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Local policy networks in support of wood-based construction: A case study from Joensuu, Finland

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ABSTRACT

Wood-based construction (WBC) is considered important for climate change mitigation, as buildings provide long-term carbon storage and contribute to sustainable urban solutions. Research shows that a lack of coordination among policy actors hinders the more rapid development of WBC in many contexts. Gaining a better understanding of the characteristics of local WBC-related policy networks is critical for speeding up WBC development. We conducted an exploratory case study on one WBC forerunner city, Joensuu, Finland. The results from our quantitative social network analysis show that the WBC policy network of Joensuu is moderately dense and mostly consists of research and business organizations. However, the local hub, Business Joensuu, holds a central position in the network despite being an intermediary non-profit business and a regional development organization. Information and knowledge sharing are the most common resources distributed among the actors, which implicitly suggests that the network is primarily contributing to research and innovation around WBC. Considering the diverse policy goal priority, statements related to WBC, actors are mostly interested in climate change mitigation measured by reducing carbon emissions from construction materials, followed by creating new employment opportunities. From the policy perspective, our findings concerning the WBC policy network of Joensuu showcase the importance of national and international policies in the local diffusion of WBC and the key role of collaborative actors.

1. Introduction

There is an increasing demand among European cities for sustainable housing while seeking to achieve their climate neutrality goals (Green Cities Europe, 2020; Huovila et al., 2022; The 100 Climate-Neutral and Smart Cities by 2030, 2022). Conventional building construction, dominantly based on concrete and steel, represents 36% of the total energy consumption worldwide and produces 39% of energy-based carbon dioxide (CO_2) emissions (UN Environment and International Energy Agency, 2017). Emissions from new buildings may account for 35–60% by 2050 (Churkina et al., 2020; Mohajer, 2021). In this context, wood-based construction (WBC) is an option, which could potentially provide carbon storage instead of carbon emissions from housing development in sustainable urban solutions by substituting conventional building materials (Høibø et al., 2015; Gosselin et al., 2017; Hamadyk et al., 2020; Ahn et al., 2022; Mark-Herbert et al., 2022). Along with resilience and fire safety measures (Ramage et al., 2017), WBC provides owners the comfort of quality living and conserves operational and embodied energy (Olanrewaju et al., 2017; Franzini et al., 2018). WBC has progressed rapidly over the past decade thanks to development in innovative wood products and industrial prefabrication (Asdrubali et al., 2017).

Despite the technological advances and benefits of WBC, the targeted policy measures and desired transition may neglect social aspects, facing a lack of alignment and cooperation from central actors in the construction sector (Weiss et al., 2017; Vihemäki et al., 2020). Decisions promoting WBC depend heavily on actor interests at various levels and their connectedness within networks. At the project level, the complexity of managing personal and organizational relationships increases with the increasing number of actors involved, often resulting in

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misperceptions, communication problems, delays, and accountability issues (Gosselin et al., 2017). The formation of a policy network relies on actors who, in practical terms, engage with each other based on their interests, values, and aims (Yu et al., 2022). There is thus a need to evaluate actual WBC policy networks at the local level.

Considering the various challenges that WBC must overcome, governments in North America and Europe have established a set of policies to encourage an increase in wooden building construction (Wiegand and Ramage, 2022). The United Nations Environment Programme – Sustainable Buildings and Climate Initiative (UNEP-SBCI) works for promoting sustainable construction policies and their implementation worldwide (United Nations, 2016). Deployment of the Timber Innovation Act (2017) ensures legal aid for advancing WBC in the US (Franzini et al., 2018). At the EU level, aligning with the ambitious 2030 Climate Target Plan for renewable energy efficiency, the EU Energy Performance Directive, Renewable Energy Directive, and Energy Efficiency Directive focus on building codes and conducts (Dodd et al., 2016). Moreover, The European Commission regulates Green Public Procurement (GPP), which empowers public agencies to appraise products and services with minimal environmental effects and provides industries with incentives to secure a sustainable environment (Deloitte, 2021).

Nordic countries are at the forefront when it comes to policies fostering wood construction (Maniak-Huesser et al., 2021). Their policies aim to increase wood utility in the construction sector, enhance value creation in industrial production, and promote overall socio-economic prosperity. In Sweden, the government guides and regulates municipalities through the planning and environmental legislation related to wooden construction, whereas the municipality and its collaborative actors are seeking to meet the public housing demands and achieving national and regional environmental and climate goals (Lindblad, 2022). For instance, the Swedish National Timber Construction Strategy (SNTCS) incentivized Växjö City to implement more timber construction (Wiegand and Ramage, 2022) via public-private partnerships, including industry and research organizations to ensure more energy-efficient wooden buildings (Khan, 2013). In the Nordic countries, municipal government organizations actively introduce regulations and facilitate tools, planning, and zoning directives to promote local development of WBC (Franzini et al., 2018; Maniak-Huesser et al., 2021; Salmi et al., 2022). Building designer companies (including architects) in Sweden, Finland, and the United States West Coast have been found to perform influencer role while selecting wooden materials for construction (Conroy et al., 2018; Ilgin and Karjalainen, 2021; Markström et al., 2018). Also, business and construction companies (main contractors and project managers) have strong decision-making power while promoting innovations in building construction (Gerding et al., 2021). Academic and research institutions are mainly a source of knowledge that train and generate specialists required to wood construction field (Pajunen et al., 2023; Viljanen et al., 2023).

Finland is a country with long traditions in constructing wooden single-family buildings (Ympäristöhallinnon Yhteinen Verkkopalvelu, 2020; Franzini et al., 2023). Despite the increasing demand for sustainable housing, Finland's WBC system is developing slowly (Kylkilahti et al., 2020; Vihemäki et al., 2020), and the current market share of wooden multi-story buildings is estimated at only 6% (Hurmekoski et al., 2018). Increasing the market share of WBC will aid in achieving Finland's carbon neutrality goals towards 2035 (Finnish Government, 2019). Finnish construction is regulated by national and municipal laws and building standards, and municipalities play a significant role in decision-making (Salmi et al., 2022). Several national, regional, and local policies aim to boost domestic WBC business growth (Lazarevic et al., 2020; Vihemäki et al., 2020; Toivonen et al., 2021; Franzini et al., 2023). For instance, the national Wood Building Programme (2016–2022), a roadmap for low-carbon buildings made of renewable materials, has already been implemented (Finnish Ministry of the Environment, 2019). Other policy examples include the North Karelian Regional Development Programme 2014 and the North Karelia Climate and Energy Program 2030, and the National RDI Roadmap intends to support collaboration between the public and private sectors and between the state and municipalities, such as the City of Joensuu. Overall, Finland presents a particularly intriguing example because of the contradiction between a high level of policy encouragement and persistently low rates of implementation (Franzini et al., 2023).

Joensuu is the municipality capital of North Karelia province, Finland, accommodating approximately 80,000 people. With a total area of 2751 km^2, the city is considered the second-largest municipality in the province (Area of Finnish Municipalities, 2018). North Karelia harbors 1.5 million ha of coniferous forest zone (Hyvönen et al., 2020), facilitating the forest industries to play a prominent role in the area, along with substantial research and development in wood material science (Weiss et al., 2017). Joensuu has become an important area for North Karelia's entrepreneurship due to its expertise and ability to build large-scale WBC projects. The city is also actively developing support measures for value-added wood-based products, contributing to the evolution of the building sector (Heräjärvi et al., 2021). While the bulk of WBC is ongoing in central Joensuu, regional-level policy implementation is still needed to reach the city's 2025 ambitious carbon neutrality goal. Actor collaboration and sharing of resources are crucial to the future development of the municipal construction sector (Viljanen et al., 2023). Thus, Joensuu is a prime example to better understand the local policy network structure and actor engagement.

