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Transcending sectoral boundaries? Discovering built-environment indicators through knowledge co-production for enhanced planning for well-being in Finnish cities

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A B S T R A C T

Worldwide urbanisation emphasises the importance of planning for cities that sustain and promote the well-being of their residents. The planning of a living environment that supports well-being requires both intersectoral cooperation between policy sectors and interaction between researchers and practitioners. With 12 case studies (of 11 Finnish municipalities and one city region), we provide a description of a knowledge co-production process originating from the use of a new planning-support tool called StrateGIS that can be used for discovering built-environment indicators for integrated planning for well-being. Based on spatial multi-criteria analysis, we also investigate how the tool fostered intersectoral discussion among practitioners during the process. Practitioner knowledge was merged with scientific knowledge at different stages of the process: in structuring the value tree, in setting the objectives, in selecting the criteria and in defining the spatial representation for each criterion. Intersectoral discussion during the process was seen as fruitful and relatively easy despite the different types of expertise present in the workshops. Based on our results, the local experts specialised in spatial data have an intermediary role between practitioners since they can build understanding of how data is translated into spatial information when using a spatial planning-support tool.

1. Introduction

The well-being of citizens is linked to many factors in their physical living environment. Personal factors are critical in determining health, but the urban environment has the potential to either exacerbate or mitigate well-being outcomes (Barton, 2009). There is a growing record of evidence of the importance of nature, and green and blue spaces for the physical and mental well-being of humans (see, e.g. White et al., 2010; Russell et al., 2013; Wolch et al., 2014; Tu et al., 2019). In addition, the built environment – which includes land use (the distribution of activities across space), the transport system (the infrastructure) and the urban design (the physical elements within a city) – affects well-being (Handy et al., 2002). For example, land-use decisions affect well-being by enabling services close to residents of all age groups (Stoeckel and Litwin, 2015), and urban design has an important role in creating opportunities for walking and cycling in cities (Handy et al., 2002; London, 2020).

Worldwide urbanisation increases the need for urban planning that supports the well-being of its citizens. However, it also means growing competition between functions and land uses, which makes the integrated planning of well-being challenging. Particularly problematic is the lack of coordination and integration between traditional well-being sectors, like public services or security, and urban planning and the built environment (Blas et al., 2016). In Finland, the legislation requires municipal strategic planning, both to set goals for the promotion of health and well-being, based on local conditions and needs, and to define measures to support these goals. However, the municipalities struggle with a lack of integrated planning of functions and intersectoral co-operation in the planning of well-being (WHO Regional Office for Europe, 2002). This silo effect is the result of rigid administrative boundaries between land-use planning and other policy sectors (Karppi and Vakkuri, 2019), and it forms barriers for enhancing well-being in cities (Carmichael et al., 2012) as well as the effective use of planning-support tools (Silva et al., 2017). Despite their relevance, the built-environment-related well-being indicators are weakly monitored in the statutory municipal welfare reports required by the Finnish Health Care Act (Sahamies, 2018). At the city-region scale, the municipal boundaries and inter-municipal competition for land uses and

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taxpayers makes integrated urban planning difficult (Mäntysalo et al., 2015; Hytönen et al., 2016). These challenges call for more effective planning tools that can help set priorities and address trade-offs between conflicting interests and values.

The need for frameworks and methods for incorporating well-being-related knowledge into urban planning has long been apparent (van Kamp et al., 2003; Pineo et al., 2020). It is also widely recognised that responding to complex urban problems requires the inclusion of different kinds of knowledge, both academic and practical knowledge, in order to pool a broad range of perspectives and information (Corburn, 2009; Lang et al., 2012; Frantzeskaki and Kabisch, 2016; Webb et al., 2018). Multi-criteria decision analysis (MCDA) methods are often used for complex urban and environmental planning problems that involve multiple stakeholders and decision-makers (see, e.g. Huang et al., 2011; Cegan et al., 2017). MCDA methods can be combined with geographic information systems (GIS) to analyse spatial information (spatial MCDA or SMDCA) (Ferretti and Montibeller, 2016). While the use of MCDA in the context of urban sustainability is relatively common, covering urban water management (Lai et al., 2008; Gigovic et al., 2017; Kim et al., 2017) and ecosystem services (Langemeyer et al., 2016), there are not many applications of MCDA to aspects of urban well-being (for exceptions, see Faria et al., 2018; Oppio et al., 2018).

Previous research has highlighted the importance of urban planners and planning institutions in developing sustainable urban futures (Bergsten and Zetterberg, 2013; Frantzeskaki and Kabisch, 2016; Gil Solá and Vilhelmson, 2019; Hysing, 2009). However, they also play an important intermediary role between local decision makers, community residents, and researchers and other experts, and they possess important information, including their knowledge of planning systems and knowledge of 'how the city works' (Tennøy, 2010, p. 218).

