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Enhancing wood use in construction: networks and circular solutions in Finland

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Academic dissertation

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ABSTRACT

Recent policy development and technical support have created prerequisites for Finland to become a forerunner in wood-based construction. However, especially utilizing reclaimed wood, wooden retrofits, and wood as part of nature-based solutions in construction all remain at a nascent stage in Finland. Therefore, the overall aim of this dissertation is to identify the processes for enhancing wood use in construction. This dissertation is comprised of three empirical case studies, utilizing the policy network and the business and innovation ecosystem lenses as theoretical underpinnings. Methodologically, a descriptive social network analysis and two qualitative studies using thematic analysis were conducted. The research proceeded by first understanding the characteristics of the local wood-based construction policy network (Article I), then exploring business ecosystem and solutions for overcoming existing barriers for reclaimed wood use (Article II), and finally by suggesting ways for enabling the development of innovation ecosystem when diversifying wood use in construction (Article III). The analysis of the local wood-based construction policy network (Article I) illustrates that the actors revolve centrally around research, industry, business, and government in the local diffusion of wood-based construction. The study on reclaimed wood use in construction (Article II) addressed high circularity potential, while its adoption is hindered by many limiting factors. Addressing these barriers requires engaging expert intermediaries and leveraging solutions across the market, technological, regulatory, and cultural domains. Article III shows that the development of an innovation ecosystem could be accelerated by the key actors' engagement, while facilitating actor links is possible through information sharing and greater communication, technological and platform development, re-education, and co-creation. Results show that municipalities have the capability to serve as ecosystem orchestrators, facilitating knowledge and skill development, disseminating best practices, and reinforcing local level governance. Expert actors' and intermediaries' support is paramount from planning stage to the end of life of buildings. Overall, the mainstreaming of wood-based innovative solutions requires active engagement of relevant actors both at the local and the ecosystem level. This calls for continued interaction through stronger collaboration and sharing responsibilities between municipalities and construction companies.

Keywords: Business ecosystem, innovation ecosystem, policy network, reclaimed wood, wood-based construction, Finland

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TIIVISTELMÄ

Rakentamiseen liittyvä sääntely ja tekninen kehitys ovat luoneet edellytykset sille, että Suomi voisi nousta puurakentamisen edelläkävijäksi. Puurakentamisen markkinaosuus ja erityisesti kierrätyspuun käyttö, puun käyttö kaupunkimaisessa korjausrakentamisessa ja puu osana luontopohjaisia ratkaisuja ovat Suomessa kuitenkin vielä alhaisella tasolla. Tämän väitöskirjan tavoitteena on tunnistaa erilaisia puunpohjaisia ratkaisuja rakentamisessa sekä kuinka näiden leviämistä voitaisiin edistää. Väitöskirja koostuu kolmesta osatutkimuksesta, joissa hyödynnetään teoreettisena perustana politiikkaverkostojen sekä liiketoiminta- ja innovaatioekosysteemin näkökulmia. Menetelminä työssä käytettiin kuvailevaa sosiaalisen verkoston analyysia ja kvalitatiivista haastatteluihin perustuvaa temaattista analyysia. Ensimmäisessä osatutkimuksessa tarkastellaan yhtä puurakentamisen edelläkävijäkaupunkia eli Joensuuta paikallisten politiikkaverkostojen esimerkkinä. Tutkimuksessa tunnistettiin paikallisen puurakentamisen politiikkaverkoston ominaispiirteitä (Artikkeli I). Toisessa osatutkimuksessa tunnistettiin ratkaisuja kierrätyspuun käytön esteiden poistamiseksi (Artikkeli II). Lopuksi tunnistettiin tapoja innovaatioekosysteemin kehityksen mahdollistamiseksi ja puun käytön monipuolistamiseksi rakentamisessa (Artikkeli III). Paikallistason puurakentamisen politiikkaverkostoanalyysi (Artikkeli I) osoittaa, että avaintoimijat edustavat tutkimusta, rakennustuotantoa ja liiketoimintaa sekä julkishallintoa puurakentamisen yleistymisessä. Kierrätyspuun käyttöön liittyvässä osatutkimuksessa (Artikkeli II) tunnistettiin puun uudelleenkäyttöönliittyvää potentiaalia, mutta myös käyttöönottoa rajoittavia tekijöitä ja puuttuvia toimijoita. Näiden esteiden poistaminen edellyttää asiantuntijoiden vahvempaa roolia ja ratkaisujen hyödyntämistä markkinoilla, teknologian, sääntelyn ja kulttuurin aloilla. Innovaatioekosysteemin kehitystä koskeva tutkimus (Artikkeli III) tarkastelee ekosysteemin heikompia osia (kuten esimerkiksi toimijoiden sitoutumista ja rooleja, yhteistyötä, lainsäädännön vaikutusta, teknologisia mahdollisuuksia ja liiketoiminnan kehittymistä) ja näitä tukevia prosesseja. Tämän pohjalta siinä todetaan, että innovaatioekosysteemin kehittämistä voitaisiin nopeuttaa ottamalla tiiviimmin mukaan asiantuntijatoimijoita, parantamalla tiedon jakamista ja viestintää, ja vahvistamalla koulutusta ja projektien yhteiskehittämistä. Puun käytön lisääminen edellyttää edistämistä sekä paikallisesti että ekosysteemitasolla ja ratkaisujen laajentamista rakennusten koko elinkaaren ajaksi. Tulokset osoittavat, että kunnilla on kyky toimia kaupunkien rakennetun ympäristön kehittämisen vetäjinä edistämään ekosysteemin osapuolten osaamisen kehittämistä, levittämään parhaita käytäntöjä ja vahvistamaan paikallistason hallintoa. Kehittyvien ekosysteemien tulisi varmistaa sekä horisontaalinen että vertikaalinen sidosryhmäyhteistyö innovatiivisten puupohjaisten ratkaisujen edistämiseksi kaupunkiympäristöissä. Asiantuntijoiden ja välittäjien tuki on näiden ratkaisujen laajentamisessa keskeistä. Tämä vaatii jatkuvaa vuorovaikutusta, yhteistyön vahvistamista sekä vastuun jakamista kuntien ja rakennusyritysten välillä.

Avainsanat: Liiketoimintaekosysteemi, innovaatioekosysteemi, politiikkaverkosto, kierrätyspuu, puurakentaminen, Suomi

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"If you want to go fast, go alone; if you want to go far, go together."
— African proverb

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12th of March 2026
Md. Rayhanur Rahman

LIST OF ORIGINAL ARTICLES

This thesis is comprised of the following publications:

Article I:
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Article II:
Rahman, M. R., Korsunova, A., Dmitrijevaa, A., Toppinen, A. (2025). From barriers to solutions for reclaiming wood in construction: a business ecosystem case in Finland. Circular Economy and Sustainability 5, 3551–3574. https://doi.org/10.1007/s43615-025-00575-7

Article III:
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Division of labor in co-authored articles

	Article I	**Article II**	**Article III**
Concept and design	MRR, IW	MRR, AK1, AT	MRR, AV
Data collection	MRR	MRR, AK1, AD, AT	MRR, AV
Data analysis	MRR	MRR, AK1, AD	MRR, AV
Manuscript writing	MRR, IW, AT, RT	MRR, AK1, AT	MRR, AV, EJN, AK2
Editing and reviewing	MRR, IW, AT, RT	MRR, AK1, AD, AT	MRR, AV, EJN, AK2, VK
Overall responsibility	MRR	MRR	MRR, AV

MRR – Md. Rayhanur Rahman, AT – Anne Toppinen, RT – Ritva Toivonen, AK1 – Angelina Korsunova, IW – Ida Wallin, AD – Anastasija Dmitrijeva, AV – Anne Viljanen, EJN – Erkki-Jussi Nylén, AK2 – Atte Koskivaara, VK – Vesa Kanninen

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GLOSSARY

Wood-based construction (WBC) is defined as wood use for any structural elements of buildings, ranging from single-family homes to multistory buildings, including modern hybrid construction and modular methods, such as light frame construction, along with engineered wood products (cross-laminated timber and laminated veneer lumber) for buildings.

Business ecosystem (BE) is a network of organizations involved in collaborating or competing to co-evolve toward value creation and capture.

Innovation ecosystem (IE) often works parallel to a BE. The IE concept underscores the requirement for complementary innovation and niche development, where organizations have extensive willingness to collaborate and share information that leads to novel business development.

Circular economy (CE) is considered an approach with the main goal of transforming waste into resources and offers closed-loop cycles by incorporating multiple R concepts (e.g., refuse, repair, reuse, recycling, etc.). This economic concept replaces the conventional linear framework of "take-make-dispose" with a more sustainable production and consumption system.

Reclaimed/Recovered wood (RW) refers to all previously utilized wood products, whether in a building, as support structures during construction, or in packaging and transportation, which are brought back into circulation through reuse, repurpose, or recycling.

Wooden retrofits (WR) involve using wood as façade replacements or rooftop extensions when renovating multistory buildings.

Nature-based solutions (NBS) bring more nature and natural features and processes into urban landscapes, through locally adapted, resource-efficient, and systemic interventions. NBS are innovations that consider advancing green infrastructure, enhancing biodiversity, pollution reduction, and carbon sequestration, co-benefit as social cohesion, and well-being and economic advantages. Within the urban built environment, NBS includes using raw and processed materials available from nature (e.g., building with wood), which can be returned to nature after reusing and at the end of their life cycle.

INTRODUCTION

Human activities create constant pressure on the Earth system that can unbalance the biophysical system and hit tipping points, which are irreversible situations for the environment (Rockström et al. 2009). To date, six out of nine planetary boundaries (land-system change, biosphere integrity, biogeochemical flows, novel entities, freshwater use, and climate change) have trespassed the safe operating space (Richardson et al. 2023; Beier et al. 2025). The rapid increase in urban construction and operation is one of the key contributors to resource overconsumption and environmental degradation, causing one third of global carbon emissions. Every five days, the world accumulates infrastructure in the same magnitude as the size of Paris (United Nations Environment Programme UNEP 2024, 2025). The UNEP (2020) emissions gap report addressed a major shortfall between current global greenhouse gas (GHG) emissions caused by the built environment and the reduction measures required to remain consistent with the Paris Agreement (Hurlimann et al. 2021). This underscores the need for sustainable construction advances through strategic management and planning while scaling up critical innovative solutions (Hanssen et al. 2024; Lee et al. 2024; Yap et al. 2025). Consequently, diverse stakeholders require adopting their roles and collaboration practices to effectively contribute to decarbonizing the built environment (Kaya and Monsù Scolaro 2025; Olanrewaju 2025).

Wood as a renewable resource not only offers a substitution for emission-intensive material but also works as carbon storage (Lim et al. 2025). On average, the GHG emission reduction level from wood-based construction (WBC) is one third to half that of conventional buildings (Andersen et al. 2021). A comparative analysis by Hart et al. (2021) reveals that the mass of a concrete frame superstructure is five times greater than that of a timber structure. The embodied carbon emissions of wood are approximately 36% lower than those of concrete and 48% lower than those of steel (Lim et al. 2025). Furthermore, depending on the average floor area per capita, a new WBC could store between 0.01 and 0.68 gigatonnes of carbon (GtC) per year (Churkina et al. 2020).

The development of engineered wood products, such as cross-laminated timber (CLT) and laminated veneer lumber (LVL), ensures physical and mechanical durability, versatility, and fire resistance, making wood a more adaptable material for multistory buildings (Gosselin et al. 2017; Mohammadi and Ling 2017). With less construction time, reduced noise levels, and less product transportation demand during construction, modern wood construction is considered environmentally friendly and an efficient alternative to conventional materials (Švajlenka et al. 2017). Moreover, citizen attitudes towards wood construction are positive (Ruokamo et al. 2024), which contributes to an improved quality of urban living spaces (Franzini et al. 2018; Toppinen et al. 2018a).

