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Article

Land-Use Planning in Municipalities as a Driver for Sustainable Residential Building in Finland: A Regional Innovation System Approach

Atte Koskivaara *, Katja Lähtinen

Natural Resources Institute Finland, Helsinki, 00790, Finland

* Correspondence: Atte Koskivaara, Email: atte.koskivaara@luke.fi.

ABSTRACT

Land-use planning has been identified as an important tool in pursuing sustainability by guiding the construction and development of our built environment. Sustainability action places large requirements for municipalities to develop and introduce priorities in their planning. Land-use planning system in Finland relate to regulation and decisions of authorities connected to national, regional, and municipal levels. In general, municipal level has the most power in decision making by holding e.g., planning monopolies. Municipal land-use planners operate in the junction of different actors including businesses, local politicians, citizens, and research institutions. Thus, they provide an interesting opportunity to study the operationalization and objectives of land-use planning in different regions. This study takes the regional innovation system approach to illustrate planning systems, involvement of different stakeholders and the sustainability objectives of land-use planning in varying regions in Finland. Quantitative methods (i.e., exploratory factor analysis, statistical tests) are used in the online survey data analysis. Our results suggest a strong connection between informal planning system and municipalities' sustainability objectives as well as stakeholders representing research and governance organizations whereas statutory planning system is more connected with users of existing knowledge. Regarding regional characteristics, urban municipality planners were found to perceive informal planning as more important than planners in other municipalities. Additionally, connected to the results on sustainability objectives, urban municipality planners paid attention especially on goals for sustainable building, while those working in other municipalities emphasized both goals on sustainable building and securing ecosystem services.

KEYWORDS: land-use planning; sustainable building; residential areas; rural; urban; statutory; informal; stakeholders

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INTRODUCTION

Land-use planning plays a central role in enhancing sustainable development [1]. For example, Sustainable Development Goals (SDGs) [2] place constantly increasing requirements for municipalities to develop their land-use governance [3] with SDG 11, precisely targeting the built environment with an objective of improving sustainability, resilience, inclusiveness, and safety in human settlements. Land-use planning influences decisions on the built environment, which is often considered as covering the buildings, infrastructure, and other physical elements, including greenspace, that constitute human settlements [4]. Thus, land-use management decisions on the built environment are also connected to a consideration of ecosystem services (e.g., the protection of biodiversity and groundwater services, enhancing recreation possibilities and preserving cultural landscapes) [5].

Local politicians and civil servants in municipalities are key actors in governing land-use planning and influencing businesses and citizens in systemic collaboration [6] which has been found to be an important part of achieving sustainability aims [7–9]. Furthermore, in addition to collaboration between actors within municipalities, cooperation between municipalities has been shown to support sustainability, for example, through reductions in greenhouse gas emissions [10–12]. Independently of national land-use system, local planning processes are in a key role in Europe, for example, to manage urban-rural development [13], to consider place-based circumstances [14], and to foster innovations for sustainability [15]. Yet, the role of local governance is especially important in countries with hierarchical land-use planning systems like Finland, Sweden, and Norway, which give high autonomy to municipalities in setting their land-use management goals within the boundaries of national land-use guidelines and regional plans [16]. Understanding the Finnish land-use planning system from the sustainability perspective is particularly interesting, as the country has been found to be successful in several SDGs and is ranked in first place regarding SDG 11 [17], for example.

In Finnish municipalities, local politicians and civil servants possess a great amount of power in land-use planning through local planning monopolies [18,19]. Compared to politicians and other civil servants, urban planners in Finland have a strong power to influence local development through their role in land zoning as information gatekeepers, communicators, preparers, and introducers of the plans [20]. In addition, because they collaborate with multiple actors in various tasks, they play a key role in affecting sustainability change in the built environment through sustainable construction [21,22], for example, as regional innovation initiators [23,24]. Additionally, they can affect different ecosystem services within the area [25]. Thus, Finnish municipalities with considerable power in their territories provide information on the possibilities of local actions in land-use management also in countries with other types of national land-use systems in Europe and other parts of the world (e.g., [26–28]).

Innovations also play a large role in steering societies toward environmentally, socially, and economically sustainable development within municipalities [29]. For example, in relation to construction, the European Green Deal initiative assigns a key role to innovation for meeting its goal of climate neutrality by 2050. Despite this, integrating innovation initiatives with the implementation of governance tools has been found challenging [30]. In the context of land-use planning and construction, actor collaboration has been found to strengthen innovation capabilities and affect the diffusion of innovations in combination with politically devised governance systems (e.g., [23,31,32]). For example, the Finnish climate network (HINKU) has shown to be a platform to legitimize and enhance building of expertise in local climate actions [6].

The demand for sustainability in the built environment not only concerns land-use planning but also construction activities regarding requests for climate-change mitigation, securing natural ecosystems, and the enhancement of human well-being [33,34]. Compared with national-level governance giving general platforms for innovations, local actions have more practical opportunities to enhance sustainable construction through support for knowledge accumulation within municipality actor networks [35]. For instance, they can promote small-scale experiments, learn from best practices, and support common learning via networks within municipalities [35]. In addition, urban planners especially may act as a lobbying voice for sustainability issues at different phases of land-zoning processes [36].

The innovation system approach has been used in developing various policy tools to address social and institutional factors that affect a region's economic development [37]. In Finland, municipalities as land-use governance entities may support the local innovation environment through planning processes, local policies, and other actions that boost activities within firms and research organizations [38]. To develop functioning innovation activities, there are no "best practices". Instead, different regions require different approaches, and we therefore need to study different kinds of regions, as success stories are of only limited use for less favored regions [39]. Yet, the focus in innovation studies has been predominantly on urban areas [40], while research on rural regions has been scant and requires more emphasis [41].

By utilizing the regional innovation system (RIS) framework [39], our results highlight substantial regional differences in how land-use planners perceive different planning means. This suggests differentiated approaches to land-use development including, for example, innovation in building and housing between urban and other regions. According to Tödtling & Trippl [39], the main characteristics of many peripheral regions are weakly developed RIS prerequisites, which can lead to low levels of innovation. In Finland, Sweden, and Norway, peripheral regions face challenges because of their distant locations and a lack of key actors in innovation processes, as well as a lack of resources [42]. At the same time, forests, and agricultural lands in non-urban areas in Finland, Sweden, and Norway provide tangible (e.g., renewable materials) and intangible ecosystem services (e.g., climate change mitigation, biodiversity, recreation) with industrially manufactured products (e.g., wood products, food) that are all crucial for societal sustainability change [43,44]. Consequently, it is not only the collaboration between actors within municipalities and between similar municipalities that is important but also between urban and other areas [7].

