previous section, where a suitable team or partner has been found. This development cycle can be used to illustrate not only a development of a single circular solution but also in wider scale, in considering the overall advancement of circularity. As mentioned in previous chapters, there exists numerous projects in the region that participate actors in building and piloting joint innovations. They usually concentrate

on innovation, design, piloting the delivery and communication, whereas the further development and mainstreaming of successful results is often the task of existing public or private organizations and depend upon the profit potential they see in the innovation. City of Turku has proved examples of wider scale circular solutions that have been mainstreamed, similarly it has operators that are actively assisting new actors to innovate further. The more solutions are mainstreamed, the more it is expected to affect to the social and consumption behaviors. Citizens as consumers are more probable to start requiring sustainability as they are more exposed to it and experienced its benefits. Similarly, the increased mainstreaming and proven profitability of solutions will increase the level of interest of the businesses to develop circular solutions.

Urban nexus innovation areas, law and policy, design and technology, delivery models, communications and user behavior and finally, institutional development can be considered as domains of knowledge. The content of these domains needs to be collided from multiple angles to come up novel innovations. According to systems thinking, an innovation on one area may cause advancement in another areas, similarly a challenge faced in one domain may be solved with support from other areas. Currently, all the Urban nexus innovation areas are presented in the circular scene of Turku. Law and policy seem to be under evaluation and there exits an emerging discourse about the ways they could support environmental objectives. Design and technology of CE are actively being developed in numerous private sector businesses, research institutions and joint projects. Delivery models are in strong practical development phase that is most visible in the sharing solutions and various platforms emerging constantly and altering user status and behavior. Public sector has a focal role in many projects that are concerned with the sustainable ways to arrange physical delivery of goods. Institutional development can be observed through the municipal organization of Turku and through for example Turku University of Applied Science, that has integrated CE in its approach.

5.2.3 Focal factors contributing to the urban circular transition

The theoretical framework of Urban nexus used in this study presents the key elements, strategies, practical application modes and areas of urban circular transition, of which each has a significant role in the process. In pursuit of determining the focal factors contributing to the circular transition, they form an important groundwork. This chapter highlights and aims to justify the few cross cutting central elements that are, based on the literature and the case study, among the most influential ones in determination of the pace and scale of the transition.

Literature concerning circular transition repeatedly elevates the responsibility of the governance and their actions in promotion of CE. As a reinforcement to this, a weak

governance is named as a barrier to circular transition. In fact, many of the enablers and barriers of CE of the literature review were directly or indirectly linked to governance or public sector. The results of the case study show an increasing commitment starting from the city council through the city officials and departments and realizing in the city owned corporations providing services. The results of the case study strongly implicate the focal role of local governance in advancing the transition process. A municipality is a powerful operator through its own infrastructural development, which in the city of Turku is visible through water and energy related systems. Additionally, the procurement and investments criteria and building regulations have substantial influence over a wide range of operators.

The role of economics is strong in the determination whether the circularity transition will proceed. It is vital that a clear logic for economical profitability for circular production will be attained in order to proceed the transition. The water treatment example of Turku shows, that it is possible in at least some instances. In other fields it may require the increase of the price of primary source raw materials in relation to recycled ones, fiscal and financial means or the life cycle cost consideration. However, as the logic for economic profitability is discovered, the process has potential to proceed. As we are talking about a systemic phenomenon, it does have the capacity to expand quite rapidly if the benefits can be proven to exceed investment costs. Especially the private sector is rather fast in advancing those causes they anticipate being profitable.

Reflecting this notion of economical profitability back to the role of the governance, if there exists the goal striving to proceed circular transition, they have means to find ways to support it or deduct the profitability of the counteraction. Several interviewees argued that altering the direction of presently given subsidies might be a solution. For example, if the prevailing subsidies e.g. for fossil fuels and agriculture were strongly directed towards increasing the production of renewable energy and plant-based solution, it would potentially alter the market and improve the status of circular products. An interesting suggestion during the case study was for government to make a decision and immediately communicate that in e.g 3 years, the amount of recycled materials in all public procurement purchases should exceed for example 30% percent. The hypothesis of the given interviewee was, that this would immediately start directing the innovation, product development and production towards the given goals because of the major volume public procurement has. This type of legislative action would probably not be in the level of municipality but in the national level. However, municipalities, especially the large ones possess strong leverage to national decision making.