Finland is a forest-rich country with widely available virgin wood (wood harvested from a living tree and not previously used or processed), thus up to 90% of detached and semidetached houses (including leisure buildings) are constructed with timber. The long history of Finnish wooden construction and operational experience paves the way for innovative solutions, making Finland a frontrunner in WBC (Ilgin and Karjalainen 2022). Due to growing urban housing demand, utilizing wood in Finnish multistory buildings is a trend with the potential to boost wood use in construction. To date (1995–2025), Finland has constructed around 200 wooden apartment buildings (buildings of at least two stories), containing 6000 apartments in total (Puuinfo 2025a).

Wood construction policies have been supported in Finland for decades, for instance the national bioeconomy strategy (Toppinen et al. 2018b; Arasto et al. 2021), the national "Program for Wood Construction" (2016–2023) (MoE 2023a), national targets for growth in public wood construction (45% WBC by 2025) (MoE 2020), and other regional and local regulatory strategies aim to boost business around WBC (Vihemäki et al. 2019; Toivonen et al. 2021a; Normann et al. 2025). Nevertheless, the practical implementation of using wood when constructing multistory buildings seems to have been limited so far. The market remains at a niche level (Toivonen et al. 2021b; Jussila et al. 2022), with a share of 6% (Puuinfo 2025a; Karjalainen and Ilgın 2025). This reflects challenges in perceived profitability of WBC among industry actors.

A number of innovative wood-based solutions (i.e., circular solutions) have been identified, including use of reclaimed wood (RW, Niu et al. 2021), wooden retrofits (WR, Viljanen et al. 2024), wood-related nature-based solutions (NBS, Atanasova et al. 2021; Kandel and Frantzeskaki 2024) (See Glossary for definitions). In addition, the regenerative building (structures help to restore nature and accelerate well-being, by using local natural resources, and assisting in closing the loop of materials used) approach (Andreucci et al. 2021; Koskinen et al. 2022) aims to mitigate resource overconsumption. Circular solutions based on using wood in urban built environment help in *narrowing* the loop; WR and NBS in *slowing* the loop, and RW wood in *closing* the loop (Bocken et al. 2016; Geissdoerfer et al. 2017). Overall, these solutions have significant potential to decarbonize the built environment, but they have remained at a nascent stage in Finland so far.

In the context of RW, it is possible to recover 50% of the 17.5 million tons of existing wood stock in Finnish residential houses (Nasiri et al. 2021). However, in addressing RW potential through wood cascading, Niu et al. (2021) recommended prioritizing material recovery over energy recovery. Hence, in this thesis, I focus on multiple value retention strategies (e.g., the "Rs" of reuse, reprocessing, and recycling) for wood cascading and leave out lower-value retention options like incineration, energy recovery, and chipping. Moreover, WR are closely linked with material reuse and recovery and could represent an avenue for achieving Finland's goal of becoming carbon neutral by 2035. Extending the lifespan of buildings through renovation can significantly reduce embodied carbon emissions (Schwartz et al. 2018). Nevertheless, retrofitting with wood is still in its development stage in Finland (Viljanen et al. 2024). Since 79% of the Finnish building stock was constructed prior to 2000 (Hirvonen et al. 2021), there is huge potential for renovation and retrofitting businesses (Viljanen et al. 2024).

As part of the NBS for urban built environments (see Glossary for definition), Pearlmutter et al. (2020) emphasized three levels of NBS deployment: green (bio-based) building materials, green building systems, and green urban sites (see also Bona et al. 2023). In this thesis, NBS includes multistory buildings' green roofs, green walls, and biodiversity-enhancing yards. Moreover, urban NBS in construction have been connected with wood in their carbon storage potential (Kuittinen et al. 2021; Kinnunen et al. 2022). According to the European Commission, the procurement of sustainable natural resources from local habitats represents one type of NBS (Bauduceau et al. 2015; Kandel and Frantzeskaki 2024), specifically using locally originated wood in urban infrastructure. This involves giving wood back to the community and supporting local wood businesses to flourish (Kampelmann 2021). However, the adoption of such innovative solutions depends on the involvement of planners at all levels, from national to municipal (Štrbac et al. 2022).

Furthermore, the availability of raw materials and the capacity for innovation in Finland could position the country as a pioneer in the creation and marketing of nature-based building products (Puuinfo 2025b). Given the opportunity of regenerative buildings, sustainable innovation has the potential to be integrated throughout the entire life cycle of construction, for example through renovations and extended product–service systems, offering a systemic innovation approach to the development of Finnish WBC (Viljanen et al. 2025b). To synthesize, this thesis anticipates that there are synergistic opportunities among RW, WRs, NBS, and regenerative buildings, which are connected with WBC. Here, leveraging these phenomena around WBC could ultimately accelerate wood utilization.

While developments in regulation, such as the EU-level Circular Economy Action Plan (EC 2020a), the Construction and Demolition Waste Management Protocol (EC 2024a), and the Construction Products Regulation (EC 2024b), are directing towards material circularity in construction, wood cascading remains marginal in Finland. Wood is the second largest source of Finland's construction and demolition waste (C&D) (Puuinfo 2024), often ending up in incineration along with energy recovery (Statistics Finland 2020). In 2022, 1.7 million m^3 of recycled wood and pellets were incinerated (LUKE 2023). This is often due to controversies between energy policy, waste policy, and a lack of coordinated actions from the EU (Giorgi et al. 2022). However, the recently introduced EU Renovation Wave (EC 2020b), EU Taxonomy (EC 2025), Finnish Circular Economy Green Deal (MoE 2024), Finnish Waste Plan 2027 (MoE 2022), and Finnish Construction Act 2025 (MoE 2023b) create further stimuli for construction industries to adjust their circularity models, local businesses to adopt innovations, and the built environment to enhance the overall standard of living by accepting renewable materials.

In Finland, path dependency manifests itself through conservativeness and risk aversion in the construction industries (Hurmekoski et al. 2018; Jussila et al. 2022), leading to institutional lock-ins (Lazarevic et al. 2020). The business ecosystem (BE) of wood construction is highly fragmented, where multiple subcontractors are involved in separate tasks at various stages in a building project (Toppinen et al. 2022). These results in a lack of clarity and shared goals among construction BE actors (Viholainen et al. 2021; Toppinen et al. 2022). The involvement of many actor groups within the wood construction business network is responsible for the inefficient diffusion of information (Franzini et al. 2018; Lazarevic et al. 2020). In addition, Vihemäki et al. (2020) emphasized the importance of intermediaries in BEs lacking cohesion in terms of vision and roles. This could hinder the effectiveness of promoting WBC. Furthermore, the Finnish wood construction sector lacks efficiency in policy governance (Franzini et al. 2018) and has not been proficient in experimenting at all municipal levels, except in larger cities (e.g. Helsinki and Tampere) (Salmi et al. 2022). Even so, wooden buildings can offer economic feasibility to their builders over conventional construction (Talvitie et al. 2021).

The advancement of wood use in multistory buildings, from a niche innovation to a successful business, requires the development and reconfiguration of BEs and innovation ecosystems (IEs), along with policy networks (Lazarevic et al. 2020; Toppinen et al. 2022; Erikshammar et al. 2024). In the construction business, actors collaborate and cooperate to create value-added relationships, sharing and accumulating innovative knowledge simultaneously (Gosselin et al. 2018; Evertsen and Knotten 2024). In light of this, Toppinen et al. (2019) and Viholainen et al. (2021) highlight the significance of actors' smooth communication and collaboration needs within BEs. From a circular viewpoint, Harala et al. (2023) explains that ecosystem development requires actors to expand their roles and advance beyond their conventional patterns of collaboration. This also means that intermediary actors must play an active role in sharing knowledge and connecting various groups within a RW BE (Niu et al. 2021). Erikshammar et al. (2024) stressed how an IE can be evolving and pushing new ideas around innovative building projects, along with adaptability required for actor role renewal in the construction industry. Moreover, Lazarevic et al. (2020) emphasize that wood promotion in construction should focus on market development. This requires reconfiguring local actor networks.

Given the above challenges, this thesis explores how network and ecosystem development can enhance wood use in construction, examining these issues through the lenses of local policy networks and BEs and IEs. The following chapter offers a detailed conceptualization of the frameworks used in this dissertation. Although research places emphasis on actor mapping and collaboration networks for national-level bioeconomy and discourse networks in general (Korhonen et al. 2018; Giurca 2020), the evidence for examining local policy networks around WBC is non-existent. In addition, previous studies of BEs have focused on wooden multistory buildings, particularly at the project level (Viholainen et al. 2021; Toppinen et al. 2022; Viljanen et al. 2023; Erikshammar et al. 2024), overlooking larger meso-level scenarios of the construction industry. Moreover, the adoption of RW in construction BEs has remained under-investigated, apart from Niu et al. (2021) and the study by Kathri et al. (2024) on consumer viewpoints regarding RW use, whereas IE studies have focused more on individual organizations, overlooking the sectoral context (Wickramaarachchige et al. 2024).

Furthermore, scholarly attention has mostly focused on businesses engaged in the wood construction value chain, whereas the standpoint of municipal actors and their extended roles and capabilities has rarely been evaluated, except by Salmi et al. (2022). Therefore, while promoting a more sustainable urban built environment with various approaches to using wood seems likely, future development depends on societies' abilities to build and manage this change. Echoing with Ashrafi et al. (2025) and Vosman et al. (2023), this thesis fills the gaps on the previously underexplored meso scale (beyond the project level), encouraging wood reuse across built environments through collaborative networks and the ecosystem perspective. Overall, this thesis offers a better understanding of network complexity and intertwined relationships among stakeholders, including various supportive measures that are necessary for promoting wood use in construction.

The aim of the dissertation

This thesis sheds light on innovation and strategic business management in construction by utilizing Finnish meso-level cases within the urban built environment with a focus on enhancing wood use and reuse. The study contributes with novel viewpoints on how local policy network structure assists in WBC diffusion (using the city of Joensuu), advances a solution-oriented approach towards RW use in construction, and discusses how to develop an IE within a regenerative built environment supports the mainstreaming of various innovative solutions.

Specifically, Article I focuses on the characterization, mapping, and evaluation of one local policy network, whereas Articles II and III not only focus on identifying the BE and IE respectively but also enabling approaches to involve new/underrepresented actors and discuss their roles in the construction sector in promoting wood-related innovation and business. The specific research questions covered in each article are presented in Table 1.

Table 1. Research questions formulated for the individual articles.

	Article I	**Article II**	**Article III**
Research questions	What types of organizations are involved in the local-level wood-based construction (WBC) policy network?	What kind of business ecosystem exists around reclaimed wood?	Which actors are missing among the Finnish innovative solutions of regenerative building that have key roles in innovation ecosystem (IE) formation and development?
	How is the WBC policy network structured in terms of influential organizations, relationships, and resource mobilization?	What are the root causes for the modest use of reclaimed wood in construction?	Which collaborative links, resources, and innovative activities are present or missing in the studied initiatives for fostering a regenerative building IE?
	Which policy goals are favored by local actors concerning WBC?	What are the potential solutions for increasing reclaimed wood use in construction?	How could the perceived lacks be facilitated by the emerging IE actors?

Additionally, Figure 1 explains that the promotion of wood use in construction can be possible through wood as a building material solution in general (Article I), RW utilization solutions as a particular case (Article II), and diversifying wood use as solutions, considering several selective wood-based innovative initiatives (Article III). This figure also explains the main goal of the individual sub-studies included in this thesis. Overall, I anticipate that the interdisciplinary nature of this thesis will contribute to the organizational, business, and innovation management literature in the context of the built environment.