In this study, we present a novel approach for capturing the different dimensions of human well-being in an urban planning context by using a new planning-support tool, StrateGIS. Since the tool does not aim at solving a specific decision problem, we use the term *spatial multi-criteria analysis* (SMCA) rather than *SMCDA*. StrateGIS is a transparent and flexible tool for producing understandable and spatially explicit knowledge in order to support the planning of well-being. The tool was developed and applied in close interaction with urban planners and sectoral authorities in eleven Finnish municipalities and one city-region authority who used it to translate their well-being strategies into a set of spatial indicators. Unlike many other SMCA applications, the StrateGIS process was designed to be repeated independently by practitioners in the future using the extensive educational material produced by the researchers. Drawing on the experiences of real-life cases, we investigate the role of the tool in supporting knowledge co-creation between scientists and municipal actors with expertise in multiple well-being dimensions in their localities. We also investigate how the StrateGIS tool helped to support intersectoral discussion for human well-being among practitioners.

2. Theoretical background

Multi-criteria decision analysis (MCDA; sometimes termed *multi-criteria analysis*) is a framework for supporting multi-dimensional and complex decision-making processes that allows comparison among decision alternatives by systematically evaluating multiple objectives and criteria in a transparent and consistent manner (see, e.g. Lahdelma et al., 2000; Adem Esmail et al., 2018). MCDA methods can be combined with GIS to analyse the decision alternatives spatially (Ferretti and Montibeller, 2016; Mahmoud and Garcia, 2000; Janssen et al., 2005). In spatial MCDA, the MCDA provides tools for structuring and designing decision problems, and evaluating objectives, whereas GIS is mainly used for analysing results on a map (Malczewski, 2006) since it provides location-based information. The spatial dimension in MCDA is particularly useful in urban planning where both factual and value-based spatial information are needed. Spatially integrated decision-support systems can also be used to foster knowledge exchange between decision makers and the complex models produced by researchers (Maniezzo et al., 1998). In particular, GIS-based visualisations have been found helpful in stimulating dialogue and discussion, and also in providing arguments and evidence for policy discussions (Frantzeskaki and Kabisch, 2016).

MCDA and SMCDA methods are often used to support participatory urban and environmental planning situations involving multiple stakeholders and decision makers. Stakeholders are usually engaged in framing the decision-making problem, and identifying policy alternatives and criteria, against which the alternatives are evaluated, as well as being engaged in the weighting of the alternatives (Grêt-Regamey et al., 2017; Adem Esmail et al., 2018; Tiitu et al., 2018). For example, in the work of Grêt-Regamey et al. (2017), MCDA stakeholders helped to define local sustainable development goals, stating and weighting their preferences in terms of different goals and criteria, leading to the creation of suitability maps for sustainable urban development. Achieving the meaningful participation of the key stakeholders is also crucial for the acceptance of the outcome of the MCDA process (Gamper and Turcanu, 2007).

Concurrently, there are calls for broader knowledge production and the wider integration of local knowledge in structured decision-making in order to foster the creation of socially robust knowledge (Failing et al., 2007; Saarikoski et al., 2019). Local knowledge covers a wide variety of sources (see, e.g. community members, city experts) and types, including data and observations about local condition, practices and processes (Failing et al., 2007). In Finland, the Local Government Act (410/2015) obligates municipalities to have a strategy that considers the promotion of well-being, and the Health Care Act (1326/2010) obligates municipalities to monitor the well-being of its residents. These obligations require gathering and maintaining a lot of local data on well-being. MCDA provides a framework with which to utilise and structure this local information in planning to meet the municipal strategy objectives, but it also transfers academic knowledge into practical planning processes, which remains a major challenge in planning (see, e.g. Tennøy et al., 2016; Longato et al., 2021).

Knowledge co-production offers an alternative perspective onto MCDA-based applications. Knowledge co-production refers to the 'active involvement and engagement of actors in the production of knowledge that takes place in processes either emerging or being facilitated and designed to accomplish such active involvement' (Voorberg et al., 2015; Frantzeskaki and Kabisch, 2016). In particular, the creation of knowledge exchange and working spaces (e.g. workshops, discussion forums) that are separate from the normal and formal functions of the participating actors enables new kinds of encounters and interactions, including developing and testing new planning concepts and tools (Erixon Aalto et al., 2018; Hansson and Polk, 2018; Westberg and Polk, 2016). In addition to producing policy-relevant knowledge and contributing to problem solving, knowledge exchange and sharing among different actors can help increase trust and improve relationships between different actors, thus contributing to breaking organisational silos (Frantzeskaki and Kabisch, 2016; Hansson and Polk, 2018; Silva et al., 2017; Schneider et al., 2019).