Previous academic research has shown that local land-use governance (e.g., [3]), actor collaboration (e.g., [45]) and innovation activities (e.g., [29]) play a key role in enhancing sustainability in the built environment. They are also interconnected as initiators of mutual learning, the co-creation of new knowledge, and the use of existing knowledge to drive sustainability change in the built environment (e.g., as discussed by [32,38,46]). However, there are research gaps in how they are systemically connected, and whether connections in urban localities differ from those of other areas. In addition, most studies have focused on cities as drivers of sustainability change in the built environment, while the role of rural communities has been bypassed (e.g., [41]), despite their importance in societal sustainability change [43].

To fill this void, this study's overall purpose is to evaluate the use of local land-use planning practices and actor collaboration in new knowledge creation and existing knowledge use in connection with sustainable land-use planning, especially in the context of residential building. The study's first objective is to assess the structures of municipalities' land-use planning and identify their subsystems based on the RIS framework. The second objective is to compare RISs between municipality groups classified on an urban-rural scale. The third objective is to analyze interlinkages between RIS subsystems and between sustainability objectives in municipalities' land-use planning. The study's data are based on an online survey gathered from urban planners in 2021 working in different land-use management tasks in Finnish municipalities. The results are analyzed quantitatively with exploratory factor analysis and statistical tests (i.e., Mann–Whitney *U* test and Pearson correlation).

EMPIRICAL BACKGROUND

Land-Use Planning System in Finland

Planning theory and practice have been influenced by ideas that promote democracy in planning processes [47]. Especially in the Nordic countries, the ideal of deliberative democracy is also expressed in the primary objectives of land-use planning laws emphasizing open and participatory planning processes [16]. In Finland, land-use planning is a public responsibility, in which municipalities play an important role based on rules and legislation. This is particularly apparent through the "planning monopolies" they possess.

Land-use planners are civil servants who play a pivotal role in governing land management and promoting sustainability in the built environment [48]. Consequently, they have the power to promote policy objectives regarding sustainable construction by setting requirements regarding material selection, for example. Additionally, land-use planners are key actors in conducting spatial design, as well as implementation, in all levels of planning processes [16,21]. Their responsibilities are governed by the Land Use and Building Act [49], which targets sustainable development and participatory processes in urban planning.

However, the statutory land-use planning system in Finland is hierarchical, but not hierarchically binding as the latest plan is in effect [16]. Table 1 presents the three levels of the Finnish statutory planning system, the responsible authorities and legal effect of each level. At the system's highest level, central government sets national land-use policy guidelines that are interpreted at the regional level (regional land-use plan). The guidelines steer policy regarding land use issues that are considered relevant throughout the country [50], relating, for example, to the quality of the living environment, sustainable transportation, energy supply, natural and cultural heritage, and the use of natural resources [51]. The level to which national guidance interferes in local planning varies depending on the ruling government's willingness to do so. The effect of regional planning on municipal planning on the local level is considered low especially in the Nordic planning context [16]. The regional plans are interpreted at the municipal level (local masterplan and local detailed plan). As the most detailed plan, a local detailed plan directs land use and building according to requirements set by local conditions and landscape, good building practices, and other agreed objectives set by municipalities. Eventually, actual land use is prepared and approved by the local authorities and political decision makers [52].

Table 1. The levels of statutory land-use planning system in Finland (based on [50]).

Planning levels	Planning authority	Planning instrument	Legal effect
National	Government	National land-use guidelines	Advisory
Regional	Regional councils	Regional plan	Binding
Local	Municipal councils	Local master plan	Optional
		Local detailed plan	Binding

A similar, three-tier planning system is in effect in nearly every European country [53] where national level may influence the planning results through setting guidelines on regional and local level plans. Furthermore, what is widely similar in different countries' planning systems' is the central role of the local level governance establishing a legal right to develop land-use planning [54]. Additionally, due to the important role of namely land-use planners in conducting spatial planning, they have been identified as favorable research subjects in cross-national research and used in comparative studies (see e.g., [55–58]).

In addition to the statutory planning system, various informal means to improve the strategic quality of land-use planning have emerged in several countries (see, e.g., [59,60]) including the Nordic countries [61]). The informality of these means refers to their being outside the statutory land-use planning system [61]. Informal strategic plans may be related to public-private partnerships, land-use development schemes, regional visions, and structural plans [61], for example. Practical examples of such means are think tanks, living labs, and networks of key public and private actors working on development schemes, the hiring of planning consultancy firms, and idea competitions [61]. Several reasons have been proposed for the emergence of informal strategic approaches: regions need to reposition themselves in global competition; they need to be able to respond to new challenges, including environmental issues, social cohesion, and quality of life; traditional approaches are seen as incapable of addressing the complex challenges regions face; the fragmentation and multiplication of actors increase the complexity of decision-making processes with the emergence of multilevel governance forms [59]. All in all, strategic spatial planning is considered a visionary process that integrates policy agendas, activities, and actors [59,62], with the potential of providing answers to sustainability issues [63,64].

Innovations in Land-Use Planning

Planning process can be considered a systematic way of making collective decisions to achieve future goals on sustainability change and innovation activities in municipalities [32,38]. It is by nature a collaborative social process that is strongly influenced by interpersonal relationships [45,65]. Additionally, it is argued that planning depends on the utilization of multiple capabilities [66], and the effective use of knowledge is considered crucial to enable planning to make a positive change [67]. Knowledge co-creation, especially in the context of novel, specialized knowledge areas, is a complex process that requires not only knowledge transfer between sources but also a knowledge transformation in which participants transform their existing knowledge into new knowledge that complements and stimulates others' knowledge transformation [68].

It is suggested in the planning literature that rational processes are inadequate for addressing complex societal issues. Instead, new knowledge is developed in networked settings, allowing interaction, and often including conflicting values [69,70]. Furthermore, Innes and Booher [45] claim that classical modern planning cannot solve the wicked problems of our time, but collaborative rationality is needed instead to develop innovative spatial planning strategies. Empirical research has also found that land-use planners in Finland consider social interaction the most important individual skill in their daily work, followed by vision and process management [20].

All kinds of innovations, including disruptive and incremental, as well as product, process, and organizational innovations, are considered important for all kinds of regions and their development [39]. According to Hossain et al. [46], the demand for innovations in construction is strongly related to the need to enhance the life cycle sustainability of buildings through developments in the use of durable and recyclable materials (i.e., product innovations), building design and modular prefabrication (i.e., process innovations), and in business models (i.e., organizational innovations).

From an innovation development perspective, the public sector's role in land-use planning can be considered from two perspectives [71]. First, urban planners act as facilitators for innovation by granting building permits. Additionally, the public sector can promote sustainable construction and innovations by being customers or partners in public-private partnerships [71–73], which may support development of local industries [74]. From this perspective, an innovation occurs when new products, services, goods, or systems are delivered, or when the delivered product is adopted in a new context. Second, the public sector may act as an innovator itself by introducing new social or organizational elements such as new knowledge, a new organization, or new social practices [75,76].