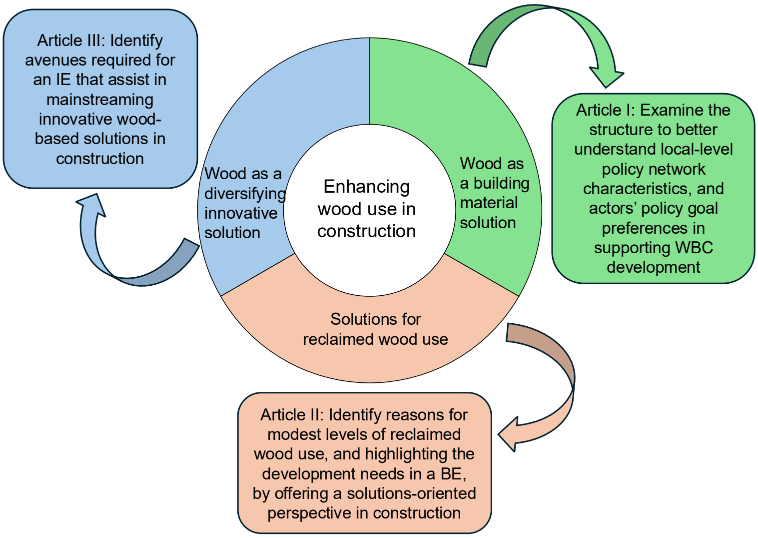

Figure 1. Articles and their main research goals in connection with enhancing wood use in construction. WBC = wood-based construction, IE = innovation ecosystem, BE = business ecosystem

CONCEPTUAL BACKGROUND

This thesis draws on the concepts of local policy networks and on two ecosystem variants: the BE and IE approaches. Originating from strategic stakeholder management (Freeman 1984), the network concept has brought light to various forms such as the actor network, organizational network, policy network, business network, and value network (Marsh and Smith 2000; Callon 2001; Lusch et al. 2010; Moliterno and Mahony 2011; Ford and Mouzas 2013). This thesis employs the policy network approach to analyzing local-level characteristics, structure, and policy goal preferences of the network when promoting wood use in construction.

In addition, a variety of ecosystem sub-concepts exist, including the innovation ecosystem, entrepreneurial ecosystem, knowledge ecosystem, platform ecosystem, digital ecosystem, industrial ecosystem, and business ecosystem (see, Adner 2006; Tsvetkova and Gustafsson 2012; Clarysse et al. 2014; Pilinkienė and Mačiulis 2014; Valkokari 2015; Stam and Spigel 2016; Sussan and Acs 2017; Jacobides et al. 2018; Tsujimoto et al. 2018). Among these, this thesis considers the BE — identifying barriers and solutions for RW use in construction — and the IE — in exploring various connecting phenomena towards the ecosystem formation and development considering several WBC-related innovative solutions.

Local policy network as an enabler for wood use in construction

Policy networks are considered a meso-level concept, incorporating relations among governmental and other organizational actors, along with intermediation processes (Marsh and Rhodes 1992). According to Rhodes (Marsh and Rhodes 1992, p. 182), a policy network is:

"a cluster or complex of organizations connected to each other by resource dependencies and distinguished from other clusters or complexes by breaks in the structure of resources dependencies."

To put it simply, policy networks offer a holistic view of the actors involved in a policy subsystem, their influence and connection patterns, and the effects of such interactions toward their goals and strategies (Dowding 1995; Yu et al. 2022; Metz and Brandenberger 2023). In other interpretations, according to Yu et al. (2022), a policy network is understood as a structural arrangement of interactions between various governance levels.

The characteristics of policy networks have received substantial attention in literature. Since *actors* form the backbone of a network structure, the variety of actor types engaged in a network indicates whether it is open (heterogeneous actors) or closed (homogeneous actors) (Howlett 2002; Metz 2017). *Collaboration* and interconnectedness among policy actors are unique characteristics of policy networks (Bressers and O'Toole 1998; Metz 2017). In this process, an actor with many cooperators, credible expertise, and a valuable skillset is considered influential in the network (Hasanagas 2016). However, a diverse network composition is encouraged, with openness towards including actors and generating new information and ideas (Adam and Kriesi 2007; Metz 2017).

This draws attention to *resource distribution* within the network (Figure 2). The interests of actors reflect their resource-sharing intensity in a policy network (Smith 1993; Normann 2017). In addition to the other available shared resources and support (e.g. financial, institutional, and policy advice), scientific knowledge, and skills provide innovative ideas within a network. Considering *policy goal preferences,* Sabatier and Jenkins-Smith's (1993) Advocacy Coalition Framework (ACF) explains that policy preferences of actors steered their behavior in policymaking and in policy enhancement processes. However, the spread of an innovation policy depends on actor interconnectedness. But to achieve policy goals, it is important to share various resources (Liu and Xu 2018; Wang and Zhang 2023). Notwithstanding the fact that a policy network may possess a variety of functions that could be accomplished during policymaking and policy outcome (Marsh and Smith 2000), the acceleration towards utilizing any innovative solutions through governmental policy objectives and strategies could potentially be influenced by the associated policy network (Sandström and Carlsson 2008).

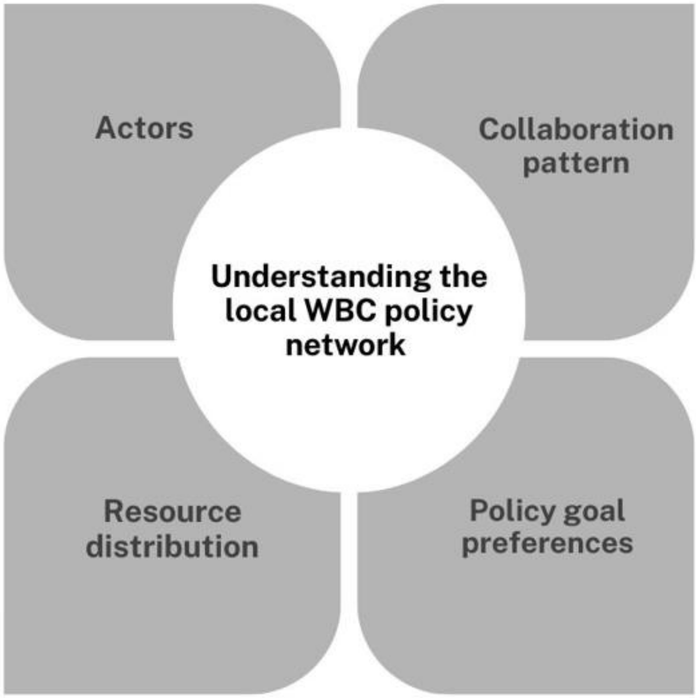

Figure 2. Characteristics in understanding the local wood-based construction (WBC) policy network (based on Marsh and Rhodes 1992; Marsh and Smith 2000; Metz 2017).

Examining the structure of policy networks can help in making assumptions regarding the effectiveness of existing policies and the enhancements required during decision-making processes (Yu et al. 2022). As Papadopoulou et al. (2011) noted, policy outcomes merely reflect the interactions of actors within the network. Moreover, analyzing local policy networks is important since they reveal existing gaps in connections and indicate the development pathways needed for products, markets, and innovations to succeed (Gellynck and Vermeire 2009).

Policy network lenses have been used to analyze rural development through project implementation (Papadopoulou et al. 2011) and in understanding policy actors' preferences regarding timber harvesting for wood product utilization (Creutzburg and Lieberherr 2021). They have also assessed influential actors in forest policy networks (Hasanagas 2016) or even when considering a greater policy arena, such as energy transition, climate change mitigation, and ocean ranching (Normann 2017; Yu et al. 2022; Wang and Zhang 2023).

Regarding construction, studies have focused on actor networks in facilitating innovative building construction in Australia (London and Pablo 2017), the value network in the case of Quebec (Gosselin et al. 2018), and even the forest-based bioeconomy networks of Finland and Germany (Giurca and Metz 2018; Korhonen et al. 2018). In a case-specific study of Finland, Viljanen et al. (2023) emphasized the significance of Finnish policy instruments, along with actor involvement and networking, in the innovative use and diffusion of wood in construction. Kanninen et al. (2024) analyzed actor alignment and perceived characteristics of network relations toward climate-wise construction. To date, the implication of the policy network approach to understanding the structure and its influence at a local level (especially as a policy sub-sector) is missing from the literature, giving rationale to Article I in this thesis.

Business and innovation ecosystems around wood-based construction

The term '*ecosystem*', which is rooted in ecology, was initially used to explain the relationship between organisms and their physical environment (Tansley 1935). Later, James Moore introduced the concept '*business ecosystem*' to business management studies in a metaphorical sense, explaining that companies should not be considered in isolation, but as part of a web of cross-industry activities. According to Moore (1993, p.76), characteristic to a BE is that

"*Companies co-evolve capabilities around new innovation: they work cooperatively and competitively to support [the development of] new products, satisfy customer needs, and eventually incorporate the next round of innovations.*"

In other words, a BE is an economic network comprising suppliers, key producers, consumers, competitors, and other stakeholders, who interact with each other to develop goods and services while following the strategic direction of core companies (Moore 1996, 1998). Regulatory and media influences, although less direct, can also influence BE development (Iansiti and Levien 2004). Companies are considered to play a strategic role as niche players, keystones, or dominators (Iansiti and Levien 2004). Decades later, the BE concept evolved further alongside other overlapping ideas, such as the IE (Adner and Kapoor 2010; Ritala et al. 2013; Aarikka-Stenroos and Ritala 2017; Ritala and Almpanopoulou 2017; Baiyere 2017). Ron Adner (2006; p.98) proposed the concept of IEs to be as

"the collaborative arrangements through which firms combine their individual offerings into a coherent and customer-facing solution. Enabled by information technologies that have drastically reduced the costs of coordination, innovation ecosystems have become a core element in the growth strategies of firms in a wide range of industries."

The distinction between BE and IE is often challenging, as both concepts have been widely interpreted and subjected to scholarly critique (Oh et al. 2016; de Vasconcelos Gomes et al. 2018; Scaringella and Radziwon 2018; Ritala and Gustafsson 2018; Granstrand and Holgersson 2020). The IE concept has been met with skepticism, as if it were an "old wine in new bottles" (Scaringella and Radziwon 2018). Some literature has referred to BE and IE as interchangeable concepts (e.g. Overholm 2015; Gawer and Cusumano 2014), while others view them as distinct in terms of their logic of action (Valkokari 2015).

Granstranda and Holgersson (2020) noted that the BE concept focuses more on competition and production (Moore 1993). This differs from the IE, which places greater emphasis on collaboration and the development of innovation (Adner 2006). Thomas and Autio (2020, p.16) defined "*an innovation ecosystem as "a community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output*". Therefore, the characteristics of IE include a unique, non-hierarchical process for facilitating innovation and collaboration to achieve system-level goals. These characteristics somewhat differ from those of conventional market and business networks (Jacobides et al. 2018; Wolff et al. 2022). Moreover, in their systematic literature review of ecosystem approaches, de Vasconcelos Gomes et al. (2018) made a key assertion: the BE is primarily concerned with value capture, whereas the IE is primarily concerned with value creation.

Thus, it is possible to conclude that "*an innovation ecosystem captures the complex synergies among a variety of collective efforts involved in bringing innovation to market*" (Wessner 2007, p.5), whereas BE is seen as a prerequisite for market creation and revenue flow (Pellinen et al. 2012). For a business to function effectively, it must embrace innovation, foster collaboration, and be adopted by the ecosystem. As mentioned earlier, companies co-evolve by developing capabilities around innovation, allowing them to grasp future innovations (Moore 1993). All in all, BE represents a broad concept that adopts a dynamic, interconnected approach, enabling multiple organizations to collaborate in delivering holistic solutions to end users (Clarysse et al. 2014; Aarikka-Stenroos and Ritala 2017). Article II of this thesis provides an overview of the development needs for the construction BE by focusing on RW solutions.

However, scholars sometimes refer to 'ecosystem' without making any distinction between the two. For example, in organizational management, Adner (2016) defines ecosystems as "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize.*" Ecosystem principles have been shown to positively influence value creation within construction networks (Pulkka et al. 2016).

This dissertation argues that while BE and IE are closely interconnected concepts, each holds a distinct value proposition and goals within the construction sector. Based on the works of Moore (1993) and Thomas and Autio (2014), stakeholders from both the production and user sides — such as producers, suppliers, customers, and financiers — contribute complementary resources to ecosystems. Table 2 shows a list of actors typically involved in both construction ecosystem types. Even though this is not an exhaustive list, there are clearly many diverse actors involved in the construction ecosystem.