3. Materials and methods

The StrateGIS tool is an iterative process that aims at identification and generation of spatially explicit well-being indicators for a certain area. The method applies elements of SMCA: setting the objectives and identifying the indicators (criteria) into a value tree that is weighted and converted into a set of maps. The process is mainly conducted as workshops, after which the spatial analyses are done by GIS experts. The main difference between StrateGIS and traditional SMCA tools is that StrateGIS was developed as a simplified and user-friendly version of SMCA that can be applied and repeated independently in the municipalities according to changing planning strategies. With the education material, including an educational report with workshop instructions, example criteria and value trees, and a set of open source GIS tools, the method is free to use for all Finnish municipalities and regional authorities (so far, the material is in Finnish). StrateGIS requires some prior knowledge on well-being, and GIS expertise from the person that conducts the spatial analyses. Unlike many other SMCA applications, StrateGIS aims at identifying built-environment-related well-being differences in general, rather than finding a single optimal location for a specific function in a certain area. StrateGIS tool differs from other planning-support GIS methodologies such as public participation GIS (PPGIS) so that it is specifically designed to serve the needs of practitioners themselves for enhancing the planning for well-being within the municipality organisation: in addition to the resulting maps, it is a tool to identify and structure the thinking in identification of the different aspects of well-being. However, different PPGIS datasets might serve as an important input data for the StrateGIS process.

The StrateGIS tool was tested in eleven Finnish municipalities and one city-region authority, all of varying sizes and different geographical locations, in order to provide spatial knowledge of the built environment well-being indicators (see Fig. 1). We tested the StrateGIS tool as a part of a national project called 'Modelling the well-being environment database and developing well-being management (HYMY)', funded by the Ministry of Social Affairs and Health, in which these areas had been selected as case studies. A similar approach to that of StrateGIS was previously tested for integrating a residential infill development and urban green spaces in the city of Järvenpää, Finland (Tiitu et al., 2018). In this study, the tool was further developed to enhance the planning of well-being according to a joint strategy by integrating scientific built environment indicators of well-being into local knowledge and expertise.

The case study areas consist of intermediate cities or their surrounding areas. The cities of Tampere, Jyväskylä, Lahti and Kuopio are the most urban municipalities in the studied area, having populations ranging from 119,000 (Kuopio) to 238,000 (Tampere) in 2019. The city region of Tampere is the second largest city region in Finland (after Helsinki) in terms of population. The municipalities of the region besides Tampere are municipalities surrounding Tampere with a peri-urban or even rural character.

Following Frantzeskaki and Kabisch (2016), we conceptualised the knowledge co-production process underlying the StrateGIS tool into two different phases: (1) *a preparatory phase* that identified the complexity of well-being requiring knowledge co-production for its solution and (2) *a discovery phase* that contextualised the problem by linking it with the spatial dimension. Following this approach, we analysed the science–-practitioner interactions by focusing on the contribution of different actors (practitioners & researchers) during the process. The third phase identified by Frantzeskaki and Kabisch (2016), *knowledge consolidation*, is not dealt with in this article since we are focusing on the knowledge production at the earlier stages of the SMCA process.

As the main material for analysing our case studies we used workshop materials (value trees, notes from joint-feedback discussions) from altogether ten workshops, of which the last one was arranged online. In addition, a supplementary online feedback survey was conducted for all the participants after the process, to which we got 10 responses (see Annex A). As a methodology, we used participant observation.

