Dissertationes Forestales 362

Business ecosystems for urban sustainability: retrofits, wood construction, and nature-based solutions in Finland

Anne Viljanen

Department of Forest Sciences

Faculty of Agriculture and Forestry

University of Helsinki

Academic dissertation

To be presented, with the permission of the Faculty of Agriculture and Forestry of the University of Helsinki, for public examination in Biocentre 2, hall 2041 Viikinkaari 5, 00790 Helsinki, on the 11th of April 2025 at 12:00 noon.

Title of dissertation: Business ecosystems for urban sustainability: retrofits, wood construction, and nature-based solutions in Finland
Author: Anne Viljanen

Dissertationes Forestales 362
https://doi.org/10.14214/df.362

Thesis Supervisors:
Professor Anne Toppinen
Department of Forest Sciences, University of Helsinki, Finland

Docent Mikko Kurttila
Natural Resources Institute Finland (Luke), Joensuu, Finland

PhD Hanna-Liisa Kangas
Finnish Environment Institute (Syke), Finland

Pre-examiners:
Associate Professor Johan Holström
Department of Management and Engineering, Linköping University, Linköping, Sweden

Professor Kes McCormick
Department of People and Society, Swedish University of Agricultural Sciences, Lund, Sweden

Opponent:
Professor Lars Stehn
Department of Civil, Environmental and Natural Resources Engineering, Luleå University, Luleå, Sweden

ISSN 1795-7389 (online)
ISBN 978-951-651-814-8 (pdf)

Publishers:
Finnish Society of Forest Science
Faculty of Agriculture and Forestry of the University of Helsinki
School of Forest Sciences of the University of Eastern Finland

Editorial Office:
Finnish Society of Forest Science
Viikinkaari 6, 00790 Helsinki, Finland
https://www.dissertationesforestales.fi

Viljanen A. (2025). Business ecosystems for urban sustainability: retrofits, wood construction, and nature-based solutions in Finland. Dissertationes Forestales 362. 58 p. https://doi.org/10.14214/df.362

ABSTRACT

Combatting environmental problems, such as climate change, biodiversity loss, and the overconsumption of natural resources, requires the dual strategies of mitigation and adaptation to enhance resilience. There is a need for new sustainable solutions targeting the markets. Wood material-based construction retrofits offer new possibilities but are currently rare in the urban context. Along with new wooden multistory construction, wooden retrofits and novel nature-based solutions are being introduced to urban building stock. These solutions bring synergies with better resource efficiency, circular economy, and resilience to environmental risks. Theoretically, this dissertation draws from literature ranging from business and innovation ecosystems, policy instruments, dynamic capabilities, and co-creation of solutions toward a more resilient urban environment. Following, it explores the visions, roles, and actions of frontrunner businesses and municipal decision-makers through the lens of building and retrofit projects in Finnish case cities. The constellation of local ecosystems began materializing through the empirical datasets of 51 qualitative interviews, data from 8 workshops, and other supporting materials. Results show that wooden multistory construction and wooden retrofits could be catalyzed by both policy instruments and better collaboration in business ecosystems (BEs) and that the policy instruments have been more effective when they include characteristics of the building projects. However, the municipalities could take on even more active collaborative roles and a common pool of challenges exists, which calls for greater resident support. To turn the identified strategic aims, vision, and resident needs into actionable initiatives, cities face three key challenges: the lacking inter-organizational division of labor and cooperation, limited interaction channels, and the unidentified ownership of responsibilities during the change processes. In local ecosystems of wooden retrofit projects builders and their customers are key actors. Motivations for retrofit projects are driven by urban densification strategies, by improving the attractiveness of suburban neighborhoods, and by more efficient space utilization. Results further elaborate a certain degree of difficulty in project-level, early-stage decision-making. To aid the strategic thinking in the realms of preparedness, the urban transition pathways of were fashioned up to 2050 regarding nature-based solutions. Overall, mainstreaming nature-based solutions and the wood construction and retrofit projects calls for expanding the knowledge base of innovation ecosystem actors via experiments and co-creative activities.

Keywords: business ecosystem, innovation ecosystem, retrofits, wood construction, nature-based solutions, sustainable urban environments

Viljanen A. (2025). Business ecosystems for urban sustainability: retrofits, wood construction, and nature-based solutions in Finland. Dissertationes Forestales 362. 58 p. https://doi.org/10.14214/df.362

TIIVISTELMÄ

Ilmastonmuutos, luonnon monimuotoisuuden väheneminen ja luonnonvarojen ylikulutus ovat aikamme suuria ympäristöongelmia. Nämä edellyttävät kahdensuuntaisia strategioita, joissa sekä torjutaan näitä muutoksia että sopeudutaan niihin. Uusille kestäville markkinaratkaisuille on tarvetta. Uudenlainen puupohjainen korjausrakentaminen on harvinaista kaupunkiympäristöissä, mutta siihen liittyy uudenlaisia mahdollisuuksia. Puisen kerrostalorakentamisen rinnalle onkin syntynyt uusia ratkaisuja kaupunkien rakennuskantaan, kuten vanhojen kerrostalojen korjaamista puulla ja luontopohjaisia ratkaisuja. Näillä ratkaisuilla on synergioita resurssitehokkuuteen, kiertotalouteen ja ympäristöriskeihin sopeutumiseen. Näiden osalta tarvitaan systeemisiä innovaatioita ja uudenlaista yhteistyötä toimijoiden välille liiketoiminta- ja innovaatioekosysteemeissä. Tämän väitöskirjan ydinkirjallisuus pohjautuu liiketoiminta- ja innovaatioekosysteemeihin, poliittisiin ohjauskeinoihin, dynaamisiin kyvykkyyksiin ja yhdessä kehittämiseen kestävyysmurroksessa kohti sopeutuvampia kaupunkiympäristöjä. Väitöskirjassa tutkitaan edelläkävijäyritysten ja kuntapäättäjien visioita, rooleja ja toimia käytännön uudis- ja korjausrakentamisen projektien kautta suomalaisissa tapauskaupungeissa. Kaupunkialustaiset ekosysteemit alkoivat hahmottua empiiristen aineistojen avulla, jotka sisälsivät 51 laadullista haastattelua, 8 työpajaa ja muuta lisätietoa antavaa aineistoa. Tuloksien perusteella puista kerrostalorakentamista ja puista korjausrakentamista voisi katalysoida poliittisin ohjauskeinoin ja yhteistyöllä liiketoimintaekosysteemeissä. Lisäksi poliittiset ohjauskeinot ovat vaikuttavampia, kun ne huomioivat rakennusprojektien erityispiirteet. Kunnat voisivat aktiivisesti edistää yhteistyötä toimijoiden välillä paikallisissa liiketoimintaekosysteemeissä. Kunnilla on kuitenkin paljon yhteisiä haasteita ja tarve kansalaisten tuelle. Päähaasteena ovat tiedonkulkua estävät siilot, rajoittuneet kanavat yhteistyölle ja muutosprosessissa epäselvyydet vastuunjakautumisesta kunkin toimijan omalle alueelle. Puisessa korjausrakentamisessa päätoimijoita ovat rakentajat ja asiakkaat. Korjausrakentamisen hankkeita motivoivat kaupunkien tiivistämisen tavoitteet, lähiöiden viihtyisyyden kasvattaminen ja tilankäytön tehokkuuden lisääminen. Tuloksissa on nähtävissä tiettyä vaikeutta projektitason varhaisessa päätöksenteossa. Strategisen ajattelun ja ennakoinnin tueksi kehitettiin kestävyysmurroksen polkuja vuoteen 2050 saakka luontopohjaisten ratkaisujen osalta. Uusien puupohjaisten ja luontopohjaisten ratkaisujen yleistymiseksi tietopohjaa on laajalti lisättävä eri innovaatioekosysteemin toimijoiden parissa kokeilujen ja yhteiskehittämisen avulla.

Asiasanat: liiketoimintaekosysteemi, innovaatioekosysteemi, korjausrakentaminen, puurakentaminen, luontopohjaiset ratkaisut, kestävät kaupunkiympäristöt

ACKNOWLEDGEMENTS

Prior to actual dissertation, I would like to take this opportunity to thank many people, who's assistance and collaboration was golden throughout this dissertation process. First and foremost, I would like to express my deepest gratitude and appreciation to my main supervisor, prof. Anne Toppinen. She has been an inspirational, kind, and thoughtful mentor, a guiding force for the dissertation and inspired research collaborator. It has been a fascinating PHD journey together, us two Anne's. You have helped me every step of the way and have not only shaped a lot of the PHD to its current form, but you have also impacted tremendously on my scientific thinking, for all of this my most heartfelt thank you Anne! Secondly, to my supervisor Mikko Kurttila, I would like to say that I really appreciate your dedication to this dissertation supervision. Even at the time you were on work leave, you worked on our shared article "as a hobby". This says a lot of your work ethics and dedication to junior researchers. Thirdly, to my supervisor Hanna-Liisa Kangas, I express appreciation for your advice concerning my PHD summarizing report and all the information you shared on the overall PHD experiences collected among SYKE researchers.

Thank you also to all of the co-authors of my PHD articles. In addition to Anne Toppinen and Mikko Kurttila, I sincerely thank Katja Lähtinen, Vesa Kanninen, Eliisa Kylkilahti, Charlotta Harju and Janina Harmanen. We have had good collaboration and interesting scientific discussions among us, and I'm extremely happy about the ways these PHD articles turned out in the end. Moreover, I want to also thank others who in one point or another contributed in to the scientific discussions around my PHD in the DecarbonHome -project and in some cases also in the FoREfront -project: Atte Koskivaara, Liina Häyrinen, Juhani Marttila, Jouni Räihä, Kaarina Kaminen, Enni Ruokamo, Anna Strandell, David Lazarevic†, Jani Lukkarinen, Santtu Karhinen, Kaisa Korhonen, Sampo Vesanen, Erkki-Jussi Nylén, Sara-Ellen Laitinen, Joni Vainikka, Pia Bäcklund, Md. Rayhanur Rahman, Eveliina Salmela, Liisa Kääntä, Merja Koskela, Hanna Ahtosalo, Henna Syrjälä, Jarek Kurnitski, Alo Mikola, Joonas Lindfors, Uula Saastamoinen and Niina Pykäläinen. Many of you also participated in the data collection, especially for organizing the municipality workshop co-creation process, you know who you are, I thank you all, this research was definitely a collaborative process. I would like to thank the Strategic Research Council of the Academy of Finland for funding my research under the DecarbonHome and Business Finland for funding my research under the FoREfront -project. I also thank all the stakeholders of the two projects for your valuable assistance and insights on the researched topics.

I would like to thank my PHD steering committee, comprising of Pekka Jokinen, Jarmo Vehmas and Lauri Hetemäki. You were extremely positive and supportive throughout the years, thank you! A lot of my thinking on futures studies and environmental policy has been originally shaped by you three. Also, there are many colleagues in the University of Helsinki's Forest Department and especially our own FBBS research group who have created a positive working environment and have given a lot of food for thoughts along the way, my heartfelt thanks to you all! From the FBBS group, I would especially like to thank Angelina Korsunova-Tsaruk who guided me in to teaching bachelor students and who's expertise on circular economy I really value.

I would like to thank my dissertation pre-examiners Kes McCormick and Johan Holström for the very positive feedback in your evaluations of this dissertation in your pre-examination reports, you really made me happy. I'm extremely pleased that the topic of the study is recognized to be both timely and significant internationally. I would already now like to thank

my opponent to be, Professor Lars Stehn, for taking the time to come all the way from Sweden to Finland and showing interest in our research at the University of Helsinki's Forest Department. I can see this to lead into fruitful collaborations between the University of Helsinki and the three Swedish Universities.

Finally, I want to thank my own friends and family for the all the love and support also during these PHD years. Special thank you goes to my husband Tero Viljanen for all the encouragement and I wish you best of luck with your own PHD journey. Thank you to my now 10-years old son Aku Viljanen for listening and being interested in my research, you may become a researcher someday yet. Thank you to my sweet now 6-years old daughter Pihla Viljanen for all the love (as for the whole family). My daughter once asked me what I wanted to become, and as I replied, "a researcher", my husband continued "mommy already is a researcher". Sometimes it is good to appreciate what you already have. How lucky to have all of your support and to my family: I love you!

At Tampere home office,

6th of March 2025

Anne Viljanen

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on four articles. The articles are reprinted with the permission of the publishers. The articles are referred to in the text by their roman numerals.

I **Viljanen, A.,** Lähtinen, K., Kanninen, V., Toppinen, A. (2023). A tale of five cities: The role of municipalities in the market diffusion of wooden residential multistory construction and retrofits. Forest Policy and Economics 153, article id 102991. https://doi.org/10.1016/j.forpol.2023.102991

II **Viljanen A.,** Kurttila M., Toppinen A. (2024). Retrofitting urban areas with wood: the origin of new projects in an emerging business ecosystem. Silva Fennica 58(4), article id 23068. https://doi.org/10.14214/sf.23068

III Kylkilahti, E., **Viljanen, A.**, Toppinen, A. (2024). Taking the initiative, driving social innovation? – Cities co-creating services to support low-carbon housing and retrofits. Manuscript.

IV **Viljanen, A.,** Harju, C., Harmanen, J., Lähtinen, K., Toppinen, A. (2024). Toward resilient urban environments: transition pathways in nature-based solutions. Manuscript.

Author contributions in the co-authored articles

	I	II	III	IV
Conception and design	AV, VK, KL, AT	AV, MK, AT	EK, AV, AT	AV, CH, KL, AT
Planning	AV, VK, KL, AT	AV, MK, AT	EK, AV, AT	AV, CH, KL, AT
Data collection	AV	AV	EK, AV, AT	AV, JH
Data analysis and interpretation	AV, VK, KL, AT	AV, MK, AT	EK, AV, AT	AV, CH, KL, AT
Writing the article	AV, VK, KL, AT	AV, MK, AT	EK, AV, AT	AV, CH, KL, AT
Editing and reviewing	AV, VK, KL, AT	AV, MK, AT	EK, AV, AT	AV, CH, KL, AT
Overall responsibility	AV	AV	EK	AV

AV = Anne Viljanen, AT = Anne Toppinen, KL = Katja Lähtinen, VK = Vesa Kanninen, MK = Mikko Kurttila, EK = Eliisa Kylkilahti, CH = Charlotta Harju, JH = Janina Harmanen

GLOSSARY

BE	**Business ecosystem** is a concept that has been developed in the 1990s and onwards to portray interdependence, cooperation, competition, and coevolution embedded in contemporary business activities. In addition to value creation, the concept can provide insights on value capture (profit-making).
CLT	**Cross Laminated Timber**
CO_2	**Carbon dioxide**
DC	**Dynamic capabilities** are a conceptual approach to strategic management. In it companies' dynamic capabilities are distinguished from ordinary capabilities. Three main forms of dynamic capabilities are sensing, seizing and transforming.
GHG	**Greenhouse Gas**
IE	**Innovation ecosystem** is either a conceptual branch of business ecosystem or an all-encompassing conceptual frame for other ecosystem concepts (including the business ecosystem concept) depending on various scientific viewpoints. At the core of this concept is value creation through knowledge sharing, resulting in innovation.
NBS	**Nature-based solutions** are innovations, such as blue-green roofs or facades, that draw inspiration from nature and/or use nature to provide ecosystem services. They can be used to integrate biodiversity components into built environments.
WMC	**Wooden multistory construction** is a building higher than two stories. It has been built using significant levels of wood and modern industrialized housing techniques, such as posts and beams, mass timber, and modular timber construction. For example, cross-laminated timber, laminated veneer lumber, and glulam have been used with these engineered products.

CONTENTS

INTRODUCTION

The world is in turmoil and is faced with massive and interlinked environmental problems. According to Rockström et al. (2009), as early as 2009 humanity had transgressed outside of the safe operating space with respect to three out of nine planetary boundaries, including biodiversity loss and climate change. Since then, these challenges have continued to worsen, as six out of the nine planetary boundaries were considered to be beyond the safe operating space in 2023 (Richardson et al. 2023). Humankind is continuously over-consuming global natural resources, which will lead to future declines in economic growth (Lampert 2019). To respond to environmental problems with innovative solutions, a wide range of actors and activities are required to engage in creative problem-solving processes (Ansell and Torfing 2021).

The call for urban resilience has become stronger in the face of growing environmental problems and diminishing natural resources (Ribeiro and Gonçalves 2019; Wardekker et al. 2020). Resilience can be defined as a system's ability to recover (Logan et al. 2022), and urban resilience designates the way an urban system can absorb disturbances while maintaining the benefits and ecosystem services of the urban fabric (Langemeyer et al. 2021). Scientists have warned us of negative climate tipping points that, if met, could spiral average global temperatures to devastating degrees (Lenton et al. 2019). However, lately, there is growing scientific discussion concerning positive tipping points for global sustainability, which could catalyze positive sustainability change and could emerge from socio-economic spheres of agency, policymaking, business, sustainable innovations, and information guidance (Lenton et al. 2022; Mey and Liliestam 2022). Therefore, as a response to altering this dire course of ever-deepening environmental problems, scientists are bringing forth e.g., the need for research regarding systemic change and complexity (Köhler et al. 2019), the formation and management of ecosystems around a focal systemic innovation (Foss et al. 2023), taking on new research of sustainability transition combined with business models (Köhler et al. 2019), and promoting socially equitable climate-wise housing and solutions (Kanninen et al. 2024). Thus, the problems and suggested solutions are complex, and therefore the actors producing the solutions are also part of complex actor networks, which in this dissertation are referred to as business ecosystems (BE) (Moore 1993) or innovation ecosystems (IE) (de Vasconcelos Gomes et al. 2018).