To enable a more comprehensive analysis and understanding of innovations from land-use planning practitioners' perspective, several scholars have recently introduced the concept of social innovation in the spatial planning literature (see, e.g., [77–80]). According to Christmann et al. [77], novelties in land-use planning have typically been considered responses or reactions to other societal structural changes. Additionally, they suggest that the terminology used in land-use planning research emphasizes continuity instead of disruption. Furthermore, instead of using the term innovation, studies are more likely to discuss "shifts" [60], "transformations" [70], or "reshaping" [81]. Additionally, planners themselves do not often label their new approaches as "novel" or "innovative" [77].

Social innovations are new activities and services that are mainly spread by social organizations [82]. Social innovation "brings up social change that cannot be built based on established practices," and it is characterized by an immaterial structure, which comes to the fore through the institutionalization of new social practices [75]. It is claimed that social innovation differs from technical innovation in its intended result, as technological innovations often emphasize the role of economic profitability and commercial success, while social innovations are motivated by the goal of meeting social needs [75,82]. According to Cajaiba-Santana [75], social innovation is distinguished from other forms of social change in that it is something new and inherently purposeful that arises from "intended, planned, coordinated, goal oriented and legitimated actions" [83,84]. Additionally, it is suggested in the social innovation literature that once a novel solution is imitated, it becomes an innovation instead of an invention [77].

The relationship between social and technological innovation is considered complex [85]. Social innovation often exploits new technologies, and although they are typically easy to distinguish [86], they often coexist and build upon each other [87], creating a two-sided non-linear interplay [85]. For example, various inclusive city planning instruments have been developed in various regions globally [86] (see, e.g., Helsinki's inclusive budgeting: omastadi.hel.fi) that engage citizens (social innovation) thanks to the development and wide distribution of easy-to-use information technologies and software (technological innovation). In this study, innovation is used as an umbrella concept to cover new approaches to enhance sustainability change in the built environment, especially in residential areas, through land-use planning processes.

Analytical Framework for Evaluating Finnish Municipalities as Regional Innovation Systems

Innovation studies commonly address innovations as a system comprising two main constituents: components of some kind (i.e., actors) and their relations (i.e., interaction) [88]. The system also has a function, and it is possible to identify its boundaries. The regional innovation system framework (RIS) [89,90] extends the innovation system model to encompass spatial analysis by providing a framework for a regionally differentiated approach [39]. It emphasizes the importance of spatial proximity and favorable institutional settings for innovation activities [91]. The RIS framework also enables interregional analysis and higher spatial levels (national and international) [39].

Both organizations and institutions are crucial components of an RIS [92]. In an RIS system, organizations are represented by actors such as the public authorities, research institutes, universities, and companies, as well as other municipalities [93–96]. In the context of Finnish municipalities and their sustainability actions, different actors also possess various roles in the accumulation and dissemination of knowledge (Table 2). By comparison, institutional elements such as regulation and culture may act as drivers or barriers for innovation and thus affect the innovation outcomes of an RIS [97]. Institutions in an RIS can be formal or informal [91,94]. Formal institutions are laws, regulations [98], innovation policies [99], or action plans [100]. Examples of informal institutions include routines, norms, conventions, and habits [98]. In the Finnish land-use planning system, formal institutions are connected with the statutory land-use planning system (i.e., laws and regulations), while informal institutions are related to informal approaches (e.g., public-private partnerships and land-use development schemes) (e.g., [16,61]). Public-private networks and partnerships are increasingly considered an effective mode of governance that is especially needed to respond to "wicked problems" [101,102].

The RIS approach covers many possible spatial scales, and the "region" has been applied in various territories and jurisdictions [90]. Generally, there has been no correct way to define a system's frontiers because the system is only a theoretical construct. It is suggested that the conformation of an RIS can be evaluated from two perspectives [103]. First, a region can be described as a geographically defined administratively supported system with a link to its jurisdiction and financing capacity, as well as for investment activities. Second, a region can be considered from a regionalization perspective and assessed as a cultural entity [90,103]. Related to this, there is a widely shared opinion that increasing interaction in the form of cooperation and competition is largely augmented by geographical proximity [91,104].

Based on literature review results of Suorsa [42] on the definition of regions in empirical RIS studies, a municipality may be defined as a sub-national administrative unit composed of RIS actors and their connections. For example, in the context of Finland, Pekkarinen and Harmaakorpi [105] have used the municipality as a regional innovation system in a study of innovation networks, regional core competences, and social capital.

The RIS approach emphasizes the role of interdisciplinarity and interaction between actors in enhancing capability building. In addition to approving drafted land-use plans, urban planners may also affect their content [20]. In their work, land-use planners communicate with other actors related to land-use planning and building and collect, produce, and govern knowledge [20]. For example, sustainability innovations (e.g., those contributing to SDGs) in construction activities have been found to be crucially dependent on actor collaboration [46]. Additionally, with their power and legal responsibilities, land-use planners have a panoramic view of the land-use planning system, including all its actors, and can also themselves affect the sustainability of residential areas [21,22]. Figure 1 visualizes the RIS framework applied in this study in the context of land-use planning in Finnish municipalities [93,94,98].

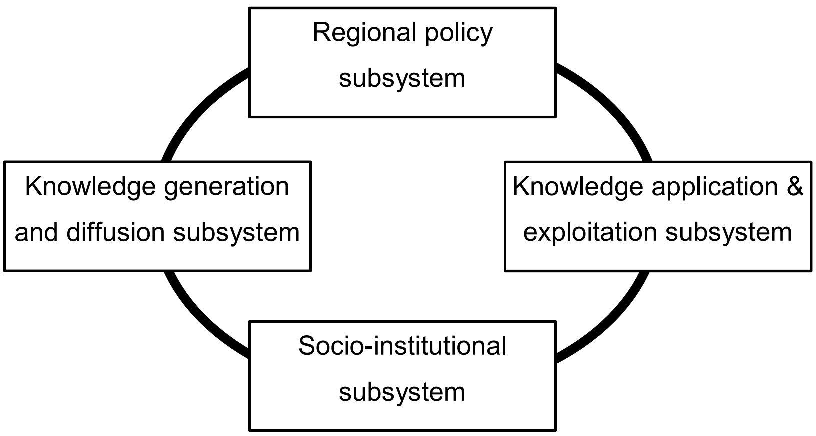

Figure 1. RIS subsystems in land-use planning (modified from [98]).

As civil servants, land-use planners operate in the Regional policy subsystem, as do local politicians. The socio-institutional subsystem, including formal and informal institutions such as informal and statutory planning approaches, affects how a local operation and networks are set up. The knowledge generation and application subsystem refers to new knowledge creation, while the knowledge application and exploitation subsystem is connected with existing knowledge use. However, new knowledge creation and existing knowledge use may be connected [93,106], although actors quite often mainly represent either of the knowledge subsystems (Table 2).