Innovation ecosystem actors of the construction industry primarily exhibit heterogeneity according to the triple helix model (Leydesdorff and Etzkowitz 1998). This consists of knowledge brokers, innovation policymakers, public entities, and industry (Valkokari 2015; Vosman et al. 2023). On the meso-level IE, a government-sponsored intermediary facilitates collaboration among institutions, such as firms, industry associations, and universities, to enhance industry capabilities (Wickramaarachchige et al. 2024). Regulators make legal decisions, govern policies, and independently assess innovation feasibility (Dedehayir et al. 2022), while policies at the EU and national levels that encourage innovation and boost product competitiveness could create major influence on ecosystem development (Tsatsou et al. 2010; Fernández and Kubus 2018; Neto et al. 2024).

The business ecosystem encompasses comparatively formal relationships among actors, often governed by contractual agreements and more stable roles aimed at value capture. However, the IE fosters flexible, exploratory relationships that adapt to uncertainties in value creation (Aarikka-Stenroos and Ritala 2017). Such openness enables experimentation and learning, distinguishing IE from the more predictable and efficiency-driven BE.

Empirical studies further illustrate the emergence of both ecosystem types in WBC. For instance, Toppinen et al. (2022) and Viholainen et al. (2021) explored BE development within construction projects. Meanwhile, Erikshammar et al. (2024) and Stehn and Erikshammar (2025) emphasized the role of IE in niche innovation development across construction projects.

Table 2. List of actors typically involved in the construction ecosystem (Erikshammar et al. 2024; Viholainen et al. 2021; Wielopolski and Bulthuis 2023; Rahman et al. 2025; Viljanen 2025a).

Actor types	Description
Financier or investor or customer	Initiates construction work by providing capital and can set the goals and request specific types of building materials.
Developer, owners and users	Building operators. Housing companies are owned by a city or privately, including apartment shareholders.
Designer(s)	-Architects are considered the primary designers — they are the experts who plan, oversee construction, and produce detailed drawings. -Other engineers are appointed by the architect. They bring specific expertise to the coordination of the design and plan, for instance in the form of structure and service engineers.
Builder and main contractor	Appointed by the client and responsible for supervising construction work by ensuring effective planning, budgeting, time management, and safety.
Material or product manufacturer	Providing materials or products, e.g., engineered wood products: cross-laminated timber (CLT), laminated veneer lumber (LVL), prefabricated components
Subcontractor	Specialized contractors hired to perform specific tasks during construction such as electrical work and plumbing.
Service provider /supplier	Involved in design, delivery and logistics, and assembly of materials and structural or modular wood framing, depending on construction-specific requirements.
Maintenance service provider	Inspects and provides repair and renovation services for buildings.
End-of-life service provider	-Planning, organizing, handling, and waste treatment during and after construction work. -Investigation, planning and operation of demolition, and deconstruction activities, including the measurement of material recovery potential.
Regulator	At the local, national, or EU level. However, local regulatory activity includes the provision of construction permits, zoning, and site-related infrastructure
Knowledge provider	Academic and research organizations that offer novel scientific information
Other service provider	Designing and planning outdoor spaces, including green areas

From the perspective of Article III, it is relevant to note the formation and development of IE, as also explained by previous researchers (Dedehayir et al. 2018; Erikshammar et al. 2024; Neto et al. 2024). Dedehayir et al. (2018) explored the potential of IEs to accelerate further economic growth. Ecosystem success depends on companies accepting innovative ideas and turning them into products or services within the value network, thereby offering added value to consumers (Ma et al. 2018). This also includes receiving feedback from the value network to upgrade products and services through IE (Erikshammar et al. 2024; Ma et al. 2018). However, the collective nature of IE could create challenges for organizations, as they face both individual market and technological uncertainties and uncertainties arising from their interconnectedness (De Vasconcelos Gomes et al. 2018; Shengxi et al. 2025).

According to Granstrand and Holgersson (2020), IE actors, artifacts (products, services, resources, technologies, standards, and policies) and activities (Khizar et al. 2025) interact through a cooperative and competitive environment. In a comprehensive review, Durst and Poutanen (2013) revealed that IE success relies on actor collaboration, resources, strategy and leadership, organizational culture, regulations and governance, and technological support (Hoffecker 2019).

Furthermore, Dedehayir et al. (2018) portrayed numerous actor roles in IEs, emphasizing the ecosystem leader's role in initiation, governance, collaboration, platform management, and value distribution. In addition, Lehtimäki et al. (2023) highlighted leveraging technology, business, and legislation to create integrated environments that address complex challenges, driving practical solutions for urban evolution. Cities, government organizations, companies, civil society, the academic community, and end users are the actors responsible for this change (Lehtimäki et al. 2023). However, all these critical components may be missing during IE development, which prompts further investigation into Article III in this thesis.

Leadership in IE is crucial for addressing coordination and cooperation challenges. It facilitates ecosystem formation, allocates resources, and builds connections, as market mechanisms alone are insufficient (Dedehayir et al. 2022; Foss et al. 2023). Leaders engage in strategic and transformative action in IE — this position is known as '*the orchestrator*' (Iansiti and Levien 2004; Dhanaraj and Parkhe 2006; Dedehayir et al. 2018; Machado et al. 2025). Orchestrator activities in an ecosystem are included but not limited to strategic design of an ecosystem, resource integration, and facilitating relational, technological, and innovation practices (Shen et al. 2024). There also involves another type of actor, 'the expert', who encourages technology transfer, provides consultation, and generates new ideas (Dedehayir et al. 2018; Dedehayir et al. 2022). In the WBC context, Viholainen et al. (2021) emphasize the importance of collective efforts among various specialized actors within the ecosystem to achieve successful outcomes.

Collaboration and interaction between ecosystem actors are essential for niche creation in IE (Dedehayir et al. 2018). The social and behavioral habits of organizations could influence effective collaboration (Neto et al. 2024). Collaboration among niche innovation actors in the circular construction ecosystem can be multi-dimensional (Erikshammar et al. 2024; Evertsen and Knotten 2024) and adopting a long-term collaborative approach can further enhance industry integration (Vosman et al. 2023). As Neto et al. (2024) indicated, affirmative collaboration depends on mature ties (based on time and frequency) and recognizing the need for digital communication channels.

This demonstrates that interactions among IE actors can be enhanced by **technological** dependency (Adner and Kapoor 2010). Fukuda (2020) revealed that a technological upgrade causes disruptive innovation by altering the production and marketing of goods and services, thereby changing the existing ecosystem. Additionally, Kwak et al. (2018) suggested that IE growth can accelerate through platform development (e.g., online service platforms). For value addition and solutions for the CE in IE (Kortus et al. 2025), platforms can facilitate information storage and sharing, along with securing an advantageous market position for individual products (Kretschmer et al. 2020). Applying various digital technologies in the construction ecosystem, such as building information modeling (BIM) (Singh 2025) and material standardization and certification (Bekele et al. 2024), has significant potential for upgrading conventional built environments. In this context, Vigren (2022) illustrated how the digitalization process enhances organizational functionality and reshapes IE in the construction industry.

Moreover, **regulations** can drive IE growth by introducing various innovative solutions and circular policies (Mazzucato and Robinson 2018; Patterson 2021; Lehtimäki et al. 2023; Wickramaarachchige et al. 2024). Key policy enhancements should address financial aspects and policy integration, requiring reform from the EU level down to the local level (Lehtimäki et al. 2023). For instance, subsidies are noted as complementary resources for boosting organizational innovation performance, along with effective implementation of public support regarding IE (Costa and Moreira 2022). Clarysse et al. (2014) suggests that policy should support niche innovation companies and encourage larger companies to connect and contribute. They further emphasize the scope of **intermediaries** in the ecosystem, who can facilitate collaboration across organizations within an IE (Baker et al. 2021; Khizar et al. 2025). Although intermediaries can facilitate innovation by seizing opportunities (Satheesh et al. 2024), fragmentation in IEs and intermediaries' limited capacities were found to hinder WBC diffusion in construction ecosystems (Vihemäki et al. 2020). However, this dissertation argues that the roles of intermediaries and orchestrators are interconnected. Accordingly, Ng et al. (2023) illustrated how government-affiliated intermediaries can also function as key orchestrators. Their role surpasses acting as mere experts and brokers and expands into distributing and leveraging resources to achieve broader policy objectives, and development of an IE.

Municipalities act as intermediaries — foster collaboration, enable organizational adaptation, and develop new approaches (Soberón et al. 2023). As local governments, they connect organizations by building shared understanding, balancing public involvement with informal networks, and introducing innovation intermediaries (Masuda et al. 2022; Wegner and Verschoore 2022). Municipalities with traditional wood use, including local woodworking industries, could create strategic targets in promoting wooden construction (Blasco et al. 2021). Furthermore, municipalities can advance the CE at the local level by merging top-down and bottom-up approaches, depending on their scope and strategic choices (Gustafsson and Mignon 2020).

Finnish municipalities are self-governing local administrative units responsible for providing public services and exercising significant decision-making power. That is, Finnish municipalities hold planning monopolies (Salmi et al. 2022; Koskivaara and Lähtinen 2023). In construction operations, their role extends to operational ecosystem through land-use zoning decisions, construction permits, and site infrastructure guidance (Viholainen et al. 2021). Considering the BEs of wooden multistory buildings in five Finnish cities, Viljanen et al. (2023) explained how municipalities act as both key and collaborative actors. Hence, Finnish municipalities have scope to improve their facilitation in developing IE in regenerative buildings. Article III of this thesis offers a Finnish meso-level perspective regarding this facilitation.

Apart from local policy networks (Article I), this dissertation further focuses on examining the growth of the local BE and the evolution of IE. Articles II and III investigate phenomena characterized by uniqueness, focusing on meso-level actors within the construction sector. The originality lies in an analysis of the development of BEs dealing with RW and the development of IEs for RW, as well as for some emerging innovative practices, such as retrofits and NBS. These dynamics are closely connected with ecosystem governance, and creation of added value through business and innovation network management (Aarikka-Stenroos and Ritala 2017). Here, the actors are interdependent and co-evolve, particularly within systems that integrate technologies, markets, institutions, cultures, and regulatory structures within the urban built environment (Aarikka-Stenroos and Ritala 2017).

To summarize the overarching conceptual framing of this dissertation, I argue that a network of actors and collaboration between them are crucial in the development of an ecosystem. This constitutes a focus on my empirical analysis.

DATA AND METHODS

This study adopted a mixed-methods approach, drawing on qualitative and quantitative research traditions. Table 3 summarizes the data sources and analytical methods used in each sub-study. Building upon the theoretical underpinnings, Article I quantitively (descriptive) explored the characteristics of local WBC policy networks. Article II qualitatively examined the existing BE connected with circular wood, identifying barriers and future-oriented solutions for cascading use at the national level through a thematic analysis of interview transcripts. Additionally, Article III applied the thematic analysis (inductive) of qualitative interview data to examine various connecting phenomena required for IE emergence and development, thereby supporting the mainstreaming of innovative wood-based solutions in regenerative buildings.

Table 3. Summary of methodologies implemented in all sub-studies (Articles I, II, III).

Article	I	II	III
Type of research	Empirical	Empirical	Empirical
Method	Descriptive (quantitative) social network analysis	Qualitative, thematization	Qualitative, thematization
Data sources	Online literature review and online questionnaire survey data (N=15) collected from organizational actors involved in the construction sector	Semi-structured interviews (N=14) and workshops (N=2), data collected from stakeholders involved in various lifespans of buildings	Semi-structured interviews (N=32) and workshop (N=1), data collected from stakeholders involved in the construction sector
Unit of analysis	Local (meso-level) policy network	Regional (meso-level) business ecosystem	Regional (meso-level) innovation ecosystem
Data collection period	2021	2022–2024	2021–2024

Note: N refers to the number of survey interviews and workshops.