Cities can be seen as platforms of collaborative ecosystems, linking various actors, such as businesses, citizens, educational institutions, and government to create city-based innovation (Rajakallio et al. 2018; Appio et al. 2019; Mukhtar-Landgren et al. 2019). Globally, the construction and building sector currently accounts for nearly 40% of energy- and process-related carbon dioxide emissions (GlobalABC et al. 2019). The trend of urbanization has been depicted as adding to growing carbon dioxide emissions, yet policies for sustainable urbanization and measures to cut the emissions could counter this spillover effect (Chen et al. 2023). Simultaneously, urbanization creates more pressure on urban land use, but there is a need to reverse this trend (Holström et al. 2024).

Wooden multistory construction (WMC) in urban settings has been identified to possess a great deal of unused potential (Toppinen et al. 2018). However, barriers to WMC in Finnish cities have also been detected, which indicate gaps in information, effective policies, or industrial actors or active intermediaries (Franzini et al. 2018; Vihemäki et al. 2020). In Finland, the utilization of industrialized timber as load-bearing structures has been prevalent

in detached houses (Jussila and Lähtinen 2020) but the share of wooden multistory building has remained small in the overall construction volume, with 5% of the structural frames of multistory buildings having been built with wood in 2016–2020 (Statistics Finland 2021), despite the continuous efforts in Finland (and by the Finnish Government) to promote the issue over the past 30 years (Vihemäki et al. 2019; Lazarevic et al. 2020). Wood can be considered to have a place among and synergies with nature-based solutions (NBS) and has been connected along the array of urban plants with carbon sequestration and the storage potential of cities (Kinnunen et al. 2022) and to local wood and urban forestry bringing financial impetus for urban NBS (Kampelmann 2021).

Industrial wood and wood-based elements could also play a part in multistory building retrofits. Some estimates project that the role of retrofits is increasingly gaining significance (especially in certain parts of the world where the building stock has mainly been built already). In Europe, the estimated part of the current building stock still standing in 2050 is a staggering 85–95% (EEA 2022). Therefore, the market opportunities lie in building retrofits e.g., with ever-tightening carbon dioxide (CO_2) emission goals (Killip et al. 2020). The European Union's Renovation Wave (EC 2020) at the European level and the renewal of the Finnish Building Act taking effect in 2025 (Finnish Ministry of the Environment 2023) set a new operational environment for the retrofit markets. Building retrofits have synergies with resource efficiency (Kim et al. 2024) and circular economy (Hjaltadottir and Hild 2021), as they may create less demand on natural resources and utilize some of the natural resources already tied to them. Building retrofits have scarcely been studied in the past (Lima et al. 2021), and literature is especially hard to find in the context of wooden retrofits on regular multistory buildings, with the exception of Holtström et al. (2024). Systemic solutions are needed at the grassroot level of cities and in collaboration with the businesses that innovate and produce these solutions.

This dissertation aimed to shed light on the novel and rare phenomena of using wood as a construction and retrofitting material along with NBS in urban multistory buildings. The main aims were bringing new understanding of the formation, leadership, management, and roles of various actors in the local BEs/IEs. To understand the overall functioning of the ecosystems in this light, the following research questions were asked in the four articles of this dissertation:

Article I:

- What policy instruments do cities use in steering the market diffusion of new WMC and wooden retrofits?
- What perceptions do the city and other BE actors have concerning the role of municipalities in promoting WMC and wooden retrofits?

Article II:

- Who are the key actors in the emerging project-based wooden retrofit business ecosystem?
- What kind of contextual and decision-making -related factors and dynamic capabilities can be identified among wooden retrofit projects?

Article III:

- What kind of challenges and future assumptions (including climate commitments) steer innovation activities toward low-carbon housing in cities?
- What kind of citizen support for low-carbon housing could cities engage with?
- How could cities better govern social innovation initiatives?

Article IV:

- What factors catalyze the NBS innovation ecosystem?
- What kinds of visions and pathways for the futures of NBS are envisioned by the local innovation actors?
- How do NBS in the innovation ecosystem contribute to the future urban resilience in the case cities?

CONCEPTUAL BACKGROUND AND PREVIOUS LITERATURE

Contextual background of retrofits, wooden multistory construction, and nature-based solutions

The largest overarching contextual themes running through all the articles of this dissertation are building retrofits in an urban setting connected with multistory buildings. A meta study by Lima et al. (2021) showed a research gap regarding building retrofits among the construction literature. However, decarbonizing the building stock of Europe and Finland requires mainstreaming retrofits. For instance, many of the suburban multistory houses built in the 1960s and 1970s in Europe require renovation, but the literature typically discusses this only from the viewpoint of energy efficiency (Karvonen 2013; Brown 2018; Killip et al. 2020), leaving out research that also examines retrofit materials and their sustainability. Another connecting theme of this dissertation is wood use in urban construction and retrofits. Wooden retrofits on regular multistory buildings include rooftop stackings, i.e. adding new floors on top of multistory buildings (Wijinants et al. 2019), or facade replacements using prefabricated wooden elements (Sandberg et al. 2016). This phenomenon of wooden retrofits also exists and is being piloted in Sweden (Holström et al. 2024) and Estonia (D'Oca et al. 2018), for instance. Finland provides an intriguing contextual backdrop to these phenomena, with strong traditions in wooden construction (Norvasuo 2021) and an ambitious national climate neutrality goal towards 2035. The sustainability of wooden retrofits is linked with smaller energy use and a decreased need for virgin materials (Hasik et al. 2019; Piccardo et al. 2020), championing with a lower-impact renewable material base, and extending the life cycle of the existing building stock and all materials embedded in them (Holström et al. 2024). This also contributes to the densification strategies of growing cities (Amer and Attia 2019).

Nature-based solutions have been defined as nature-based interventions, such as green roofs and green facades, that may contribute to the restoration of reduced ecosystems while

providing ecosystem services (Davies and LaFortezza 2019; Dorst et al. 2022). According to Frantzeskaki (2019, 101), NBS are *"inspired by nature, use nature and/or are supported by nature"*. Nature-based solutions are envisioned to simultaneously combat many environmental problems (Dorst et al. 2022), and they have been connected with climate change mitigation and adaptation (Davies and LaFortezza 2019), urban resilience (Tozer et al. 2023), food security, sustainable water resources, and disaster risk management (Kabisch et al. 2016), 'green–blue infrastructure' (Raymond et al. 2017), and to protecting natural capital (Raymond et al. 2017). By introducing biodiversity components, such as ecosystems, species, and genes, to buildings in the form of e.g., rooftop gardens, the roof lifespan increases and the buildings remain cooler, thereby diminishing building energy consumption. Additionally, soil micro-organisms can contribute to waste management and carbon sequestration and can promote sustainable water management (Blicharska et al. 2019). Green roofs can be connected with solar energy solutions, which, compared to other conventional solutions, have been researched to produce more energy and less greenhouse gas (GHG) emissions (Fleck et al. 2022), which highlights the benefits of integrating sustainable solutions. Wood as a bio-based construction material has been linked with growing plans of NBS by their carbon storage properties (Kinnunen et al. 2022; Schellnhuber 2024).

The third overarching contextual theme of this dissertation is the way these wooden retrofits have synergies with other sustainable building and retrofitting solutions. Wooden construction, wooden retrofits, and NBS are connected with regenerative building and are needed because *"if civilization is not merely to survive, but to develop in diversity and solidarity, we must take a new holistic view of the built environment."* (Schellnhuber 2024, 172). Thus, the contextual trio of wooden retrofits, WMC, and NBS began forming as the foundational phenomena of this thesis.

Conceptual evolution from business ecosystem to innovation ecosystem

An increasing amount of literature on ecosystems has been developed in recent years (Daymond et al. 2022). The plethora of ecosystem concepts includes entrepreneurial ecosystems, BEs, platform ecosystems, IEs, knowledge ecosystems, entrepreneurial ecosystems, industry ecosystems, technology ecosystems, service ecosystems, sector ecosystems, social IEs, and social economy ecosystems (Banoun et al. 2016; Alvedalen and Boschma 2017; Autio 2022; Catala et al. 2023). In this dissertation, the phenomena are studied with the concepts of BE (Moore 1993; 1998) and IE (de Vasconcelos Gomes et al. 2018) to highlight the emergence, co-creation, and governance/management of these novel phenomena with complex organizational actor networks. Hence, various other literature strands are relevant in the context of this dissertation connected with actor roles, policy instruments, dynamic capabilities (DC) in strategic management and planning, ecosystem emergence, and co-creation processes to create new innovations. Table 1 depicts the range of concepts used in different parts of the dissertation.

Table 1. Conceptual framework and approaches of the dissertation articles.

	I	II	III	IV
Ecosystem concept	Business ecosystem	Business ecosystem	-	Innovation ecosystem
Conceptual framework	Policy instruments	Dynamic capabilities	Social innovation	Nature-based solution, innovation system
Approach used	Case studies	Case studies	Co-creation process	Identification of transition pathways

At the core of this dissertation is the BE concept, first introduced by James Moore (1993; 1998). For example, Aksenova et al. (2019) defines BEs as a way to view firms not as part of an industry but as an ecosystem in which cooperation, competition, and co-evolving capabilities are centered around a novel innovation at the global market level and for the purpose of competitiveness. The BE concept originally draws inspiration from systems theory, complexity theory, and evolutionary biology (Aarikka-Stenroos and Ritala 2017; Iansiti and Levien 2004). It belongs to the economical "branch" of a wide array of ecosystems research, and the concept originates, draws inspiration, and uses metaphors from biological ecosystems. These metaphors include "predators and prey" as a metaphor for "out-innovating the competition" (Moore 1993); using the biological term "evolution" in relation to actors, technologies, or institutions or the "co-evolution" of business activities (Aarikka-Stenroos and Ritala 2017); or drawing other metaphors from the natural ecosystems sphere, such as "keystones, dominators, and niche", to identify a firm's ecosystem strategy (Iansiti and Levien 2004). Previous literature indicates the BE concept having been the original concept from which a wider pallet of other ecosystem concepts have originated from, including the IE concept (Aarikka-Stenroos and Ritala 2017; de Vasconcelos Gomes et al. 2018; Vigren 2024).

The IE is another useful concept parallel to the BE. The IE is defined by Adner (2006, 2) as *"the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution"*. Granstrand and Holgersson (2020) build their definition on this and elaborate the IE further as *"the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors."* (Granstrand and Holgersson 2020, 1).

IE is used synonymously with BE or at least as 'significantly overlapping' by some researchers (Vigren 2024), whereas others have attempted to differentiate between the two (and other ecosystem) concepts (Aarikka-Stenroos and Ritala 2017; de Vasconcelos Gomes et al. 2018;). For instance, according to de Vasconcelos Gomes et al. (2018), the two concepts differ because the BE concept is concerned with value capture and the IE deals with value creation. Conversely, some literature states that both the IE and BE are concerned with value capture and value creation, even if the emphasis of BE is on value capture (Gobben et al. 2022), and both ecosystem types aim to innovate (Vigren 2024). Moreover, Aarikka-Stenroos and Ritala (2017) emphasize that value in many ecosystem streams is actually *co-created* in these ecosystems (instead of merely being created) in a systemic manner, using the various resources and resource integrating practices.

The BE concept was first adopted to view the construction sector by Pulkka et al. (2016). Business and innovation ecosystems have recently been studied in the context of new wooden multistory building by Toppinen et al. (2019, 2022) and Viholainen et al. (2021), in the context of construction with cross-laminated timber (CLT) products by Erikshammar et al. (2024), and in the context of wooden rooftop stackings by Holtstrom et al. (2024). Nature-based solutions have been studied in the context of innovation systems (van der Jagt et al. 2020) and are typically connected with biological ecosystems and NBS providing ecosystem services, ecosystem benefits, or ecosystem-based adaptation (e.g., Raymond et al. 2017; Davies and Lafortezza 2019; Frantzeskaki 2019; Tozer et al. 2023). Notwithstanding, to the knowledge of article IV co-authors, NBS have not been studied from the IE perspective and, so far, no future studies have examined how the NBS IE may contribute to building urban resilience.

Some researchers merely mention "ecosystem" as a standalone concept (Adner 2016; Aarikka-Stenroos and Ritala 2017), without clarifying the exact terminology of the "ecosystem" stream in relation to business and innovation, and possibly attempt to create a more comprehensive "ecosystem construct". For the sake of clarity and simplicity, the difference and slight variation of the two concepts can be found from the terminology that indicates that *business* ecosystem places slightly more emphasis on the flow of business whereas *innovation* ecosystem emphasizes innovation as a starting point, but the difference is not notable. This is also the overall position of this dissertation, suggesting that the concepts are highly interlinked and valuable in their own right. Hence, BE is claimed to focus slightly more on business flows and actor networks while IE is oriented slightly more towards solution and information flow, but the difference is marginal. Nonetheless, it is important to use exact terminology with the prefixes of "business" and "innovation" to separate business-oriented ecosystems from e.g. biological ecosystems.

Business ecosystems can be differentiated from business networks in terms of their actor diversity (see Figure 1). Business networks typically only contain firms and customers, whereas BEs have a wider range of actors, additionally including e.g., complementors, competitors, collaborator companies, research institutions, and universities (Moore 1998; Heikkilä and Kuivaniemi 2012).

As depicted in Figure 1, articles I and II in this dissertation continue to illustrate the diversity of actors involved in the contexts of local Finnish BEs connected with WMC and wooden retrofits of regular multistory buildings. While article I focuses on the cities' roles in the BEs and also draws insight from other BE actors, article II takes on a business perspective regarding wooden retrofits, to see who the key actors actually are. The emphasis in article II shifts to housing companies, as multistory buildings in building retrofits always have pre-existing owners, which in the Finnish case are housing companies or rental housing companies. Cities once again play a large role in article III, but the focus of this wide municipality workshop process is to engage the whole local BE. Finally, article IV takes on an IE perspective yet allows new NBS actors to be merged in the ecosystem. The perspective of article IV is from the planners and enlarged business sphere, with new actors such as landscape and green area experts and maintenance operators gaining prominence. All the articles I–IV have overlaps but are also unique perspectives to the formation, leadership, and management of local BEs/IEs and to the roles of various actors in these ecosystems. Thus, all the articles represent different layers of a mental model of the BEs/IEs in various local contexts that are manifested in different case cities, projects, and plans.

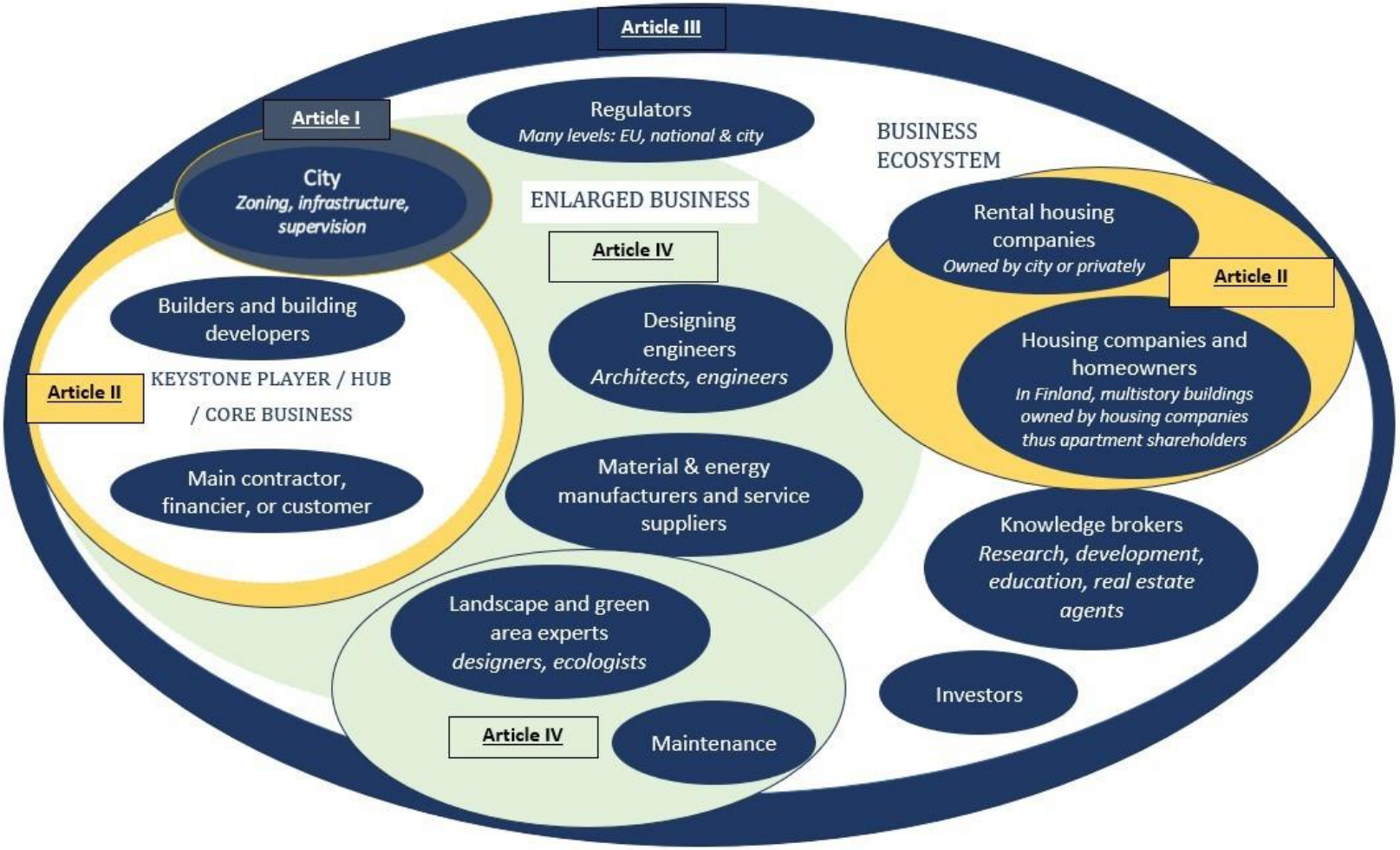

Figure 1. Focus of article I–IV actors within the business ecosystem/innovation ecosystem model.