Table 2. Examples of actors and their roles in new knowledge creation (i.e., connections with Knowledge generation and application subsystem) and the use of existing knowledge (i.e., linkages with Knowledge application and exploitation subsystem) related to sustainability efforts in Finnish municipalities.

Actor	Examples of roles	Source
Companies	Innovators and adopters of new technological knowledge and business models that affect sustainability change	[22]
Interest organizations	Advocates and lobbyists to uptake new solutions, interpretation of the meanings in municipalities' processes in relation to various (and sometimes conflicting) interest organizations' goals	[19,107]
Authorities outside municipality	Steering through fiscal instruments (e.g., taxation and subsidies), programs (EU, national, regional), and information (e.g., evaluation reports), and negotiations (e.g., consideration of viewpoints of different societal actors)	[108]
Research organizations	Intermediaries providing data and analysis skills, assessing, e.g., feasibility of technological solutions and producers of new academic knowledge to complement the existing local general knowledge, e.g., of nature	[107,109,110]
Educational and teaching organizations	Intermediaries for enhancing the credibility of e.g., new technological solutions and awareness of them among experts	[111]
Non-governmental organizations	Compilers of existing knowledge and communicators in multi-actor networks	[112]
Citizens	Informants for the local decision-making processes and actors, who add to or diminish the local acceptance of sustainability through statutory participatory processes or informal civil activities	[113,114]
Media	Information deliverers to add knowledge of on-time events, etc. with effects also on the acceptability of municipality actions	[113]
Other municipalities	Peers to produce and circulate together knowledge about climate change mitigation	[112,115]

DATA AND METHODS

Material Collection

The data for the study were gathered with an online survey in three rounds (main contact and two reminders) in March–April 2021. The target group of the data gathering was civil servants responsible for different land-use management tasks in the Finnish municipalities (in total 309) located in mainland Finland and Åland. Since there is no information on the actual population of Finnish land-use planners (see, e.g., [20]), the information of the online survey recipients was to be collected from Finnish municipalities' webpages in February (in total, 1012 professionals). To gather the data, the recipients were contacted by email with a cover letter, which also contained an electronic link for the online questionnaire available in both official languages in Finland (i.e., Finnish and Swedish).

The final dataset comprises responses from 163 land-use planners (16% of the total number of recipients), who worked for 92 Finnish municipalities in land-use planning tasks locally. Compared with the statistics, the 92 municipalities represented approximately 70% (3.78 million) of the population of Finland in 2020 (5.51 million) (Association of Finnish Municipalities, www.kuntaliitto.fi). Compared with the size of Finnish municipalities, the average number of residents in a Finnish municipality in 2021 was 18,751. In the 92 municipalities represented in the online survey data, 49 were bigger, and 47 were smaller. This also supports the assumption of the data validity for providing information on Finnish municipalities' land-use planning characteristics. Finally, the respondents' professional profiles resembled those of land-use planners working in the Finnish municipalities (for a more detailed description, see, e.g., [24]).

In the online questionnaire, a total of around 20 questions on economic, social, and environmental aspects linked with the land-use planning processes and practices of Finnish municipalities were presented. All questions are illustrated in Supplementary Table S1, including reasoning for why particular questions (or in some cases individual variables in some questions) were included or excluded from the study. In the cover letter emailed to the recipients, they were asked to answer all the questions from the perspective of their own professional views and experience. For example, this was important for obtaining information on the personal actor collaboration relationships playing important roles in the context of the RIS framework (e.g., learning, knowledge sharing, institutionalization of new practices). In this study, questions providing information in relation to the RIS (Figure 1) from the perspective of local land-use planning practices and actor collaboration for promoting local sustainability in residential areas were analyzed (Table 3 and Table 4).

In relation to the RIS framework (Table 3), Question 14 (all variables, a–h) addressed the importance of informal and statutory land-use governance mechanisms (i.e., the operationalization of the Socio-institutional subsystem) and Question 17 (all variables, a–b) and 19 (all variables, a–h) actor collaboration (i.e., operationalization of Knowledge generation and diffusion subsystem/Knowledge application and exploitation subsystem). The variables of Questions 14, 17, and 19 were operationalized using the Land Use and Building Act in Finland and information in [95,96].

In connection with the enhancement of sustainability through local land-use planning objectives (Table 4), Question 20 (all variables, a–t) addressed ecosystem services, Question 21 (all variables, a–e) urban infill, and Question 22 (variables a and b) material selection in construction. The variables of Questions 20 and 21 were operationalized by employing information received from [116] and [117] and the variables of Question 22 especially using [24]. The respondents were asked to rate the importance of a variable on a five-point Likert scale (1 = Not at all important, 2 = Not very important, 3 = Neither important nor unimportant, 4 = Quite important, 5 = Very important). In addition, respondents were given an opportunity to choose an "I don't know" option, which was omitted from the analysis.

Table 3. Questions and variables used to assess informal (denoted by I) and statutory (denoted by S) mechanisms and collaboration with other actors in municipalities' land-use planning.

	How important are the following options for implementing the land-use planning aims in your municipality?		**How important is collaboration with other municipalities to fulfill the land-use planning aims in your municipality?**		**How important is collaboration with the following actors to fulfill the land-use planning aims for residential areas in your municipality?**
Q14a.	Strategic alliances for development projects (e.g., public–private partnerships) (I)	Q17a.	Formal collaboration with other municipalities (e.g., committees with strategic goals and procedures, projects with financing)	Q19a.	Collaboration with companies
Q14b.	Municipal development programs (e.g., sustainable building programs) (I)	Q17b.	Informal collaboration with other municipalities (e.g., workshops to share ideas and knowledge)	Q19b.	Collaboration with interest organizations
Q14c.	Regional development programs (e.g., development programs of Regional Councils) (I)			Q19c.	Collaboration with authorities outside the municipality
Q14d.	National development programs (e.g., government programs to promote building with wood) (I)			Q19d.	Collaboration with research organizations
Q14e.	Statutory plans made by the authorities at a detailed municipal level (i.e., local detailed plans and their attachments) (S)			Q19e.	Collaboration with educational and teaching organizations
Q14f.	Statutory plans made by the authorities at general municipal level (i.e., local masterplans and their attachments) (S)			Q19f.	Collaboration with non-governmental organizations
Q14g.	Statutory plans made by the authorities at regional level (i.e., regional plans) (S)			Q19g.	Collaboration with citizens
Q14h.	Statutory decisions made by the authorities at national level (i.e., national land-use objectives) (S)			Q19h.	Collaboration with the media

Table 4. Questions and variables used to assess municipalities' sustainability objectives in land-use planning in the built environment, with a special focus on residential areas.