Data collection process

Online survey and supplementary data

For *Article I*, an explorative case was selected, as it offers a detailed illustration of the network phenomena (Siggelkow 2007). The case city — Joensuu (capital of North Karelia) — is a major hub for WBC and innovation, supported by extensive forest resources and strong research and development (R&D) in wood material science (Weiss et al. 2017). The city promotes large-scale wooden multistory projects and value-added wood products (Heräjärvi et al. 2021), aiming for carbon neutrality by 2025. Actor collaboration and regional policy implementation remain crucial for advancing sustainable construction and achieving the city's goals.

For data collection, an online literature search was conducted using databases (Scopus, Google Scholar, Science Direct), the online libraries of the University of Eastern Finland and the University of Freiburg, and casual platforms e.g., ResearchGate. Literature included peer-reviewed articles, book chapters, reports, and webpages, identified through keyword searches e.g., "Finnish wood construction", "Joensuu wood organizations", "Finnish wood construction policy network", "wood construction benefits and barriers", and "North Karelia" (All retrieved documents are listed in Appendix 1). This process initially identified

10 relevant organizations (‘actors’), and snowball sampling among Joensuu’s research community added more (Bryman 2012), resulting in 18 organizations (Appendix 2).

The data were collected through an online survey (July to September 2021), which includes four reminders every two weeks after initiation. The survey first collected participant details (respondent name, organizational name, affiliation, position), followed by allowing self-categorization into actor types (e.g., government body, academia or research, industry or real estate business or consultancy firm, certification agency, environmental nongovernmental organizations (ENGOs), and other). Later, using a roster of 18 organizations (Agneessens and Labianca 2022), participants noted their contact frequency — with daily to monthly contacts considered frequent and yearly contacts considered infrequent (Giurca and Metz 2018; Korhonen et al. 2018). A name generator technique (Adams et al. 2020) was followed, through which respondents identified 11 additional actors, who subsequently completed the same questionnaire.

In the next section, respondents ranked WBC policy goal preferences on a 1 to 10 scale (Brockhaus et al. 2014; Korhonen et al. 2018) (Appendix of Survey questions 2). These arguments were derived from key policy documents, including the North Karelia Climate and Energy Programme 2030, the Finnish Ministry of the Environment’s Wood Building Programme (2019), the Finnish Bioeconomy Strategy (2014), the Ecosystem Agreement between Joensuu and the Ministry of Economic Affairs and Employment (2021–2027), and the regional smart specialization program. A content analysis of these documents guided and highlighted in identifying key policy goal statements. An expert individual specializing in sustainable WBC was selected (one actor per organization), representing 15 responses and covering a response rate of 51%. This rate is within the usual range for social science surveys (Tikkanen et al. 2003). However, the missing responses were mostly from the construction business and industry category. Although higher actor participation would have enriched network strength, the response rate in this study was sufficient to provide meaningful insights into the network structure.

Qualitative interview data

Qualitative thematic analysis has been used for sub-studies II and III, where the focus was a deeper understanding of underlying ecosystem phenomena. In *Article II,* semi-structured interviews were conducted to explore stakeholder perceptions regarding RW. The semi-structured interviews were conducted among actors dealing with RW in construction BEs, including consultancy firms on circular solutions, waste management companies, and Finnish CE expert companies (Table 4).

Companies involved in wood processing and the facilitation of reused wood materials in construction were selected for the interviews. Experts from these companies were chosen based on their responsibilities, which range from environmental and sustainable development to architectural design and planning. The semi-structured interview guide was tailored by a set of five to six prepared questions (e.g., organizational involvement in the CE, motivation for RW use, collaboration pattern, barriers related to upscaling RW, circularity success stories, and ways of facilitating RW in construction) to each interviewee based on the company’s category (See Appendix 3). Participants were identified through company websites, LinkedIn, and desktop research regarding the construction sector in Finland, supplemented by snowball sampling approach (Kirchherr and Charles 2018). Interview invitations were subsequently sent via email.

Table 4. Stakeholders involved in the semi-structured interviews.

	Interviewee role in the company	Sector	Interview length
1	Public Affairs and Sustainability	Recycling services	31 min
2	Project Manager	Business consultancy	41 min
3	Senior Consultant	Business consultancy	24 min
4	Sustainability Specialist	Construction	55 min
5	Wood Construction Director	Construction	29 min
6	Wood Construction Specialist	Construction	25 min
7	ESG Vice President	Construction	30 min
8	Plant Manager	Construction	30 min
9	Project Manager	Construction	24 min
10	Environmental Specialist	Construction	36 min
11	Head of Sustainable Development	Construction	21 min
12	Environmental Manager	Construction	29 min
13	Senior Expert, Expert Services on Circular Economy	Intermediary promoting circularity and sustainable development	46 min
14	Founder, Recycled wood building materials	Wood product manufacturing for construction	56 min

Sub-study III used the existing RW stakeholders' data reinforced by the viewpoint of innovative wood construction project stakeholders survey (dealing with WRs and NBS) that filed under the DECARBON-HOME and FoREfront projects. Thus, this study relies primarily on project survey data collected between 2021 and 2024. This study involved a thematic analysis of a large interview and workshop dataset, focusing on two issues: missing links (e.g., actors and connection) and ways to fill these gaps. Altogether, 32 qualitative interviews and 1 roundtable discussion (see workshops section) that matched the study's research questions were finally used for the coding and categorization (See the participants list appendix 4).

Workshops

The qualitative data in this dissertation have been complemented by participatory workshops (Articles II and III) with stakeholders from the construction sector involved in RW operation, management, and planning. The first stakeholder workshop was held in April 2024 and was subsequently followed by a roundtable discussion in June 2024 that focused on a facilitated, solution-oriented dialogue (Nielsen et al. 2017). The first stakeholder workshop was attended by stakeholders involved in various phases of a building's life (see Table 5). The event began with brief participant presentations, followed by small-group discussions on potential solutions considering an interactive environment and dialogue. The key aim was to explore the collaboration among actors (See the expert workshop questions guide appendix 5). The second workshop was an interactive roundtable organized in association with the Sustainability Research and Innovation Congress, which was held in June 2024 in Espoo, Finland. One of the main themes of this international congress was to co-produce research and innovation initiatives aimed at advancing sustainability. The event began with presentations from all speakers, followed by an in-depth discussion. Participants included representatives from the Finnish Ministry of the Environment, CE scholars from Finland and Belgium, company circular services lead, and the audience (Table 5) (See the interactive roundtable discussion on RW BE questions guide appendix 6).

All qualitative interviews for this thesis were conducted via Microsoft Teams, while workshops were held on-site and were audio recorded and subsequently transcribed. The recorded interviews were transcribed in both Finnish and English by a professional third-party service to ensure uniform formatting and linguistic precision. Since the data collection for this study was conducted during the Covid-19 pandemic, the most efficient method of data collection was online interviewing.

Table 5. List of participants in stakeholder workshops.

<table>
<tr><th>Event</th><th>Organizational background</th><th>Number of participants</th></tr>
<tr><td rowspan="7">Interactive workshop for stakeholders involved in a building’s life cycle</td><td>Construction planning and design companies</td><td>4</td></tr>
<tr><td>Federation of the Finnish Wood Working Industries</td><td>1</td></tr>
<tr><td>Construction, renovation, and refurbishment company</td><td>1</td></tr>
<tr><td>Expert services for accelerating sustainable development (a state-owned company), B2B</td><td>1</td></tr>
<tr><td>Association for Maintenance of Real Estate Property</td><td>1</td></tr>
<tr><td>Association of the Recycling Industries of Finland</td><td>1</td></tr>
<tr><td>Total</td><td>9</td></tr>
<tr><td rowspan="5">Interactive roundtable discussion</td><td>Representative from the Finnish Ministry of the Environment</td><td>1</td></tr>
<tr><td>Circular economy manager, Circular Economy Services (Finland)</td><td>1</td></tr>
<tr><td>Circular economy scholar, University (Belgium)</td><td>1</td></tr>
<tr><td>Forest Business and Markets scholar, University (Finland)</td><td>1</td></tr>
<tr><td>Audience (international scholars)</td><td>10</td></tr>
</table>

Methods

Descriptive social network analysis

A social network analysis (SNA) was employed to examine the characteristics and structure of the local policy network (Article I), drawing on evidence from a quantitative online survey (Henning et al. 2012). To analyze the data, this study applied the SNA at two levels (Agneessens and Labianca 2022): (i) a network-level analysis assessing density, centralization, diameter, and average path length to evaluate overall structure, and (ii) an actor-level analysis using centrality measures to identify influential actors and their roles (Granovetter 1973; Freeman 1977; Scott 2000). Visualization and analysis were conducted in Gephi 0.9.2 (Bastian et al. 2009), including the calculation of centrality and other network metrics. The purposes for communication among actors were assessed by computing relative ratios across six categories using survey respondent data. Policy goal preferences were assessed by averaging respondents' ranking scores for each WBC policy statement, providing insights into the actors' prioritization of policy goals.

Qualitative thematic analysis

A thematic analysis of the data was carried out following Braun and Clarke (2006). The process began with repeated readings to become familiar with the data. Next, initial codes were generated, and intercoder reliability was ensured (O'Connor and Joffe 2020). The codes were revised by the members of the research team in an iterative process, until reaching consensus on code names, groupings, and resulting themes. Coding and theme identification analysis was performed using the ATLAS.ti software, while Excel served as a supplementary tool for interpretation. To analyze barriers in the RW BE, we combined Kirchherr et al.'s (2018) CE categorization framework with construction industry insights and the building life cycle phases outlined by Sáez-de-Guinoa et al. (2022).

Research trustworthiness and validity

Trustworthiness refers to the overall rigor and quality of the study, which means: "*.... when readers interpret the written work, they will have a sense of confidence in what the researcher has reported*" (Stahl and King 2020, p.26). Since this thesis largely relies on qualitative data (Articles II and III), trustworthiness could be addressed through the criteria of credibility, dependability, confirmability, and transferability (Lincoln and Guba 1985).

Credibility in this thesis was ensured through data triangulation, as addressing how well the findings reflect reality is essential in qualitative research (Stahl and King 2020). This involved collecting primary data through in-depth and reflective discussions in the form of interviews and workshops (Articles II and III), along with supplemented additional sources such as literature reviews and snowball sampling. Triangulation was further strengthened by conducting two focus group discussions during one of the workshops. Multiple researchers collaboratively collected, examined, and interpreted the data across several stages. This involved data reviewing, interpreting, refining themes, ensuring thorough and careful engagement, recognizing relevant patterns, and linking them with the theoretical concepts of this study.

Transferability in this thesis was supported by comprehensive documentation in the form of "*thick description*" and purposeful sampling of the research approach (Anney 2014). This includes methodological and contextual details, selection criteria, interview protocols, and transcripts. Additionally, key respondents in this study have been selected purposively for their extensive expertise and skill in the context. The degree of transferability will allow other researchers to replicate the same study with a different group of participants, at different times, under different circumstances.

The dependability of this research has been recognized through the provision of clear descriptions of data collection and analysis procedures and the application of standardized protocols. To ensure confirmability, all recorded interviews were transcribed. Researchers also marked their own reflections and observations in the notes during the interviews and workshop sessions, and these have been used for further interpretation. Data analysis was documented to provide a clear and traceable record of the process.

Furthermore, to adhere to ethical norms, while collecting data, interviewees were given a consent form outlining the purpose of the study, confidentiality statements, information regarding voluntary participation, and the right to withdraw. Participants' names were anonymized using codes. All data are handled and stored in accordance with ethical guidelines for data management plans produced by the University of Helsinki and the Finnish Advisory Board on Research Ethics (TENK).

Finally, regarding positionality, a researcher should explain their own experiences and background. These could reflect the potential effect on the overall research process (Bourke 2014). While my lack of background in WBC (e.g. timber engineering) and my non-European ethnicity could raise a question about my technical and institutional knowledge of the topic, this outsider position also fostered my curiosity to learn and understand this narrow field of research without holding any preconceptions or biases. On the other hand, my multidisciplinary educational background and being part of a diverse research group facilitated and enriched my critical and cognitive thinking during data collection and analysis of this thesis.