Typically, the ecosystem literature, irrespective whether it is BEs or IEs, discusses "value creation, value capture or a focal value proposition" (Erikshammar et al. 2024). With BE, the focal value proposition is greater than each firm's separate and standalone offers via complementarities and commercialization, and marketing can be more successful with complementary technologies, goods, and services across many industries and finally, systems that are more substantial than the sum of their parts (Agarwal, S. and Kapoor, R. 2023; Baldwin et al. 2024). As the environmental problems faced are complex and interlinked, so must the business solutions corresponding to them be, and few companies can achieve this alone. Thus, this dissertation argues that this complexity must be studied with the BE and IE approaches.

Cities or urban environments can, in some cased, be seen as platforms for "collaborative ecosystems", *"that facilitate innovation, by creating linkages among citizens, government, businesses, and educational institutions"* (Appio et al. 2019, 2). One array of supporting the innovations is through policy mixes (Kern et al. 2019). Policy mixes are concerned with utilizing, in varying degrees, all the policy instruments, which are classically categorized into regulatory, economic, and information (Bemelmans-Videc et al. 1998). The use of policy instruments has also been connected with WMC in previous research (Wiegard and Ramage 2022). The three main categories of policy instruments can be used as part of a broader set of integrated combinations or mixes of interventions as response to growing complexity and uncertainty (Pacheco-Vega 2020). Lately, the scientific discussion has evolved from policy mixes promoting innovation to policy mixes enhancing significantly wider socio-technical changes or a sustainability transition at large, thus emphasizing policy goals and policy strategies for the wider engagement of actors (Kern et al. 2019; Köhler et al. 2019).

Strategic management, leadership, and dynamic capabilities

Many previous BE/IE studies portray the management or "orchestration" of these networks for wider collaboration (Aarikka-Stenroos and Ritala 2017; Daymond et al. 2022; Foss et al. 2023). This dissertation follows this stream of literature, which has links with leadership of ecosystems (Foss et al. 2023), dynamic capabilities used by the companies as part of the ecosystems (Teece 2009), and "ecosystem architects", i.e. public or private actors nurturing ecosystem emergence and evolution (Daymond et al. 2022). DCs have been categorized into three main spheres: 1) sensing of opportunities or threats, 2) seizing of opportunities, and 3) reconfiguring or transforming business activities (Teece et al. 2016; Stehn et al. 2021). DCs have been viewed as especially useful in times of turbulence and uncertainty (Helfat et al. 2007; Teece et al. 2016). Ecosystem leadership has been examined through the DC concept by Foss et al. (2023) and Linde et al. (2021). Foss (2023) connects sensing with facilitating a common vision, seizing to invite others to make investments to the ecosystem, and reconfiguring or transforming into spontaneous problem-solving to create and sustain persistency. These DCs and lead actors are discussed in detail in article II. Vision forming is part of research that led to articles III and IV.

All decisions being made at the present time are based on assumptions of the future irrespective of whether they are policies or plans (Bengston 2017). In the context of this study, the organizational actors' future assumptions are materializing in city strategies, city development plans, and in the concrete retrofit project plans of companies. But the future is not set. It is fuzzy, uncertain, and likely to surprise us. Yet, some developments are extremely slow and stable, whereas certain changes happen rapidly. The key is to be prepared for a

multitude of different futures (Bell 2009, Bengston 2017). Therefore, strategies and plans need to be constantly reassessed and evaluated, as the array of possible futures is changing and evolving with every new decision and action of the actors (de Jouvenel 2000).

What is commonly said, our thoughts of the future affect our actions today and aid in deciding the best course of action (Glenn 1994; Bell 2009; Bengston 2017). The future is being made by the decisions and actions of today (de Jouvenel 2000). In the urban context, co-creation and co-design are ways for various actors to actively innovate, experiment, collaborate in creativity, and to share knowledge, experiences, and goals (Sanders and Steppers 2008; Webb et al. 2018; Mukhtar-Landgren et al. 2019). The principle that many futures, possible, probable, preferable, and un-preferable, exist is the premise for research analyzing the long-term future. (Bengston 2017; Glenn 1994). There is a need to actively promote the possible and preferable futures, with imagining and creativity using transition pathways and backcasting as useful tools (Vergragt and Quist 2011; Rosenbloom 2017). Simultaneously, it is important to prepare for possible but unpreferable futures using risk and recovery capacity assessments and emphasis on resilience and preparedness (Logan et al. 2022). In this thesis, articles III and IV are devoted to future perspectives but from two different angles. Article III studies the futures through the existing strategies of four cases cities and the future assumptions that would, according to the estimates by city informants, lead to the vision of socially equitable decarbonized cities. Moreover, the early co-creation process unites these cities, their key stakeholders, and researchers to co-create desirable futures through initiating sustainability pathways among and between the case cities. In article IV, the visions and pathways of nature-based and resilient urban environments were created through dialogue between the forefront businesses and cities, and the study also included estimates of undesirable yet possible futures, the foreseen risks of which urban resilience should be strengthened against.

To sum up, the emergence of local BEs followed by local IEs, is highlighted in this dissertation. The phenomena studied in all the articles (I, II, III, IV) of this dissertation concern novelty and rareness, with a multitude of ambitious projects and actions being planned and co-created. Thereby, mature ecosystems of actors are not investigated, but the main focus is on origins and the emergence of new constellations in the context of retrofits and NBS in particular. These thematically link with the governance of ecosystems and the actors therewithin and place cities in a significant role as collaborative ecosystems. Cities are investigated as a place of nurturing multi-beneficial and responsible business. It forms a collaborative decision-making platform for companies to initiate projects. Finally, the roles of various actors stemming from city and business organizations begin emerging.

DATA AND METHODS

First and foremost, this thesis relied on multiple qualitative datasets, in which expert interviews and workshop discussions provided the main data used in the articles (Table 2). The main data were supplemented by various other datasets, such as actor–project mapping, city strategy papers, city walks, and citizen diaries for convergence and reliability. Time frames for data gathering ranged from 2021 to 2024. The local emerging BEs, as study subjects, were in formative phase, the choice of the qualitative approach was justified because expert informants held information on the newest project and city plans or were even co-creating them during the qualitative processes.

Table 2. Data and methods in articles I to IV.

Article	I	II	III	IV
Data	Interviews & actor–project mapping	Interviews & actor–project mapping	Workshops (6), city strategy papers, discussions during city walks, citizen diaries	Workshops (2), interviews
Method	Triangulation of methods with qualitative content analysis of interview data (40 interviewees) and supporting qualitative actor–project mapping for cross-check	Triangulation of methods with qualitative content analysis of interview data (27 interviewees) and supporting qualitative actor–project mapping for cross-check	Qualitative content analysis combining various qualitative data	Backcasting method used in data collection, workshop and interview data analyzed with qualitative data analysis
Unit of analyses	Cities	Projects	Local ecosystems	Cities
Data gathering period	2021–2022	2021–2022	2021–2024, process ongoing until 2026	2023

Case cities

The case study approach was used in the research articles of this dissertation. The unit of analyses varied between the city, local ecosystem, and project levels (see Table 2). All the articles were empirical, and data were collected in conjunction with certain Finnish cities, especially Helsinki, Turku, Vantaa, Joensuu, and Tampere (see Table 3). First, Helsinki presented an interesting case as the capital and largest municipality in Finland by population. Its coastal positioning and large construction volume provided an interesting setting for the study. Second, Turku is another large city in Finland by population and is the historical capital of the country. The mix of historical buildings and new construction along with its coastal positioning provided southwestern viewpoints to the mix. Third, Vantaa borders the capital city Helsinki and is a fast-growing city. Vantaa is part of the Helsinki metropolitan region and well known as the location of the Finnish international airport. Fourth, Joensuu, with its eastern location on the northern shore of lake Saimaa, is the regional center of Northern Karelia. Joensuu as a regional center has most ties to the surrounding rural areas, and the city itself is not as densely built as the other cities, thus providing an alternative contextual setting for the study. Fifth, Tampere is an old industrial city located approximately 180 km north of the capital. Located in between lakes Näsijärvi and Pyhäjärvi, this fast-growing city is the

Table 3. Background data for the case cities of the dissertation.

	Case city 1: Helsinki	Case city 2: Turku	Case city 3: Vantaa	Case city 4: Joensuu	Case city 5: Tampere
Description	Capital of Finland, located in coastal southern Finland.	Historical capital of Finland, located in coastal southwest Finland.	Bordering city with Helsinki and part of the Helsinki metropolitan region.	Regional center of Northern Karelia with most ties to rural areas, located in eastern Finland.	Fast-growing old industrial city, located approximately 180 km north of the capital.
Population in 2023*	674 500	201 863	247 443	78 062	255 050
Population change from previous year, % on average between 2009–2023*	1.0	0.9	1.7	0.5	1.3
Analyzed in articles	I, II, III, IV	I, II, III, IV	I, II, III	I, II, III	I, II

*Statistics Finland 2024.

regional center of Pirkanmaa, is increasing its housing and construction volumes, and thus presents an interesting supplement to the analyses.

Of these cities, Helsinki and Turku were studied the most during this dissertation project, as all the PHD articles relied on information and informants connected with these cities. Also, Vantaa and Joensuu were prevalent in three of the PHD articles, as important information providers. In addition, Tampere was recognized as an important location in relation to Finnish WMC and wooden retrofits and was therefore included in the analyses of articles I and II. Together these five cities represent 26% of the overall Finnish population (Statistics Finland 2024). Thereby, the decisions, developments, and plans of these five cities have relatively high national significance in Finland.

Informants from the interviews, workshops, and city walks represented a total of 37 organizations (coded between O-1 and O-37) and engaged a total of 95 experts (see Appendix 1). During the research phase, the informing organizations were selected based on their being linked with the studied phenomena, either as planners, practical producers (as in the case of businesses), or as promoters, enablers, or commissioners (as in the case of city actors and in the analysis supporting intermediaries and housing companies). Appendix 1 provides information on the detected projects linked with each organization, but this is not an extensive listing and the organizations could have been involved in more projects that this research has revealed. For instance, NBS-related projects were not mapped as extensively as wooden retrofits and wooden multistory buildings were, as only one of the thesis articles (IV) focused on NBS and only in connection with two cities (other cities were not studied from this viewpoint).

Empirical dataset collection process

Qualitative interview data

At the beginning of this dissertation process within the Decarbon-Home project, large qualitative interview datasets, with the number of interviewees totaling 40, were collected in 2021–2022 related to WMC and wooden retrofits on regular multistory buildings. The final set of interviewees consisted of both city representatives and other BE actors. The first interviewee group, i.e., city representatives (see Appendix 2, M01–M10), had expertise and influence in building production, land zoning, wood construction project leadership, environmental issues, sustainability, or overall management. The second interviewee group, i.e., the other BE actors (see Appendix 3, C01–C17, C19–C25, and C27–C28), mainly included companies with businesses in WMC and wooden retrofit BEs. They were either connected solely to a WMC case(s), to both WMC and wooden retrofit cases, solely to a wooden rooftop stacking case, or dealt with WMC in general. In addition, the business actors were supplemented with wooden retrofit building owners (i.e., a privately owned housing company owned by residents and a rental housing company) and intermediary organizations with intricate knowledge of the local BE (see Appendix, C18; C26; I01–I02). All but one face-to-face interview were conducted online in Finnish. Interviews took place between fall 2021 and spring 2022, and each lasted 30–120 min. The interview guide, drawn from the literature review, composed themes of the BE actors and their roles, cooperation, and instruments promoting low-carbon construction.

The second round of interview data on which this dissertation relies on were collected in 2023. These interviews were conducted in the context of the Decarbon-Home spin-off project FoREfront. A total of 11 expert interviews were carried out in the fall of 2023 (approximately 11 hours of taped conversations). The thematic focus was on NBS and urban resilience. The informants represented city zoning, architectural businesses, green solution and landscape architectural businesses, and design engineering businesses, and were supplemented with a knowledge broker (Appendix 4). The informants were carefully selected as they were experts working in one of the two case cities (frontrunners belonging to the EU Mission for 100 Climate-Neutral and Smart Cities (EC 2024)) or businesses identified as having operations in the NBS field.

Workshops

A large proportion of this dissertation data, especially articles III and IV, relies on workshop data either in conjunction with the closest municipal stakeholders or businesses. First, the largest workshop datasets were gathered in a municipality co-creation process that included six municipality workshops in 2021–2023. Part of the workshops utilized service design as a tool for understanding users, use contexts, customer needs, relevant target groups, and organization's strategic aims and resources (Stickdorn and Schneider 2010) that affect the adoption of sustainable building solutions. This process provided a rich and detailed dataset, as many other interlinked data and processes were connected with or collected during the workshops, including citizen diaries and profiles, a short questionnaire, city strategies, and city walks with city representatives explaining to the researchers the challenges and plans of suburban development. An example of the municipality workshop series discussion topics and tasks from workshop 3 can be found in Appendix 5. Forty city representatives and eight

stakeholders were included as informants in this process. Two more workshops, held in the Finnish coastal cities of Helsinki and Turku, were organized in August 2023 with NBS and urban resilience as their themes. These workshops and connected thematic interviews were more at the interface of cities and businesses, with relatively equal representation. Workshop discussions centered on defining terminology, actors, and cooperation, and preferable urban futures (discussion frames are included in Appendix 6).

Supplementary data

Supplementary data for the qualitative interview and workshop datasets included actor–project mapping (I, II) along with city strategy papers, discussions during city walks, and citizen diaries (III). First, information was gathered of the existing WMC and wooden retrofit projects and the affiliated actors in Finland. The gathered data were stored in Excel. Vertically, the database included project names, geographical locations (municipality in Finland), progress stages (completed, building phase, or planned), year of project completion or estimated project completion, and the reference. Horizontally, it included the names of the affiliated actors and the roles of these actors in the projects as mentioned by media sources (e.g., builder, wooden part producer, architect, city). Project by project, each of the actors mentioned by the media sources were given a value of either 1 = actor involved in the project or 0 = actor not involved in the project. Thereby, the scope of the phenomenon was assessed, as were the currently active actors, whether these actors have repeated the projects, and who they have collaborated with, in which geographical location, and when. This information gathering resulted in approximately 70 WMC or wooden retrofit projects (built or planned for the near future) from the year 2003 onwards and included 243 affiliated actors in total. This original mapping also provided this study with a small dataset of quantitative material to assess the size of the phenomena being researched and the collaborative networks existing between the studied actors of the emerging BEs. Even if these data were not analyzed in detail for this dissertation, they nonetheless provided support and added reliability for the qualitative data analyses.

Second, we analyzed the climate agenda-related strategy and program papers and the housing and construction plans of four cities (Appendix 7). The analyzed cities were Helsinki, Vantaa, Turku, and Joensuu. The resulted data supported the future-oriented analyses included in article III. Third, city walks organized by city representatives led a group of researchers into the realities of particular city suburbs faced with development or socio-economic challenges and needs for low-carbon construction and retrofits. On a positive note, the city representatives also provided their exemplary cases of participatory processes aimed for citizens along with their zoning plans aimed for climate-wise housing. During those walks the city representatives also showcased functioning developments and buildings, also connected with WMC. Fourth, citizen diaries provided a backdrop on the types of citizens living in climate-wise housing and citizen viewpoints on the cities' roles in supporting this.

Methods

The focus of the study was to understand certain topical phenomena in their formative phase. The sub-studies leading to articles III and IV also included envisioning and co-creating future-oriented action to strategically manage sustainable pathways for case cities that provide a platform for urban BEs and IEs. Therefore, the emphasis was heavily on narratives,

and the main empirical data collection and analysis was based on qualitative research (Silvermann 2000). The empirical analysis of the phenomenon included the gathering of qualitative interview material, which was the main original data source of the study with its rich and detailed expert views. This type of co-creation for long-term futures and insights on emerging phenomena would have been impossible to obtain without qualitative research methods. The following qualitative content analysis consisted of thematization of the workshop and interview data, while the total of number of actors (including the city walks) consisted of 95 actors that were included in the participatory processes of the two projects (see Appendix 1). Typically, the data were analyzed using the Qualitative Data Analysis & Research Software ATLAS.ti 9 and by simultaneously using Excel as a supportive tool for data interpretation. The unit of analyses was either cities or projects linked with local BEs (see Table 2). The chosen qualitative content analysis enabled us to formulate carefully constructed categories on the newly collected qualitative datasets and to interactively revise and clarify these categories for reliability throughout the analysis process (Drisko and Maschi 2015).