Information in its many forms and the division of it is another focal factor contributing towards circular transition. Information in terms of knowledge, expertise and knowhow is essential for developing circular solutions. Especially the understanding of chemistry is required in most of the circular processes. Information in terms of data is another enabler or barrier, depending on the availability and openness of it. It affects in e.g.

determination of available material stocks and flows of side stream materials, optimization of resource usage and in the management of production versus consumption. A concern from a professor interviewed was, that the lack of wide scaled understanding chemistry professionals may become a barrier of circular transition as the action scales up.

5.3 Future development of circular transition

5.3.1 Future of circular transition in the city of Turku

The situation of Turku and Finland in general is very strong with regards to access to all vital resources. The relative per capita resource consumption rate is extremely high, but due to the northern location and small population the people are relatively safe from the most acute and devious expected outcomes of the climate change. This means the city of Turku is not currently in a position where is its forced to develop circularity to secure its own infrastructure to meet the short period needs, but it does so with anticipation of future, where the access to resources is not as secure it is today. Through its actions, Turku seeks to demonstrate climate responsibility that is expected from cities by several advocators of sustainability, starting from the United Nations. An objective to secure the position as one of the leaders of the circular development is also a strong source of engagement in the cause. Albeit the criticism given in the interviews of municipality not directing enough resources to support CE properly, it is evident by the overall research material, that a constantly growing number of resources are being directed to advance it. Additionally, with innovation of CE expanding to new departments and domains, there exists resources that can be allocated to support it.

The current systemic stage of commitment towards advancing urban circularity in the city of Turku is relatively strong, however the development phase is yet immature and the scale of action requires major upsurge. Essentially, the city of Turku appears to be in a lucrative position in its efforts to advance circular economy. There are powerful actors involved, different layers of society have been activated and successful projects have proven the economical decoupling promise given by CE advocators. Reflecting back a few years and taking into account the development attained, there exists a concrete potential for the next 10 years targeting to the climate neutrality in 2029 will show profound development in the field of circularity. Whether that will be enough to claim the transition has been realized, will significantly depend on the resources allocated to advance the CE. Similarly, the results and impact of the current and coming CE initiatives and the system form are a considerable precondition of future investments.

Following the founding principles of the futures studies, future is not predetermined, cannot be predicted and is ultimately a product of collaborative human actions. However, anticipating the future of circular transition in the city of Turku based on the past development, current situation and the ambitious goals the city has set for carbon neutrality in 2029, an upward trend cycle is an entirely possible development path for the years to come. The strong commitment of stakeholders, increased interest of research institutions and the growing number of projects forms a strong precondition for future positive development and support the positive scenario towards developing circular transition.

The pace and scale of the circular development are, nonetheless, subject to several uncertainties. At the current early stage of development, the successful proven initiatives have a strong power to advance the cause, similarly do the failed and unprofitable efforts to disadvantage it. The current projects advancing circularity are primarily financed by organizations such as European Regional Development Fund, which demands concrete advancements in the causes they finance. This sets high expectations and demands to the co-operation of research institutes, municipalities and businesses to find circular solutions with considerable impact that can be both measured and scaled up in the systems. According to an interviewee, the level of ambition needs to be high not only in the goals but also in the actions of the stakeholders. Failures to meet the goals taken and the expectations raised about the life cycle economic profitability will have the power to turn the trend downwards through decreasing the funding for the innovational work.