SUMMARY OF KEY FINDINGS

This chapter provides a synthesis of the three original articles forming the basis of the dissertation, highlighting their main findings (Table 6). These distinctive and emerging trends have been explored in Articles I–III. However, despite substantial policy support and technological progress, wood use in construction — particularly RW, WR, and NBS — remains a niche in Finland. Further, niche creation and market development require the active involvement of underrepresented actors, effective communication, and coordination across all stakeholder groups. Advancing these innovative wood use practices requires collective action and companies' strategies that strengthen existing networks and promote circular solutions within the broader context of a decarbonizing urban built environment (Table 6).

Table 6. Research focus and contribution covered by each sub-study (Articles I, II, III).

Article	Main contribution
Article I: Local policy networks in support of wood-based construction: A case study from Joensuu, Finland.	Understanding the characteristics of local policy networks in the dissemination of wood-based construction (WBC) remains uninvestigated. This study advances the policy network approach by depicting the structure of policy networks, the relationship patterns among local policy actors, and the mobilization of resources, along with their policy goal preferences, to enhance the adaptability and diffusion of wood use (as a renewable natural resource) in construction.
Article II: From barriers to solutions for reclaiming wood in construction: a business ecosystem case in Finland.	Greater wood cascading in the construction industry requires eradicating existing barriers and clearly defines the reclaimed wood construction business ecosystem. Hence, this sub-study reveals potential forward-looking solutions to existing challenges in the utilization of reclaimed wood, considering the business ecosystem and different building life phases in the construction sector.
Article III: Bridging missing actor links for innovative wood-based solutions in regenerative building.	Collaboration, intermediation, and activities between stakeholders are key to the formation and development of innovation ecosystems. This study sheds light on the crucial role of underrepresented actors and the connecting phenomena required to mainstream innovative wood-based solutions within the innovation ecosystem of a regenerative built environment.

Article I portrays how a policy network structure supporting WBC development locally (Joensuu) aligns with Finnish WBC strategies by using the policy network approach. The network has been examined considering the policy actors involved in WBC. The key focus of this study relies on familiarizing and understanding the characteristics of a WBC policy network, along with priority policy goal preferences among actors involved in WBC diffusion at a local level.

Firstly, to answer the first research question ("What types of organizations are involved in the local-level WBC policy network?"), this study represents the availability of the diverse actor groups ranging from academic and research institutions, governmental organizations, and local- to national-level business organizations (Figure 3). On the other hand, the second research question ("How is the WBC policy network structured in terms of influential organizations, relationships, and resource mobilization?") relates to the distinguished characteristics of the network. This involves the central intermediary actor as a nonprofit business organization and its brokerage potential in the network. With moderately dense connectivity, the rate of communication is found to be limited (almost 50% of communication happens a few times per year) within the network. Hence, many weak ties persist, which alternatively indicates how the network is gaining resources, new ideas, and support from both national and international actors. The study additionally highlights the flow of knowledge and expertise among the core actor groups, which not only facilitates research but also accelerates innovative practices across this local network.

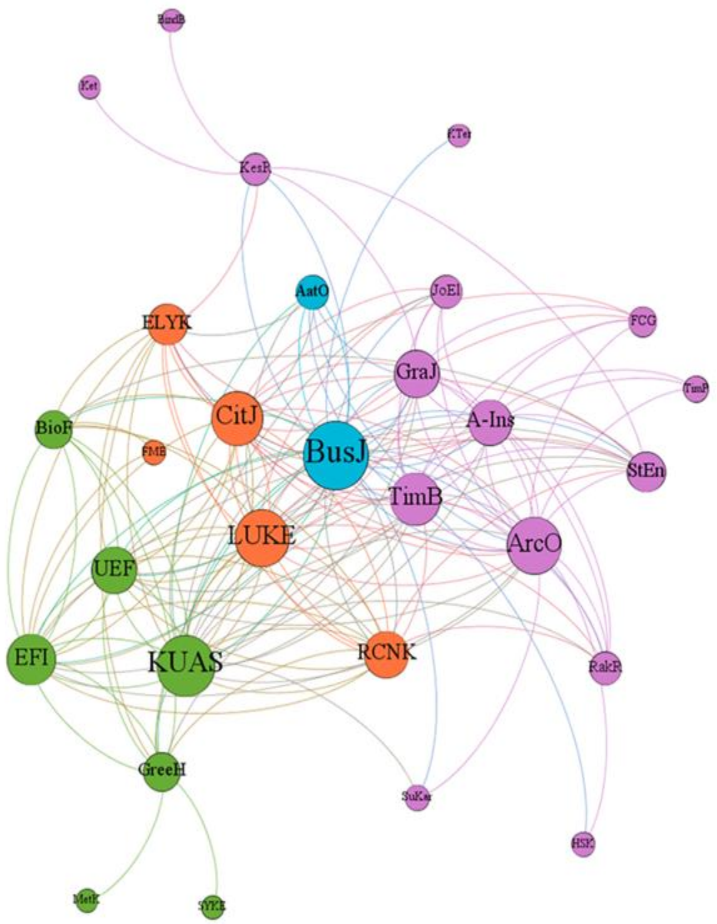

Figure 3. A network of wood-based construction policy actors in Joensuu based on an online survey (Node = 29, edges are undirected and unweighted). The colors indicate various actor categories (academia and research = green; government body = orange; industry, consultancy, or real estate business = purple; and others = blue). The more contacts a node has, the larger its size (Adapted from article I).

Secondly, while identifying the top policy goals (third research question “Which policy goals are favored by local actors concerning WBC?”), the attention mostly goes to mitigating climate change impact from the construction sector by increasing material efficiency, while market development, startups, and emerging business will create new employment opportunities around this sector. Taken together, this is reinforced by national and international policies, and Joensuu’s WBC policy network represents key enablers for local WBC diffusion, alongside the contribution of collaborative actors.

Article II focused on RW use in the construction sector. Actor involvement in the various phases of a building’s life cycle, the barriers to RW use, and the potential solutions to these barriers were studied following the BE framework (Moore 1998; Moore 2006) and the principles of material circularity (Kirchherr et al. 2018). To recap, this multistage exploratory study was based on data from 14 semi-structured qualitative interviews and two participatory workshops with experts, each providing insights from different stages of a building’s lifespan.

To begin answering the first research question of Article II “What kind of business ecosystem exists around reclaimed wood?”, the study shows that the ecosystem is complex, whereas actor connectivity and engagement are still missing. The core actors in the BE are mostly involved in the planning, design, and construction phases (e,g., architects, building designers and planners, real estate investors, construction companies), while extended actors mostly function in the manufacturing, use, and end-of-life phases (e.g., manufacturers, construction material retailers, waste management companies, real estate maintenance operators, and demolition or deconstruction companies). Notably, neither RW product monitoring nor products consulting companies exist in Finland.

When explaining the root causes for the low recycling rate of wood from construction, technological, regulatory, market, and cultural obstacles are mentioned (Table 7). Considering the market, forest industry dominance and the easy accessibility of virgin wood make the situation counterproductive for RW utilization in Finland. Those market barriers are linked with cultural barriers. This means that virgin wood availability leads to a lack of engagement and enthusiasm for wood cascading in the construction industry, thereby hindering changes in existing business models.

The conservatism of the construction industry and fears of adopting new approaches and the perceived higher risks associated with recycled wood materials were recognized as cultural barriers. Moreover, a lack of technological support has been highlighted. For instance, actor knowledge and practical expertise are very limited in this field. Additionally, digitalization and standardization are not advanced enough yet for effective operation and management of RW products. From a regulatory perspective, the stakeholders emphasize that regulation is also non-supportive. The lack of incentives and stricter policy requirements are not motivating the construction industries to shift towards recycled wood use practices.

Table 7. Four identified barrier categories against reclaimed wood (RW) use in Finland and comparisons with examples from previous literature.

Category	Barriers	Previous studies
Market	low price of virgin wood	Kirchherr et al. (2018); Hart et al. (2019)
	expensive labor and working hours	
	high upfront investment costs	Hart et al. (2019); Guerra and Leite (2021)
	lack of economic feasibility	Husgafvel et al. (2018)
	lack of end users and industrial destinations in Finland for reclaimed wood in construction	
	absence of market for circulated wood	
	low cost of incinerating wood	
	abundance of virgin wood	
	the strong positions of the forest industry in Finland	
Cultural	lack of interest and engagement in wood cascading throughout the whole value chain	Adams et al. (2017); Kirchherr et al. (2018); Hart et al. (2019)
	construction industry's conservatism, resistance to change, and wariness of innovation	Kirchherr et al. (2018); Hart et al. (2019); Guerra and Leite (2021)
	the fears and prejudices against new approaches and perceived high risks	
	lack of cooperation, collaboration, and their coordination in construction	Kirchherr et al. (2018); Hart et al. (2019)
	indifference to a clear sustainability vision by the industry	Hart et al. (2019)
Regulatory	strict and obstructing laws and regulations	Adams et al. (2017); Husgafvel et al. (2018); Kirchherr et al. (2018)
	lack of enforcement mechanisms and incentives for a circular economy	Adams et al. (2017); Kirchherr et al. (2018); Hart et al. (2019); Guerra and Leite (2021); Liu et al. (2021)
Technological	long life cycle of the buildings	Hart et al. (2019)
	technical material challenges in recirculating wood	Adams et al. (2017); Husgafvel et al. (2018); Hart et al. (2019)
	lack of knowledge concerning wood and its circularity potential	Li et al. (2021)

To answer the third research question in Article II ("What are the potential solutions for increasing reclaimed wood use in construction?"), this study highlighted the significance of closely following EU and national policy instruments, such as the EU Green Deal and taxonomy, in developing the regional and local market. This further indicates the need for better harmonization of construction policies. This sub-study found that actor collaboration, communication and community and platform development are crucial to the success of RW use and management. In this regard, the stakeholders emphasize stronger partnerships required between the public and private organizations, leading to broader experimentation and large-scale demo piloting projects and attracting greater consumer attention.

Furthermore, upon completing initial service life, RW holds its own story; this could be emphasized to increase the narrative value of reused material in business. The study also found the emergence of diversifying the use of recycled wood, which needed to go beyond the current limited range. Ultimately, this study found that developing various intermediary services, including various digital tools, and creating physical sorting space, cleaning, and storage facilities could reduce the technical challenges of RW implementation. Concurrently, all these could effectively remove market barriers and ensure product safety and usability.

Article III covers how wood can be used more effectively by diversifying its applications. This study examines actor engagement through the IE framework (Dedehayir et al. 2018) for innovative wood applications, such as RW, WRs, and NBS, within regenerative building, while identifying other gaps and activities to support the ecosystem formation and development. This study examines how underrepresented stakeholders, various connecting phenomena, and various supportive actions could enhance the mainstreaming of these innovative solutions.

To answer the first research question in Article III ("Which actors are missing among the Finnish innovative solutions of regenerative building that have key roles in IE formation and development?"), this study finds that RW clearly lacks an orchestrator or leader, including complementors, experts and champions, entrepreneurs, sponsors and regulators. On the other hand, the challenge for NBS is not the certain category of actors but their limited number. WR has also a small number of business actors and skilled professionals. A few construction companies offer innovative guidance services, yet holistic retrofits guidance services are missing.

To answer the second research question in Article III ("Which collaborative links, resources, and innovative activities are present or missing in the studied initiatives for fostering a regenerative building IE?"), RW solutions respondents addressed collaboration gap between innovative woodworking companies and construction companies and various construction projects. Collaboration gap was identified between energy efficient solution providers and innovative wood material producers of WR projects. Regarding NBS, there are missing links between the preliminary and use phases of construction actors, e.g. architects and construction and maintenance experts. The feedback loop between builders and planners, or between users and future project planners, is not maintained after construction is completed or once users begin residing in the building. All these together emphasize the importance of strategic information sharing and skill enhancement among actors, and maintaining an iterative process from planning, use and maintenance towards the end of life of a regenerative building.