The supplementary data were combined with large qualitative thematic interview and workshop data for convergence, complementarity, and divergence between datasets (e.g., it was possible to check the information of wooden retrofit project actors, who seem to be the key actors in terms of recent activity, and the number of projects and collaborations). The interview and workshop discussion guides were jointly developed by several researchers, and the interviews and workshops were carried out by several individuals to ensure impartiality and objectivity. In fact, a total of 20 researchers were involved in either organizing the workshops and/or conducting the interviews in 2021–2023. This ensured neutrality and carefully considered research designs. The recorded interviewed data were transcribed in Finnish by a third-party company for uniformity and precision. The qualitative datasets were triangulated, as they consisted of a multitude of knowledgeable organizational and layman informants from business and city organizations and supported by citizens and knowledge brokers to strengthen the analysis with multiple viewpoints (see Appendix 1 for informant details). Finally, as a supportive tool for reliable data interpretation in each sub-study, at least three researchers cross-checked that the used data and the created themes, categories, and codes were in line with the main study concepts. Information was often absorbed simultaneously and cross-checked between the key concepts and data sources while conducting the content analysis (along the lines of reflection and design thinking in Jungmeister (2016)).

In the workshops related to sub-studies III and IV, the data collection was guided by the future studies methodology, namely for identifying visions, future assumptions, risks, service, and transition pathways. The focus group method was used during the second-phase workshops themed with nature-based and resilient urban environments. In line with Sim and Waterfield (2019), the analytical focus of the focus group data gathering was to gain "co-production perspectives" supplemented with interviews to acquire comprehensive information on the transition pathways for NBS as solutions for urban sustainability. The backcasting method has typically been used as a strategic tool in which preferable futures are first imagined and then pathways towards these futures are sketched by looking backwards from those preferable futures to see what has had to have happened to reach the initial visionary state. Sometimes when applying the backcasting method, a researcher can also begin from an unpreferable future to devise actions to prevent those futures (Glenn 1994; Vergragt and Quist, 2011.) Backcasting has previously been used to sketch out the industrial wood construction markets by Toivonen at al. (2021). While using the backcasting method

in sub-study IV, a desired future was initially sketched, followed by looking backwards in a stepwise manner from that future to the present (i.e., the far distance, midterm distance, and short-term future) to strategize and plan the needed actions for sustainability change.

Research reliability and validity

This research was guided by the pursuit of knowledge and driven by scientific curiosity of the studied topic. The data and methods were selected based on consideration of where relevant information could be found. The key aims of this research are in line with the general aims of research, namely the pursuit of knowledge and truth and improving the world we live in. Therefore, information has been gathered from multiple sources and research triangulation has been used. As for the aspiration for truth, the systematic manner of coding and analyzing the qualitative data has been conducted with openness among the co-authors and the greater research teams involved. The aims of research are founded on the ethical norms of adding to knowledge and trust and avoiding errors. This avoidance of error is ensured through working in a research team with cross-checks and reviews.

The personal information collected during both the interviews and workshops is highly limited, as it only concerns the names and contact information of the informants. The informants are expressing their professional views and are not talking of themselves or sharing personal information. Regarding the interviewees, they were provided a data privacy notification and a consent form to participate in the research, explaining the purposes of the research, the confidential and voluntary approach, and their rights as interviewees, also to withdraw their data from the research if so inclined. All the interviewed informants confirmed their consent by e-mail. During the analysis phase, all the names of the interviewees have been anonymized and the interviewees have been given codes. The material has been treated with confidentiality during all phases of the research. This dissertation has followed the Data Management Plan of the Decarbon-Home project during all phases of research. The plan included clear guidelines for content data; ethical and legal compliance, documentation and metadata; data storage and backup; opening, publishing, and archiving the data after the research project; and data management responsibilities and resources to ensure research validity and reliability.

RESULTS

Table 4 revisits the research questions and provides key highlights from each article. Overall, articles I–IV researched niche and emerging phenomena. These sub-studies examined the various roles that the actors among the cities and companies had assumed within their local BEs, and the need for more active and dynamic roles was recognized. The confronted challenges of communication gaps and the holistic approach create impetus for concrete actions to generate markets for sustainable solutions in urban built environments. Co-creation and normative future pathways creation highlighted the need for efficient collaborative actor networks that require strategic management. Opportunities are foreseen especially in the realm of ‘sensible retrofitting’ that requires innovative activities in systematically combining sustainable retrofitting solutions connected with the sustainable use of natural resources in urban built environments fostering decarbonization and resilience (Table 4).

Table 4. Key findings in articles I–IV.

	Research questions (RQs)	Main takeaways
I	RQ1: What policy instruments do cities use in steering the market diffusion of new WMC and wooden retrofits? RQ2: What perceptions do the city and other BE actors have concerning the role of municipalities in promoting WMC and wooden retrofits?	• Wooden multistory construction and wooden retrofits have remained a niche in residential building markets • Markets of wooden construction and retrofits may be catalyzed by diverse policy instruments • Steering for wooden multistory construction and wooden retrofits by financial instruments is rare in Finland. The use of policy instruments is rarer in wooden retrofits than in wooden multistory construction. • Cities may face challenges in adopting an instrumental role as a key actor and/or collaborative actor
II	RQ1: Who are the key actors in the emerging project-based wooden retrofit business ecosystem? RQ2: What kind of contextual and decision-making -related factors and dynamic capabilities can be identified among wooden retrofit projects?	• Decarbonizing the building stock requires businesses to create new solutions for markets. • Wood material-based retrofits offer new possibilities but are currently rare in the urban context. • City-owned housing companies are found to be most aware of seizing opportunities of climate benefits and facelifts in less appealing suburban areas. • Actors use dynamic capabilities in niche-level projects, yet the reconfiguring stage of business models is not visible
III	RQ1: What kind of challenges and future assumptions (including climate commitments) steer innovation activities toward low-carbon housing in cities? RQ2: What kind of citizen support for low-carbon housing could cities engage in? RQ3: How could cities better govern social innovation initiatives?	• Local initiatives are significant in driving decarbonization targets and the cities' role is key • Cities face a common pool of challenges, the inter-organizational division of labor and cooperation within cities, the multiplicity of actors with limited interaction channels, and unidentified ownership of responsibility in the process, yet co-creation can bridge these issues • Socially equitable decarbonized cities toward 2035 can be reached though undesirable developments, e.g., a lack of resources or via desirable developments, e.g., increased spread of innovation • The concrete paths for municipal action are seen in the emerging themes of sensible retrofitting and in the creation of a knowledge network of climate-wise actors
IV	RQ1: What factors catalyze the NBS innovation ecosystem? RQ2: What kinds of visions and pathways for the futures of NBS are envisioned by the local innovation ecosystem actors? RQ3: How do NBS in the innovation ecosystem contribute to future urban resilience in the case cities?	• There is a need to build resilient urban environments to manage expected environmental risks • Nature-based solutions combined with wooden building materials provide benefits and resilience to foreseen risks in case cities • Four transition pathways for sustainable futures in 2050 were created for the case cities using the backcasting method to highlight the actions needed today • The local innovation ecosystem could catalyze the desired trajectories via efficient and ambitiously goal-oriented creative learning and a shared knowledge base

Article I: City agency springs from wooden construction to retrofits in a Tale of Five Cities

The focus of article I was on five Finnish case cities: Helsinki, Turku, Vantaa, Joensuu, and Tampere (see short descriptions of these cities on page 10). The interest first lied on the roles that the cities have as part of the local BEs connected with WMC and wooden retrofits of regular and existing multistory buildings. This was studied both from the perspective of city representatives and the perspective of other BE actors (mainly companies). Secondly, the policy instruments that the cities had used to guide these phenomena were highly interesting. Five main roles for the cities in local BEs were detected in the study: minor actor, key actor, fluid role actor, collaborative actor, and administrative actor. The municipalities themselves stressed their collaborative role among other BE actors, while other BE actors considered the municipalities to be in the key role.

All the main category policy instruments (regulatory, economic, and information) were detected in at least one of the studied cities. Regulatory instruments of land zoning and the transfer of plot conditions, including information-related pilots, were typical tools used by all the cities. However, economic policy instruments were very uncommon, with only a few interesting exceptions. While applying these policy instruments, the cities were functioning at and affecting various layers of the BE: core business, enlarged business, and the BE in its largest sense, also depending on the specific phenomenon (either new WMC or wooden retrofits). At their best, cities can take on a collaborative role, with strong mechanisms for inner city cooperation and for orchestrating the outer BE actors by networking, cooperating, and facilitating, while concurrently also taking a key actor role as an active enabler that promotes and serves, for example via innovative and context-specific policy mixes.

Article II: Wooden retrofits and dynamic capabilities in emerging business ecosystems

Article II focused solely on the phenomenon of wooden retrofits on regular multistory buildings. The article centered on related and rare projects, emphasizing the project and business perspectives. This study enabled drafting a project portfolio of the wooden retrofit projects in Finland stemming from 2010–2022 and reaching towards futures with 22 projects being planned at the time (in 2022) with. Also, it was possible to pinpoint the key actors of various project activities. The builders were construction companies and consultants while customers were private building owners, rental housing companies (owned by the city or privately), and housing companies. The latter actors occasionally also involved a developer, a real estate agent, a steward, or an architect that played a key role, typically an excited and knowledgeable individual. The building retrofit context therefore always includes the building owners (unlike in the case of new construction), and in the Finnish case this meant that the housing companies and rental housing companies emerged as an important actor group in article II (see also Figure 1).

The dynamics of early decision-making on whether to execute a project varied among the key actors. The decision-making process was rapid in the case of construction companies, city-owned housing companies, and private building owners, whereas the decision-making processes in housing company cases have taken a long time due to democratic processes and the need to have a shareholder majority to back the projects. Typically, economic rationale has been the sole guide for engaging in these exceptional projects, with projects implementedin expensive areas of cities needing efficient space utilization and with projects

implemented at opportune moments with favorable changes in the operational environment (e.g., changes in fire codes or city strategies enabling actors to accomplish something new). By contrast, city-owned housing companies as an actor group appeared to be an exception from the others, with wider sustainability goals for carbon neutrality and social justice and the need for facelifting the less appealing city suburbs in which their projects were located. The identified actors are further involved in future schemes for wooden retrofits, some with ambitious deep renovation plans with wood.

Article III: Cities co-creating sustainable retrofits aiming to initiate social innovation

Article III resulted in an analysis of the early stages of an extensive municipality co-creation process in four Finnish cities (Helsinki, Turku, Vantaa, and Joensuu), especially an analysis of the 'fuzzy front-end' of the process (Sanders and Steppers 2008). Results of article III suggest that a common pool of challenges exists, indicated by the cities' strategic climate goals, which are the future-oriented documents of these cities. On a global scale, the challenges include various environmental crises and uncertainties, and, on a national level, aging, urbanization, and digitalization. Local challenges mainly included economic and segregation issues, but other varied challenges were occasionally shared by some cities. The study detected several future assumptions that guide the envisioning of the future in 2035 and surprisingly, they were not all positive. From the negative side, challenges are posed by city growth in some city cases in which the high volume of housing construction threatens the quality of housing, climate change poses risks, and the need to adapt and the availability of restricted monetary and natural resources will steer towards a circular economy and be both a barrier and driver on the way towards a low-carbon society in 2035. Additionally, there is a call from the citizens to the cities for greater development of citizen support. A rich setup of interlinking ideas was formed at the fuzzy front-end of the co-creation process, with three main directions of service pathways identified: climate-wise housing as a service, sensible retrofitting as a service, and knowledge networks of climate-wise actors. To turn these strategic aims, visions, and citizen needs into actionable initiatives, cities face three key challenges: the inter-organizational division of labor and cooperation within cities, the multiplicity of actors with limited interaction channels, and unidentified ownership of responsibility in the process. Nonetheless, according to Deserti and Rizzo (2018), co-creation is a way to bridge these challenges. From the initial steps of co-creation, the cities were most interested in implementing concrete actions along the paths of sensible retrofitting and the creation of a knowledge network of climate-wise actors.

Article IV: Nature-based solutions for urban resilience

Article IV continued with future-oriented research, resulting in future-related transition pathways up to 2050 regarding nature-based and resilient urban environments. These transition pathways consisted of visions of preferable futures concerning nature-based and resilient urban environments and the pathways leading to these futures. The created visions showed similarities across two cities regarding preferable futures, e.g., to make cities greener, calmer, and more comfortable places to live. In the far distance futures (2040–2050) of the pathways, the informants considered certain boldness and unconventional solutions and innovations to be co-created among the IE actors, with happiness and well-being spreading

to all species. In the midterm futures (2027–2040), innovative retrofits combining various solutions (e.g., solar energy and green solutions) were envisioned with existing indicators of nature positivity. For the short-term futures (2023–2027), the expert informants believed that the responsibility of "opening the game" lay with the city processes, i.e. tighter goals and criteria, the use of tools such as the blue–green factor, plot conditions, public procurement, and, all in all, engaging in awareness raising of the citizens. When applying the NBS innovation system framework by van der Jagt et al. (2020), it was evident that certain catalyzing changes should be made in the city–business actions of today, namely via the need to educate and expand the knowledge base of the IE actors via experiments and co-creative activities. This article also presented the notion of urban resilience at the interface of environmental risks and benefits of NBS that create opportunities for being prepared for unknown futures.

DISCUSSION

This dissertation investigated the emerging business and innovation ecosystems of wooden retrofits, wooden multistory construction, and nature-based solutions at the interface of five Finnish cities and local construction businesses (Figure 2). Both of these actor groups uniquely impact the development of local BEs and IEs, supporting the development toward sustainably built environments. Both cities and companies apply strategic thinking and, at their best, provide a fruitful setting for innovation and successful business bearing in mind the urban goals (Teece 2009; Webb et al. 2018), also in the WMC context (Vihemäki et al. 2019).

Articles I and III particularly focused on cities. They were found to provide the institutional setting for enabling or constraining the studied phenomena, and previous studies have found their role to be substantial in transforming to sustainable construction in the context of WMC (Salmi et al. 2022; Franzini et al. 2023). Proper and comprehensive policy mixes are key for enabling sustainability transitions (Kern et al. 2019), and municipal strategies and visions can steer the selection of policy instruments towards a comprehensive mix (see Figures 2 and 3). Policy instruments have been most effective when they include characteristics of well-designed building projects (article II). Based on articles I and III, it was evident that the other actors, especially business organizations but also citizens, expect Finnish cities to take on a more ambitious role as active collaborators and facilitators and even as leaders in promoting low-carbon living and housing, more so than the city representatives themselves realized (Figure 2). However, article IV illustrated a slightly contradictory result by portraying that *some* city representatives do at least see the need to raise the ambition level of their own strategies and plans along with the need for cities to ambitiously show the way toward a more resilient and nature-based urban future.

Cities face three key challenges when turning the identified strategic aims, visions, and citizen needs into actionable initiatives: the lacking inter-organizational division of labor and cooperation within cities, the limited interaction channels with other climate-wise actors, and the unidentified ownership of responsibilities in the change process (articles I and III, see also Figure 2). Overall, cities are faced with collaboration and communication difficulties that manifest as organizational silos (Deserti and Rizzo 2018) and as varying degrees of funding available for the case municipalities for promoting the issues, resulting in gaps in using financial policy instruments for guidance, also visible in the results of articles II and III.

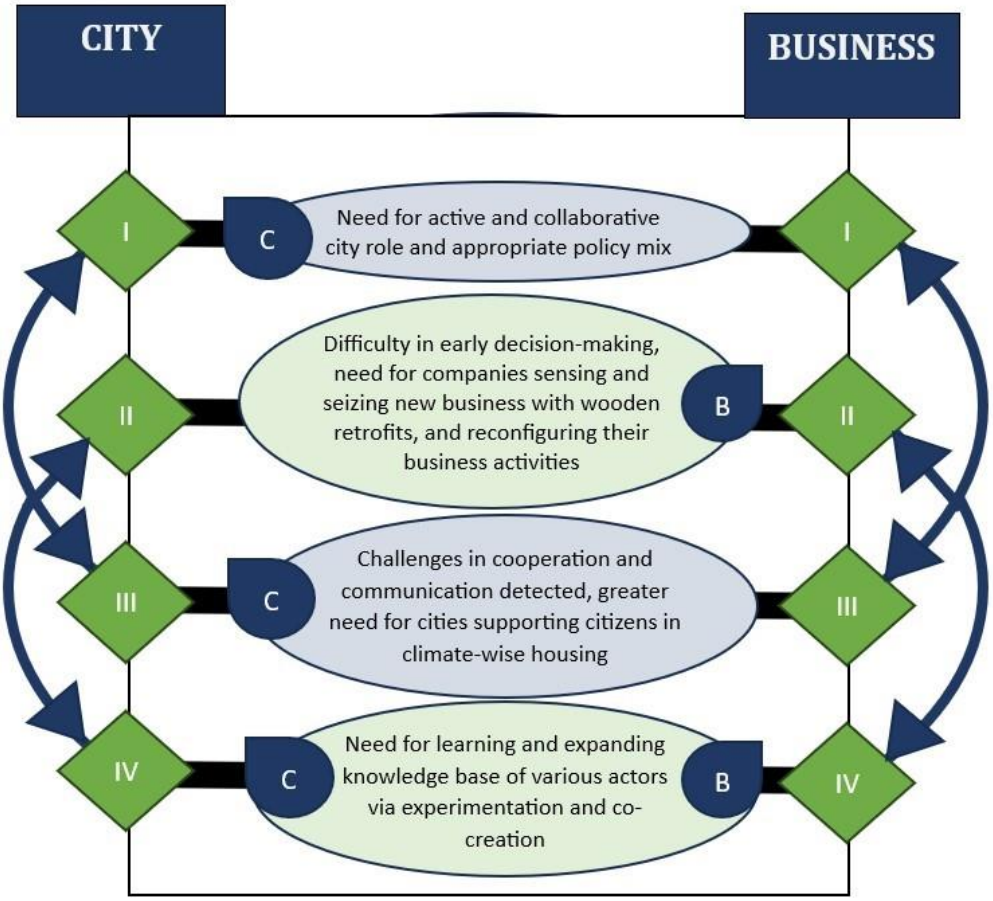

Figure 2. Interface of cities and businesses with the key findings of articles I–IV summarized from the perspective of detected challenges and development needs. Article central focus in C = City, B = Business, or both.