Reflecting back to the thematic sectors explored in the case study and presented in detail in the results chapter of this paper, it is probable that the circular development in the urban planning and construction and building sectors of Turku will continue. The urban planning sector is considering and realizing the application circular solutions beneficial to existing infrastructure. The national building guidelines and legislation are under a development to support circularity through which the principles have potential to mainstream. Building more sustainable residential areas with integrated sharing services ties social factors closely of CE and entails the potential to create more equitable living environments. Additionally, with the sector affecting significantly in the product and process development of large building contractors, it is probable that the circular principles will expand wider through their operations, as the power players of the industry engage in new technologies and operational models. However, these sectors are extensive, cost-driven and the projects are both time consuming and the results affect throughout the decades to come. It is not evident from this research, that the circular or environmentally sustainable development would currently be a priority for the majority of the operators of the field. This research shows that the early stage initiatives and a certain level of commitment exist, but that does not yet provide a reasonable estimation of the pace of advancement. Reflecting this to the coming decade, if the development towards circular solutions is heavily invested in, the progress may be significant. However, if the field acts

conservatively and does not actively seek for novel solutions, a decade is a short period and the curve of development may substantially shallower.

In relation to the governance of the city and especially the public procurement, it is probable the development of environmentally beneficial criteria and impact assessment will be advanced in Turku within the coming years. The advancements are not in the sole influence of the single municipalities, but this development appears to be priority for many large global networks like ICLEI which enables systemic co-operation between cities. This development is similarly subject to temporal pressures and it is probable that a development of impactful criteria will take years. Simultaneously with the wider national and international development it is taking part of, Turku is advancing its own processes of procurement and investments to consider circularity more efficiently.

The circular future of the private sector that is reflected in this study through industrial symbiosis forms an interesting future development domain to observe. As I was not able to comprehensively interview the representatives of businesses during this research, I am not in the position to directly assess that development potential. However, the profitability of pilot initiatives will determine the progress of the private sector circular transition. The recycling of waste demands a development of market for the recycled materials in order to grow further. Businesses require enough volume, stable quality and security of supply from the materials they purchase in their production, as stated by a circular business specialist. Systemic encounter of these demands will probably be one key factor towards circular transition. If a large company decides to take circularity as its priority, if will practically enforce its whole network of suppliers to follow the development, causing a similar cause-effect-chain that can be realized in the public procurement, since the volumes incorporate power of changing organizational behaviors.

The systemic approach of Turku region towards water-food-energy nexus is probably the most active example of this study and shows a strong probability of circular advancements in the coming decade. In terms of food this is especially visible in the academic research that continues to develop circular approach to the food chain. There are small companies and start-ups that are actively bringing new circular solutions to the market, which indicate the development will continue. Strongest actors of the field are the large food producers, that are currently producing food with extremely low profit margins and investing scarcely on product development, which was identified by one of the interviewees to delay the systemic process. Water related circular development of the region is strong. Especially the Baltic Sea water quality challenges and the impact of fertilizers used in agriculture are actively addressed by the research institutions and global co-operation networks. The circular development in energy systems appears to continue, since the major investments have been made and the new systems with collection of energy from renewable sources actually appear to improve the profitability of the energy sector.

The determining factor with regards to the future realization of the circular transition in the city of Turku are the collective actions taken in the coming years. Whether the initial advocators and practitioners will succeed to scale up the level of circularity by proving the profitability and impact of CE will probably be determined more in detail during the first years of the 2020s.

5.3.2 Future of urban circular transition worldwide

The results of this empirical case study cannot be drawn to directly answer to the question of the wider potential of global urban circular transition. However, there are some notions that can be drawn from the research material.

Reflecting the current situation to the wave- theory presented in chapter 2.3.2. it seems obvious that the sixth wave needs to be a system correcting and stabilizing era, where the environmental system exploitation of the fifth wave is turned towards more balanced interplay between humanity and environment. It is to be expected, that the urban areas worldwide will during the next decade face the constantly intensifying effects of the megatrends of population growth, urbanization and climate change, each product of the fifth wave developed countries lifestyles. The combined effects inflict both growing demands and decreasing supply of resources in terms of the basic livelihood needs of fresh water, food and energy.