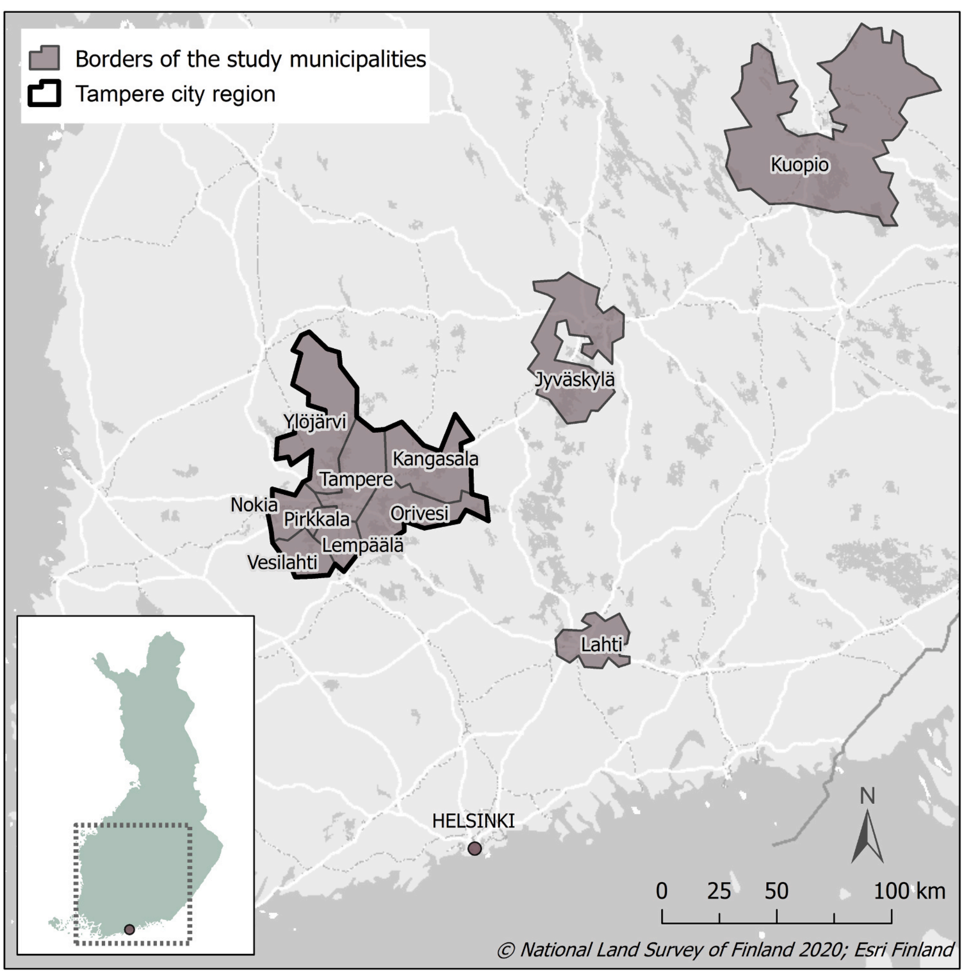

Fig. 1. The location of the case study areas.

4. Results

4.1. The knowledge co-production process

The workflow of the process in presented in Fig. 2. The process was mainly carried out as workshops between researchers and practitioners, but it also required spatial data processing and analysis that were conducted by city GIS specialists.

4.1.1. Preparatory phase

The preparatory phase consisted of workshop preparations and a literature review. The coordinating practitioners of the HYMY project in each case municipality and the city region authority identified experts from different sectors to be involved in the process. The participating practitioners included planners, well-being coordinators and city officials from different sectors, providing various perspectives on well-being (see Annex B). If available, the GIS experts of the municipalities and the city region authority were also involved in the process.

The process was structured around three workshops, which were conducted between October 2019 and February 2020 (Table 1). The first workshop introduced the method and the construction of the value tree with objectives and criteria was initiated. The second workshop focused on the criteria definitions and the third one on weight elicitation. The workshop schedule in presented in more detail in Table 1. There were separate workshops for the cities and the city region, and the city workshops #1 and #2 were organised jointly with practitioners from all cities. In the joint workshops, the practitioners worked in city-specific groups. All the workshops were coordinated and facilitated by the researchers. In addition to the workshops, some municipalities held internal meetings working on their value tree and objectives between the workshops #2 and #3. This was especially the case in the city-region scale StrateGIS process, since they only had two workshops due to the tight schedules of the participants. In addition, some municipalities, which were only able to send a few participants (see Annex B) to the workshops #1 and #2 due to resources or time constraints, worked on their value tree with a larger number of practitioners in their own meetings before the workshop #3. The planning and preparation of the workshops were carried out by the researchers who also reviewed and gathered built-environment-related well-being criteria from scientific literature to be used later in constructing the value trees.

4.1.2. Discovery phase

4.1.2.1. Construction of the value tree. The construction of the value tree was an iterative process. In the beginning, the researchers introduced the workshop participants to a selection of built-environment well-being criteria from the related scientific literature (see Table S1). This was followed by discussion in order to foster a common understanding among the participants regarding different aspects of well-being, after which the practitioners were asked to define the main objective for their city-specific value tree. The main objectives reflected the city-specific strategies for promoting well-being, for example, the objective that the built environment supports the well-being of families with children (see Fig. 3).

The construction of the value tree was carried out in city-specific groups so that the practitioners were asked to classify the pre-selected criteria under different themes (e.g. accessibility to daily functions, public services) to create hierarchy levels in their value tree. The upper hierarchy level was called *themes* in the workshops, and they were further divided into more specific criteria at the lower hierarchy level. The themes were further clarified using theme-specific objectives in each workshop group. In the workshop #1, the practitioners were already encouraged to supplement their value tree with criteria that emerge from their own expertise on well-being and local conditions. Using both the pre-selected criteria from the literature and criteria emerging from practitioners' local expertise, the initial version of the value tree – including the objectives, themes and criteria – was drafted. The drafted value tree was further developed and finalised during the next workshops (#2 and #3) by complementing the value tree with new criteria or excluding existing criteria, for example, due to a lack of relevant spatial data (see Fig. 3). This was done with the guidance of both the researchers and local GIS experts.