From a practical solution-oriented perspective, to address the third research question in Article III ("How could the perceived lacks be facilitated by the emerging IE actors?"), RW respondents stress the need for stronger national regulations, including incentives for RW. To boost RW demand and supply and overcome logistical and operational barriers, stakeholders prioritize creating a physical storage place and an online marketing portal.

On the other hand, the interviewed stakeholders (Article III) claim that the acceptance and enactment of the RW, WR, and NBS should begin at the municipal level. In this instance, Table 8 indicates that the participants underline the extended responsibility of municipality organizations and how these three solution categories are spreading in the market to become more mainstream. The local municipal authority can provide support by creating platforms and piloting projects that encourage collaboration, idea generation, training and guidance, with the aim of promoting re-education and the adoption of innovation in industries. This further highlights the need to integrate solutions based on national regulatory measures, research-driven insights across WR and NBS projects by using RW, under the umbrella of the regenerative building approach. Priority should be given to develop the RW market through several targeted instruments and coordinated activities by orchestrators and intermediaries, although some existing municipal level actions have been noticed for WR and NBS (Table 8).

Table 8. List of instruments and tasks for creating links during IE development within three innovative wood-based solutions. The red signifies the missing link to be bridged, yellow signifies a neutral approach, and green signifies positive experiences in the way circular initiatives have been facilitated.

Facilitation process	**Reclaimed wood**	**Wooden retrofits**	**Nature-based solutions**
Orchestrator and intermediaries could facilitate by			
National regulation			
National monetary incentives			
City regulation			
City information guidance			
City creating a platform for piloting and business			
Research and development			
Education on circularity			
Technological – online platform building			
Face-to-face meetings and discussion events			
State or municipal development companies' involvement			

DISCUSSION AND CONCLUSION

Contribution of the dissertation

This study considers the context of the urban built environment in Finland. With over 75% of its land covered by forests and strong traditions in wood industry, Finland is a pioneer in the forest-based circular bioeconomy. Finland has strong sustainability and material circularity goals. However, the use of both wood and reused wood faces barriers, such as conservative industry attitudes and technological and innovation challenges (Article II), though initiatives like circular material markets are emerging to address these challenges. The new Finnish Construction Act (2025) is expected to be a strong enabler in the future, with its key focus including carbon footprint assessment and digital and technical solutions that ranges from building design to end of life, improving longevity and enhancing overall circularity (Building Act 2023). These tensions make Finland a strong case for analyzing wood use and reuse in construction.

This thesis highlights the emergence of a holistic understanding regarding the potential of wood and its various forms, in construction, an area that is often overlooked. With wood use in urban construction still being a niche, untapped potential exists for scaling innovative practices in RW, WR, and NBS. The potential for using virgin wood and innovative practices in construction stems from the strong availability of wood, cultural tradition of wooden construction, and its current low adoption rate in urban multistory construction in Finland. Moreover, growing resource scarcity and increasing economic pressures are prompting construction industries to adopt more circular solutions within their business models. In this context, innovative wood use in construction could help construction industries reduce dependency on virgin wood and mitigate supply risks.

The efficient use of urban space, driven by city densification, creates opportunities for WR, NBS, and regenerative buildings within the existing urban landscape. These approaches also align with circularity principles. Wood use helps to narrow the loop, while WR and NBS help to slow it down and RW helps to close it. All these approaches have the potential to help cities meet their climate and housing goals.

However, the long lifespan of buildings makes tracking wood and RW products and maintaining stakeholder relationships for end-of-life management difficult (Giorgi et al. 2024). Despite long-standing policy initiatives in Finland, the market share of wood in construction remains low. Wood reuse rates in Finland are lower than in other EU countries such as France, Italy, and Germany (Borzecka 2018). Hence, innovative housing solutions (e.g., WBC) need to shift from niche applications to more widespread adoption. According to the key premises of this thesis, this calls for cross-sectoral actors involvement, collaboration and stronger integration of various circular solutions.

The focus of this dissertation is promoting more versatile wood use for construction. The primary contribution of this study is its consideration of networking and collaboration across the entire building life cycle as consisting of a BE. This aspect has largely been overlooked in previous studies, with the exception of Evertsen and Knotten (2024) and a few project-level studies on wooden multistory construction (Pulkka et al. 2016; Gosselin et al. 2018; Toppinen et al. 2022; Erikshammar et al. 2024; Holtström et al. 2024). Another novelty of this thesis is that it expands on studies of wood use in construction and extends the analysis of wood use in building lifespans. This further underscores the importance of understanding actor collaboration beyond the project level and across various building life stages.

Enhancing wood use in construction requires **more novel actors** spanning local to national contexts (Articles I–III). Evidence from Articles II and III indicates a clear necessity for expert intermediaries to address wood heterogeneity and ensure quality and safety, complementing the findings of Evertsen and Knotten (2024) and Niu et al. (2021) by defining further required roles and expertise. There is also the scope to lead innovation in a sector that is increasingly prioritized by both regulators and stakeholders. This study acknowledges the role of academia, research, and innovation industries within the 'triple helix' alongside the Finnish Government driving policy and sustainable planning. Beyond core planning, design, and construction actors in a BE, public–private partnership actors and state-owned companies can be key extended actors driving sustainable wood and RW businesses through innovative practices (Articles I–III). Novel woodworking companies are emerging, yet they face long-term survival challenges. However, there is room for government innovation funding organizations and non-profit social organizations engaging in wood and RW diversification and promotion through guidance and practical resources. Changing consumer perceptions and fostering a cultural shift toward appreciating material reuse, renovation and broader potential in NBS practices, is potential outcome, for example. There is also scope for large forest industry actors to revisit their strategies and invest in circular practices and identify new sources of revenue.

Moreover, this thesis established that **closer collaboration** is necessary for utilizing innovative wood in construction (Articles II and III), encompassing both core and extended actors. The results of this thesis showcase the need to extend collaboration beyond contemporary single WBC projects (Viholainen et al. 2021) toward more systemic approaches. Collaboration between innovative wood material producers and major construction actors (e.g., designers, developers, and building owners) are needed to transfer technologies and novel market solutions for RW, underscoring the collaboration gap noted by Evertsen and Knotten (2024). This study addressed that collaboration across a building's lifecycle is hindered more by temporal gaps caused by the long lifespan of buildings than by a lack of intent. This is even more difficult for cases using WR and NBS (Article III), as such buildings are already in the middle of their life cycle, shaped by age, context, and original construction methods (Viljanen 2025a). In addition, given a few short-term collaborations between wood innovators and construction companies, experimenting with RW does not facilitate scalability. Large construction companies rarely seek collaboration with innovative start-ups. Scaling up wood use in construction would be easier if large companies recognized the need to take forward-looking steps towards building cross-sector partnerships.

A noteworthy insight of this study is emphasizing the need for **system-level orchestration of change**. This thesis claimed municipalities to be performing as key orchestrator roles in driving innovation around WBC through skill development, best-practice sharing, and governance — similar to Salmi et al. (2022). This is driven by the Finnish municipalities' carbon neutrality goals, which assign them responsibilities, including market creation via public building activities. Articles II and III indicate that the current market development and the adoption of reused wood in construction depend on large-scale, co-creative municipal pilots, intended to demonstrate feasibility and trust and enable learning, as highlighted by Khatri (2025). However, the extensive responsibilities, fiscal constraints, and limited technical capacities of Finnish municipalities prevent them from effective systemic change without strong private sector involvement. This indicates that municipalities face inertia and hence, the progress in promoting wood use remains slow. While municipal-level piloting represents a forward-moving trend, its scalability remains limited.

Moving forward, construction industry actors would need to engage more in orchestration to drive systemic change, but currently they are conservative — highlighted in Article II. However, municipalities still need to continue their active roles by creating collaboration platforms, connecting stakeholders, and establishing prerequisites for local-level governance (Salmi et al. 2022). Construction companies need to contribute diverse innovations (e.g. material and digital solutions) into their operational practices. Given the new regulatory changes in building code and potential avenues coming from digitalization (Klitkou and Nylen 2025), it is clear that the construction industry would need a paradigm change. Construction industries need to strengthen the orchestration within the partner networks and shared capabilities — aligned with Toppinen et al. (2018b). This further involves collaborating on multiple projects, as discussed by Evertsen and Knotten (2024). The progression and stability of construction companies will therefore be key to future market maturity, reflecting the development of IE — as is the main takeaways from Article III.

From a managerial recommendation perspective, this thesis calls for construction companies to adopt a proactive, **future-oriented mindset** as part of their strategic thinking. Although construction companies are at the time of writing this facing financial instability, those who act early could reap first-mover benefits while securing a stronger market position. EU taxonomy additionally encourages companies to adopt green strategies, enhance transparency, and secure long-term access to sustainable finances. Construction companies can become frontrunners in adopting innovative wood solutions (e.g., RW, WR, NBS) to show environmental responsibility, aligning with the Finnish Green Deal. Again, another major enabler of this change is the new Finnish Construction Act (2025), which strongly integrates advanced digital technologies. Articles II and III address technological upgrade requires overcoming technical and data-related challenges to facilitate wood reuse in construction. Both articles (II and III) are in line with Nylén and Klitkou (2025) and El Jazzar et al. (2021) that transforming the construction industry requires deploying digital technologies (e.g., BIM and material passport); integrating them across the entire lifecycle; ensuring connectivity; and shifting from a project-oriented mindset to a more process-oriented one.

However, two aspects may motivate companies for this change. The first is the fear of losing competitiveness amid evolving regulations. The second is the opportunity to benefit when legislative changes disadvantage some other material solutions. Another key argument of this thesis is that reuse of wood can be repurposed or adapted for diversified uses other than building structure. By adopting these practices, construction companies can promote values such as sustainability, local production, and emotional connection (Pitti et al. 2020), since reused wood carries its own history (Article II). Overall, this aligns with the recommendation identified in previous research that the cultural mindset of the construction industry should continue to evolve if wood material is to gain wider acceptance in built environments (Gosselin et al. 2018).

Moreover, this thesis found that enhancing and mainstreaming wood and innovative wood-based solutions call for more active **communication and interaction** among the various stakeholders involved in the different stages of a building's life cycle. In practice, construction industry managers can foster this by engaging with stakeholders such as waste management companies, innovative start-ups, and building maintenance companies (Articles II and III). Furthermore, extending building lifespans through innovative wood-based solutions should be considered already during the design phase, particularly in case where reused wood will be integrated into the solutions. This helps to avoid further complexity and ensures that the use of buildings could adapt to future needs. Wood element producers should be particularly involved from the very beginning of construction to support the buildings' adaptability (Toppinen et al. 2022).

This dissertation found untapped potential for scaling and diversification of wood use in Finnish construction that lies in **enlarging the roles of other actors**. The absence of stable green investors in RW use (Article II) addressed that it could drive the faster integration of wood into construction. The current absence could be due to the long lifespan of buildings, making financial returns hard to predict for investors, a common issue in innovative WBC, as addressed by Jussila et al. (2025). Despite that, there is scope for banks to offer green loans and specialized funds with lower interest rates and longer repayment periods to developers using innovative wood materials, as discussed by Evertsen and Knotten (2024).

Developers can gain expertise from one project and transfer the learnt knowledge to other projects, thus ensuring more effective knowledge dissemination (Vosman et al. 2023). As of now, such collaboration is not that common in the WR and NBS practices, as shown in Article III. Both innovative start-ups and research organizations have the scope to introduce cutting-edge knowledge into the construction BE and IE, offering education regarding wood circularity practices (Articles II and III). Research organizations need to continue developing innovative technologies to tackle reused wood challenges. Meanwhile, municipalities need to keep contributing by creating digital marketplaces and storage facilities and upkeeping their management to boost business growth and performance around wood and RW (Articles II and III).