Nonetheless, a certain type of ecosystem leadership (Daymond et al. 2022; Foss et al. 2023) is expected from the cities to facilitate and nurture the emerging BEs and IEs by engaging various actors under commonly shared goals and strategies, along with attracting funding for sustainable retrofit and construction solutions (articles I and III, see also Figure 3).

The strategic management perspective was emphasized in article II and to some extent in article IV (Figure 2). Based on the results, companies should nurture DCs at times of turbulence to sense and seize the opportunities of the expected changes in the operational environment, along with reconfiguring their business models in the long run. However, the results elaborate a certain degree of difficulty in project-level, early-stage decision-making (article II, see also Figure 2). This is where the dissertation follows and contributes further to the literature on DCs as part of BEs in line with Teece (2009) and to exploring, exploiting, and creating business opportunities. Thereby, more than sensing and seizing opportunities, businesses should actively shape new opportunities. This includes *"scanning, creation, learning and interpretive activity"* (Teece 2009, 9). In this study, which is connected with

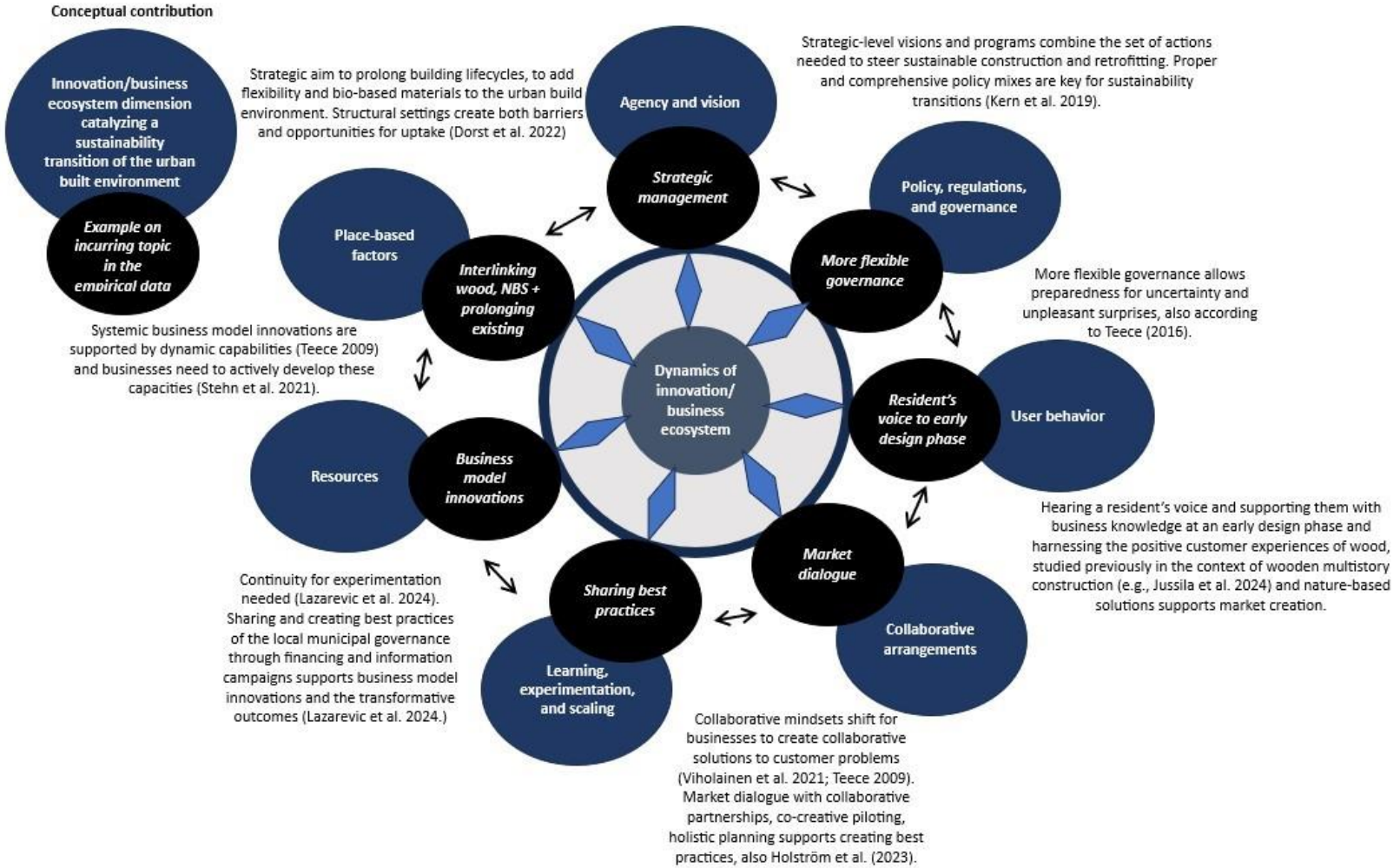

Figure 3. Navigating toward urban sustainability. Innovation/business ecosystem dimensions catalyzing the sustainability transition of the urban built environment and the insight of this study connected with previous literature (mod. Teece 2009, 2016; Kern et al. 2016; Van Der Jagt et al. 2020; Stehn et al. 2021; Viholainen et al. 2021; Dorst et al. 2022; Holström et al. 2023; Jussila et al. 2024; Lazarevic et al. 2024).

practical co-creation and co-designing city development, article III poses creativity as a collective endeavor (Sanders and Steppers 2008; Ansell and Torfing 2021;), see also Figure 3.

Motivations for retrofit projects are driven via urban densification strategies, by improving the attractiveness of suburban neighborhoods, and more efficient space utilization (article II). In comparison to the study by Stehn et al. (2021) on the contexts of industrial house building using wooden frames to produce WMCs in Sweden, this thesis (article II) also investigated the narratives of businesses on project initiation. Moreover, in article II, the studied wooden retrofit projects were attached to many organizations and the focus was on early decision-making. In their work, Stehn et al. (2021) highlighted strategic directions of corporate asset build-up through the continuous development of DCs by the standardization of components, value chain integration, and the standardization of processes and managing relationships towards new business models. In comparison to Stehn et al.'s (2021) work, the actors involved in the investigated Finnish wooden retrofit projects had used the first-order DCs to a degree. These DCs are most apparent among those actors that have repeated these projects, as occasionally project repetition has occurred with more or less the same team of organizations. However, the businesses may face difficulties in forming long-term partnerships and managing partnerships towards new business models for wooden retrofits. The continuous development of DCs would require novel combinations of actors, such as seating a wood product manufacturer and an energy retrofit solution provider around the same table (article II) to negotiate and create a systemic sustainable retrofitting solution built around complementary resources, as indicated by Stehn et al. (2021).

The exploration for novel innovations often deals with combining complementary innovations that respond to customer problems with a systemic innovation creating a new solution (Teece 2009, 14). To innovate the required solutions, strategic collaborations, co-evolution, and co-specialization with other business actors are needed to produce more complex solutions with systemic value proposition that meets societal and customer needs (Moore 1993; 1998; 2006; Teece 2009; Foss et al. 2023). Collaboration requires understanding the other actors' perspectives and continuing to build long-standing partnerships, thus the 'collaborative arrangement' dimension portrayed in Figure 3. This poses requirements for renewing the educational system to educate beyond sectoral and professional borders. It therefore requires a new flexible and collaborative mindset shift for businesses, noted already in the context of novel residential WMC projects (Viholainen et al. 2021), see also Figure 3. The field in the wooden retrofit context seems to be more fragmented, with less advance planning compared to new WMC, as retrofitting is more context specific. In retrofittings, the buildings vary in age, original construction method, and retrofitting needs, and it appears to be easier for the businesses to agree together on common parameters in the new construction context rather than in the case of retrofits.

Based on the tracked wooden retrofit projects in article II and, to some extent, also on the NBS in article IV, a small and persistent group of business actors exist that have experimented on and even repeated these projects, including builders, architects, group building architects, and, on occasion, the same customers. Based on article II, the builders and their customers are key actors of wooden retrofit projects in local BEs in Finland. However, there is definitely room for more business actors to enter the ecosystem and to strengthen these new fields and to diversify their business models in this novel direction (articles II and IV). There is also a need for engaging new actors to participate in these novel activities in the realm of BE at large, including housing companies, landscape and green area experts, building operators, and yard maintenance experts (see Figure 1).

Moreover, in the expert discussions of articles III and IV it became evident that both the cities and businesses need each other for promoting sustainable construction and retrofit solutions, and the discussions and co-creative processes are important (Mukhtar-Landgren et al. 2019), see Figure 2. The cities need to know what they can demand from the businesses when using various policy instruments or policy mixes, as outlined by Wiegand and Ramage (2021) and Kern et al. (2019), see also Figure 3. Cities are interested in the forefront companies' innovations and solutions that are available or alternatively possible to produce in the realm of sustainable building. Therefore, cities can use this knowledge and ambitiously demand these solutions by using public procurement tools or other measures that create suitable markets. On the other hand, companies need to know what the cities expect and will demand of them to innovate and produce solutions that meet the cities' needs. Thus, a well-functioning city–business interface is key in fostering local urban sustainability at the local level (see Figures 2 and 3).

In the realm of possible futures, articles III and IV depict various pathways ahead for the studied case cities' urban environments and for the collaboration therewithin. Yet, even if the main foci of articles III and IV were on preferable futures, the studies also brought forth possible futures that are unpreferable. Even while the informants were included in the preferable vision formation process (resulting in article III), not all the informants' future assumptions leading to decarbonized futures in 2035 were positive. The envisioned, yet somewhat negative future assumptions also included city housing construction that favors quantity over quality and restricted monetary and natural resources that would, nonetheless, lead to decarbonization (article III). Moreover, connected with article IV, the worsening environmental challenges of climate change and biodiversity loss pose risks to urban environments, such as extreme heat and floods, decreases in biodiversity, and increases in invasive alien species brought on by climate change, which create risks to human health and to building durability (article IV). This calls for a need to adapt (article III) and for a need for preparedness and added urban resilience against the risks (article IV). Simultaneously to futures with risks and uncertainty, some futures developments are slow (Bengston 2017). Certain future assumptions of the informants reflected this slowness of development by assuming that most of the building stock will still be standing in 2035 (article III), which coincides with general estimates of 85–95% of current buildings still existing in Europe in 2050 (EEA 2022). This highlights the importance of retrofitting the existing building stock, and it was evident in the research carried out that building retrofits are in more direct need of solutions and actors than sustainable new construction is (articles II, III, IV). However, future developments also contain uncertainties. To manage these uncertainties in an innovation economy, organizational flexibility is needed to manage upcoming surprises (Teece 2016; Bengston 2017). Nature-based solutions have a lot to offer for enhancing urban resilience, as they enable urban systems to absorb disturbances while maintaining the benefits and ecosystem services of the urban fabric (Langemeyer et al. 2021). The informant discussions in article IV supported this, as the multiple benefits of NBS were the most discussed topic in the data, also in the context of building urban resilience against environmental risks and uncertainties.

Concerning NBS, preferable futures were also investigated in the form of visions, pathways, and positive future assumptions that would enable decarbonized and resilient urban environments (articles III and IV). To aid strategic thinking in the realms of preparedness, transition pathways for both cities and businesses were created up to 2050 regarding NBS (article IV). Moreover, the focus was also on NBS dimensions in the IE framework that could catalyze the wider uptake of NBS (mod. van der Jagt et al. 2020)

(article IV). In this thesis summary, it is possible to connect these IE dimensions with the whole dissertation (Figure 3). As a conceptual contribution of this dissertation, the van der Jagt et al. (2020) NBS innovation system frame has been taken one step further and modified to portray the catalyzing dimensions linked with all the studied phenomena and the main conceptual foundations of this thesis (see Figure 3). The main emphasis of this dissertation is on the following five out of van der Jagt et al.'s (2020) seven catalyzing dimensions: agency and vision; policy, regulation, and governance; collaborative arrangements; learning, experimentation and scaling; and resources (Figure 3).

When mainstreaming NBS, WMC and wooden retrofits call for expanding the knowledge base of IE/BE actors (Figure 3). This thesis detected the need for creating a more efficient information flow between the ecosystem actors. First, to bridge the silos, information sharing should be fluent within the city from one city unit to another (articles I and III), following the logic of Deserti and Rizzo (2018). Second, information flows and facilitating progress in terms of a sustainability transition in urban built environments are needed between the city and other BE actors (article III and IV). Third, information should be shared effectively between planners (both the city and businesses, such as architects) and practical projects and their implementation experiments. This would enable the practical operators to be aware of the strategic goals and related actions, and conversely, the planners would understand the logics of practical projects and maintenance practices (as indicated in article IV). Also, the efficient information sharing was apparent in the underlying need for supporting knowledge for the decision-making of the housing companies, with democratic slow processes and resident shareholders in need of expert knowledge (article II, see also Figures 1 and 3.) Fourthly, according to Lazarevic et al. (2024) and Kivimaa et al. (2017), information should be passed on from project to project to circulate, replicate, and scale up the experiments and sustainable innovations therewithin for a sustainability transition. This confirms the findings of this dissertation, see also Figure 3.

The main novelty of this research lies in contributing to and continuing the conceptual foci of the BE and IE constellations described by Erikshammar et al. (2024) and Vigren (2024). The key is the need for a new sustainability-based systemic value proposition to be placed at the core of the emerging BEs/IEs. The value creation in these BEs/IEs is achieved through novel collaboration and communication building on the conceptual foci described by Erikshammar et al. (2024) and Vigren (2024).

In the thesis, many similarities could be found with Virgen's (2024) results on higher-order ecosystem conceptualizations in construction management, namely of ecosystems being local and city-based, new value being based on ecosystem collaboration, ecosystems being formed around projects and including actors with various roles. According to our findings, however, ecosystems can be formed around more complex systems than mere technologies, also including social innovations (articles III and IV). Erikshammar et al. (2024) found IEs co-existing with CLT-based building projects and found interdependencies within individual projects and between projects. Compared to the research results on wooden retrofits, some of these project-based interdependencies are detectable in and between the projects and among the small group of actors that have persistently repeated these projects. In the studied projects, individual champions are driving their projects forward (article II). As for the customers, i.e. for privately owned housing companies in the case of wooden rooftop stackings, these projects happen only once in a building's lifetime. But some builders have repeated this business model. And if their collaboration with other companies has been fruitful, it is likely to continue because the field of actors with competence and references is limited (article II).

The research on wooden retrofits made evident that such projects were hard to find in Finland. One implication is that they are scarce. But it is also possible that the retrofitting companies have not realized the effects that the various materials have on low-carbon retrofits, that these effects could be calculated, and that these solutions are offered and marketed as low carbon to customers. The material streams of retrofits require better understanding. However, statistics on these solutions are currently missing. As the new Finnish Construction Act takes effect in 2025, with more demanding requirements for documenting the environmental impacts and carbon footprints of new residential construction, there is hope that the renovation side will follow.

Wooden retrofits seem to be most affordable in the largest and most rapidly built cities in Finland, which are already densely built. Thus, the only way to add housing to expensive locations is to build up, e.g. in Sweden the vertical building program has been denoted the "timber on top". However, many locations in Finland are still quite scarcely populated, including some of the case cities, with lots of room for additional building. Also, the availability of flat roofs, which are most suitable for rooftop stackings, may vary among the case cities along with requirements posed on the city landscape. These reasons may affect the slow adoption of wooden retrofits on urban multistory buildings. However, wood as a lower-impact, bio-based material has a superior 'strength-to-weight ratio' that benefits significantly its use in rooftop stackings (Holström et al. 2024), and wooden facade modules replacing or installed in addition to the existing building facades have added insulation benefits (Sandberg et al. 2016). Article II supports Holström et al.'s (2024) observation that wood has been chosen for many rooftops stackings due to its lightness, so that the existing building structure can bear the added weight. Abreast with wooden materials, article IV recognizes NBS to offer many benefits to urban design. As far as sustainable material flows are concerned, the research results can be applicable also when researching other materials in the construction and retrofitting setting beyond wood, such as reclaimed materials.

The results of articles II and IV show highly ambitious and exceptional project concepts and plans for both urban wooden retrofits and NBS in large Finnish cities, but the actual realization of these plans is still a curiosity (articles II and IV). To create demand for deep renovations fostering a sustainability transition in urban built environments, the emerging BEs and IEs need both market creation and ability to undertake more ambitious projects.

The evidence from this dissertation may also be applicable beyond the Finnish context in areas facing the same global issues of natural resource overconsumption and in areas mitigating and adopting to the environmental challenges of climate change and biodiversity loss. Compared to Finland, neighboring countries Sweden and Estonia are experimenting with wooden retrofits on multistory buildings (D'Oca et al. 2018; Holtström et al. 2024). Globally, cities of various continents, such as Cape Town, Mexico City, or Melbourne, are introducing NBS for urban resilience and have been using various value propositions for justifying NBS (Tozer et al. 2023). The most powerful arguments for NBS are responding to numerous sustainability challenges and the quest for resilience. However, building the intrinsic value societal base for nature would also enhance social equity and benefits to NBS (Tozer et al. 2023.