Previous literature has confirmed that the decision-making process for wooden building projects in Finnish municipalities has been affected by various sectoral actors (Vihemäki et al., 2019; Viljanen et al., 2023). Toivonen et al. (2021) analyzed three types of national policy narratives accelerating WBC in Finland and identified a lack of coherent policy goals and understanding among actors as the main obstacles for boosting the WBC market. In an earlier project-level analysis, factors affecting WBC diffusion and business ecosystem in Finland were analyzed by Toppinen et al. (2022a). Moreover, Viholainen et al. (2021) showed the importance of obtaining knowledge and skills and that end-user inclusion is critical for WBC business ecosystem. Vihemäki et al. (2020) emphasized, when assessing the effectiveness of a national-level network, the low degree of coordination among the intermediary actors, whose scattered structures may be hindering the facilitation of WBC transition processes. Most recently, considering the local business ecosystem, Viljanen et al. (2023) suggest that both policy instruments and actor collaboration could effectively promote WBC and use of wood in renovations. However, no studies exist that examine local policy networks related to WBC, but related research has focused on actor collaboration from the perspective of value network in the case of Quebec (Gosselin et al., 2018), conceptualization on actors collaboration in innovative building construction environment in Australia (London and Pablo, 2017), acceptability of wood construction as a climate change mitigation measure in a Swiss region (Creutzburg and Lieberherr, 2020), at the level of national bioeconomy systems (e.g. Giurca and Metz, 2018; Korhonen et al., 2018 in case of Germany and Finland), unpacking the German bioeconomy discourse network (Giurca, 2020), actor mapping and project strategies on knowledge diffusion considering European circular forest bioeconomy (Hedeler et al., 2020), exploring the multi-actor environment and their influence on decision making process in circular building cases in the Netherlands (Gerding et al., 2021), or even forest land-use governance perspective in Germany (Aurenhammer, 2017). Addressing the above-mentioned gap in literature, the aim of our study is to better understand local-level policy network characteristics and actors' policy goal preferences in supporting WBC development. Therefore, we aims to respond to the following specific research questions:

- What types of organizations are involved in the local-level WBC policy network?
- How is the WBC policy network structured in terms of influential organizations, relationships, and resource mobilization?

- Which policy goals are favored by local actors concerning WBC?

To reach this aim, we specifically analyze the policy networks related to the City of Joensuu, Finland. Joensuu as a case study is interesting as a best-case scenario, where WBC development has been comparatively successful and is supported by the city's ambitious carbon neutrality target of 2025 (Joensuu, 2020).

2. Theoretical framework

2.1. Policy network theory

Policy network theory incorporates a network's structure and the agents that function within it (Marsh and Smith, 2000). Agents are mainly actors who support their preferences for policy development and innovation within the network (Marsh and Smith, 2000; Buttoud et al., 2011). Marsh and Rhodes (1992) define a policy network as a representation of the interaction between various interest groups and the government (Marsh and Smith, 2000). The role of actors' individual relationships and exchange of resources could further influence decision-making in policy subsystems, a topic which has come to light according to the Advocacy Coalition Framework (ACF) (Sabatier and Weible, 2007). Concurrently, a two-dimensional paradigm of network structure is presented by Adam and Kriesi (2007), based on actor categories and their interconnections.

In policy network analysis, a typical assumption begins with understanding the types of organizational actors involved and identifying any influential actors, how they share resources, and their relationships within the network structure. Also, understanding actor preferences could help explain the ultimate policy enhancement options (Metz, 2017). Policy networks may, in some cases, be characterized as closed, elitist, focused on individual interests, and undemocratic, which is why the policy enhancement and innovation adaptation process is challenging (Hay, 1998; Marsh and Rhodes, 1992; Blanco et al., 2011). An example of a policy network approach for the urban policy subsystem is given by Blanco et al. (2011) by mentioning connections and resource dependencies among construction planners, housing developers, funding organizations, and political groups, are crucial and require examining.

Actors are considered one of the fundamental aspects in forming a network. An actor is a participant, either an individual, group, or governmental or private sector organization, who can form interactive relationships (Dente et al., 1998). Policy network structures can therefore be directly influenced by various organizational actors, i.e., business entities or consulting agencies in addition to governmental actors (Kenis and Raab, 2008; Rhodes, 2008; Beyers and Braun, 2014). Third-sector actors (non-profit business organizations) can also contribute prominently to the network (Vihemäki et al., 2019; Toivonen et al., 2021).

The most influential and powerful actors in the network are placed at the center (Klijn, 1996; Creutzburg and Lieberherr, 2020). Conversely, disconnected actors mostly remain in the periphery. Whether an actor can acquire a central position depends vastly on their individual resources (Ingold et al., 2021). In this study, the number and categories of actors will identify multi-actor involvement, while actor positions will determine the influential actors in the network.

Policy networks begin to be formed by various actor categories when they share resources (Smith, 1993). To obtain specific policy objectives, actors are dependent on each other's assets while communicating among themselves to reach a win–win solution (Dente et al., 1998). In this process, a strong emphasis has been given to resource exchange between actors within the network (Normann, 2017). Dente et al. (1998) distinguish four resource categories. First, to secure other resources, network actors may exchange or transfer financial resources, which are referred to as capital in the policy process. The next category is called political resources, and it contains coalition building, institutional support, and power, which can help justify actor positions within the network. Legal resources comprise the third category, where actors can engage in discourse concerning specific laws or policy advice that they can share, but they cannot dominate by using these resources on the other actors. The last category is called cognitive resources, such as scientific knowledge and skill sets. By opening to new ideas and information, actors reinforce transferring knowledge and skills and fostering innovation potential (Alvarez-Meaza et al., 2020). Although information or knowledge sharing can occur without conducting research and innovation activities, the value creation in innovation process is largely dependent on knowledge sharing among organizations (Castaneda and Cuellar, 2020), and is considered one of the key factors for innovations to be successful (Kremer et al., 2019). Weiss et al. (2021), in their recent review on innovation governance, also point out that new trends from innovation research increasingly include the role of societal changes and various stakeholders such as civil society organizations and users.

Actor relationships are crucial because individual actors cannot effectively spread their resources across diverse groups. Two types of relationships can form within a network; Granovetter (1973) describes frequent communication to represent strong ties, while occasional and rare contact denotes weak ties. Nevertheless, from a well-operating network viewpoint, the existence of both strong and weak ties is crucial, since they provide support and various benefits to individuals.

Most frequent interactions form strong ties and facilitate joint action within the network (Prell et al., 2009; Bond et al., 2012; Korhonen et al., 2018). Strong ties encompass actors' inclinations to associate and interact with other likeminded actors. Given this situation, actors can share their resources faster and more reliably (McPherson et al., 2001). A lack of communication represents weaker ties, also representing bridging ties between two actors who have had no prior connections (Borgatti and Lopez-Kidwell, 2016). These ties can create opportunities for the networks to access a large resource pool. Weak ties also have the capability to circulate information and ideas from the network core to the periphery.

According to Granovetter (1973), organizations with many strong ties could gain strong, rigid integrity but overall weaker cohesiveness at the network level. The presence of numerous weak ties may help organizations form alliances, potentially leading to the spread of new ideas and to international exposure (Borgatti and Lopez-Kidwell, 2016). Hence, there are always trade-offs between these types of ties in a network, as they serve various purposes. In our study, actor relationship types will thus help determine actor interdependencies and strengths.

Policy goals are a part of policy component, a general and broader group of ideas that assist the development of policy and deal with governmental aims and aspirations within a particular policy subsystem (Howlett and Benjamin, 2009; Howlett, 2010). To contribute to the dynamic relationship of structure and agent, Ringe (2005) formulated policy goal preferences in legislative politics. Strategic alliances of actors with their preferences and policy goals are most typically the driving force for policy process to work persuasively (Brockhaus et al., 2014). A policy can have multiple objectives, where the actors choose the best one that contributes most to societal improvement and well-being, and helps accelerate the decision-making process (Vihemäki et al., 2020; Layard, 2021; Toivonen et al., 2021). Irrespective of whether the actors are individuals, firms, or organizations, no analysis of actor relations is feasible without recording actor preferences (Frieden, 1999). According to Berman (1998), individual aims in obtaining specific objectives in the network lead to diverse preferences. In our study, actor policy goal preferences are used to define the ultimate choices of actors for enhancing the existing WBC policies.