Table 2 illustrates the origin of the knowledge for each criterion in the final value trees of the study areas. Most of the criteria (52–93%) originated from the scientific literature and were provided by the researchers in the first workshop. However, the practitioners played an important role in selecting those science-based criteria that were most relevant for their municipalities. They also introduced new criteria

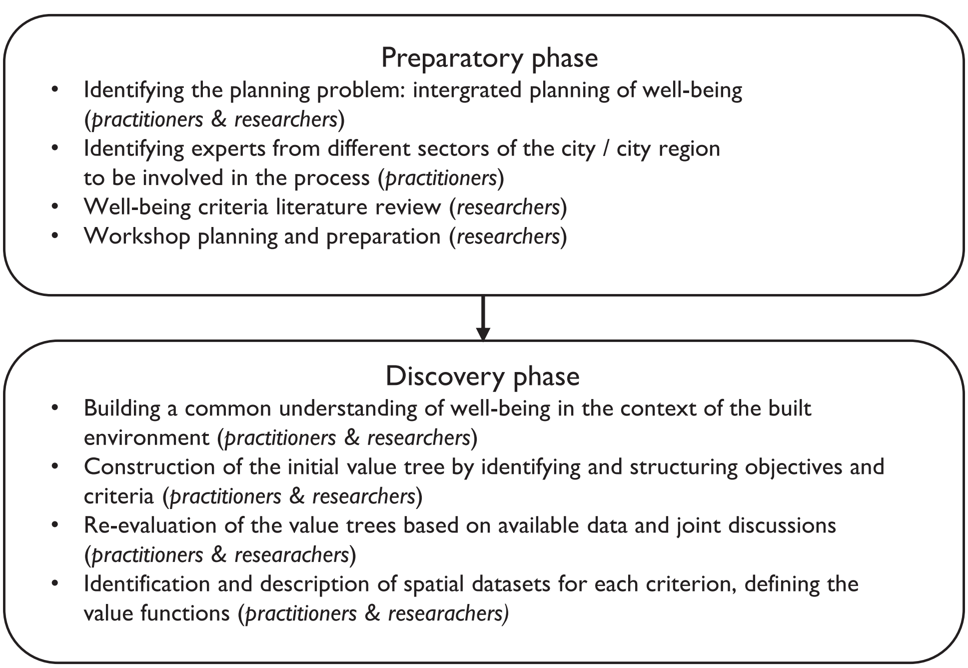

Fig. 2. The general workflow of the StrateGIS knowledge co-production process and the contribution of researchers and practitioners during it.

Table 1
A list and a description of the arranged workshops in a chronological order.

Date	Name of the workshop	Content and outcome of the workshop	Participants (for a detailed list of the participants see Annex B)
25 Oct 2019	City-region workshop #1	Introduction: getting to know the method, drafting the objectives and criteria **Outcome:** initial draft of the objectives and the value tree criteria	Practitioners of the city region
5 Nov 2019	City workshop #1	Introduction: getting to know the method, drafting the objectives and criteria **Outcome:** initial draft of the objectives and the value tree criteria	Practitioners of all cities
13 Nov 2019	City workshop #2	Working on the objectives and criteria, identifying the spatial description of the criteria and GIS datasets **Outcome:** further developed objectives and value tree criteria with preliminary description of how the criteria will be transformed into spatial data	Practitioners of all cities
20 Nov 2019	City workshop #3	Finalising the objectives and criteria and their spatial descriptions, weighting the criteria **Outcome:** weighted value tree	Practitioners of City 3
27 Nov 2019	City workshop #3	Finalising the objectives and criteria and their spatial descriptions, weighting the criteria **Outcome:** weighted value tree	Practitioners of City 2
29 Nov 2019	City workshop #3	Finalising the objectives and criteria and their spatial descriptions, weighting the criteria **Outcome:** weighted value tree	Practitioners of City 4
2 Dec 2019	City workshop #3	Finalising the objectives and criteria and their spatial descriptions, weighting the criteria **Outcome:** weighted value tree	Practitioners of the Cities of 1, 5, 6, 7, 8, 9, 10, and 11
10 Dec 2019	Educational GIS webinar	Instructing the local GIS experts on how to process the GIS data **Outcome:** open source GIS tools delivered to GIS experts for the spatial analyses	GIS experts of all cities and Tampere city region
11 Dec 2019	City-region workshop #2	Finalising the objectives and criteria and their spatial descriptions, weighting the criteria **Outcome:** weighted value tree	Practitioners of the city region
19 Feb 2020	Online feedback workshop	Collecting feedback on the StrateGIS tool from the practitioners' perspective (semi-structured group interview based on questions of Annex A) **Outcome:** interview material	Practitioners of all cities and city region