Contrary to Turku, several large urban areas worldwide are in a demanding or catastrophic situation with regards to their infrastructural systems of water, food and energy, that are essential in ensuring the livability of their areas and security of their residents. In most of these metropolitan areas, per capita consumption of the basic infrastructural services is much smaller than in Finland on average, but the population size in comparison to available resources is multifold to that in the Nordic countries. In some urban areas it is not a question of profitability of the circularity in comparison to linear model, but a more efficient division and recovery of the scarce resources altogether.

Paradigm of growth, which has been criticized to have left unquestioned in CE discourse, is one of the determining factors of the development. The population growth combined with GDP growth of the developing countries increases the demand for resources, simultaneously as the scarcity of them is expected to deepen. The promises of CE with regards to economic decoupling of resource use and growth are tempting, since economic growth is often considered as the synonym of increased wellbeing, an objective that is seldom compromised. Simultaneously, the resource usage and wellbeing are extremely unevenly distributed, some using multifold the actual need whereas some are left with less than required. Following this logic of inequality, the development of urban resource

efficiency in the form circularity seems to be a necessity of survival for some urban areas whereas for others it is a way to decrease the environmental footprint.

As the population growth and urbanization are still increasing, the solutions for the resource scarcity need to be found through the more efficient use of resources, which is why the demand for developing circular solutions has intensified in urban areas. ICLEI, the worldwide network advocating sustainability, is advancing circularity through its Green Circular Cities Coalition, which was nominated in August 2019. Their mode of operation is to inflict co-operation between cities and governments to create and disseminate circular practices. However, each city is a unique system with its own subsystems, which indicates all the solutions will be locally adjusted to meet the requirements and preconditions of the given system.

Whether the circular transition will realize, and the paradigm change from linear to circular come true, will in the developed countries be mostly determined by the results and profitability of the ongoing circular actions and the availability and access to virgin resources. If the results are encouraging, a growing number of innovators will seek to develop the reuse loop of resources, especially if there exists a lack or other barrier to use virgin resources. If primary raw material resources continue to be available with competitive pricing, it will most probably hinder the escalation of CE and thus weaken the circular transition. A critical factor determining the transition is also the development of personal attitudes towards more sustainable consumption and the increase in responsibility experienced towards the environment. Most of the urban areas of developed countries are in the position, where the next decade can probably be carried out with the current lifestyle without critical constraints to the supply of vital resources.

In the urban areas of developing countries however, the determining factor of circular development will more probably be the initial access to resources and the successful ways to recover and share them. Many of the given urban areas are in the situation, where the success of circularity will determine the livability of the areas. In the poorest urban areas, the question it is not even about the wellbeing, but the survival. For these urban areas especially, the developed circular technologies like water purification, hydrophonics food production and raw material recovery from waste will probably be essential in improving the quality of life.

The contradictions and challenging nature of the sixth wave are evident in the large cities worldwide. In the current economical paradigm, the emergence and spreading of new technologies is mostly a result of profitability, not conditions that force masses of people to poverty and shortage of basic resources. Whether the circular economy and developing technologies will find the required solutions for increased wellbeing for the growing demands of the growing population is a focal theme for the sixth wave. Currently, as there still exists a high level of denialism of the anticipated effects of the climate change and indifference towards deteriorating environment as the heritage of the fifth

wave expectations, the objective seems ambitious. Simultaneously however, the development towards increased understanding and willingness to change lifestyles and systems seems to proceed, which contributes to the circular transition.

6 CONCLUSIONS

6.1 Significance, limitations and generalizability of the study

According to literature review, CE is an emerging concept that is insufficiently detailed and assessed regarding its impact. Simultaneously it is a phenomenon gaining ground as the solution for humankind to survive the climate change, resource scarcity and biodiversity loss related challenges. This study confirms, that from the academic perspective, this to be true. However, the practitioner context revealed an image of constant advancement and ambition. Applications of CE are actively being developed and the practical knowledge is rapidly expanding.