	How important are the following matters in your municipality's land-use planning in residential areas?		How important are the following objectives in your municipality's infill development?		How well do the following claims fit with your municipality's land-use planning in residential areas?
Q20a.	Protection of biodiversity	Q21a.	Concentration of community structure and/or reduction of sprawl by increasing interregional commuting connections	Q22a.	Our municipality guides the use of building materials in new construction
Q20b.	Preserving living environments	Q21b.	Concentration of community structure and/or reduction of sprawl by building additional stories in existing apartment buildings	Q22b.	Our municipality guides the use of building materials in renovation
Q20c.	Addressing land for agricultural and forestry use	Q21c.	Enhancing carbon neutrality of infrastructure and buildings		
Q20d.	Preserving habitats for collectibles (e.g., berries, mushrooms) and wildlife	Q21d.	Enhancing energy efficiency of infrastructure and buildings		
Q20e.	Preserving groundwater supplies	Q21e.	Introduction of smart technologies		
Q20f.	Regulating water circulation and flood control				
Q20g.	Pollinator protection (securing cultivated and wild plant crops and fostering seed spread)				
Q20h.	Advancing local and regional climate conditions (e.g., urban trees)				
Q20i.	Protecting/advancing recreational uses of nature (e.g., outdoor routes)				
Q20j.	Protecting/advancing nature's teaching opportunities (e.g., forest areas near kindergartens and schools)				
Q20k.	Preserving traditional landscapes and environments (i.e., natural landscapes and built environment)				
Q20l.	Preserving natural sites' cultural and spiritual values (e.g., archeological sites and native peoples' holy sanctuaries)				
Q20m.	Preserving nature's intrinsic values for future generations (e.g., destinations which present value remains unrecognized)				
Q20n.	Minimizing land treatment expenses on building sites before releasing (e.g., contaminated sites)				
Q20o.	Prioritizing building in areas with inherent possibilities for energy efficiency (e.g., sun radiation, yard slope)				
Q20p.	Prioritizing building in areas with existing infrastructure (e.g., roads, sewage)				
Q20q.	Maintaining municipality's land ownership (e.g., renting land)				
Q20r.	Minimizing noise pollution				
Q20s.	Enhancing/preserving air quality (e.g., fine particle emission, industrial smell nuisance)				
Q20t.	Repairing previously made esthetic flaws in landscape/urban milieux				

Prior to analysis, municipalities were categorized as densely populated (urban), intermediate density (towns and suburbs), and thinly populated areas (rural), based on Eurostat's Degree of Urbanization classification (Degurba) [118]. The categorization is developed based on a combination of geographical contiguity and population density measures so that each municipality (or local administrative unit) exclusively belongs to only one of the three classes. The approach classifies 1 km^2 size grid cells of an entire territory and assesses how many grid cells with a certain population density are located side by side to create clusters. Local units (e.g., municipalities) are then classified based on the kind of grid cells within the region [118].

Methodological Steps

The study's main analysis is composed of three sequential quantitative approaches. Additionally, as a background for the analysis, the frequencies of the land-use planners' five-point Likert scale responses addressing RIS (Supplementary Table S2) and sustainability objectives (Supplementary Table S3) in local land-use planning were evaluated. Firstly, exploratory factor analysis (EFA) with Kaiser normalization, Varimax rotation, and Maximum Likelihood Estimation were used to identify RIS structures (questions and variables in Table 3) and sustainability objectives (questions and variables in Table 4) in municipalities land-use planning. Secondly, different municipality groups were compared using Mann-Whitney *U* tests to study differences between municipality groups in relation to EFA findings from the first part of the analysis. Thirdly, two-tailed Pearson correlations were calculated to assess the interdependencies between EFA solutions for the three separate models and municipality groups.

The study's first objective is to assess the structures of municipalities' land-use planning and identify their subsystems based on the RIS framework. To meet this objective, as the first phase of the data analysis, the number of the original survey variables on land-use planning mechanisms and collaboration with other actors (Table 3) and sustainability objectives in municipalities' land-use planning (Table 4) were reduced. That procedure was implemented with EFA, which is a method to evaluate an empirical phenomenon by revealing underlying structures, also called latent variables or factors [119,120]. An essential goal of EFA is to assess the possibility of representing a large set of variables more parsimoniously [121]. The final EFA solutions depend on both theoretical and empirical considerations (e.g., operationalization of variables in relation to analytical frameworks) and statistical figures [119,120,122].

In this study, three separate EFA models were constructed: The first EFA model was executed to reveal the underlying structures (i.e., latent variables) on the use of informal and statutory land-use planning mechanisms to fulfill land-use planning aims (Question 14). The second EFA model was constructed to explore the roles of actors as collaborators in a land-use planning RIS in relation to knowledge application and exploitation, and knowledge generation and diffusion (Questions 17 and 19). Finally, the third EFA model was created to assess sustainability objectives in municipalities' land-use planning (Questions 20, 21, and 22). The empirical interpretation of the EFA results was based on the empirical studies used to formulate the survey questions (e.g., [24,95,96,116,117]) but also on the other relevant literature (see, e.g., Table 2).

The EFA results were assessed statistically using several measures: A Kaiser eigenvalue >1 was employed as a background criterion for the number of factors to be retained, and the Kaiser-Meyer-Olkin measure (minimum value of 0.50) and the Bartlett test of sphericity (correlation between original variables is assumed to exist) were utilized as measures for sampling size adequacy. To be kept in the model, a threshold value of 0.4 was used for the original variable factor loadings (i.e., contribution of a variable to the model), alongside checking the extracted communality value (i.e., estimates of the variance of a variable with other variables in the model) to be at least 0.2 [123]. Additionally, for the clarity of the interpretation of the EFA results, original variables with double loadings in multiple factors were omitted from the models. Thus, in seeking an empirically valid solution, the conceptual consistency of the factors was also assessed.

To respond to the study's second objective of comparing municipalities' RIS structures and their sustainability objectives, as the second phase of the data analysis, EFA factors were compared between municipality groups using the Mann-Whitney *U* test. Furthermore, the number of municipality groups to be analyzed further was determined in accordance with the results at this phase. Mann-Whitney *U* test is a non-parametric statistical test used to study differences of means between groups [124]. Compared with an independent samples T test, which is used for continuous variables with normal distribution, the Mann-Whitney *U* test is more suitable for ranked data [124]. The following definition for different levels of statistical significance was used: suggestive evidence of statistical significance = $0.05 \leq p\text{-value} < 0.1$; moderate evidence of statistical significance = $0.01 \leq p\text{-value} < 0.05$; and very strong evidence of statistical significance = $p\text{-value} < 0.01$.

To respond to the study's third objective of analyzing the interlinkages between RIS subsystems and between sustainability objectives in municipalities' land-use planning, as the third phase of the data analysis, two-tailed Pearson correlations were calculated. The Pearson correlation measures the linear relationship's strength between two variables. The results from the first and second phase of the data analysis (i.e., EFA factors and municipality groups) were used and correlations for municipality groups were calculated separately (Supplementary Table S4 and Supplementary Table S5). Finally, Figure 2 presents a summary of the results and enables an overview and comparison of the relationships between RIS factors and sustainability objectives.