3. Materials and methods

3.1. Research design

We used a single WBC policy subsystem and network (City of Joensuu) for our explorative case study analysis because it can depict phenomena in considerable detail (Siggelkow, 2007). The goal of this study is to explain what contemporary events are occurring within the boundaries of the network, to disclose gaps hindering and prospects for developing the network. Any relevant organizations in the WBC subsystem are regarded within the case boundary. The quantitative online survey provided evidence concerning the network key attributes and further supported a social network analysis (SNA) to identify the structure and characteristics of the policy network (Henning et al., 2012).

3.2. Data collection

During the first phase of data collection, a comprehensive online literature search was conducted to identify the key actors involved. The literature dataset includes peer-reviewed scientific articles, book chapters, webpages, and reports. Scopus, Google Scholar, Science Direct, and University of Eastern Finland and University of Freiburg online libraries, along with other, more casual search websites, i.e., ResearchGate, were used to locate the literature. The search was performed by investigating the literature for keywords such as "Finnish wood construction", "Joensuu wood organizations", "Finnish wood construction policy network", "wood construction benefits and barriers", and "North Karelia". Appendix A offers a complete list of all retrieved documents. Through this approach, we were preliminarily able to identify all relevant organizations involved in the case area. Organizations are referred to as "actors", while the most suitable individual professionally represents any specific organization.

Ten actors were initially identified from the literature search and through personal acquaintances. Eventually, we followed a snowball sampling process to identify additional actors (Bryman, 2012). We concurrently contacted six experts from the academics and research field of Joensuu, and these participants identified further organizations with similar expertise or attributes (Bryman, 2012). A further eight actors were pinpointed using this approach, resulting in a total of 18 organizations (see Appendix B). Afterward, the contact information of suitable persons affiliated with each organization were collected by searching organizational websites, and these were recorded in an Excel spreadsheet.

The survey questionnaire was formed using the Survio online software. It included closed and open-ended questions and took 12 min to answer on average. The first series of questions were participant information, such as respondent names, organization names or affiliations, and positions within the organization. The actors had the option of self-categorizing themselves into one or more categories out of six (government body, academic or research, industry or real estate business or consultancy firm, certification agency, environmental non-governmental organizations (ENGO), and other). Next, respondents were given a roster list (Agneessens and Labianca, 2022), which included all 18 identified organizations, embedded with a frequency of contact question (i.e., daily, weekly, monthly, a few times a year, not at all). The actors were asked to select as many contacts as possible and to identify how frequently they contacted each other. For the frequency assessment, we considered daily, weekly, and monthly contacts to be frequent and contacts a few times a year to be infrequent (Giurca and Metz, 2018; Korhonen et al., 2018).

In the following step, a "name generator" process (Adams et al., 2020) was used, where participants could add more organizations with whom they had contact with but that were initially not included in the provided roster list. Eleven additional organizations were identified in this manner, and the same questionnaire was sent to each organization immediately after recording a new individual (see Appendix B). To determine the purpose of contact (Henning et al., 2012), actors had the option of selecting one or more from the following alternatives: policy advice, organizational and strategic planning, scientific information and knowledge sharing, resource exchange (construction materials, tools), providing or receiving financial support, other reason, and no contact at all (Brockhaus et al., 2014; Giurca and Metz, 2018; Korhonen et al., 2018).

In the next segment, a series of statements were formulated for the respondents in the survey questionnaire to rank from 1 to 10, thus allowing the respondents to reveal their WBC policy goal preferences (Brockhaus et al., 2014; Korhonen et al., 2018). The following sources were used to gather information materials for the operationalization of policy preferences: the North Karelia Climate and Energy Programme 2030, the Wood Building Programme of the Finnish Ministry of the Environment (2019), wood construction in the Finnish Bioeconomy Strategy (TEM, 2018), wood building highlighted in innovation agenda through the Ecosystem Agreement between Joensuu and the Ministry of Economic Affairs and Employment (2021–2027), and the regional smart specialization program — a roadmap towards an oil-free and low-carbon North Karelia 2040. The content analysis of these key documents at local level was used to reveal the actors' preferences for overall policy goal priorities. To this end, the survey participants encountered some open-ended questions enquiring about actor willingness to collaborate in the future with others whom they are not currently connected with (Appendix C Survey Questionnaire).

Once the questionnaire was prepared, it was pre-tested among a pool of academic experts. Afterward, the online survey was distributed to suitable individuals dealing with sustainable WBC from every organization by sending an email invitation with a hyperlink, which was open for three months (July to September 2021). The actors received four reminders (every two weeks) before the survey closed. To boost the response rate, several actors were called directly and explained the significance of their participation in our study. In total, the questionnaire reached out to 29 actors, 15 of whom responded (one individual from each organization), giving a response rate of 51%. This is a rather typical rate for a social science survey (Tikkanen et al., 2003). We used MS Excel to organize, analyze, and simplify the collected raw data from the online survey.

3.3. Data analysis

3.3.1. Social network analysis

The policy network analysis (SNA) incorporates the concepts of social networks (Galey-Horn and Ferrare, 2020). A social network is comprised of a certain number of actors, where the actors form any established relationships between themselves (Wasserman and Faust, 1994), and the analysis approach can profoundly influence all phases of empirical research (Friemel, 2017). However, a social network mainly consists of several key elements. These are: a *node*, defined as the members of the network (often referred to as actors) who become the focus of the analysis (Wasserman and Faust, 1994). The lines that link the nodes form *edges*, and the interactions and relations between nodes through edges are called *ties*. Edges with arrowheads from the source to the target are called *directed ties*, while symmetrical lines with no arrowheads represent *undirected ties*.

Our study focused on quantitative SNA, where two levels of network analysis were considered (Agneessens and Labianca, 2022): (i) the general structural aspects of a network, which include identification of density, centralization, diameter, and average path length to describe overall network performance and (ii) actor-level metrics that detailed the position and functions of particular actors in a network, which includes recording various centrality measures to identify influential actors and individual activity within the network (Granovetter, 1973; Freeman, 1977; Scott, 2000). A detailed explanation of network-level and node-level measurements are given in Table 1.

Table 1
Definitions of SNA measurements.

Measures	Definitions	References
Density	Network density is a measure of network node connectivity. Density is measured as the number of observed ties divided by the total number of possible ties between the nodes.	Perez and Germon, 2016
Centralization	Centralization is the extent to which a few individuals control most of the network's connections. It also denotes the degree to which a single user's connectivity is centered.	Varda, 2017
Diameter	Diameter is the length of the longest path (number of edges) between any pair of nodes in a network.	Li et al., 2016
Average path length	Estimates how many hops in between are typically required to move from one node to another in a network.	Cardillo et al., 2013
Degree	The degree of a node determines the size of its vicinity. It refers to the number of edges connected to a node. Helps to identify most central actors.	Perez and Germon, 2016
In-degree centrality	In-degree centrality denotes the number of incoming edges to a single node, i.e., the number of times the same organizational actor is connected by other actors. Helps in determining the most popular actors.	Borgatti et al., 2018
Betweenness centrality	Determines how many shortest paths pass through a single node, i.e., the actor's capacity to control resources is measured by betweenness centrality. The larger the betweenness centrality, the better the actors' resource control ability.	Freeman, 1977; Sun et al., 2016
Modularity maximization	Commonly refers to clustering for community detection. The segmentation of a network into densely connected groups or communities, where nodes within the community have greater connections among themselves than nodes in other communities.	Haq et al., 2019
K-shell decomposition	Involves narrowing the network down to nodes with more than k neighbors. Identifies core and periphery structures of the network. The innermost k-shell is designated for nodes with the highest degree of connectedness, whereas nodes with less connections are designated to the outer shells.	Pittel et al., 1996; Carmi et al., 2007

In the first phase of SNA, the collected unweighted data were transformed into adjacency matrices (Frey, 2018), which determine whether two actors are connected. As we found 29 organizations in total, our adjacency matrix is 29 × 29.