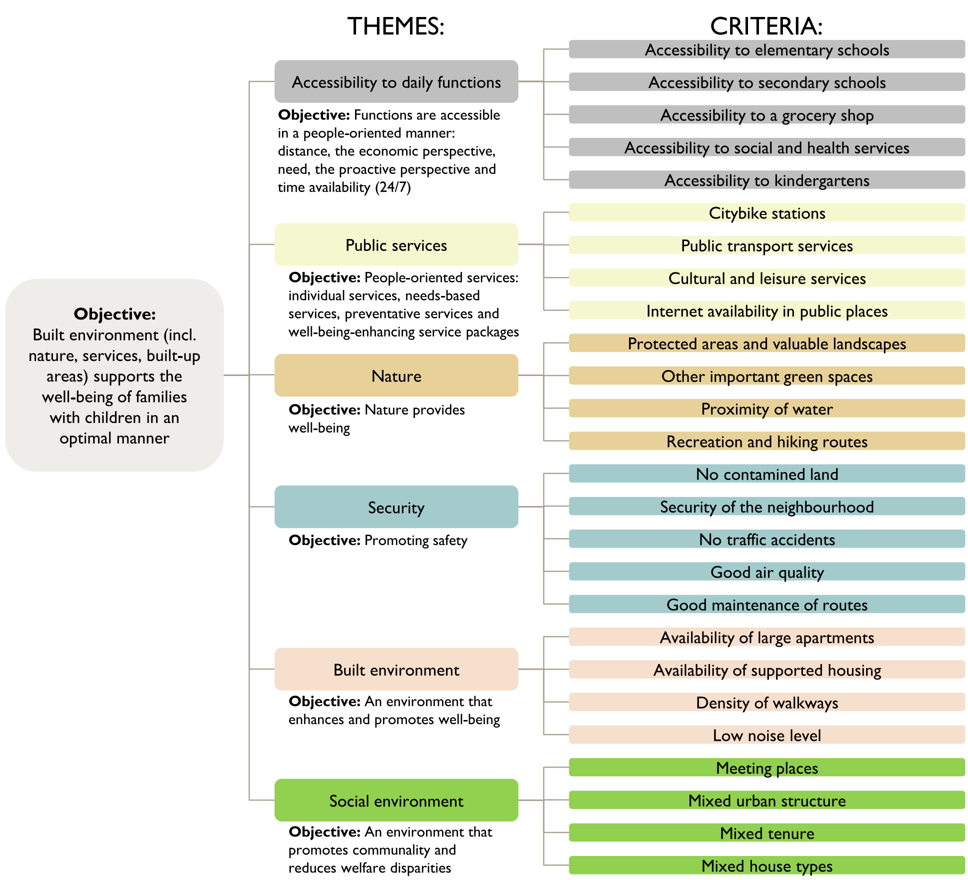

Fig. 3. An example of a value tree including the objectives, themes and the criteria for the provision of well-being. The themes and objectives were set by the city practitioners. The criteria were the result of a knowledge co-production process between researchers and practitioners.

drawing on their own knowledge of scientific literature as well as their place-based expertise of local conditions. The share of the latter was relatively low (0–8%) of the total number of criteria whereas the science-based criteria proposed by the practitioners varied between 7% and 41% of the total number of criteria included in the value trees (see Table 2). The criteria drawing on local knowledge included, for example, 'a low radon concentration', 'holiday and tourism facilities', 'the existence of a water supply and sewerage' or 'services related to water'. All the criteria provided by the practitioners were validated by the researchers to ensure that the criteria are consistent with the

Table 2
The origin of the knowledge for each criterion used in the value trees. Researchers = the criterion was provided by the researchers; Practitioners = the criterion was provided by the practitioners; Scientific = the criterion was based on scientific literature; Local = the criterion was mainly based on the practitioners' local knowledge.

Study area and type	Origin of knowledge			Total number of criteria
	Researchers	Practitioners		
	Scientific (%)	Local (%)	Scientific (%)	
City 1 Urban	84	0	16	25
City 2 Urban	70	4	26	23
City 3 Urban	62	0	38	29
City 4 Urban	69	8	23	26
City 5 Peri-urban	81	4	15	27
City 6 Peri-urban	75	0	25	20
City 7 Peri-urban	70	5	25	20
City 8 Peri-urban/rural	89	0	11	27
Cities 9, 10 and 11Peri-urban/rural	93	0	7	27
City region Urban/peri-urban/rural	52	7	41	44

objectives and that their wording is as clear as possible for the weight elicitation. In the city-region-scale value tree, the percentage of criteria provided by practitioners, based both scientific and local knowledge, was the highest (48%). Tampere city region, as the coordinating authority of the HYMY project, was the most committed and active in developing their value tree according to their own insight, also as internal meetings. Criteria based on practitioners' expertise were also used more in the municipalities that developed their value tree internally, representing the overall commitment to the StrateGIS process. Some other cities took the process as an initial tutorial experience (with only a couple of practitioners present in the workshops, see Annex B) that they would repeat independently after the workshops. This may have influenced their activity to develop entirely new place-based criteria. There were also differences between practitioners in how quickly they adopted the new method, which affected the activity of using their expertise in developing new criteria.

In several cities, the practitioners identified criteria that would have been relevant to consider in the planning of well-being, but no suitable spatial data describing the criteria was available. In these cases, some criteria had to be left out from the value trees. These criteria included, for example, safety indicators, the number of privately rented apartments and an indicator for the moderate price of apartments. Some cities were also inspired to identify criteria that would be relevant to consider in the future but not necessarily in the current analysis, such as online shopping pick-up points.