RESULTS

Exploratory Factor Analysis Results for Actor Roles and Institutional Variables in Land-Use Planning System

The first EFA model connected to the Socio-institutional subsystem in RIS (Table 5) resulted in two factors that illustrate the use of informal and statutory approaches to fulfill land-use planning objectives in Finnish municipalities. As results of the EFA modelling, the number of eight original Question 14 variables were reduced to six in two factors explaining 68% of the variation in the original data. Two variables were omitted due to double loadings in two factors (Q14 variables g and h in Table 3). The first factor comprises all the original variables related to informal planning approaches, and it was named Informal planning, while the second factor is composed only of variables in local statutory land-use planning approaches and was thus called Local statutory planning.

Table 5. Exploratory factor analysis results on the latent variables, illustrating the use of informal and statutory land-use planning approaches in the Finnish municipalities.

Statutory and informal land-use planning approaches	Communalities (Extraction)	F1: Informal planning	F2: Local statutory planning
Strategic development programs	0.257	0.413	0.294
Municipal development programs	0.379	0.496	0.364
Regional development programs	0.489	0.688	0.124
National development programs	0.810	0.897	0.078
Local detailed plan	0.681	0.130	0.815
Local masterplan	0.746	0.210	0.838
Cronbach's a		0.749	0.815
Eigenvalues		1.756	1.607
Explained variance, %		47.61	20.68

Kaiser-Meyer-Olkin measure of factorability 0.673; Bartlett's test of sphericity $p < 0.001$.

The second EFA model addresses the importance of different collaborators to fulfill the land-use planning aims linked with Knowledge generation and diffusion subsystem and Knowledge application and exploitation subsystem in RIS (Table 6). Like the first EFA model, the second also resulted in a two-factor solution. The two factors explain about 58% of the variation in the original data, and they are formed by seven of the ten Question 17 and 19 original variables. The reason for omitting the original variables in the model were double loadings in three factors (Q17 variable a, Q19 variables c and e in Table 3). The first factor was called Information compilers, deliverers, and users, and the second Research and governance organizations. The naming of the factors was based on the results in the empirical literature concerning the typical roles of different actors in the municipalities, especially regarding the quest for local sustainability in Finnish municipalities' actions (see Table 2).

Table 6. Exploratory factor analysis results on the latent variables, illustrating collaboration with different actors in knowledge generation and diffusion, and knowledge application and exploitation in the Finnish municipalities' land-use planning.

Collaborators in land-use planning	Communalities (Extraction)	F1: Information compilers, deliverers, and users	F2: Research and governance organizations
Companies	0.226	0.450	0.153
Interest organizations	0.392	0.519	0.350
Non-governmental organizations	0.424	0.590	0.276
Citizens	0.379	0.585	0.191
Media	0.553	0.725	0.165
Research organizations	0.744	0.301	0.808
Other municipalities (informal)	0.234	0.136	0.464
Cronbach's a		0.763	0.599
Eigenvalues		1.796	1.153
Explained variance, %		43.06	14.49

Kaiser-Meyer-Olkin measure of factorability 0.795; Bartlett's test of sphericity $p < 0.001$.

The third EFA model (Table 7) was built to assess whether general themes for sustainability objectives in municipalities' residential land-use planning existed. As a result, the 27 variables addressing consideration of ecosystem services (Question 20) and sustainable building (Question 21 about infill development and two variables on Question 22 about building materials) were reduced to eight variables in two factors, which explain 65% of the variation in the original data. The omitted variables had factor loadings below 0.4, or they were double-loaded in two factors, which would have caused ambiguity in the empirical interpretation of the EFA result. Based on the original variable loadings, the first factor was named Sustainable building focus, and the second Ecosystem service focus.

Table 7. Exploratory factor analysis results on the latent variables, illustrating the ecological sustainability objectives for the built environment in the Finnish municipalities' land-use planning.

Sustainability objectives	Communalities (Extraction)	F1: Sustainable building focus	F2: Ecosystem service focus
Enhancing carbon neutrality	0.339	0.914	0.217
Enhancing energy efficiency	0.529	0.882	0.207
Introduction of smart technologies	0.691	0.671	0.289
Guiding the use of building materials in new construction	0.342	0.477	0.334
Preserving nature's intrinsic values	0.396	0.155	0.817
Preserving/advancing nature's teaching opportunities	0.533	0.193	0.701
Protecting pollinators	0.883	0.255	0.575
Prioritizing building in areas with natural opportunities for energy efficiency	0.821	0.293	0.507
Cronbach's a		0.859	0.717
Eigenvalues		2.503	2.032
Explained variance, %		49.43	16.51

Kaiser-Meyer-Olkin measure of factorability 0.807; Bartlett's test of sphericity $p < 0.001$.

Statistical Comparison between Municipality Groups Regarding RIS and Sustainability Objectives

The next phase of the results compares different types of municipalities using the Degurba classification (Table 8). Municipalities were compared in three groups (i.e., urban, towns and suburbs, and rural areas). However, after comparing each group, it was concluded that municipalities classified as towns and suburbs and rural areas shared very similar characteristics (e.g., many municipalities classified as towns and suburbs also have rural areas). They were therefore combined into one group, labeled “other municipalities”.

Table 8. Mann-Whitney *U* comparisons with urban and other municipalities in relation to exploratory factor analysis (EFA) results on regional innovation system (RIS) (i.e., Socio-institutional subsystem, Knowledge subsystems) and sustainability objectives in municipalities’ land-use planning.

		EFA results on latent variables	***n***	**Mean rank difference (urban—other municipalities)**	***p*-value**
Regional innovation system	Socio-institutional subsystem	F1: Informal planning	138	24.73	<0.001***
		F2: Local statutory planning	138	8.95	0.198
	Knowledge subsystems	F1: Information compilers, deliverers, and users	135	10.21	0.143
		F2: Research and governance organizations	135	17.55	0.012**
Sustainability objectives		F1: Sustainable building focus	118	26.68	<0.001***
		F2: Ecosystem service focus	118	–13.95	0.030**

*Suggestive evidence of statistical significance = $0.05 \le p$-value < 0.1; **moderate evidence of statistical significance = $0.01 \le p$-value < 0.05; ***very strong evidence of statistical significance = p-value < 0.01.

To provide detailed information about the differences in the three EFA model results by urban and other municipalities, as the second phase of the data analysis, the differences between the factor scores of the two municipality groups were compared using non-parametric Mann-Whitney *U* testing. As presented in Table 8, a more detailed analysis of the RIS subsystems (i.e., the Socio-institutional subsystem, the Knowledge generation and diffusion subsystem, and the Knowledge application and exploitation subsystem) shows statistically significant differences between the two municipality groups in the use of Informal planning and Research and governance organizations (i.e., new knowledge creation). Furthermore, the results suggest that these factors are considered more important by urban municipality land-use planners than planners in other municipalities. In addition, regarding sustainability objectives in residential building, both the Sustainable building focus and the Ecosystem service focus have statistically significant differences between the urban and other municipalities. The former is considered more important in urban municipalities, and the latter more important in other municipalities.