CONCLUSIONS

The scientific novelty of this dissertation is that it bridges the link between the business ecosystem and innovation ecosystem mindset in wooden retrofits and nature-based solutions and thereby follows the path set by research on wooden multistory construction (Toppinen et al. 2019; Stehn et al. 2021; Viholainen et al. 2021; Holtström et al. 2024). This dissertation increases our understanding of less researched sustainable retrofits (Lima et al. 2021) and, as a theme, building retrofits run through all the research articles. Wooden retrofits and WMC have synergies with resource efficiency, circular economy, and even enhancing resilience of the built urban environment (Hjaltadottir and Hild 2021; Kinnunen et al. 2022; Kim et al. 2024), voicing political agendas from the EU Renovation Wave, and decarbonization of the built environment. As a conceptual contribution, this dissertation combines IE/BE dimensions with strategic planning and management literatures to increase our understanding of catalyzing the development to support sustainable urban environments. The mainstreaming of wooden retrofits, WMC, and NBS can be concluded to call for expanding the knowledge base of BE/IE actors via experiments and co-creative activities.

There are also some obvious limitations. The dissertation's empirical data collection and analyses were conducted between 2021 and 2024. The relatively compact time frame had its advantages, but nonetheless many extraordinary developments were ongoing concurrently that affected the data collection and participatory processes. The work began under a global pandemic, and Covid-19 restrictions were still largely in place in Finland at the beginning of this study. This affected the participatory processes of many of the interviews, and even the workshops were carried out either online or in some hybrid form, which may influence the data quality. Concurrently, it also perhaps enabled more efficient organization of the workshops and interviews and participation beyond physical locations. And for a researcher, it provided a fruitful time for conducting an in-depth study without interruptions during the otherwise isolated times.

A strength of this thesis is the access to large, mainly qualitative datasets that provide a rich and detailed picture of the developments concerning the studied phenomena of wooden retrofits, WMC, and also NBS to some extent. However, there are also limitations that come with such large and heterogenous data. Not all the data are of the same quality and depth of inquiry. They were gathered at slightly different time frames with slightly varying purposes and contexts. When compiling the interview datasets, many versions of interview guides existed with different foci: sometimes on a certain project (or two) and sometimes on the phenomenon itself. The interview guides were adjusted to suit the organization type and the kinds of information that that particular actor could be knowledgeable of. Some questions and themes, however, run through multiple datasets, making them more compatible and comparable with each other. The validity of the qualitative research results stems from the interviewees being key experts in their fields and from the collected data being well saturated. As WMC and wooden retrofits are a rare phenomenon in the Finnish context, the number of experts in this field is limited. Thus, most of the relevant organizational actors were interviewed. Result reliability was ensured by precision in the systematic gathering, handling, and analysis of the results with multiple investigators.

Clearly, there are many unresolved questions in this thesis that deserve further research. The overall themes of circular economy and resilience are increasingly important to study to respond to globally increasing challenges. The circular economy and wooden construction contexts include many interesting streams of follow-up research that could be conducted in

the realm of less impactful renewable building materials and extending the life cycle of the existing building stock and all materials embedded in them following Holström et al. (2024) and Schellnhuber (2024). Resident experiences have been investigated regarding WMC and have typically provided good results with residents finding the wooden spaces comfortable, natural, warm, and healthy (Lakkala et al. 2020; Viholainen et al. 2020; Jussila et al. 2024). Resident experiences concerning sustainable retrofits have been beyond the scope of this thesis. However, they would be worth researching, especially if more systemic and sustainably ambitious retrofits with wood and NBS could be piloted more. The phenomenon of wooden retrofits linked with other sustainable innovations is worth looking into beyond the Finnish context. Circularity and wood reuse and its integration into business models offers possibilities for future research (Niu et al. 2021), also contributing to the less studied stream of research connecting sustainability transitions and business models (Köhler et al. 2019). Finally, urban resilience is a rising topic and worth investigating in various contextual settings and in comparative international settings, also aiming for more quantitative approaches instead of case studies among a few cities in Finland.

In this thesis, a few initial steps have been taken into investigating this fast-evolving and intriguing field of navigating via BEs towards sustainable urban built environments via the sub-studies and subsequent conceptual contribution portrayed in Figure 3. In conclusion, many future research pathways and needs for more efficient information flows are foreseen to make sustainable urban futures possible. Most importantly, the role of urban experimentation must be understood as pivotal (Bulkeley et al. 2019) in future research. It is clear that the ambition level must be higher in these experiments. Only then can the learning from project-to-project to replicate and scale-up experiments (Lazarevic et al. 2024) make a sustainable effect. And this is a route to mainstream systemic solutions for the urban built environment to achieve a true sustainability transition.

REFERENCES

Aarikka-Stenroos L, Ritala P (2017) Network management in the era of ecosystems: systematic review and management framework. Ind Mark Manag 67: 23–36. https://doi.org/10.1016/j.indmarman.2017.08.010.

Adner R (2016) Ecosystem as structure: An actionable construct for strategy. J Manage 43: 39–58. http://dx.doi.org/10.1177/0149206316678451

Adner R (2006) Match your innovation strategy to your innovation ecosystem. Harvard bus rev 84: 1–11.

Agarwal S, Kapoor R (2023) Value Creation Tradeoff in Business Ecosystems: Leveraging Complementarities While Managing Interdependencies. Organ sci 34: 1216–1242. https://orcid.org/0000-0003-3939-8207

Aksenova G, Kiviniemi A, Kocaturk T, Lejeune A (2019) From Finnish AEC knowledge ecosystem to business ecosystem: lessons learned from the national deployment of BIM. Const Manag Econ 37: 317–335. https://doi.org/10.1080/01446193.2018.1481985

Alvedalen J, Boschma R (2017) A critical review of entrepreneurial ecosystems research: Towards a future research agenda. Eur plan stud 25: 887– 903. http://dx.doi.org/10.1080/09654313.2017.1299694

Amer M, Attia S, (2019) Identification of sustainable criteria for decision-making on roof stacking construction method. Sustain Cities Soc 47: 1–14. https://doi.org/10.1016/j.scs.2019.101456.

Ansell C, Torfing, J (2021) Co-creation: The new kid on the block in public governance. Policy Polit 49: 211–230. https://doi.org/10.1332/030557321X16115951196045

Appio F, Lima M, Paroutis S (2019) Understanding smart cities: innovation ecosystems, technological advancements, and societal challenges. Technol Forecast Soc 142: 1–1. https://doi.org/10.1016/j.techfore.2018.12.018

Autio E (2022) Orchestrating ecosystems: a multi-layered framework. Innov Org Manag 24: 96–109. https://doi.org/10.1080/14479338.2021.1919120

Baldwin C, Bogers M, Kapoor R, West J (2024) Focusing the ecosystem lens on innovation studies. Res Policy 53: 1–13. https://doi.org/10.1016/j.respol.2023.104949

Banoun A, Dufour L, Andiappan M (2016) Evolution of a service ecosystem: Longitudinal evidence from multiple shared services centers based on the economies of worth framework. J Bus Res 69: 2990–2998. http://dx.doi.org/10.1016/j.jbusres.2016.02.032

Bell W (2009) Foundations of Futures Studies. History, Purposes and Knowledge. Human Science for a New Era, Volume 1. Transaction Publishers, New Brunswick (U.S.A.) and London (U.K.).

Bemelmans-Videc M-L, Rist R, Vedung E (1998) Carrots, Sticks & Sermons. Policy Instruments and Their Evaluation (Fifth Pape). Transaction Publishers.

Chen W, Wang G, Yang L, Huang C, Xu N, Gu T, Zeng J (2023) Spillover effects of urbanization on carbon emissions: A global view from 2000 to 2019. Environ Impact Asses 102: 1–13. https://doi.org/10.1016/j.eiar.2023.107182

Bengston D (2017) Ten Principles of Thinking about the Future: A Primer for Environmental Professionals. United States Department of Agriculture, Forest Service, Northern Research Station, General Technical Report NRS-175, December 2017. https://doi.org/10.2737/NRS-GTR-175

Blicharska M, Smithers R, Mikusiński G, Rönnbäck P, Harrison P, Nilsson M Sutherland W (2019) Biodiversity's contributions to sustainable development. Nat Sustain 2: 1083–1093. https://doi.org/10.1038/s41893-019-0417-9

Brown D (2018) Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Energy Effic 11: 1497–1517. https://doi.org/10.1007/s12053-018-9629-5.

Bulkeley H, Marvin S, Palgan Y, McCormick K, Breitfuss-Loidl M, Mai L, von Wirth T, Frantzeskaki N (2019) Urban living laboratories: Conducting the experimental city? Eur Urban Reg Stud 26: 317–335. https://uk.sagepub.com/en-gb/journals-permissions

Catala B, Savall T, Chaves-Avila R (2023) From entrepreneurial and innovation ecosystems to the social economy ecosystem. J Bus Res 163: 1–10. https://doi.org/10.1016/j.jbusres.2023.113932

Chen W, Wang G, Yang L, Huang C, Xu N, Gu T, Zeng J (2023) Spillover effects of urbanization on carbon emissions: A global view from 2000 to 2019. Environ Impact Asses 102: 1–13. https://doi.org/10.1016/j.eiar.2023.107182

Davies C, LaFortezza R (2019) Transitional path to the adoption of nature-based solutions. Land Use Policy 80 (2019) 406–409. https://doi.org/10.1016/j.landusepol.2018.09.020

Daymond J, Knight E, Rumyantseva M, Maguire E (2022): Managing ecosystem emergence and evolution: Strategies for ecosystem architects. Strat Mgmt J 44: 1–27. http://dx.doi.org/10.1002/smj.3449

De Jouvenel H (2000) A Brief Methodological Guide to Scenario Building. Technol Forecast Soc 65: 37–48.

Deserti A, Rizzo F (2018) A service design experiment in the Municipality of Turin to overcome organisational silos. In: Service Design Proof of Concept, Proceedings of the ServDes. 2018 Conference, Milano, Italy, (eds) A. Meroni, A. M. Ospina Medina, and Villari, B., pp 230–233.

De Vasconcelos Gomes L, Figueiredo Facin A, Salerno, M, Ikenami R (2018) Unpacking the innovation ecosystem construct: evolution, gaps and trends. Technol Forecast Soc 136: 30–48. http://dx.doi.org/10.1016/j.techfore.2016.11.009

D'Oca S, Ferrante A, Ferrer C, Pernetti R, Gralka A, Sebastian R, Veld P (2018) Technical, financial, and social barriers and challenges in deep building renovation: integration of lessons learned from the H2020 cluster projects. Buildings 8, article id 174. http://dx.doi.org/10.3390/buildings8120174

Dorst H, van der Jagt A, Toxopeus H, Tozer L, Raven R, Runhaar H (2022) What's behind the barriers? Uncovering structural conditions working against urban nature-based solutions. Landscape Urban Plan 220: 1–13. https://doi.org/10.1016/j.landurbplan.2021.104335.

Drisko J, Maschi T (2015) Content analysis. Oxford University Press, New York. https://doi.org/10.1093/acprof:oso/9780190215491.001.0001.

European Commission (EC) (2020b) A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. COM(2020) 662 final. Brussels, 14.10.2020.

European Commission (EC) (2024): EU Mission: Climate-Neutral and Smart Cities. Available at: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en Retrieved: 29.10.2024.

European Energy Agency (EEA) (2022) Building renovation: where circular economy and climate meet. Briefing. Available online: https://www.eea.europa.eu/publications/building-renovation-where-circular-economy Published: 7.7.2022, retrieved: 22.10.2024.

Erikshammar J, Gull A, Stehn L (2024) Innovation ecosystems beyond construction projects – a case study of Swedish cross laminated timber building networks. Wood Mater Sci Eng, 1–13. https://doi.org/10.1080/17480272.2024.2376180

Finnish Ministry of the Environment (2023) Parliament adopted acts that will reduce emissions from building and promote digitalization. Press release. Published in English on 7.3.2023. Available at: https://ym.fi/-/eduskunta-hyvaksyi-rakentamisen-paastoja-pienentavat-ja-digitalisaatiota-edistavat-lait?languageId=en_US Retrieved: 13.9.2024.

Fleck R, Gill R, Pettit T, Torpy F, Irga P (2022) Bio-solar green roofs increase solar energy output: The sunny side of integrating sustainable technologies. Build Environ 226: 1–10. https://doi.org/10.1016/j.buildenv.2022.109703

Foss N, Schmidt J, Teece D (2023) Ecosystem leadership as a dynamic capability. Long Range Plann 56: 1–16. https://doi.org/10.1016/j.lrp.2022.102270

Frantzeskaki N (2019) Seven lessons for planning nature-based solutions in cities. Environ Sci Policy 93: 101–111. https://doi.org/10.1016/j.envsci.2018.12.033

Franzini F, Berghäll S, Toppinen A, Toivonen R (2023) Planning for wooden multistorey construction in Finland: Insights from Finnish municipal civil servants. Eur Plan Stud 31: 168–188. https://doi.org/10.1080/09654313.2022.2116271

Franzini F, Toivonen R, Toppinen A (2018) Why not wood? Benefits and barriers of wood as a multistory construction material: perceptions of municipal civil servants from Finland. Buildings 8: 1–15. https://doi.org/10.3390/buildings8110159.

Glenn J (1994) Introduction to the Futures Research Methodology Series. AC/UNU Millennium 704 Project, Futures Research Methodology, 1–45.

Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme (GlobalABC, IEA & UNEP) (2019) 2019 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Available at: https://iea.blob.core.windows.net/assets/3da9daf9-ef75-4a37-b3da-

a09224e299dc/2019_Global_Status_Report_for_Buildings_and_Construction.pdf. Accessed 1.9.2022.

Gobben D, Ooms W, Roijakkers N, Radziwon A (2022) Ecosystem types: A systematic review on boundaries and goals. J Bus Res 142: 138–164. https://doi.org/10.1016/j.jbusres.2021.12.046

Granstrand O, Holgersson M (2020) Innovation ecosystems: a conceptual review and a new definition. Technovation 90: 1–12. https://doi.org/10.1016/j.technovation.2019.102098

Hasik V, Escott E, Bates R, Carlisle S, Faircloth B, Bilec M (2019) Comparative whole-building life cycle assessment of renovation and new construction. Build Environ 161: 1–10. https://doi.org/10.1016/j.buildenv.2019.106218

Heikkilä M, Kuivaniemi L (2012) Ecosystem under construction: an action research study on entrepreneurship in a business ecosystem. Technology innovation Manag Rev 6: 18–24. https://doi.org/10.22215/timreview/564

Helfat C, Finkelstein S, Mitchell W, Peteraf M, Singh H, Teece D, Winter S (2007) Dynamic Capabilities. Understanding Strategic Change in Organizations. Blackwell Publishing Ltd., Malden, USA, Oxford, UK & Carlton, Australia.

Hjaltadóttir R, Hild P (2021) Circular economy in the building industry European policy and local practices. Eur Plan Stud 29: 2226–2251. https://doi.org/10.1080/09654313.2021.1904838

Holtström J, Kenlind S, Nord T (2024) Project-based business models in the construction industry – key success factors for sustainable timber extension projects. Const Manag Econ. https://doi.org/10.1080/01446193.2024.2312158

Iansiti, M., Levien, R. (2004) Keystones and dominators: framing operating and technology strategy in a business ecosystem. Harvard Business School, Working Paper, 3–61.

Jungmeister A (2016) Innovation and reflectivity in the research process. Cambridge Scholars Publishing. EBSCOhost Academic Collection. ISBN 978-1-4438-0003-7.

Jussila J, Franzini F, Häyrinen L, Lähtinen K, Nagy E, Mark-Herbert C, Roos A, Toppinen A, Toivonen R (2024) Consumer housing choices among residents living in wooden multi-storey buildings. Housing Stud 39: 2654-2679, https://doi.org/10.1080/02673037.2023.2217765

Jussila J, Lähtinen K (2020) Effects of institutional practices on delays in construction–views of Finnish homebuilder families. Housing Stud 35: 1167–1193. https://doi.org/10.1080/02673037.2019.1651831.

Kabisch N, Frantzeskaki N, Pauleit S, Naumann S, Davis M, Artmann M, Haase D, Knapp S, Korn H, Stadler J, Zaunberger K, Bonn A (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecol Soc 21(2):39. http://dx.doi.org/10.5751/ES-08373-210239

Kampelmann S (2021) Knock on wood: Business models for urban wood could overcome financing and governance challenges faced by nature-based solutions. Urban For Urban Gree 62: 1–11. https://doi.org/10.1016/j.ufug.2021.127108

Kanninen V, Ryöppy S, Lähtinen K, Toppinen A (2024) Actor perceptions and network characteristics around climate-wise housing and construction in Finland. Build Res Inf 52: 941–956. https://doi.org/10.1080/09613218.2024.2376251

Karvonen A (2013) Towards systemic domestic retrofit: a social practices approach. Build Res Inf 41: 563–574. https://doi.org/10.1080/09613218.2013.805298.

Kern F, Rogge K, Howlett M (2019) Policy mixes for sustainability transitions: new approaches and insights through bridging innovation and policy studies. Res Policy 48: 1–16. https://doi.org/10.1016/j.respol.2019.103832.