Visualization and analysis were conducted with the open-source interactive network visualization and exploration software Gephi 0.9.2 (Bastian et al., 2009). All network analysis measures, including centrality, are conducted in Gephi. The communication purpose among actors was analyzed by measuring the relative ratio. To do this, we considered each actor's responses, where every single communication category (six in total) was summed up separately. To identify the percentage value of each communication category, these summed values were multiplied by a hundred and divided by the total sum of all communication types. The analysis progressed by summing up all ranking scores given by the respondents on each WBC policy statement and dividing these values by the number of respondents. We calculated the average importance of each statement, which further assisted in finalizing the actors' preferences concerning WBC policy goal importance.

4. Results

4.1. Organizations involved in WBC policy networks

Wood construction has been accelerated in Joensuu with the city's long-term development programmes and planning. The city has received national and international recognition for establishing ambitious pilot projects (e.g., Lighthouse Joensuu) with governmental support, businesses, and availability of experts from research institutions exhibiting sufficient skills. However, Joensuu's WBC policy network reveals the complexity of a local-level network (Fig. 1), where several organizational actor's groups have involved and contributing to evolve the network. This inclusiveness spans from small to large local and national level business entities, academic and research institutions, and government organizations.

The overview demonstrates that the actor category mainly points in favor of wood industry and construction, real estate business, and private consultancy, with 52% of the organizations having been identified within this category. Nearly a quarter (24%) are identified as academic and research organizations, 17% are from government bodies, and 7% belong to other categories (such as private business organizations, house-building companies, and other intermediary organizations). Most industry categories represented in this study consist of construction companies or manufacturers of wood-based products at regional, national, and international levels (See purple nodes in Fig. 1). There are also two local universities — the University of Eastern Finland and Karelia University of Applied Science — along with the European Forest

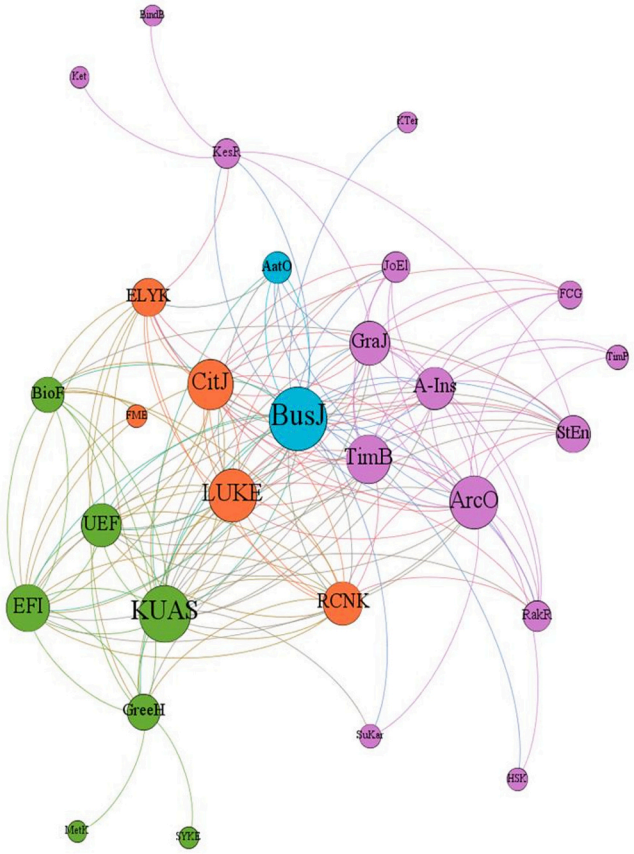

Fig. 1. A network of wood-based construction policy actors in Joensuu based on an online survey (Node = 29, edges are undirected and unweighted). The colors indicate various actor categories (academic and research = green; government body = orange; industry, consultancy, or real estate business = purple; and others = blue). The more contacts a node has, the larger the size of the node. Acronyms are spelled out in Appendix B.

Institute, Natural Resources Institute Finland (Luke), the Finnish Environment Institute (SYKE), and other highly professional wood-based research organizations that fall under the academic research category. The Finnish Ministry of the Environment, the Regional Council of North Karelia, The Centres for Economic Development, Transport, and the Environment (ELY-keskus), and the City of Joensuu represent governmental actors, whereas Aatelitalot Oy, a house building company, and Business Joensuu, a non-profit organization that works to encourage regional innovative businesses, represent organizations belonging to the category "others" within the network.

Furthermore, a few organizations considered themselves to belong to two actor categories; for instance, Natural Resources Institute Finland categorized itself as both a governmental body and an academic and research organization. To identify and avoid confusion in the network visualization, Natural Resources Institute Finland is visualized as only representing one category (a government body). But to calculate the percentage of organizational involvement in the network, we considered Natural Resources Institute Finland in both groups (a government body and a research actor). Also, despite their inclusion in the survey data collection, neither ENGOs nor certification agencies were present in the Joensuu network.

4.2. Network structure and characteristics

Considering the number of actors involved in the network, it looks like the local network is fairly comprehensive. The structure of the network also indicates that it is moderately compact, revolving around a few actors at its core, who have different relationship patterns, varied resources to share with each other's, and separate roles to perform within the network. These same actors appear as the most influential ones in the network while considering different centrality measures. On an individual level, Business Joensuu is the most central actor, participating in network's lead brokerage role, followed by several industries and businesses (e.g., Arcadia Oy, Timber Bros Oy, Granlund Joensuu Oy), academic and research (e.g., Karelia University of Applied Science, Natural Resources Institute Finland, European Forest Institute) and government organizations (e.g., City of Joensuu, Regional council of North-Karelia, ELY-keskus).

Fig. 1 shows there are 29 nodes (actors) and 176 edges (connections) in the network. The network metrics are shown in Table 2. A density score of 0.217 means that the network has 22% of the total possible number of edges that are observed. Together with a centralization score of 0.80, we can conclude that the network is highly centralized. The longest distance within the network is 4.00 in our case. The value of average path length (1.764) represents nodes that are not far away from each other.

The *degree centrality* values represent the central part of the network dominated by the sequence of others, research, governmental, and industrial actor categories. Table 3 shows the top 14 degree centrality scores for the WBC policy network. Nodes with the highest scores are densely connected with other nodes in the network. Interestingly, in our case, the highest degree of centrality is found for Business Joensuu (33), positioning itself in the most central node of the network. This indicates that the organization has the highest ability to communicate with different actor groups within the network. The second and third (shared by two organizations) highest degree centralities were recorded for Karelia University of Applied Science (28), Natural Resources Institute Finland (25), and Arcadia Oy Arkkitehtitoimisto (25), respectively.

Table 2
Network structural measures.

Network structural measure	Network values
Density	0.217
Centralization	0.8
Diameter	4
Average path length	1.764

Table 3
Top organizations with their highest degree centrality and betweenness centrality values.