The results for the interdependencies between the two EFA results on RIS subsystems (Table 5 and Table 6) and the third EFA results on the sustainability objectives in residential building (Table 7) are illustrated in the Figure 2 and also available for urban (Supplementary Table S4) and other municipalities (Supplementary Table S5) separately.

Regarding the connections between RIS subsystems (i.e., Socio-institutional subsystem, Knowledge generation and diffusion subsystem, and Knowledge application and exploitation subsystem) analyzed with the two first EFA models, the Research and governance organizations factor does not have statistically significant interdependencies with the Local statutory planning factor in either urban or other municipalities. Yet it has strong interdependencies with Informal planning. Additionally, the Local statutory planning factor shows moderate evidence of a statistically significant relationship with Information compilers, deliverers, and users, both in urban and other municipalities.

In reference to the third EFA model results on sustainability objectives in residential areas, both the Sustainable building focus and Ecosystem focus factors have a statistically significant relationship with the Informal planning and Local statutory planning factors in urban municipalities. However, in other municipalities, the sustainability objectives have a significant relationship only with Informal planning. In addition, for the other municipalities, the sustainability objective factors have statistically significant interdependencies with both Research and governance organizations and Information compilers, deliverers, and users. For urban municipalities, the sustainability objective factors have a significant correlation with the Research and governance organizations factor, while the objective Ecosystem service focus has a statistically significant relationship only with Information compilers, deliverers, and users. For other municipalities, the Information compilers, deliverers, and users factor has a statistically significant relationship with both objective factors, while the Research and governance organizations factor is significantly correlated only with the objective factor Sustainable building focus.

Figure 2 summarizes the comparisons of the Pearson correlation test results for the three EFA model results on RIS subsystems and sustainability objectives in residential building implemented as the third phase of the data analysis. By showing the results separately for urban and other municipalities, the illustration concretizes how different RIS subsystems connect with each other, and what their role in achieving sustainability aims in Finnish municipalities appears to be.

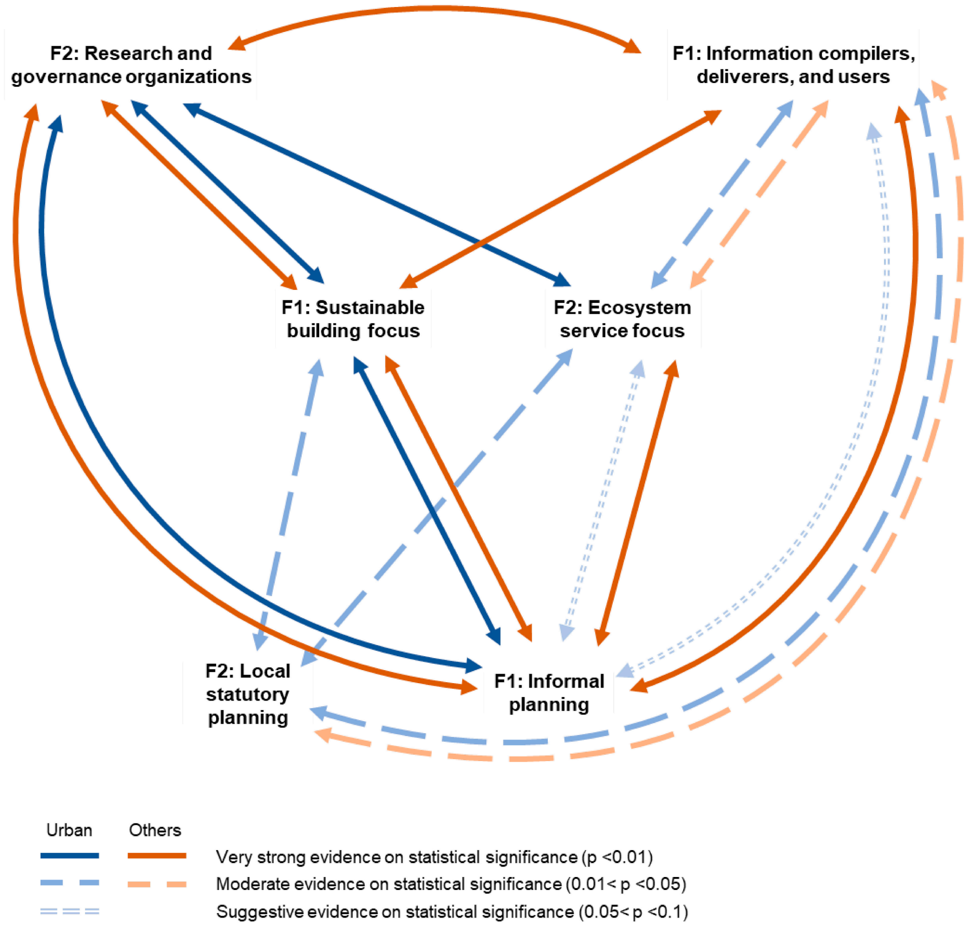

Figure 2. Illustration of two-tailed Pearson correlations between regional innovation system (RIS) subsystems and sustainability objectives for urban and other municipalities.

In relation to the Socio-institutional subsystem (in the EFA results, reflected by the Informal planning and Local statutory planning factors), the use of informal land-use planning approaches shows multiple connections with new knowledge creation (in the EFA results, reflected in Research and governance organizations), the existing knowledge use (in the EFA results, reflected in Information compilers, deliverers, and users) and sustainable residential building objectives (in the EFA results, Sustainable building focus and Ecosystem service focus). As the results are similar for urban and other municipalities, especially in relation to knowledge accumulation and the enhancement of local sustainability goals in municipalities, informal land-use planning approaches seem to supersede statutory land-use planning approaches.

In connection with the role of knowledge in enhancing sustainability objectives for residential building objectives in municipalities, new knowledge creation (in the EFA results, reflected in Research and governance organizations) shows stronger links with local sustainability than the existing knowledge use (in the EFA results, reflected in Information compilers, deliverers, and users). Although there are some differences between urban and other municipalities, the result suggests that knowledge accumulation plays a crucial role for sustainability actions and possibilities for businesses and citizens to enhance sustainability through their own practices, for example.

DISCUSSION

This study's overall purpose was to evaluate local land-use planning practices and actor collaboration in new knowledge creation and existing knowledge use in connection with sustainable land-use planning. Our special focus was to address these issues in relation to residential building, which alongside local decisions made in land-use planning [1] plays both internationally and nationally focal role for enhancing sustainable development in the built environment [33,34]. As the material of the study, we employed online survey data collected from Finnish land-use planners analyzed with exploratory factor analysis (EFA) and statistical tests.