These practical advancements contribute not only to the systemic circular change but also provide material for researchers to assess. By now, urban applications of CE researched are often detached examples of certain circular activities and it is challenging to form a wider image of a circular development phase of a given urban region through them. This study was aimed at drawing a comprehensive and systemic image of the current state of the circular transition of in the City of Turku, which among the existing academic papers today is somewhat rare.

There are some limitations to this study with regards to systemic thinking. The first actualizes through the ICLEI 6 sector framework, which does not lay equal amounts of attention to all functions in the urban domain. It concentrates heavily on more technical aspects and infrastructure of the urban environment and neglects the services provided to citizens. Additionally, a major industry of tourism was completely excluded. This study concentrates on the public sector with the cost of private sector. Therefore, this study cannot be claimed to draw a picture of the whole circular ecosystem, but some, albeit essential parts of it.

An inherent aspect of case study method is the possibility for using it to generalize theory of generalize study results to concern a wider context. I am examining it with regards to possibility of generalizing the results to be applied in other urban areas. In literature review chapter 2.2.4, it is acknowledged that each urban system is unique, and it is thus not possible to directly reproduce a successful circular initiative in another urban area with its own set of local preconditions. As Turku is only one city, I would be cautious in generalizing the results to other urban contexts. If, however, a similar research of the circular state would be conducted in other cities, the combined results could be used as drawing a circular urban ecosystem or they could be used in the work to advance the urban nexus model.

6.2 Theoretical contributions and research suggestions

In considering the planetary system domain, the debated and developed Kondratieff wave theory seems to give a comprehensive, if simplified, explanation how the system has developed to the stage were we now find it. The phases of rapid growth provide the process of the development of current megatrends of population and consumption growth, climate change and urbanization as well as make their effects faced at present understandable. In terms of theory it has been evident for decades that a transition towards more environmentally sustainable system needs to be realized. This research presents an urban area attempt towards it and reveals opportunities, practical obstacles and barriers of transforming the system. In light of the theory and practice, it is obvious that the future systems need to be developed towards resource efficiency. Whether it is called circular economy, it is evident that the elements of circularity need to be put into practice and scaled up in order to stabilize the planetary development.

With regards to the theoretical framework used in the study, the Urban nexus, the research supported its applicability as a tool for drawing the essential actors, their interconnections and systemic features of their action in a given urban area. It seems that Urban nexus as a framework can prove beneficial in a process where an urban area attempts to construct an understanding of their systemic state of circularity. The two aspects I chose for the systemic framework, Urban nexus elements, actors and strategies and practical application modes and areas of the Urban nexus provided a comprehensive base of evaluation of the system that was drawn in the empirical case study. However, for the usability and simplicity of application, I suggest the aspects to be combined in one model considering the complete system. On my view this will especially benefit the practitioners of CE and urban areas interested in mapping and evaluating their CE system.

The proposed urban circular transition management plan combines the Urban nexus elements, actors and strategies to the practical application modes and areas in order to enable the understanding of the process. In the model, the global system is considered through the systemic lens applied to understanding the constant change assessed through identifying megatrends, risks and security and geopolitical factors. Respect for the environment, striving towards increased sustainability, understanding the limitations of resource flows and economical and financial systems are focal global incentives contributing towards (urban) circular transition.