Degree Centrality			Betweenness Centrality		
Node Label	Organization	Values	Node Label	Organization	Values
BusJ	Business Joensuu	33	BusJ	Business Joensuu	111.94
KUAS	Karelia University of Applied Science	28	EFI	European Forest Institute	62.54
LUKE	Natural Resources Institute Finland	25	GreeH	Green Hub	62.54
ArcO	Arcadia Oy Arkkitehtitoimisto	25	KesR	Kesälahden Rakennus Oy	28.00
CitJ	City of Joensuu	23	KUAS	Karelia University of Applied Science	23.09
TimB	Timber Bros Oy	22	CitJ	City of Joensuu	16.51
EFI	European Forest Institute	21	ArcO	Arcadia Oy Arkkitehtitoimisto	15.17
UEF	University of Eastern Finland	18	LUKE	Natural Resources Institute Finland	14.99
RCNK	Regional Council of North Karelia	18	GraJ	Granlund Joensuu Oy	7.38
GraJ	Granlund Joensuu Oy	18	TimB	Timber Bros Oy	6.28
A-Ins	A-Insinöörit Oy	17	A-Ins	A-Insinöörit Oy	3.78
ELYK	ELY- keskus	14	UEF	University of Eastern Finland	1.61
StEn	Stora Enso	13	RCNK	Regional Council of North Karelia	1.57
GreeH	Green Hub	12	AatO	Aatelitalot Oy	0.13

Moreover, betweenness centrality represents the 'intermediary or brokers' in the network — which can round the network's comparatively dense center region towards the peripheral region. Fourteen actors have a *betweenness centrality* score >0.13. Our study revealed that Business Joensuu has the highest score (111.94), indicating substantial influence over the sharing of resources in the network. The betweenness centralities of the top 14 actors are presented in Table 3, where Business Joensuu is followed by the European Forest Institute (62.54), Green Hub (28), and Kesälahden Rakennus Oy (28), respectively. All these top-ranked actors have a specific ability to dominate over resources. These organizations connect the network's center with organizations located in the network's periphery. For instance, Kesälahden Rakennus Oy, a building construction company in the North Karelia region, connects BinderHolz Bausysteme, an international wood-based industry, and Keti, a business consulting agency. Also, Green Hub, a knowledge-sharing consultancy connects two important governmental organizations: the Finnish Forest Centre (Metsäkeskus) in Joensuu and the Finnish Environment Institute (SYKE). Without this connection, these organizations would have been excluded from the network.

Furthermore, a significant positive correlation exists between nodes with highly central positions and nodes with high betweenness centrality in the network. The value of Pearson correlation is $r = 0.70$ with a 95% significance level ($p < 0.05$). This means the most central organizations based on degree centrality also have higher betweenness measures, and hence, tend to operate as brokers linking other actors. In contrast, some organizations represent high betweenness centrality but lower degree centrality (i.e., Green Hub and Kesälahden Rakennus Oy). However, the "other" organization category holds the maximum scores depending on both centrality scores, and Business Joensuu had a central position in the network and acted as the main broker in the network. Most of the top-ranked degree centrality actors are either academic and research organizations (Karelia University of Applied Science, European Forest Institute) or government bodies (Natural Resources Institute Finland, City of Joensuu). A similar result is observed for the betweenness centrality measure, where more academic and research organizations hold the highest betweenness centrality scores (i.e., European Forest Institute, Green Hub, Karelia University of Applied Science).

Fig. 2 shows the *in-degree centrality* measures of the network, which help in determining the popular actors in the network. Again, Business Joensuu is in central position. Considering incoming edges, 14 organizations in the network communicate with Business Joensuu. ELY-keskus, a governmental organization, has the same number of connections (14) and is also placed in the top-ranked list. Stora Enso, a WBC and carpentry and manufacturer of wood-based products (biomaterials and paper), has an in-degree centrality score of 13, while the Karelia University of Applied Science (score of 11), an academic and research organization, was nearly as crucial in the network.

With the k-core decomposition approach, we identify nodes that are more closely linked to one another within the core, while periphery nodes are well connected to the core while being loosely connected to each other (Dumba and Zhang, 2018). The most strongly interlinked section of the network can be found by examining the k-core with higher values. In our case the k-core value is 12, which shows that the key organizations fall under the core zone of the networks and have degrees of >12. Nine organizations are placed at the core of the network (Business Joensuu, Karelia University of Applied Science, Natural Resources Institute Finland, Arcadia Oy Arkkitehtitoimisto, City of Joensuu, Timber Bros Oy, European Forest Institute, University of Eastern Finland, Regional Council of North Karelia), and the rest fall under the network periphery (see Appendix C). All these core organizations are also found in the top list for different centrality measures and have strong influence over controlling the resource flow within the network.

Frequency of communications is used to measure the strengths/weaknesses of the network. Our study considered each actor's response separately to enumerate the communication rate. The study represents that, among all respondents, most organizations (48%) communicate with each other only a few times per year; 30% reported being contacted monthly, and 17% have weekly communication. Most interestingly, just 5% of respondents communicate daily with each other. However, we considered the most frequent communication (daily, weekly, monthly) by eliminating all weak ties while mapping Fig. 3. When determining community structure, the modularity class analysis found a total of 23 organizations and 88 relationship ties (54.32% visible) to be strongly

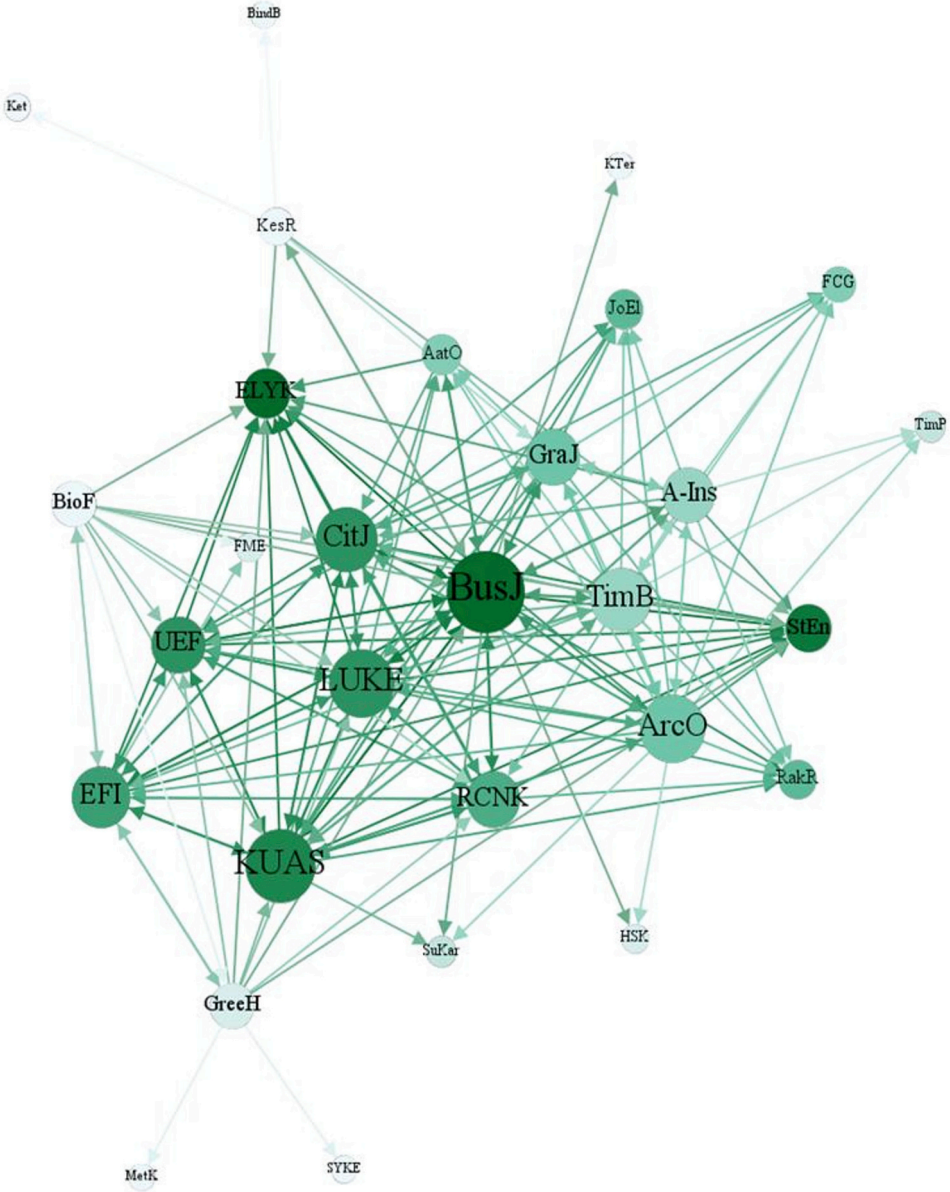

Fig. 2. In-degree centrality of the WBC policy network of Joensuu. The size of a node shows the number of contacts it has. Node colour ranges from deep green to white, indicating the highest in-degree centrality to the lowest in-degree centrality, respectively. Acronyms are spelled out in Appendix B. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