In Finland, land-use planners have room to make autonomous decisions regarding zoning and building related specific choices like material selection [96], for example. Through their role as information gatekeepers, communicators, preparers, and introducers of plans [20] they have a significant potential to advance sustainable development through decisions in land use management [48] and act as regional innovation initiators [23,24]. Additionally, their focal role enables an extensive view and understanding regarding land use management related issues. Thus, information gathered from land-use planners working in the Finnish municipalities provide insights on the local aspects of systemic innovation activities, which are considered as important to enhance sustainability independently of national land-use systems in many countries (e.g., [26]).

Regarding the analytical framework, our results were aligned with the regional innovation system (RIS) framework and the planning literature. According to the EFA, the informal and formal planning approaches constitute separate modes of planning from the perspective of socio-institutional aspects in RIS. The result is in line both with the RIS framework (e.g., [93]) and planning literature (e.g., [61]). Moreover, land-use planners' perceived importance of different actors as collaborators reveals differences between knowledge creators and knowledge users, suggesting a similar formulation between the EFA results and the RIS framework. The innovation system literature additionally suggests that actors representing knowledge creation and existing knowledge utilization may connect with each other [93,106], as was found in our results regarding other than urban municipalities. More specific elements of the Finnish statutory land-use planning system are also visible in the distribution of responses to individual variables (Supplementary Table S2 and Supplementary Table S3). This was evident, for example, when authorities in adjacent municipalities were considered important, which probably reflects the significance of the regional level co-operation (regional plans) and in other formal and informal actor networks. Citizens were also considered to have a crucial role in local land-use planning activities. This can be argued at least with the legal obligation to include citizens in the planning process to ensure legitimacy (e.g., [113]). In addition, companies were also considered highly important collaborators in land-use planning, which may be related to their role as enablers to develop and uptake sustainability innovations (e.g., [22]), for example.

From the perspective of enhancement of local sustainability, the results of this study show informal land-use planning approaches to be more connected with local innovation activities (i.e., new knowledge creation and the existing knowledge use), and seek for sustainability in the built environment (i.e., goals for sustainable building and securing ecosystem services) compared to statutory approaches. In line with earlier research results (e.g., [13,28]), this indicates that independently of national land-use systems, informal planning tools (e.g., collaboration with citizens, businesses, research and education organizations, other municipalities) play significant role in enhancing local sustainability along with statutory mechanisms. In addition to recognizing the potential of informal land-use planning approaches to enhance local sustainability, the results of this study also emphasized the differences between urban and other municipalities in their land-use planning practices and actor collaboration. While no statistically significant differences were found between the urban and other municipalities in their use of statutory land-use planning approaches, informal planning was perceived as more important by urban municipality land-use planners. The result may be caused by the greater financial and other resources to implement informal activities in urban municipalities, and their national and global competition with other regions [59]. In reference to the results on differences between urban and other regions of this study, for example Suorsa [42] has noted peripheral regions to lack key actors and resources needed in innovation activities. In our results this is reflected through findings on actors representing new knowledge creation (i.e., research and governance organizations*)* to be more important in urban municipalities' land-use planning compared with other municipalities.

Abreast with availability of actors and resources, compared to other municipalities, urban regions with often growing populations may face a greater need for more flexible land-use planning approaches to build new residential areas. In the results of this study, pressures from population growth and needs for new housing also explain why the sustainability focus in urban municipalities was especially targeted at building. In comparison, based on the results of this study, other municipalities with lower population density play more broadly attention on sustainability in the built environment (i.e., goals expressed both for sustainable building and securing ecosystem services). However, it must be kept in mind that securing ecosystem services is a fundamental part of local sustainability also in the urban areas [5]. Thus, although urban municipalities have more actors and resources to support innovation activities, for example, other municipalities may have knowledge on natural environments that might be useful for land-use planning processes in cities. In all, collaboration between actors in land-use planning does not have to be limited within the boundaries of similar municipalities, but it may add possibilities for mutual learning and development of innovations also through common efforts among different types of localities.

CONCLUSIONS

This study brings forward new information about land-use planning practices and actor collaboration in Finland from the perspective of sustainable development. Furthermore, it responds to the request to include non-urban areas in studies regarding innovation and sustainable development in the built environment. Based on the planning literature, informal planning means have often emerged in applications where municipalities must respond to new challenges, develop themselves in a competition with other municipalities locally and globally, and reduce the complexity of the planning system. In these pursuits, municipalities are seeking for means outside the statutory planning mechanisms. Our results suggest that informal planning approaches are more connected to municipalities' sustainability objectives than local statutory approaches. Additionally, the linkages found between informal approaches and the perceived importance of collaboration with research and governance organizations connects with creating new knowledge needed in sustainability innovation activities. Combined with the results about informal planning system being less important in other municipalities than in urban municipalities, there is a threat that sustainability issues specific to rural regions remain bypassed (e.g., [41,43]), although municipalities outside the urban areas may have stronger intentions to enhance sustainability through ecosystem services. Therefore, to achieve equal futures among regions and citizens, the emphasis of land-use planning approaches and objectives should be followed closely in different localities especially due to the long-term nature of land-use planning and building on sustainability also from the perspective of regional attraction.

A limiting factor in terms of generalization of our findings is the single country approach. Similar land-use planning systems than the Finnish system, where municipalities have a leading role exist, especially in other Nordic countries [16], for example. Although informal land-use planning approaches may be used independently of national statutory land-use governance systems, future research both on similar and different land-use planning contexts in other countries is needed. This would strengthen the validity of our findings and deepen the understanding of the studied phenomena. Additionally, in relation to land-use planning as an enabler of sustainable development, future studies should target other stakeholders and their perspectives regarding collaboration and different socio-institutional practices. This would enable, for example, to deepen our understanding of how innovations may contribute local sustainability in different localities through statutory and informal land-use planning approaches.

SUPPLEMENTARY MATERIALS

The following supplementary materials are available online: https://doi.org/10.20900/jsr20230006. Supplementary Table S1: Reasoning for exclusion/inclusion of questions and variables in the questionnaire; Supplementary Table S2: Land-use planners' views of the importance of regional innovation system (RIS) variables (% of responses). (I) denotes informal planning, and (S) statutory planning variable. (1 = Not at all important, 2 = Not very important, 3 = Neither important nor unimportant, 4 = Quite important, 5 = Very important); Supplementary Table S3: Distribution of responses regarding sustainability objectives related to residential areas in connection with ecosystem services, infill development, and building materials. Frequencies in percentages (%); Supplementary Table S4: Two-tailed Pearson correlations between regional innovation system (RIS) subsystems' factor loadings and sustainability objectives' factor loadings for the urban municipality group; Supplementary Table S5: Two-tailed Pearson correlations between regional innovation system (RIS) subsystems' factor loadings and sustainability objectives' factor loadings for other municipalities.

DATA AVAILABILITY

The dataset of the study is available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

The original draft was prepared by KA and LK who both contributed to the revision and editing of the manuscript. Both authors have also read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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