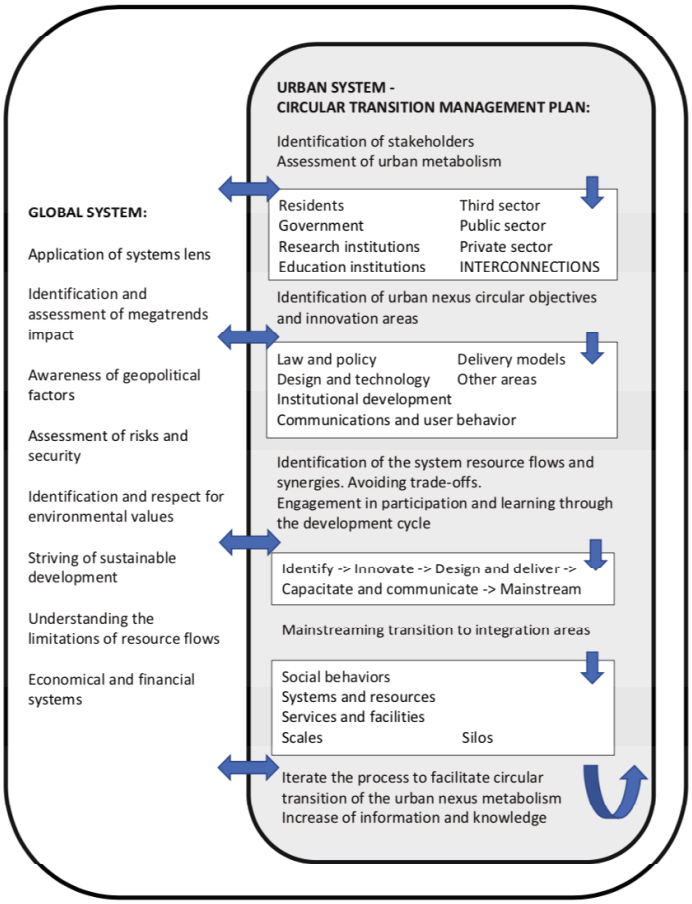

Figure 9 Urban system circular transition management plan. Applied from Urban nexus elements, actors and strategies (Hezri 2016, 25) and Urban nexus practical application modes and areas (GIZ & ICLEI 2014, 28)

As part of the global system, there exists numerous urban metabolisms that are considered individual sub-systems and thus the domain for circular transition. The urban circular transition management plan is aimed to be executed in this sub system level. The plan begins with identification of local system stakeholders and assessment of the urban metabolism, that is formed through the interconnections between stakeholders. The stakeholders will participate in identification of urban nexus circular objectives and relevant innovation areas where transition towards circularity can be initiated. Urban nexus practical application areas model (GIZ & ICLEI 2014, 28)) identified for example law and policy, design and technology, delivery models, institutional development and communications and user behavior as potential innovation areas. Other areas can be identified locally.

Considering the identified stakeholders and innovation areas, it is relevant to identify and assess the system resource flows and potential synergies inherent in them. Additionally, identification of potential system traps such as trade-offs is relevant at this stage. The model proceeds to stakeholder engagement in participation and learning within the

innovation areas through the development cycle of circularity that begins with identification and proceeds through innovating, design and delivery- stages to capacitation, communication and finally to mainstreaming the circular solutions. Mainstreaming the transition occurs through circularity integration areas, which GIZ and ICLEI (2014, 28) identified to consist of social behaviors, systems and resources, services and facilities, scales and silos. The circular transition process is based on solutions, of which each have different levels of impact to the transition. The process itself is iterative and it alters the paradigm gradually. All successfully mainstreamed solutions contain information and knowledge that can be taken back to the stakeholders in order to initiate new circular solutions.

After conducting this study, I do have to agree with the researchers who claim CE to be a contested concept still in its infancy. CE calls for wide variety of research from all possible perspectives, both academic and practical. However, a strong demand for more detailed definition for CE appears to mainly be in the interest of academia, since the practitioners of CE seem to be perfectly content with a broad and inclusive idea of circularity. Most of the practitioners understand circularity as a principle which aims in increasing the resource efficiency and decreasing the amount of waste that cannot be reused. This seemingly simple principle allows them to innovate solutions for improving the current situation. Whereas there does not exist a strong demand for CE definition among practitioners, they strongly align with researchers in the theme of impact measurement systems and ways to assess the quality of developed CE solutions. The demand for more accurate means to assess impact of individual circular solutions and circularity in general were strongly observable in the study. This also objects the concerns of broad CE definitions undermining the potential impact of the paradigm, since the desire for accurate measurement systems indicates the practitioner inclination to substantial outcomes.