4.1.2.2. The identification of spatial data. This phase of the knowledge co-production included the identification of the suitable GIS datasets for each criterion and choosing the methodology for converting the criteria into spatial information (e.g. the selection of thresholds). Available spatial data was reviewed to find the most suitable data to represent the criteria. This was done as a part of the workshops but also between workshops with the help of researchers and especially the local GIS experts. Special attention was paid to the spatial and temporal accuracy and completeness of the data (i.e. the data is up to date and covers the whole study area).

Each criterion in the final version of the value tree was described and clarified from a GIS-data perspective to create a common understanding of the content of the criteria on the map (Table 3). It was important for all the participants to know, for example, which exact GIS datasets were selected to describe each criterion and to what spatial extent the well-being effect of a certain criterion was to be limited on the map (i.e.

Table 3
Operationalising spatial indicators in order to reflect well-being benefits in urban environments. An example of the spatial content (a verbal explanation of a value function), including the thresholds for the criteria, in the 'Nature' theme for one of the case cities.

Theme: Nature		
Criteria	A spatial description of the indicator	Data source
Protected areas and valuable landscapes	A union of all polygon and line type (with a 20 m buffer zone) conservation areas: Natura 2000 areas, designated protected areas and nature conservation programme areas get the value 1; other areas have the value 0.	• Data of Finnish Environment Institute (SYKE) • Regional plan data
Other important green spaces	Parks and other green spaces (polygon data) get the value 1; other areas get the value 0.	• Municipality data (green spaces from the master plan) • Corine Land Cover data (SYKE, partly Natural Resources Institute Finland, Finnish Food Authority, Finnish Transport Infrastructure Agency, Digital and Population Data Services Agency and European Union • Topographic database of National Land Survey of Finland (NLS) 01/2017
The proximity of water	Land area in the proximity of waterbodies has a value between 0 and 1, depending on the magnitude of the estimated impact on well-being. Below the threshold of 100 m, areas have the value 1; from 100 m to 500 m, areas have a value between 1 and 0 according to a linear distance decay; above a 500 m threshold, areas have the value 0 (having no impact on the well-being of citizens).	• Data on the waterbodies of from the NLS
Recreation and hiking routes	Land area in the proximity of recreation and hiking routes has a value between 0 and 1, depending on the magnitude of the estimated impact on well-being. Below the threshold of 300 m, areas have the value 1; above 300 m, areas have the value 0.	• Sports facilities data (LIPAS) of the University of Jyväskylä • The municipality's data

what kind of value function and thresholds were to be used in the analysis). This stage was conducted separately in each group as group work. The basis for the group work was formed of researcher-drafted suggestions for the data and thresholds from scientific literature (including, for example, a 300 m threshold for 'nearby recreation') that correlates to the usage of the areas' (Coles and Bussey, 2000; Schipperijn et al., 2010). However, there was a lack of scientific knowledge for many criteria that required a certain threshold, and thus they were estimated using practitioners' local knowledge.

Many of the researcher-suggested data sources were substituted for more suitable cities' own datasets of which the practitioners had knowledge. Also, the threshold values originated from scientific literature were adjusted to meet the local conditions and value tree objectives by the practitioners. Table 4 exemplifies the diversity and impact of different local contexts (urban/peri-urban/rural contexts) and spatial scales (city/region scales) on the actual content of the criteria by

Table 4
A comparison of different spatial representations of the same well-being indicator. An example of the spatial content (a written explanation of a value function) for the criterion 'recreation routes' (or related issues) in each of the study areas, adjusted for local conditions by the practitioners in the workshops.