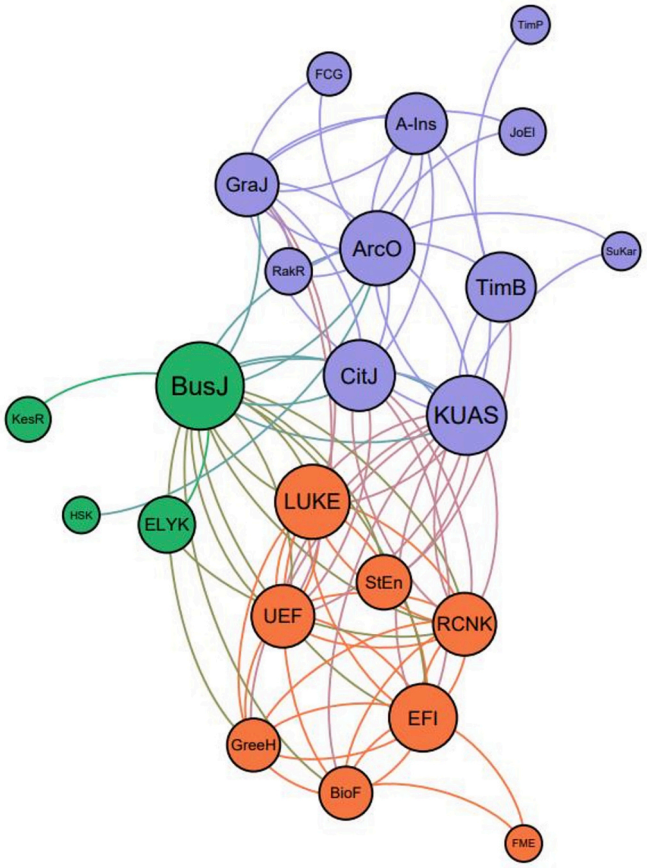

Fig. 3. The WBC policy network in Joensuu, based on the most frequently established connections (N = 23). Three main groups stand out: a research–government group (orange), a business and industry group (blue), and a mixed group (green). Acronyms are spelled out in Appendix B. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

connected. Hence, three groups mainly appeared: government–research, industry and business, and a mixed group. Business Joensuu facilitates regular contact between the two larger groups, serving as a key intermediary (Fig. 3).

Furthermore, Joensuu's relationships are built up mainly for scientific information sharing rather than policy advocacy, or financial reasons. The analysis revealed that sharing scientific information and knowledge in the network is (40%). In addition, 14% of ties fall within organizational and strategic planning, 13% of ties hold for providing or receiving financial support, 6% of ties represent policy advice, 5% of ties hold for resource or materials exchange (construction materials, tools), and 22% of ties were formed for other purposes within the network (Fig. 4). As our results show a large share of the communication to occur for information and knowledge sharing, it is also understandable that the majority of actor categories (research, industry, government) evolved not only based on the solid type of connection but also to share more knowledge and ideas among themselves.

4.3. Actors' policy goal preferences

While considering the prioritization of policy goal preferences by Joensuu's actors, they emphasized on minimizing carbon emissions and storing carbon to mitigate climate change impacts, which will ensure material efficiency in the built environment, therefore contributing to Joensuu's carbon neutrality goal by 2025. With market growth, the production and distribution of wood construction materials will be enabled. Additionally, this momentum will create the opportunity to expand the jobs where different customer groups will have their chances to develop.

We examined the organizational actors' policy goal preferences by identifying the average importance value for enhancing WBC policies at the regional level (Fig. 5). Ranking order 1 denotes the most important preferences, and 10 represents the least important preferences. A lower average score indicates a higher value of actor preference. Average levels show that the statement "using wood in building construction could prevent climate change by lowering the carbon footprint" has the highest priority among the actors (2.92), whereas new job opportunities for residents has the second highest priority (4.08). Long-term carbon storage in wooden construction is ranked as the third most crucial

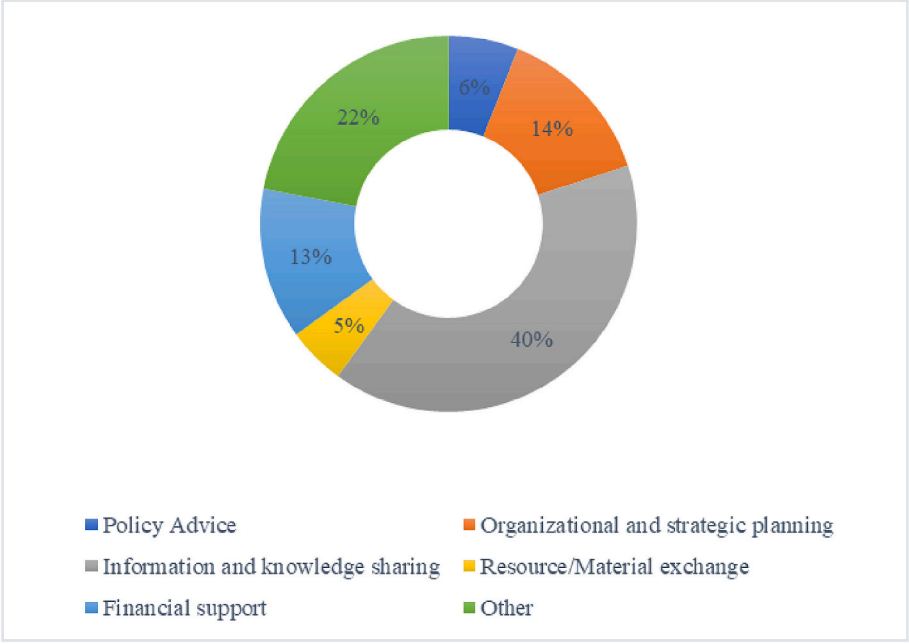

Fig. 4. Relative frequency among alternative purposes of communication.

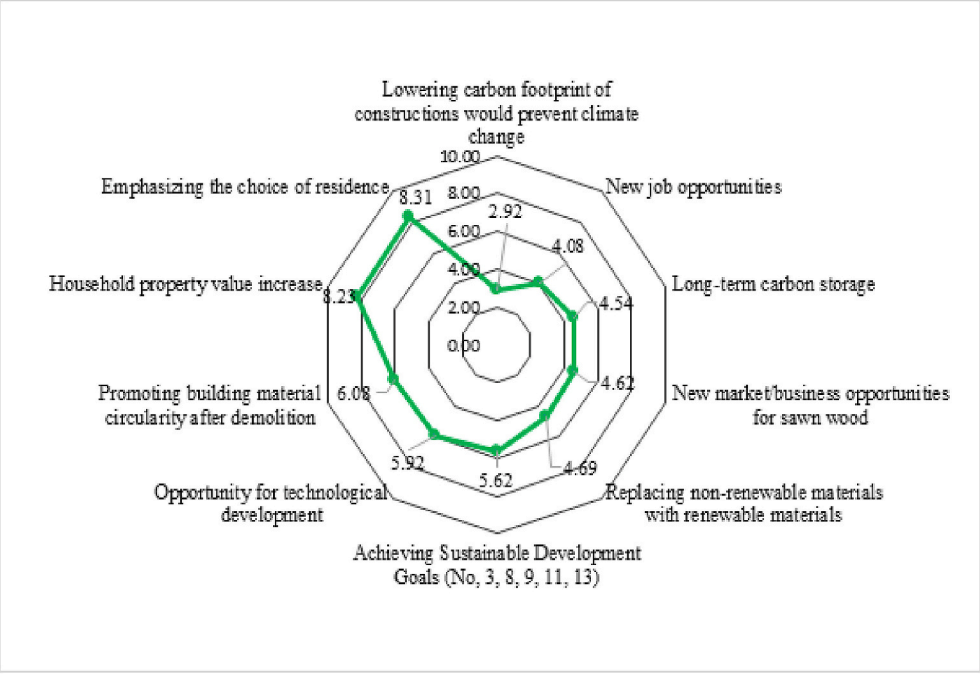

Fig. 5. Actor preferences of wood-based construction policy goals. Here, 1 = most important, 10 = least important.

argument (4.54). On the contrary, household property value increment (8.23) and choice of residents (8.31) respectively ranked last according to the actors' choices. Also, a significant difference was observed between the top and least important priority policy goals values.