The study confirms the role of support and collaboration from the part of governance as a significant factor in advancing circularity. In the study practically all the circular initiatives found were linked to the operations of municipality in some way. This is naturally due to the domains explored, since they were mostly based on urban infrastructure, notion which does not neglect the focal role of the government. In the literature review, many of the enablers and barriers were, in fact, directly or partly related to the local governance, which was a strong undercurrent in the entire study. The public sector was strongly positioned in a role of a focal actor to assemble other actors to co-operate in order to solve collective issues. Developing the systemic picture from this, the study revealed the essentiality of circular action integration between organizations and systems. Many of the circular solutions revealed in the study were also local infrastructures, role of which was emphasized in theory. Concerning CE in urban context it would be especially interesting and beneficial to research the participation and impact of citizens on circular transition. Their role if often described through “change in consumer behavior”

but this study implicated it is much more complex and contains potential for impact. Deriving from this, the relationship of circular economy and social issues would be an interesting research domain and also shed light to the question whether social impact should be included in the CE definition.

The ideal of CE appears as a perfect loop of resources, where the waste of one is always raw material for someone else. The academic research is skeptical towards this ideal and the evidence of this study does not strongly support that either. Whether it is necessary to even achieve perfect 0-waste loop is debatable. Circular economy may well prove its utility of increasing the efficiency in materials usage and decreasing the formulation of waste in relation to linear economy model even without the loops will not reach perfection. An interesting and valuable database for practitioners and researchers alike could be formed by mapping urban ecosystem CE processes in detail. This would enable the evaluation of them not only through their successes but also through the solved and unsolved challenges. The database could be essentially valuable base of information for other urban areas to utilize in their circular transition process. According to this study, the detailed information of the development phases appears to be scattered in the minds of the practitioners and probably exists in the official but confidential documentation of various ventures among other projects related information.

The industrial domain of CE would benefit from research about practical approaches businesses have taken and networks they have formed in the field of CE. Unfortunately, this may be difficult due to corporations considering their production related details confidential. However, further investigation about the private sector CE might reveal more companies engaged in circularity and simultaneously bring about wider networks. This is due to the fact, that a single actor is usually incapable of practicing CE alone, but there is always a network or collaborating actors involved.

6.3 Practical contributions and suggestions

Through conducting this study, I was able to draw an image of the system of circular transition in urban context and explore it through existing research and theory. The most essential practical contribution of the study was the understanding of the local system of circularity it was able to convey to the principal of the assignment, the officials of the city of Turku. The study also contributes to the international co-operation of Turku with ICLEI and the work of regional resource wisdom roadmap in Finland Proper, which is currently being initiated.

In the practical setting, a key finding was the variety of ways CE can be defined and actualized and how many various approaches there exits in the practical domain.

Concerns have been expressed in the literature, that a definition too broad would undermine the concept and make it obsolete in the way its predecessors did. However, in the practical domain, the content and the goals seem to matter more than the name of the concept. The process of development of circular solutions was also highly interesting and complex. Circular initiatives of existing actors often begin with a partial solution to an identified challenge in their own process, potentially developing through testing and suitable partners to a more complete circle. Some circular initiatives are developed to solve an existing demand. With relevant resources, it is possible to enable the development of them rapidly and the result may be a more perfect circle early in the process.

Next major challenge of the circular transition appears to be the justification of its principles and whether the ambitious promises given by CE advocators can be realized. Another significant issue in advancing the paradigm is to participate citizens and private sector in constantly growing numbers to innovate, initiate and prove the promises given are sound. Involvement and innovation are interlinked. Successful innovations and practical cases attract more stakeholders who can form novel solutions. This action enhances the system, which alters through the practice.

Although there exists a clear functioning circular system in the urban area of Turku, systemic aspects were rarely mentioned during the interviews. It seems that many actors realize the existence of the system, but it is not clear to most of them, how the parts of the wider system interrelate and interact. Direct causes and effects of single actions are relatively well understood, but the advancement of circular transition would benefit significantly of a more thorough systemic understanding. Furthermore, as one of the Urban nexus elements is to explore and identify risks and elevate the level of security of urban area, it would be especially beneficial for a city or Turku to engage in thorough systemic exploration and assess its systems and their potential to interconnect and form new synergies.