Killip G, Owen A, Topouzi M (2020) Exploring the practices and roles of UK construction manufacturers and merchants in relation to housing energy retrofit. J Clean Prod 251: 1–12. https://doi.org/10.1016/j.jclepro.2019.119205

Kim J, Sovacool B, Bazilian M, Griffiths S, Yang M (2024) Energy, material, and resource efficiency for industrial decarbonization: A systematic review of sociotechnical systems, technological innovations, and policy options. Energy Res Soc Sci 112: 1–32. https://doi.org/10.1016/j.erss.2024.103521

Kinnunen A, Talvitie I, Ottelin J, Heinonen J, Junnila S (2022) Carbon sequestration and storage potential of urban residential environment – a review. Sustain Cities Soc 84: 1–12. https://doi.org/10.1016/j.scs.2022.104027.

Kivimaa P, Hilden M, Huitema D, Jordan A, Newig J (2017) Experiments in climate governance. A systematic review of research on energy and built environment transitions. J Clean Prod 169: 17–29. http://dx.doi.org/10.1016/j.jclepro.2017.01.027

Köhler J, Geels F, Kern F, Markard J, Onsongo E, Wieczorek A, Alkemade F, Avelino F, Bergek A, Boons F, Fünfschilling L, Hess D, Holtz G, Hyysalo S, Jenkins K, Kivimaa P, Martiskainen M, McMeeking A, Mühlemeier M, Nykvist B, Pel B, Raven R, Rohracher H, Sandén B, Schot J, Sovacool B, Turnheim B, Welch D, Wells P (2019) An agenda for sustainability transitions research: State of the art and future directions. Environ Innov Soc Transit 31: 1–32. https://doi.org/10.1016/j.eist.2019.01.004

Lakkala M, Luusua A, Pihlajaniemi J (2020) Finnish perceptions of log and log architecture, Scandinavian J Forest Res-jpn, 35: 296–307, https://doi.org/10.1080/02673037.2023.2217765

Lampert A (2019) Over-exploitation of natural resources is followed by inevitable declines in economic growth and discount rate. Nat Commun 10: 1–10. https://doi.org/10.1038/s41467-019-09246-2

Langemeyer J, Madrid-Lopez D, Beltran A, Mendez G (2021) Urban agriculture — A necessary pathway towards urban resilience and global sustainability? Landscape and Urban Planning 210: 1–8. https://doi.org/10.1016/j.landurbplan.2021.10405

Lazarevic D, Kautto P, Antikainen R (2020) Finland's wood-frame multi-storey construction innovation system: Analysing motors of creative destruction. Forest Policy Econ 110: 1–11 https://doi.org/10.1016/j.forpol.2019.01.006.

Lazarevic D, Mokkila S, Kivimaa P, Lukkarinen J, Toppinen A (2024) Municipal experimental policy engagements in the built environment. Environ Innov Soc Transit, 52: 1–17. https://doi.org/10.1016/j.eist.2024.100888

Lenton T, Benson S, Smith T, Ewer T, Lanel V, Petykowski E, Powell T, Abrams J, Blomsma F, Sharpe, S (2022): Operationalising positive tipping points towards global sustainability. Glob Sustain 5: 1–16. https://doi.org/10.1017/sus.2021.30

Lenton T, Rockström J, Gaffney O, Rahmstorf S, Richardson K, Steffen W, Schellnhuber H (2019) Climate tipping points — too risky to bet against. Nature, vol. 575, 592–595.

Lima L, Trindade E, Alencar L, Alencar M, Silva L (2021) Sustainability in the construction industry: a systematic review of the literature. J Clean Prod 289 https://doi.org/10.1016/j.jclepro.2020.125730.

Linde L, Sjödin D, Parida V, Wincent J (2021) Dynamic capabilities for ecosystem orchestration A capability-based framework for smart city innovation initiatives. Technol Forecast Soc 166. https://doi.org/10.1016/j.techfore.2021.120614

Logan T, Aven T, Guikema S, Flage R (2022) Risk science offers an integrated approach to resilience. Nat Sustain 5: 741–748. https://www.nature.com/articles/s41893-022-00893-w

Mey F, Lilliestam J (2022) Tipping points in transitions of socio-economic systems. In: Vélez-Cuartas G, Romero-Goyeneche O (Eds), Transformative metrics: contributions to the studies for monitoring and evaluating how science, technology, and innovation can address social and environmental challenges pp. 125-158. Medellín: Universidad de Antioquia, Fondo Editorial FCSH de la Facultad de Ciencias Sociales y Humanas.

Moore J (1993) Predators and prey: a new ecology of competition. Harv Bus Rev 71: 75–86.

Moore J (1998) The rise of a new corporate form. Wash Q 21: 167–181. https://doi.org/10.1080/01636609809550301.

Moore J (2006) Business ecosystems and the view from the firm. Antitrust Bull 51: 31–75. https://doi.org/10.1177/0003603X0605100103.

Mukhtar-Landgren D, Kronsell A, Voytenko Palgan Y, von Wirth, T (2019) Municipalities as enablers in urban experimentation. J Environ Pol Plan 21: 718–733. https://doi.org/10.1080/1523908X.2019.1672525

Niu Y, Rasi K, Highes M, Halme M, Fink G (2021) Prolonging life cycles of construction materials and combating climate change by cascading: The case of reusing timber in Finland. Resour Conserv Recy 170: 1–10. https://doi.org/10.1016/j.resconrec.2021.105555

Norvasuo M (2021) Yhä ylöspäin? Suomalaisen puurakentamisen kaavoitusperiaatteita etsimässä. Yhdyskuntasuunnittelu 59: 2–3. https://doi.org/10.33357/ys.101737

Pacheco-Vega R (2020) Environmental regulation, governance, and policy instruments, 20 years after the stick, carrot, and sermon typology. J Environ Pol Plan, https://doi.org/10.1080/1523908X.2020.1792862

Piccardo C, Alam A, Hughes, M (2021) The potential contribution of wood in green building certifications. Archit. Res. Finland 5 (1). https://doi.org/10.37457/arf.113262.

Pulkka L, Ristimäki M, Rajakallio K, Junnila S (2016) Applicability and benefits of the ecosystem concept in the construction industry. Const Manag Econ, 34: 129–144. https://doi.org/10.1080/01446193.2016.1179773

Rajakallio K, Cuthbertson R, Pulkka L, Junnila S (2018) Creating urban platforms – opportunities and challenges for innovation in commercial real estate development. Cities 77: 92–103. https://doi.org/10.1016/j.cities.2018.01.016.

Raymond C, Frantzeskaki N, Kabisch N, Berry P, Breil M, Nita M, Geneletti D, Calfapietra C (2017) A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environ Sci Policy, 77: 15–24. https://doi.org/10.1016/j.envsci.2017.07.008.

Ribeiro P, Gonçalves L (2019) Urban resilience: A conceptual framework. Sustain Cities Soc 50: 1–11. https://doi.org/10.1016/j.scs.2019.101625

Richardson K, Steffen W, Lucht W, Bendtsen J, Cornell S, Donges J, Drüke M, Fetzer I, Bala G, von Bloh W, Feulner G, Fiedler S, Gerten D, Gleeson T, Hofmann M, Huiskamp W, Kummu M, Mohan C, Nogués-Bravo D, Petri S, Porkka M, Rahmstorf S, Schaphoff S, Thonicke K, Tobian A, Virkki V, Wang-Erlandsson L, Weber L, Rockström J (2023) Earth beyond six of nine planetary boundaries. Sci Adv 9, eadh2458 (2023). https://doi.org/10.1126/sciadv.adh2458

Rockström J, Steffen W, Noone K, Persson Å, Chapin, F, Lambin E, Lenton T, Scheffer M, Folke C, Schellnhuber H, Nykvist B, de Wit C, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder P, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell R, Fabry V, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley J (2009): A safe operating space for humanity. Nature, 461: 472–475. https://doi.org/10.1038/461472a

Rosenbloom, D. (2017) Pathways: An emerging concept for the theory and governance of low-carbon transitions. Global Environ Change 43: 37–50. http://dx.doi.org/10.1016/j.gloenvcha.2016.12.011

Salmi A, Jussila J, Hämäläinen M (2022) The role of municipalities in transformation towards more sustainable construction: the case of wood construction in Finland. Constr Manag Econ 1–21. https://doi.org/10.1080/01446193.2022.2037145

Sandberg K, Orskaug T, Andersson A (2016) Prefabricated wood elements for sustainable renovation of residential building Façades. Energy Procedia 96: 756–767. https://doi.org/10.1016/j.egypro.2016.09.138.

Sanders E, Stappers P (2008) Co-creation and the new landscapes of design. Co-design 4 (1): 5-18. https://doi.org/10.1080/15710880701875068

Schellnhuber H (2024) Bauhaus Earth. Sustainable Use of Wood in the Construction Sector. In: K. Wiegandt (ed) (2024): 3 Degrees More. The Impending Hot Season and How Nature can Help us Prevent it. https://doi.org/10.1007/978-3-031-58144-1_8#DOI

Silverman D (2000) Doing qualitative research. A practical handbook. Sage, London.

Sim J, Waterfield, J (2019) Focus group methodology: some ethical challenges. Quality & Quantity, 53: 3003–3022. https://doi.org/10.1007/s11135-019-00914-5

Statistics Finland (2024): Kuntien avainluvut. Available at: https://stat.fi/tup/alue/kuntienavainluvut.html#?year=2023&active1=SSS (In Finnish only). Retrieved 11.10.2024.

Statistics Finland (2021): Rakentamisen trendit ja muutokset huomioidaan rakennuskustannus-indeksin uudistamisessa. Informartional article by Statistics Finland and by Liina Arhosalo 1.10.2021. Available at: https://stat.fi/tietotrendit/artikkelit/2021/rakentamisen-trendit-ja-muutokset-huomioidaan-rakennuskustannusindeksin-uudistamisessa (In Finnish only). Retrieved 13.9.2024.

Stehn L, Engström S, Uusitalo P, Lavikka R (2021) Understanding industrialised house building as a company's dynamic capabilities. Constr Innov 21: 5–21. https://doi.org/10.1108/CI-09-2019-0086.

Stickdorn M, Schneider J (2010) This is Service Design Thinking: Basics, Tools, Cases. Hoboken, NJ: John Wiley & Sons.

Teece D (2009) Dynamic capabilities & strategic management. Organizing for Innovation and Growth. Oxford University Press Inc., New York.

Teece D, Peteraf M, Leih S (2016) Dynamic capabilities and organizational agility: risk, uncertainty, and strategy in the innovation economy. Calif Manag Rev 58: 13–35. https://doi.org/10.1525/cmr.2016.58.4.13.

Toivonen R, Lilja A, Vihemäki H, Toppinen A (2021) Future export markets of industrial wood construction – a qualitative backcasting study. Forest Policy Econ. 128, 102480. https://doi.org/10.1016/j.forpol.2021.102480

Toppinen A, Röhr A, Pätäri S, Lähtinen K, Toivonen R (2018) The future of wooden multistory construction in the forest bioeconomy – A Delphi study from Finland and Sweden. J For Econ 31: 3–10. https://doi.org/10.1016/j.jfe.2017.05.001

Toppinen A, Miilumäki N, Vihemäki H, Toivonen R, Lähtinen K (2019) Collaboration and shared logic for creating value-added in three Finnish wooden multi-storey building projects. Wood Mater Sc. Eng 14 (5), 269–279. https://doi.org/10.1080/17480272.2019.1653365.

Toppinen A, Aaltio A, Lähtinen K, Jussila J, Toivonen, R (2022) "It all depends on the project"—A business ecosystem in residential wooden multistory construction in Finland. Front Built Environ, 8:1046954. https://doi.org/10.3389/fbuil.2022.1046954

Tozer L, Bulkeley H, Kiss B, Luque-Ayala A, Palgan Y, McCormick K, Wamsler C (2023) Nature for Resilience? The Politics of Governing Urban Nature, Ann Assoc Am Geogr, 113: 599-615, https://doi.org/10.1080/24694452.2022.2130867

van der Jagt A, Ravena R, Dorst H, Runhaar H (2020) Nature-based innovation systems. Environ Innov Soc Transit, 35: 202-216. https://doi.org/10.1016/j.eist.2019.09.005

Vergragt P, Quist, J (2011) Backcasting for sustainability: Introduction to the special issue. Technol Forecast Soc 78 (2011) 747–755. https://doi.org/10.1016/j.techfore.2011.03.010

Vigren O (2024) Ecosystems in construction management and urban development: a comprehensive review of conceptualizations and contributions, Const Manag Econ, 42: 164–183, https://doi.org/10.1080/01446193.2023.2247496

Vihemäki H, Ludvig A, Toivonen R, Toppinen A, Weiss G (2019) Institutional and policy frameworks shaping the wooden multi-storey construction markets: a comparative case study on Austria and Finland. Wood Mater Sci Eng 14: 312–324. https://doi.org/10.1080/17480272.2019.1641741.

Viholainen N, Kylkilahti E, Autio M, Toppinen A (2020) A home made of wood: Consumer experiences of wooden building materials. Int J Consum Stud, 44: 542–551. https://doi.org/10.1111/ijcs.12586

Viholainen N, Kylkilahti E, Autio M, Pöyhönen J, Toppinen A (2021) Bringing ecosystem thinking to sustainability-driven wooden construction business. J Clean Prod 292 https://doi.org/10.1016/j.jclepro.2021.126029.

Wardekker A, Wilk B, Brown W, Uittenbroek C, Mees H, Driessen P, Wassen M, Molenaar A, Walda J, Runhaar H (2020) A diagnostic tool for supporting policymaking on urban resilience. Cities 101 (2020) 102691. https://doi.org/10.1016/j.cities.2020.102691

Webb R, Bai X, Smith M, Costanza R, Griggs D, Moglia M, Neuman M, Newman P, Newton P, Norman B, Ryan C, Schandl H, Steffen W, Tapper N, Thompson G (2018) Sustainable urban systems: Co-design and framing for transformation. Ambio 47: 57-77. https://doi.org/10.1007/s13280-017-0934-6

Wiegand E, Ramage M (2021) The impact of policy instruments on the first generation of Tall Wood Buildings. Build Res Inf, 1–21. https://doi.org/10.1080/09613218.2021.1905501

Wijnants L, Allacker K, De Troyer F (2019) Life-cycle assessment of timber frame constructions – the case of rooftop extensions. J Clean Prod 216: 333–345. https://doi.org/10.1016/j.jclepro.2018.12.278.

APPENDICES

Appendix 1: Organizations and their informants of the dissertation with affiliated projects

Code	Articles	BE actor type	Informants (No.)	Affiliated projects			Description of affiliations on projects researched; organizational informant selection criteria
				Wooden retrofit	*New wooden multistory*	*Nature-based solutions*	
O-1	I, II	Wood element producer	1	7	6	-	Producer in many projects in different geographical locations, e.g., Helsinki, Tampere, and Turku. Specialty: wooden rooftop stackings
O-2	I, II	Construction company	1	3	1	-	Specialty: Wooden rooftop stackings & a façade replacement
O-3	I, II	Energy efficiency service provider	1	1	-	-	Case of wooden rooftop stacking project in combination with energy renovations
O-4	I, II	Knowledge broker	1	-	1	-	Organization has been part wooden construction related projects, information guidance on the topic and part of creating local city's Wood Program that led to the construction of wooden city area. Also, they had investigated the wooden rooftop stackings locally.
O-5	I, II	Knowledge broker	1	-	1	-	Organization involved in formation of local wood program that led to a construction of one city's wooden district.
O-6	I, II IV	Architectural company	3	2	1	1	Architectural firm with experience and experiments on all of the studied phenomena.
O-7	I, II	City owned rental housing company	1	1	1	-	Commissioned a wooden multistory building and provided a site for an idea competition for an ambitious wooden retrofit experiment

O-8	I, II, IV	Design engineers	3	1	11	-	Many wooden multistory building projects and a wooden retrofit project. Written a guidebook on resilient building and informed on the topic, link to nature-based solutions in building yet number of projects unknown.
O-9	I, II, IV	Design engineers	4	2	12	1	Many wooden multistory building projects and 2 known wooden rooftop stackings, also part of planning a greener city district in one case city.
O-10	I, II	Design engineers, a group building consultant	1	2	-	-	Consultant in group building of wooden rooftop stackings, one completed another one started at the time of the interview.
O-11	I, II	Construction company	1	10	-	-	Many rooftop stackings at one case city area, in some projects they have significantly used wood (in some not).
O-12	I, II	Housing company	1	1	-	-	Wooden rooftop stacking project from a privately owned housing company perspective
O-13	I, II, IV	Design engineers	2	2	3	1	Projects linked with all of the studied phenomena.
O-14	I, II	City E (Tampere)	2	-	1	-	Around half of all detected wooden retrofits / rooftop stackings were located in this city at the time of the interviews, even if city itself has not been building them, it led in the number of projects. Former city wood program led to construction of a wooden district area in the city.
O-15	I, II, III, IV	City D (Helsinki)	16	1	4	1	Big city and with its housing production unit involved with examples of wooden multistory construction and wooden districts, and during the interviews second largest number of wooden retrofits were detected to be located there. Many nature-based solutions projects are located in the city and at least one has been commissioned by the city. City has been part of co-creation process and interested in promoting sensible retrofitting.
O-16	I, II, III, IV	City C (Turku)	11	1	1	1	The city has piloted a wooden city district and been in the background of a wooden retrofit project built to a nearby municipality. The city has initiatives with policy instruments that promote the adoption of nature-based solutions in few sites. City has been part of co-creation process and interested in promoting sensible retrofitting.
O-17	I, II, III	City B (Vantaa)	11	-	-	-	A couple of wooden multistory buildings constructed in the city area (even if not by the city itself). City has been part of co-creation process and interested in promoting sensible retrofitting.