5. Discussion

The City of Joensuu in Finland has continually promoted wood innovation policies through regional policy initiatives launched by the government and supported locally (Heräjärvi et al., 2021). Therefore, we used it as a case study area to examine the structure of the local policy network to gain a better understanding of local-level policy network characteristics and development around the WBC sector steered by the national legislation.

Considering the first research question, Joensuu's wood-based construction policy network constitutes industry and business, academia and research, and government bodies, supplemented with other actor categories. Joensuu's existing wooden construction and wood material manufacturing companies are renowned at all sectoral levels. Universities and research institutes are primarily involved in wood material science, wood technological research, forest science, business innovation, and natural resource management. Governmental organizations have introduced wood construction policies and sustainable urban land use planning in Joensuu. However, we anticipated that WBC actors might be part of the wood-based bioeconomy and forest policy networks, as they operate in parallel.

Our study revealed that Joensuu's WBC policy network mainly comprises research and industry actors, which aligns with the German wood-based bioeconomy network (Giurca and Metz, 2018). Although organizations could have identified themselves as separate policy actor categories during the survey's self-categorization process, they opted not to. Furthermore, despite knowing that ENGOs could actively raise their concerns considering climate change issues in the built environment, our study was unable to categorize them, which is in line with earlier findings by Creutzburg and Lieberherr (2020) forest policy network. Considering the absence of some crucial actor groups in our study context, we emphasize that a more diverse composition of actors could potentially be more effective in increasing the network's expertise and promoting innovation (Giurca and Metz, 2018).

Regarding the second research question, in our case, the network size is relatively small (29 organizations). However, the number of participants is always dependent on the case context and the existence of truly committed actors. Furthermore, several actors showed interest in working with organizations that are, as of yet, disconnected from the network. They observed that some room still exists for attracting national and international partners in the research and business sector, for example by implementing demonstration and pilot buildings. Such practical examples could possibly enable more knowledge and technology development and foster the sustainability transformation and boost citizen's confidence in building with wood (Maniak-Huesser et al., 2021; Salmi et al., 2022).

The structural measure of the network indicates it to be moderately dense and heavily concentrated around a few actors. This pinpoints that network connectedness is tight in the central part due to particularly active regional sectoral actors (Weiss et al., 2017), which ultimately facilitate effective collaboration rather than just interaction among the closed network actors (Gosselin et al., 2018). Nevertheless, although communication and resource sharing within the network would be faster among the more strongly connected actors, enabling the entry of new actors would probably be beneficial in meeting the network's long-term goals. Our findings are similar to the findings of several studies on national bio-economy network structures of Finland, Germany, and Sweden, with the network structure being relatively closed (Giurca and Metz, 2018; Korhonen et al., 2018; Holmgren et al., 2021). Despite that, the local network could create more opportunities for collaborative projects, increasing actor expertise and breaking traditional path dependencies. Also, the high openness of network boundaries significantly facilitates the effective implementation of WBC policy goals and wood market prospects (Weiss et al., 2017).

Business Joensuu was recognized as the most influential actor, while some previous studies confirmed that governmental organizations typically have the most central influence considering the broader policy network (Korhonen et al., 2018; Creutzburg and Lieberherr, 2020). This finding may be due to the main objectives of Business Joensuu, i.e., providing resources for developing new businesses around wood-based start-ups, enabling networking and promoting international market

entry. While playing a crucial brokerage role within the network (Giurca and Metz, 2018), Business Joensuu effectively bridges industries in the network periphery (Toppinen et al., 2022b), communicates with many national and international agencies, with the support of having higher contribution of resource mobilization and more permanent staff.

Two governmental organizations were found to be influential actors in the network. The City of Joensuu, with support from the Ministry of Environment's climate friendly construction programme, is permitting wood building projects, providing building inspections, and fostering governmental policy options by representing their local gatekeeping ability in constructing by wood (Franzini et al., 2018; Joensuu, 2022; Wiegand and Ramage, 2022). The Regional Council of North Karelia has also introduced climate resilient wood construction under regional development strategies. Thus, with regulation and support, both organizations perform as a key facilitator role in terms of sustainability transitions in wood construction sector (Salmi et al., 2022). Two academic organizations contribute as key actor roles in the network: Karelia university of Applied Sciences and University of Eastern Finland. These are working with wood products development, construction operational activities and generating firsthand knowledge, making them available to transfer. Also, they are producing graduates (e.g., specialists, contractors, designers) with high expertise for innovative construction environment (Gerding et al., 2021). Finnish Natural Resources Institute has contribution in quality construction products, wood product market and carbon footprint calculation, while European Forest Institutes brings knowledges about environmental impacts of innovative wood construction. Business and wood construction industry actors include for instance, Arcadia Oy, Kesälahden Rakennus Oy, Timber Bros Oy, Granlund Joensuu Oy, A-Insinöörit Oy that collaborate with other actors based on their preferences (Gerding et al., 2021; Wood Joensuu, 2024). Moreover, these actors are mostly aligning their activities and roles with governmental political narrative on "building with wood" (Toppinen et al., 2022b). Altogether, Joensuu's network of academic and research institutions collaborating with wood industry actors effectively builds bridges between science and business (Ingold et al., 2021; Pajunen et al., 2023).

In the future, wood technology industries and other business organizations could more effectively promote climate-friendly innovation and successful implementation of WBC projects originating in Joensuu, but as of now, most remain at the periphery of the network (Van Lancker et al., 2016; Giurca and Metz, 2018). However, the wood products and construction industries need to boost interdisciplinary communication approaches (Ilgin and Karjalainen, 2021), since collaboration with construction companies (e.g., architects and engineers) would bring more innovative knowledge for constructing with wood (Conroy et al., 2018).

Information and knowledge sharing are the main purpose of actor's communications. This is being developing to transfer sustainability issues and is considered one of the crucial timber construction policy incentives (Ludwig, 2019; Wiegand and Ramage, 2022), and therefore, acts as a catalyst while constructing with wood (Karjalainen et al., 2021). Joensuu's WBC policy network is more contributing to research, innovation, and knowledge development, which resembles results from the German bio-economy network (Giurca and Metz, 2018), and Canadian wood construction value network (Gosselin et al., 2018). In fact, experimental trials and critical responses from different actors are needed for innovations to be successful (Weiss et al., 2021). As revealed, collaboration dynamics and effective knowledge management among different stakeholders are prerequisites for mass timber construction system innovation (Riggio et al., 2020). Powerful collaborative activities and information sharing among different sectoral actors from the governmental body, industry and business, and academic research ultimately ensure the implementation of innovation support as a form of regional WBC policy instruments (Weiss et al., 2017; Vihemäki et al., 2019; Wiegand and Ramage, 2022). The distribution of financial support, material exchange, and flow of supportive policy advice through the network is minimal, which is also consistent with Korhonen et al. (2018). In contrast, almost half of all contacts could be characterized as weak ties, occurring only a few times per year (Giurca and Metz, 2018). These ties mostly serve as bridges between organizations (Granovetter, 1973), where many critical network paths connect local professionals to the national and international levels.

Regarding the third research question on policy goal preferences towards wood-based buildings, the dominant focus is on climate change mitigation targets (Creutzburg and Lieberherr, 2020). This narration also supports the Finnish national goal of carbon neutrality by 2035 (Finnish Government, 2019). WBC also contributes to creating new local-level business opportunities and enhancing the City of Joensuu's brand as a "forest city" in the European Union. Our findings are in line with Vihemäki et al. (2020), which found similar goals to be among the top priorities for accelerating Finnish wood construction and progressing the related policy processes. Although cities and business organizations can be assumed to place great emphasis on value creation for housing assets, we found that, in our case, the WBC household property value was ranked low among policy goals. In the future, more attention could also be given not only to renewable building material use, but also to increasing material efficiency and circularity, to be materialized also in the form of wooden retrofit construction (see also Finnish Ministry of the Environment, 2019; Viljanen et al., 2023).