Even with the Climate Plan 2029 existing since June 2018, many actors do not feel they have a concrete set of goals or operational instructions, which can be understood because we are dealing with a constantly evolving phenomenon with dynamic development phase. Still, ambiguity in goals and instructions may lead to inefficient or scattered response, which potentially weakens the motivation of participation and thus results. An idea expressed during the interviews was to create a circular industrial vision for Turku to support the City vision. I would go a step further and recommend the actors of the city of Turku to construct alternative scenarios and exploring concrete steps of action through them prior to drawing a vision.

When it comes to financial resources and the claimed lack of them, it is vital to realize, that a public operator such as municipality does actually have existing or annually given resources. The dilemma is in the division of them. The general atmosphere appears to be that good grounded ideas to improve sustainability in operations will probably get

attention, provided they are not radically more expensive than the current way of running operations. One interviewee emphasized optimization, essentially considering which are the domains where sustainability could be improved the most with the smallest amount of resources. This calls for innovative approaches and naturally it is important not to fall in sub-optimization, a systemic trap where improvement of one domain deters another.

With private sector, it is beneficial for the city to continue the work of participating and supporting businesses to create circular solutions. Turku University of Applied Science is significantly active in co-operation with businesses and University of Turku and Åbo Akademi also co-operate with especially larger corporations. However, with the 22000 businesses, the more support and initiatives can be given, the faster the transition has potential to proceed. According to the interviewees, Turku has a real opportunity to be strong in CE advancement. The dedication of the municipality to participate in advancing the cause is acknowledged widely and visible in their actions.

The next action Turku has committed on, partly based on this research, is the formulation of new Resource wisdom roadmap for the region. It aims to guide the practical advancement of resource wisdom and circular economy initiatives and ensure the attainment of Climate plan 2029 goals. In order to achieve concrete steps towards circular transition, the roadmap will benefit from drawing concrete goals and action plans for various sectors as well as participating the focal actors of the fields in the process. Especial importance should be invested in the leadership of change process within the local system in order to ensure the change is significant, influential and that the stakeholders understand not only the goals but their own role and its potential.

Circular transition will form though various pathways; novel more resource efficient systems replacing the existing ones, ecological reconstruction of existing systems and change in individual consumption choices. It seems yet optimistic, that a transition to a circular system would be completed by 2029, but realistic that a significant shift towards it has taken place if the local stakeholders; residents, businesses, public sector, research community and municipality have systematically joint their efforts.

The planning and action should base on critical understanding of the scarcity of time – the circular transition needs to be initiated and scaled up urgently, since the existing linear economy continues to destroy the preconditions of the planetary livability until more resource efficient systems have been built and take over.

SUMMARY

Circular economy is considered as one of the key tools for more sustainable resource consumption and circulation to mitigate the challenges of climate change and resource depletion. Although the concept is still emerging and the lack of research has been admitted, sustainability advocators promote it heavily and new practitioners are constantly joining the cause. The development of the paradigm is primarily conducted by practitioners on various domains, of which urban ecosystems may prove to be one of the most influential ones. The case study presented in this paper explores the urban circular transition in the city of Turku, Finland. It maps the current situation and explores the enablers of circular economy in detail. The results of the study are assessed through the Urban nexus systemic model to further intensify the understanding of interrelations of the circular transition. The discussion and conclusions draw a picture of city that has ambitious climate related goals, intensive government and public sector involvement and promising results of circular initiatives. Similarly, it reveals challenges in resourcing and scaling up the action that need to be overcome during the next decade to enable circular transition. A model for urban system circular transition management plan is proposed as a result of the study.

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APPENDIX 1 CASE STUDY RESEARCH DATABASE

Interviews:

Aaltonen, Stella (2018) Project manager, City or Turku Interview 5.12.2018.

Erälinna, Leena (2019) Project manager, University of Turku. Interview 10.1.2019.

Fröberg-Niemi, Linda (2018) Manager, Turku Science Park Oy. Interview 9.11.2018.

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