The findings of this dissertation indicate that local networks have the potential to foster collaboration and innovation diffusion (Article I), aligning with Sandström and Carlsson (2008). In contrast, nationwide ecosystem studies (Articles II and III) reveal greater complexity in stakeholder engagement and collaboration. The findings highlight that circular solutions require collaboration beyond location- and project-specific networks (Vigren 2024, Viljanen 2025a), considering the life cycles of entire buildings and coordination between projects and municipalities. Moreover, the evidence from this dissertation indicates that BE and IE do not develop automatically, because both are embedded with their economical, technological, institutional, cultural, and regulatory hindrances (Aksenova et al. 2019). To promote innovative wood-based solutions in urban built environments — including renovation and NBS practices — emerging ecosystems should ensure both horizontal and vertical stakeholder collaboration. Scaling pilot projects is key to mainstreaming and market adoption, and meso-level ecosystem orchestrators can accelerate such change by integrating wood use and innovative solutions (Article III).

Limitations of the dissertation and future research

As with any study, this thesis has a number of limitations. In particular, it is focusing on one national context — Finland. While the study offers valuable insights, future research could compare uses of wood in construction across countries and account for differences in socio-economic conditions and natural resource availability. This means that the study findings can be best generalized to neighboring countries, such as Norway and Sweden, which are exploring innovative and reused wood solutions (Holtström et al. 2024; Gedde et al. 2025), as well as potentially southern or central European countries are experimenting with the potential of reused wood (Kitek Kuzman et al. 2024; Cakaj et al. 2025). As another limitation, wooden retrofits and NBS were only briefly addressed in this study, as the data on these represent inputs from another thesis (Viljanen 2025a). There is significant potential for more in-depth analysis of these areas, particularly residents' experiences with WR, and how these approaches could move beyond pilot experimentations. Moreover, the survey (Article I) and qualitative interviews (Articles II and III) conducted in this thesis did not explicitly address the intermediaries' roles within the wood construction sector. These roles emerged spontaneously in this thesis during the open-ended discussions and the workshops. Since the data collection for this study was conducted during the Covid-19 pandemic, there is a possibility that online data collection methods had an impact on the quality of the data. On the other hand, it offered better time management and enabled participation for both the researchers and the participants during data collection processes. In addition, online interviewing was complemented by in-person (N=1) and hybrid (N=1) workshops, where participants had the chance to contest the initial interview findings (presented in the workshop), or confirm and elaborate on them.

Considering future research, there is an opportunity to explore specific intermediary involvement strategies across various life spans of a building and their potential to accelerate wood diversification practices that could enable scaling. In addition, more research is needed on the implementation of joint experimentation among companies and the platformization of circular ecosystems in the context of wood reuse (Konietzko et al. 2020).

Furthermore, the concept of public–private partnerships has emerged in this study as a significant opportunity for collaboration and for growing the market for wood use. Based on this approach, several digital innovations and reuse solutions are emerging in Finland. This includes piloting a physical marketplace and an online portal for reused wood materials — a key enabler of the transformation towards a circular wooden construction industry (Nylén and Klitkou 2025). Future research could benefit from tracking the progress of these pilots and assessing their effectiveness, given that the aim is to continue operating on a large-scale after the pilot phase. Future research could also involve examining the ways of increasing profitability of public–private partnerships focusing on the promotion of wood use and reuse in construction.

This study integrated previously fragmented strands of literature on wooden construction. It offers an empirically grounded, interdisciplinary perspective that responds to calls for a broader understanding within the context of circular bioeconomy. This thesis sheds light on innovation and strategic business management in construction (Vigren 2024) by utilizing Finnish meso-level cases within the urban built environment that aim at enhancing wood use and reuse. All the articles aimed at exploring enhancing diversified wood use in the Finnish construction sector, and by combining policy network, BE, and IE perspectives has allowed achieving a deeper understanding of collaboration complexities. Expert actors' and intermediaries' support is paramount in scaling innovative wood use across planning, design, construction, use, maintenance, and the end of life of buildings. Overall, the mainstreaming of RW, WR, and NBS at local level requires active engagement of relevant actors. This calls for continued interaction through strong collaboration and sharing responsibilities between municipalities and construction companies. Future research on solutions to overcome profitability challenges is also needed to enable more diversified use of wood in construction.

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Appendix 1. List of literature reviewed

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Appendix 2. Survey questionnaire on WBC policy network of Joensuu

Please, answer the following questions (Questions with * marks are required to answer)
1)Your Name*
2)Your Organization/affiliation*
3)Your position/work duties*
4) Where would you place the organization your work for in the following categories? (You can choose more than one category) *

- Government
- Industry/ real estate business/ Consultancy firm
- Academic/research
- Certification agencies
- NGO's
- Other (please specify):

5) Mark the organization on the basis of frequency of contact with them (please, select one answer in each row) *Please, select (√ mark) as many influential contacts as possible including their name and organizations who are important to you in your professional network. These can be actors who provide you with information to do your work, help you when you have complex problems, or provide developmental advice or materials supply or financial support helpful in your working life.

Organizations	Daily	Weekly	Monthly	Few times a year	Not at all
University of Eastern Finland					
LUKE					
European Forest Institute (EFI)					
Karelia Uni of Applied Science					
Regional Council of North Karelia					
Business Joensuu					
City of Joensuu					
ELY-Keskus					
Joensuu Elli					
Aatelitalot Oy					
TimberBros					
Rakennustoimisto eero reijonen oy					
Arcadia Oy Arkkitehtitoimisto					
Stora enso					
Timberpoint Oy					
Granlund Joensuu Oy					
A-Insinöörit Oy					

FCG					
Suunnittelyryhma Karrak OY					
Master Kodit Oy					
Joensuun Kodit Oy					
K. Tervo OY					
Kesalahden Rakennus Oy					

6) Please name the organization that has not been listed above but with whom you are contact concerning wood-based construction in Joensuu. (optional)

7) Please indicate for what purpose you contact with following organizations. *

You can select (√ mark) more than one purpose for one cell.

Organizations	Policy Advice	Organizational and strategic planning	Information and knowledge sharing/exchange	Resource/ Materials exchange (Construction materials, tools, etc)	Providing or receiving financial support/transactions	Others	Not at all
University of Eastern Finland							
LUKE							
European Forest Institute (EFI)							
Karelia Uni of Applied Science							
Regional Council of North carelia							
Business Joensuu							
City of Joensuu							
ELY-Keskus							
Joensuu Elli							
Aatelitalot Oy							
TimberBros							
Rakennustoimisto eero reijonen oy							
Arcadia Oy Arkkitehtitoimisto							
Stora enso							
Timberpoint Oy							
Granlund Joensuu Oy							
A-Insinöörit Oy							

FCG							
Suunnittelyryhma Karrak OY							
Master Kodit Oy							
Joensuun Kodit Oy							
K. Tervo OY							
Kesalahden Rakennus Oy							

8) Please rank the arguments based on your preferences for promoting wood-based construction at the city Joensuu. (Rank them from 1 to 10, Here 1 is the most important and 10 is less important) *

Arguments	Ranking
Lowering Carbon Footprint	
Long term Carbon storage in buildings	
New market/business for sawn wood	
Promoting Building material circularity after demolition of project	
Replacing Non-renewable materials	
New Job opportunities	
Household property value increase	
Opportunity for technological Development	
Emphasizing the choice of residence	
Achieveing Sustainable development goals	

9) Are there any organizations with relevance for your work and with whom you wish to have contact in the future, but currently do not?

10) Do you see the need for more networking and collaboration within the field of wooden construction? Answer: No/Yes/Don't know, if so, do you have any ideas or how to improve collaboration?

Appendix 3. Guides (topics) utilized in semi-structured interviewing and workshops
Semi-structured interviewing

- Introduction, warm up questions for the interviewee, organization's involvement with CE
- Circular solutions related to wood created by the company and/or promoted by the organization
- Motivation and reasons for engaging with reclaimed wood
- Questions related to the uptake of reclaimed wood in Finland and comparison to other national contexts
- Existing collaboration between different actors on the uptake of reclaimed wood in construction
- Barriers preventing the uptake of reclaimed wood in construction
- Examples of success stories, strategies and solutions for overcoming the barriers

- Recommendations for policymaking to facilitate uptake of reclaimed wood in construction
- Additional questions or comments

Appendix 4. Participants of the semi-structured interviews

No	Code	Interviewee	Sector/organization	Interview date	Interview length (Minutes)
01	WR-01	Sales manager	Construction products and services	02.11.2021	114
02	WR-02	Managing director	Construction products design, manufacturing, and services	04.11.2021	66
03	WR-03	Professor	University	03.11.2021	89
04	WR-04	Project manager	University and forest center	12.11.2021	75
05	WR-05	Architect	Architectural company	19.01.2022	62
06	WR-06	Managing director	City-owned housing company	09.12.2021	49
07	WR-07	Housing company chair	Housing company	25.01.2022	107
08	WR-08	Environmental expert	Construction	28.01.2022	38
09	WR-09	Design manager	Design engineering company	27.01.2022	68
10	NB-01	Sustainable development technology manager	Design engineering company	11.10.2023	58
11	NB-02	City zoning architect	City	16.10.2023	90
12	NB-03	Project manager	Design engineering company	17.10.2023	50
13	NB-04	Sales director	Green landscape design company	27.10.2023	57
14	NB-05	Architect	Architectural company	31.10.2023	46
15	NB-06	Team manager (city zoning)	City	01.11.2023	60
16	NB-07	Architect	Architectural company	02.11.2023	60
17	NB-08	Landscape architect	Landscape architectural company	02.11.2023	55
18	NB-09	Project manager (landscape architecture)	Design engineering company	03.11.2023	62
19	NB-10	Digital transformation manager/Lead responsibility manager	Design engineering company	15.11.2023	57
20	NB-11	Assistant professor	University	17.11.2023	57

21	RW-01	Head of sustainable development	Construction company	03.02.2023	21
22	RW-02	Wood construction specialist	Construction company	20.02.2023	25
23	RW-03	Senior expert, expert services on circular economy	Intermediary promoting circularity and sustainable development	27.11.2023	46
24	RW-04	ESG vice president	Construction company	24.01.2023	30
25	RW-05	Public affairs and sustainability manager	Circularity/recycling services	30.11.2022	31
26	RW-06	Project manager	Construction company	24.02.2023	24
27	RW-07	Sustainability specialist	Construction company	19.12.2022	55
28	RW-08	Environmental manager	Construction company	23.02.2023	29
29	RW-09	Founder, recycled wood building materials	Wood product manufacturing for construction	28.11.2023	56
30	RW-10	Senior consultant	Business consultancy	04.01.2023	24
31	RW-11	Wood construction director	Construction company	28.02.2023	29
32	RW-12	Environmental specialist	Construction company	08.02.2023	36

Here, Wooden retrofits = WR, Nature based solutions = NB and Reclaimed wood = RW

Appendix 5. Expert workshop on solutions guides

- Can you think of any "success stories" where recirculation of wood worked out better than expected?
  -What kind of practices or procedures were central to success?
- If you had the money and freedom to change processes related to construction with wood – what first steps would you suggest?
- What kind of actors could facilitate the recirculation of wood?
- In what ways could communication between the different actors of the construction with wood ecosystem could be improved?
  -What kind of information is needed?
  -What kind of events could be facilitative?
  -What kind of channels can reach different types of actors in the ecosystem?
- In the past, what were the key factors that supported the initiation of more construction with wood?
- What aspects in construction with wood are frustrating from the perspective of your organization?
- From the perspective of your organization, what policies or regulations are impeding the recirculation of wood?
  -Are there any policies or regulations that are counteractive towards each other?

- What kind of technology is missing, which would be key for accelerating the reuse of wood in construction

Appendix 6. Interactive roundtable discussion on reclaimed wood circular ecosystem questions guide

- What kind of progress has taken place in recirculation of wood in construction over the last years? What are some of the positive changes that have taken place?
- Who are the key actors in recirculating wood in Finland and in Belgium?
- What is relevant in assessing the circularity of wood?
- What kind of data streams are needed to better govern the applications and the reuse of wood?
- What kind of economic value could be created from recirculation of wood? What are some of the feasible business models?
- How can policy better support recirculation of wood? Are there any policies or regulations that are currently slowing down recirculation of wood in construction?
- What will happen in the future? Where will we be in the next five years? What kind of reuse of wood do we envision?
- Open questions from audiences