O-18	I, II, III	City A (Joensuu)	7	-	-	-	Wooden multistory construction has been piloted in the city area (at least 3 times) and identifies itself as “wooden city”. City has been part of the municipality co-creation process.
O-19	I	Construction company	3	-	2	-	The organization is traceable to at least two wooden multistory projects but was interviewed only in the context of one case project.
O-20	I	Architectural company	1	-	1	-	Traceable and interviewed in the context of one wooden multistory building only.
O-21	I	Construction company	1	-	2	1	The organization is traceable to at least two wooden multistory projects and a project with nature-based solutions but was interviewed only in the context of one wooden multistory case project only.
O-22	I	Architectural company	1	-	1	-	Traceable and interviewed in the context of one wooden multistory building only.
O-23	I, IV	Construction and development company	3	-	4	1	For article I the organizational informants have been interviewed in the context of one wooden multistory project context only. For article IV the organization has provided information on urban resilience and nature-based solutions context.
O-24	I	Construction company specializing in wooden construction	1	-	1	-	Traceable and interviewed in the context of one wooden multistory building only.
O-25	I	Design engineers	1	1	1	-	Interviewed in the context of one wooden multistory building only.
O-26	III	Stakeholder and project for city B	1	-	-	-	Project with new operational model of neighboring housing companies collaborating together on retrofits, especially energy retrofits. Part of the municipality co-creation process.
O-27	III	City-owned rental housing company	1	-	2	-	City stakeholder with experience on piloting wooden multistory buildings. Part of the municipality co-creation process.
O-28	III	Intermediary organization	1	-	-	-	Non-profit organization promoting (among other things) climate-wise living. Part of the municipality co-creation process.

O-29	III	Intermediary organization	1	-	-	-	Environmental information provider. Part of the municipality co-creation process.
O-30	III	City-owned rental housing company	1	-	-	-	Part of the municipality co-creation process.
O-31	III	Intermediary organization	1	-	-	-	Regional business support services. Part of the municipality co-creation process.
O-32	III	Retrofit company	2	-	-	-	Part of the municipality co-creation process.
O-33	IV	Design engineers	1	1	-	1	Even if this organization could be traced to one wooden retrofit project, it was interviewed solely on the thematic of nature-based solutions. The organization has produced an information package on nature-based solutions and can be traced to at least one project on this.
O-34	IV	Building developer and green construction solutions provider	3	-	-	140	Building developer with also green roofs and other nature-based solutions in their portfolio and the company lists e.g., 140 green roofs located around Finland as references.
O-35	IV	Architectural company	2	-	2	1	The company has produced a concept for green urban block and at least to wooden multistory constructions.
O-36	IV	Landscape architectural company	1	-	-	1	Part of designing a green urban block in one of the case cities.
O-37	IV	Knowledge broker	1	-	-	-	Intricate knowledge on nature-based solutions thematic in case cities.

Appendix 2 Municipality interview guide

Municipality representatives were interviewed with following questions and themes. Other actors interviewed were asked if in the projects they have learned how municipalities could by their action enforce the success of projects especially from the perspective of the use of wood.

Retrofits and rooftop stacking

1. What is the role and need of retrofits in your city?
2. What is woods significance in retrofits?
3. What is rooftop stackings' role in your city design?
4. What good and what bad experiences have emerged from the point of view of your city in the realized projects of retrofits and rooftop stacking?
5. What have been the obstacles, if the amount of these projects has been low?

City's possibilities to promote wooden building

6. What concrete measures have been done in your city to promote wooden retrofits?
7. Do the current plan regulations, in your opinion, give sufficient possibilities to enhance wooden rooftop stacking?

The regional economic effects of wooden building

8. What kinds of regional economic effects do you see wooden building having in your city?
9. Do these have impact on the set target for wooden building as an instrument to your city's low carbon building?

The significance of the intangible values of wooden building material

10. What significance do the intangible values have in the planning of your city's retrofits or rooftop stacking?

Actor roles and cooperation in the wooden building projects

11. How do you see the city's role in the field of wooden retrofits?
12. Which actors have the most important role in wooden retrofits and rooftop stacking?
13. What kind of know-how could there still be in your city's actor network?
14. Which actors do you see having the most important role for the future of wooden retrofits and rooftop stacking?
15. What has been functioning in the inner cooperation of your city? Do you feel the administrative model of your city gives sufficiently flexible opportunities in using wooden building material in different building sites?
16. Which actors do you see as the most important cooperative partners in the field of wooden construction? And in more detail concerning wooden retrofits and rooftop stacking?

Using wooden building material in the future

17. How likely do you see the generalization of wooden retrofits in your city?
18. Does your city have certain measures or tools which enable you to distinguish yourself from other cities as the innovative user of wooden building material?
19. Does the potential diminishing of the carbon footprint of the other building materials affect your plans towards city's building materials?

Appendix 3 Interview guides of companies involved with WMC and wooden retrofits

The first interview phase included five different interview guides that were modified based of interviewee organizational grouping, but they were more or less following the basic structure of the following interview guide no 1. Depending on the actor group that particular interviewee represented the questions were modified to represent that point of view, either the producing company with involvement on both WMC and wooden retrofits; or company with involvement solely with wooden retrofits; or that of the owners and investors, or that of the municipality; or an intermediary organization.

Background: Interviewee, company, and projects

1) Please, tell me shortly about yourself, who are you and what is your position in the company you represent?
2) Would you describe in your own words of the residential construction projects in which the use of wood has been significant, especially related to retrofits (e.g., rooftop stackings), but also from the side of new construction? How has the use of wood been significant in these projects?
3) Have the projects relating to wood use been established practice to your company, or have they been experimental projects?

Relationship between new WMC and wooden retrofits projects

4) What kinds of roles / tasks have your company had in the new construction projects, in which the use of wood has been significant? Have the roles/tasks of the company you represent been the same in the retrofit projects?
5) Has company you represent in your opinion been a promoter of innovations relating to wood use in construction (yes/no)?
6) Have the municipalities in which the projects have been located been in a special role in implementation of wood use based new construction or retrofit projects?
7) Has there been lessons learned in your opinion especially on the ways that the municipalities could with their actions strengthen the success of projects especially from the point of view of wood use? Have you recognized other actors, who could strengthen the implementation and success of projects especially from the point of view of wood use?
8) Are there the same collaborative partners in both new construction and in retrofit projects? In what issues in particular have the potential linkages between the new construction and retrofits either inside your own company or with other actors have promoted the generalization of wood use or the related knowhow? Or in what way could the cooperation in its best promote wooden construction and especially wooden retrofits in the future?

Special focus on wooden retrofit projects

9) With which actors have you collaborated in retrofit projects in particular? What kind of cooperation it has entailed and what have been its benefits to your company and the whole project? Do the actors and cooperation differ from the new construction projects?
10) Who of the actors were in your opinion the key in different projects? Who led these different projects?
11) What kind of role has the retrofit building/site owners or investors had in retrofit projects in which the use of wood has been in special role?
12) What kind of role could the different owners and investors have at their best in implementing and promoting wooden retrofits?
13) Do the building solutions based on wood use have in your opinion special strengths, which could benefit especially the development of building retrofits? Are there currently enough possibilities in using wood in retrofits?
14) Are renewals/changes/development needed for wooden supplementary building/rooftop stacking or in retrofit solutions based on wood use in Finland? By your experience is some knowhow lacking from Finland or your area, which for instance became clear during your own projects?
15) What has been learned from the implemented retrofit projects based on wood, for instance their challenges or observed possibilities?

Pillars of sustainable development and low carbon promotion in the society

16) Did low carbon goals have any significance in your projects? How was this visible in different stages of execution? Did different project implementing partners emphasize low carbon aspects during the projects? If the different partners/actors emphasized low carbon aspects, who were they?
17) Was there something in the network or its structure that promoted low carbon building?
18) As you are looking back on it, what kinds of benefits has there been of your project(s)?
19) What kinds of benefits would you see there to be, if wooden construction and retrofits would spread widely to the society? And who should in your opinion make this change?
20) Were there some lessons learned from these projects that other actors in construction sector or in the society should know about as new similar projects are planned in the future? What is your message to other actors in the field and in the society based on your own experience?

Appendix 4 Second round interview guides

Background information

1. Would you shortly tell who you are and what do you do in the organization you represent?

Theme 1. Nature-based solutions in housing construction

2. Are you familiar with the concept of nature-based solutions?
3. How do you see the importance of nature-based solutions as part of housing construction?

4. Do you recognize certain characteristics or qualities which affect the perception of using nature-based solutions in housing construction?
5. What kind of examples or experiences do you have about nature-based solutions or operations models related to use of nature-based solutions?

Theme 2. Low-carbon and sustainable housing construction

6. How are the low-carbon goals visible in housing construction?
7. What is the role of nature-based solutions for low-carbon housing construction?
8. What kind of examples or experiences do you have about low-carbon solutions or low-carbon operations models?

Theme 3. Actors and cooperation

9. What actors can be identified working with nature-based solutions in built residential environments?
10. How the cooperation between different actors is currently working?
11. Who do you see to be in a key role in construction projects using nature-based solutions?
12. How could companies and cities promote business around nature-based solutions?

Theme 4. Resilience of cities and residential environments

13. What do you think the resilience of cities and of residential environments means?
14. What role does nature-based solutions have for urban environment resilience and for climate solutions?

Theme 5. Prospects

15. Do you see nature-based solutions to be a part of the housing construction industry in the future?
16. What measures or actions would have an effective impact on mainstreaming nature-based solutions and adopting them to the housing construction culture?
17. What factors slow down or even act as a barrier for mainstreamed use of nature-based solutions?

Finally

18. Is there something else that you would like to bring up or comment on, or know more about the research project?

Appendix 5: Municipality workshop series discussion topics

Workshop 3 Task description for ideating

Pre-task:
• Picture in your own mind living around 10 years ago and mark it down to Post-it notes: 1-3 things that come to your mind for later discussions.
• What kinds of carbon wise solutions municipalities offer in 2022?
• VISION: Picture yourself in the year 2035. What is preferable carbon wise living like? Who all are the actors of housing service solutions and in what roles?

Following task with discussion on overall topic of 'vision of carbon wise living as a housing service':
• Current situation: How are the carbon wise living solutions managed in cities and serviced these solutions are?
• Actors: To whom and how the municipality should offer carbon wise services?
• Vision: What kinds of carbon wise service pallets exist in 2030s?

Appendix 6 Workshop discussion themes for nature-based and urban resilience

Workshop 1: Nature-based solutions as a part of sustainable built environment

Group discussion – part 1: Nature-based solutions in construction and housing
1. What is the meaning/relevance/importance of nature-based solutions in residential construction? What purpose they are designed for? For whom they are of benefit?
2. What is meant by resilience of residential environment? What kind of risks and threats against resilience these nature-based solutions could be answers for? What examples could arise from the area?

Group discussion – part 2: Actors and cooperation
3. What kind of actors are known to operate with nature-based solutions in residential environments (e.g., municipalities, producers, consumers, and other advocates)?
4. How the cooperation between actors is working at the moment?
5. Is there a need to bring (e.g., novel) actors together and if so, how?
6. How could cities and businesses together foster nature-based solution business?

Group discussion – part 3: Future and the city
7. What would a desirable and perhaps ambitious future vision of nature-based solutions be like in Turku in 2050? (Everyone thinks one subject related vision statement, that represents a desirable future for the city from your organization's point of view.)
8. What steps have had to be taken to achieve the vision of the year 2050 with nature-based solutions? (Backcasting: what must be done in the long run (years 2040-2050), in medium-term (2027-2040) and in short-term planning (2023-2027)?) Elements could be for example:
a. Economy: Innovation, marketing, local market – export
b. Environment: Expected opportunities and risks
c. City and its stakeholders, networks
d. Policy instruments of the city, urban environment development

Workshop 2: Resilient built environment by sustainable regional planning

Group discussion – part 1: Definition of urban environment resilience

1. How would you define resilience of urban environment?
2. What climate change related risks should the built environment be guarded against in Helsinki? What are probable and increasing risks? What extreme weather events threaten the resilience in Helsinki?
3. How biodiversity and urban environment resilience are connected?
4. How regional planning of built environment can foster urban resilience?

Group discussion – part 2: Actors and cooperation
5. Which actors affect the resilience of the built environment in regional planning (e.g., municipalities, producers, consumers, and other advocates)?
6. How does the cooperation currently work, is there a need to bring (e.g., novel) actors together and if so, how?
7. How could cities and businesses together promote business improving built environment resilience?

Group discussion – part 3: Future and the city
8. What would a desirable and perhaps ambitious future vision of resilient urban environment be like in Helsinki in 2050? (Everyone thinks one subject related vision statement, that represents a desirable future for the city from your organization's point of view.)
9. What steps have had to be taken to achieve the vision of the year 2050? (Back casting view: what must be done in the long run (years 2040-2050), in medium-term (2027-2040) and in short-term planning (2023-2027)?)

Appendix 7 Municipality documents under analysis

Helsinki

H-1 City of Helsinki (2021): A Place of Growth. Helsinki City Strategy 2021–2015. Available at: helsinki-city-strategy-2021-2025.pdf. Retrieved: 17.10.2023.
H-2 City of Helsinki (2021): Asumisen ja siihen liittyvän maankäytön toteutusohjelma 2020. Helsingin kaupungin keskushallinnon julkaisuja 2021:1. Available at: https://www.hel.fi/static/kanslia/Julkaisut/Kotikaupunkina-Helsinki/2020/Asumisen_ja_maankayton_ohjelma_2020.pdf. Retrieved: 9.1.2024.
H-3 City of Helsinki (2006): Helsinkiläinen kerrostaloatlas 2006. Helsingin kaupunginsuunnitteluvirasto 2006. Available at: https://www.hel.fi/static/liitteet/kanslia/aluerakentaminen/kehittyvakerrostalo/Julkaisut/helsinkilainen-kerrostaloatlas-2006.pdf. Retrieved: 9.1.2024.
H-4 City of Helsinki (2008): Kerrostalojen kehittäminen Helsingissä. Available at: https://www.hel.fi/static/liitteet/kanslia/aluerakentaminen/kehittyvakerrostalo/Julkaisut/kerrostalojen-kehittaminen-helsingissa.pdf. Helsingin kaupunkisuunnitteluvirasto. Retrieved: 9.1.2024.

Joensuu

J-1 City of Joensuu (2023): Helppo hengittää. Joensuun strategia 2021–2025. Puolivälitarkastelu 8/2023. Available at:

https://www.joensuu.fi/documents/144181/1835043/joensuu_strategia_2021-2025.pdf. Retrieved: 9.1.2024.
J-2 City of Joensuu (2021): Hiilineutraali Joensuu 2025. Joensuun kaupungin ilmasto-ohjelma 2022–2025. Available at: https://www.joensuu.fi/documents/144181/0/Joensuun+kaupungin+ilmasto-ohjelma+2022%E2%80%932025.pdf. Retrieved: 9.1.2024.
J-3 City of Joensuu (2023): Joensuun kaupungin asuntopoliittinen ohjelma. Available at: https://www.joensuu.fi/documents/144181/2331533/Joensuun+kaupungin+asuntopoliittinen+ohjelma.pdf/804e95ce-6274-fbb1-6194-8997420808a1?version=1.1&download=true. Retrieved: 17.10.2023.
J-4 City of Joensuu (2017): Joensuun täydennysrakentamisohjelma. Available at: http://dynastyjulkaisu.pohjoiskarjala.net/joensuu/kokous/2020123-12-2807.PDF. Retrieved: 9.1.2024.

Turku

T-1 City of Turku (2022): Ilmastosuunnitelma 2029. Turun kaupungin kestävä ilmasto- ja energiasuunnitelma 2029. Päivitetty 2022. Kaupunginvaltuusto 16.5.2022 § 103. Available at: https://www.turku.fi/sites/default/files/atoms/files/ilmastosuunnitelma_2022_vedos3.pdf Retrieved: 10.1.2024.
T-2 City of Turku (2022): Kaupunkistrategia – Turku 2030-luvulla. Strategiaraportti 2022. Available at: https://www.turku.fi/sites/default/files/atoms/files/strategiaraportti_2022.pdf Retrieved: 9.1.2024.
T-3 City of Turku (2022): Turun kaupunkitutkimusohjelma 2022–2025. Available at:https://www.turku.fi/sites/default/files/atoms/files/turun_kaupunkitutkimusohjelma_2022-2025.pdf. Retrieved: 10.1.2024.
T-4 City of Turku (2023): Turun strategiamittarit. Saavutettava 2023. Available at: https://www.turku.fi/sites/default/files/atoms/files/turun_kaupunki_strategiamittarit_saavutettava_2023.pdf. Retrieved: 9.1.2024.

Vantaa

V-1 City of Vantaa (2022): Innovaatioiden Vantaa. Kaupunkistrategia 2022–2025. Available at: https://www.vantaa.fi/sites/default/files/document/Vantaan%20kaupunkistrategia%202022-2025.pdf. Retrieved: 10.1.2024.
V-2 City of Vantaa (2022): Vantaan maa- ja asuntopoliittiset linjaukset. Kaupunginvaltuusto 10.10.2022. Available at: https://www.vantaa.fi/sites/default/files/document/Vantaan-maa-ja-asuntopoliittiset-linjaukset-saavutettava-08032023.pdf. Retrieved: 10.1.2024.
V-3 City of Vantaa (2022) Vantaan resurssiviisauden tiekartta. Valtuustokausi 2022–2025. Available at: https://www.vantaa.fi/sites/default/files/document/Resurssiviisauden%20tiekartta_0.pdf. Retrieved: 10.1.2024.