Overall, local-level SNA provided a more in-depth understanding of the position of the organizational actors, their mutual relationships, and the structure of the policy network that could shape the decision-making processes in the given policy subsystem. Identified complex interconnectedness of diverse actors and their collaboration within the network confirm the applicability of Marsh and Smith (2000) policy network theory in examining local WBC policy networks.

6. Conclusions

Our policy network analysis identified a moderately dense set of involved actors and divided relationship patterns in the case of Joensuu. This serves as a good example for understanding the complexity of locally evolving policy network structures that could influence future policy coordination for expanding the WBC market share. Our findings confirm that research organizations appear to have a key role in providing ideas and influencing industry and business development. Enhancing more intense collaboration between government, research, and industry may generate positive synergies. Despite being a non-profit business and a regional development intermediary organization, Business Joensuu was found to occupy a central position in the network. Information and knowledge exchange were the most often shared resources among the actors, confirming that the network is predominantly supporting WBC research and innovation. In general, such compact networks as in the case of Joensuu have still some room for further expansion to become more diverse and would thrive with more technological and financial resources included in the network. The large number of weak connections acted as a bridge from the network core to the periphery and contributed to some international collaboration. Additionally, most network actors were sharing the goal to reduce construction sector carbon emissions as their key priority.

Our study illustrates a prime example of the importance of local-level network commitment, which could pave the road towards decarbonization of the built environment in other contexts and even at the international scale. This example could help in seeking solutions in situations that require intensive resource use and collaboration to make better use of scarce public funding opportunities. Hence, we conclude that the local network structure could work as an exemplary best practice model for other municipalities aiming to upscale their activities around WBC. From a practical viewpoint, arranging more opportunities for exchange between actors (such as networking events, workshops, fairs, and policy forums) can enable higher commitment and engagement in WBC.

We assembled actor identification data from different sources (literature review, consulting with academic experts, snowball method) and applied a maximum number of possible strategies (email reminders, phone calls), since network data collection strives for maximal actor participation. Although we promised individual respondent anonymity, some key actors refused to respond because of organizational confidentiality rules. We anticipate that the number of respondents could have increased had we utilized semi-structured interviews. We also collected data during the COVID-19 pandemic, when no wood-based policy events were held at the regional or local levels. These could have facilitated higher survey participation through personal meetings.

Future research should dig deeper into implementing WBC-promoting policy agendas and monitoring them over time in various contexts and at multiple policy levels. More research is also needed to understand better the role of vertical and horizontal policy coordination and find efficient ways to build up more synergy and coherency among different enhancement policies/implementation programs. Furthermore, there is still potential to do research concerning actor's individual-level roles and policy governance. These questions may include the actors behind the WBC policymaking, policy implementation, and adaptation process which need to be figured out. With the dynamic nature of policy networks, further research should also focus on the stratification of network structures to unfold the role of policy mixes that may support further diffusion of WBC. As our study has been conducted in a single municipality context, there is ample potential to compare these empirical findings with other relevant cases and to understand the role of various knowledge brokers and intermediaries separately. This may reveal differences between local conditions and allow better recognition of the drivers that could influence WBC development. Methodologically, larger-scale quantitative approaches are preferable for revealing insights into the characteristics of national- or European-level WBC policy networks and for monitoring policy progress.

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CRediT authorship contribution statement

Md. Rayhanur Rahman: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ida Wallin:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Ritva Toivonen:** Writing – review & editing, Writing – original draft, Supervision. **Anne Toppinen:** Writing – review & editing, Writing – original draft, Supervision.

Declaration of competing interest

The authors declare that no known competing interests have come up to impact the work presented in this research.

Data availability

Data will be made available on request.

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Appendix A. List of literatures reviewed

Bioeconomy, 2021. Wood and Forest. Available at: https://www.bioeconomy.fi/tag/metsa-en/ (Accessed: 19/09/2023).

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Appendix B. List of organizational actors in the WBC policy network in Joensuu

Organization name	Abbreviation	Organization type
Aatelitalot Oy*	AatO	Others
A-Insinöörit Oy*	A-Ins	Industry/real estate/consultancy firm
Arcadia Oy Arkkitehtitoimisto*	ArcO	Industry/real estate/consultancy firm
BinderHolz Bausysteme	BindB	Industry/real estate/consultancy firm
Bioregions Facility	BioF	Academic/research
Business Joensuu*	BusJ	Others
City of Joensuu*	CitJ	Government body
ELY- keskus*	ELYK	Government body
European Forest Institute*	EFI	Academic/research
FCG*	FCG	Industry/real estate/consultancy firm
Finnish Environment Institute	SYKE	Government body
Finnish Ministry of Environment	FME	Government body
Granlund Joensuu Oy*	GraJ	Industry/real estate/consultancy firm
Green Hub	GreeH	Academic/research
HS Kiinteistösaneeraus Oy	HSK	Industry/real estate/consultancy firm
Joensuun Elli*	JoEl	Industry/real estate/consultancy firm
K Tervo Oy	KTer	Industry/real estate/consultancy firm
Karelia University of Applied Science*	KUAS	Academic/research
Kesälahden Rakennus Oy	KesR	Industry/real estate/consultancy firm
Keti	Ket	Industry/real estate/consultancy firm
Metsäkeskus	MetK	Academic/research
Natural Resources Institute Finland*	LUKE	Government body
Rakennustoimisto Eero Reijonen oy*	RakR	Industry/Real State/consultancy firm
Regional Council of North Karelia*	RCNK	Government body
Stora Enso*	StEn	Industry/real estate/consultancy firm
Suunnittelyryhmä Karrak OY	SuKar	Industry/real estate/consultancy firm
TimberBros*	TimB	Industry/real estate/consultancy firm
Timberpoint Oy*	TimP	Industry/real estate/consultancy firm
University of Eastern Finland*	UEF	Academic/research

* Actors identified preliminarily through the literature search, authors' personal acquaintances, and snowball sampling process.

Appendix C. 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 ($\surd$ 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					

(continued on next page)

(*continued*)

Organizations	Daily	Weekly	Monthly	Few times a year	Not at all
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 ($\surd$ mark) more than one purpose for one cell.

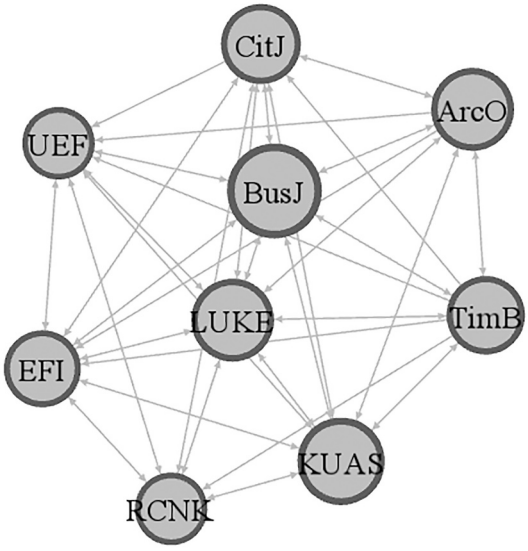
Organizations	Policy Advice	Organizational and strategic planning	Information and knowledge sharing/ exchange	Resource/Materials exchange (Construction materials, tools, etc)	Providing or receiving financial support/ transactions	Others	Not at all
University of Eastern Finland							
LUKE							
European 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.
11) If so, do you have any ideas or how to improve collaboration?
12) If you have any other comments on the questionnaire or the topic of the study, please feel free to write them down here (optional)Answer:
13) If you would like to receive the final research results of this study, please fill in your email address here.

Appendix D. K-core decomposition indicating the core network



Appendix E. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2024.103225.

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