Study area and type	Theme name	Theme objective	Criterion name	Spatial description of the criterion	Data source
Researchers' draft criterion description	X	X	Recreation routes (or related issues)	Recreational route density in, e.g. 250 m grid cells	LIPAS data (University of Jyväskylä) (or a city's own data if available)
City 1 Urban	Green spaces and recreation possibilities	Promoting possibilities for recreation	Recreation routes	The length (in km) of exercise tracks, skiing routes and waterways in 250 m grid cells	LIPAS data (or a city's own data if available)
City 2 Urban	A green environment, exercise and outdoor recreation	An environment that enables recreation in nature and encourages exercise	Recreation routes	Accessibility surface (distance decay from 0 to 1) with the maximum threshold of 500 m from the routes. Routes included: lakeside routes, walking and skiing routes, nature trails.	A city's outdoor recreation database
City 3 Urban	An environment that promotes exercise in nature	An environment that attracts exercise and promotes well-being	Routes for outdoor exercise	The length (in km) of exercise tracks and skiing routes in 250 m grid cells	LIPAS data (or a city's own data if available)
City 4 Urban	Green spaces / nature	Well-being gained from nature	Recreation and hiking routes	All areas up to 300 m from the routes get a value 1, other areas get a value 0	LIPAS data (or a city's own data if available)
City 5 Peri-urban	The accessibility of leisure and recreation services	Diverse services close to residents	Recreation routes	The length (in km) of exercise tracks, skiing routes and waterways in 250 m grid cells	LIPAS data (or a city's own data if available)
City 6 Peri-urban	Stimulating leisure time	Promoting well-being	Hiking routes (including skiing)	A buffer zone of 500 m from the exercise tracks and skiing routes (all areas up to 500 m from the routes get a value 1, other areas get a value 0)	LIPAS, a city's own outdoor recreation database, OpenSnowMap
City 7 Peri-urban	Mobility	Providing residents with possibilities for functional and active work and leisure mobility	The proximity of a recreation route	The existence of an exercise track, a skiing route or a particularly popular nature trail in a grid cell (if such exists, it gets the value 1; if it does not, it gets the value 0)	A city's service database
City 8 Peri-urban/ rural	Nature and recreation	Preserving adequate nature and recreation areas	Recreation routes	The length (in km) of exercise tracks, skiing routes and waterways in 250 m grid cells	LIPAS and the municipal statistics of sports facilities
A joint group of Cities 9, 10 and 11 Peri-urban/ rural	Nature and recreation	Preserving adequate nature and recreation areas	Recreation routes	The length (in km) of exercise tracks, skiing routes and waterways in 250 m grid cells	LIPAS, the municipal plan for sport facilities
City region Urban/peri-urban/rural	Experiences	Strengthening and preserving the distinctiveness of the environment and the cultural environment	Regional recreation routes	Accessibility surface (distance decay from 0 to 1) with the maximum threshold of 1 km from the routes. Routes included: hiking routes, nature trails and tracks, skiing routes, lakeside routes.	Datasets of the regional plan, a dataset of regional recreation and hiking routes

presenting the different spatial interpretations for the criterion 'recreation routes' in each of the case areas. In general, larger thresholds for accessing the recreation routes were selected in peri-urban and rural municipalities compared with most urban cities. According to the workshop discussions, this was due to the viewpoint that in a peri-urban/rural environment, longer distances to services were considered more acceptable by the residents compared with residents in urban environments since it is not realistic to have many services within walking distance in the peri-urban/rural environment due to the low population density. The residents also probably acknowledge this when selecting their home location and emphasised different aspects (such as the tranquillity of the neighbourhood) in their housing preferences. The spatial scale of the city region also increased the threshold since only the regionally important routes that attract residents from further away were included in the dataset.

Although we focus on the early-stage knowledge co-production process in this study, we provide a short description of the later stages of the StrateGIS process. The practitioners weighted each theme and criterion in a separate workshop, and the weightings were linked to the corresponding spatial data or a combination of spatial datasets. Overlay analysis was conducted by summing the weighted datasets to create maps describing the distribution of the well-being provision potential in each case area, based on the practitioner's weightings. Spatial data processing was conducted by the GIS experts of the municipalities and the city region under the guidance of the researchers.

4.2. *Sectoral silos and finding shared understandings*

According to the online survey and discussion in the feedback workshop, the group work and the discussion between practitioners representing different sectors were seen to be rewarding and fruitful by the participating practitioners. Further, despite the different disciplines and expertise, the practitioners found that there were not many conflicts in the discussions concerning the value tree formation and well-being indicators (60% of the online survey respondents answered that the discussions were 'very unified' or 'quite unified', 40% answered 'not particularly unified or contradictory'). However, the groups that had a GIS expert present seemed to find better common understandings of the content of each spatial indicator in regard to how the indicator transforms into spatial information. GIS experts could explain the spatiality of the indicators and brought data-oriented 'realism' to choosing the criteria.

The intersectoral discussions were mentioned as one of the most beneficial factors in the process. Two practitioners (out of eight practitioners who answered the question) named intersectoral discussion as the easiest part of the process in the open question about what has been the easiest / the most beneficial aspect in applying the method. One of the key challenges concerning the intersectoral interaction during the workshops was finding a common language between practitioners representing different sectors or expertise. These difficulties concerned, for example, the definition and meaning of certain concepts – such as *well-being, communality* and *individuality/identity* – and the actual content of spatial indicators and their thresholds. For example, there were difficulties in building a shared understanding of the distance-based thresholds and the different options for defining *accessibility* (Euclidean distances / distances along the street network / time distance), especially in the groups where there was no GIS expert present.

In the workshops, participants from two of the twelve case organisations said that, in general, intersectoral co-operation and reports have become more common in recent years (not necessarily concerning the planning of well-being). However, some practitioners pointed out that at the city-region level, they interact and network more with the neighbouring municipality practitioners that represent the same sector compared with the practitioners of their own municipality that represent a different sector.

When asking about applying the method in the future, the practitioners raised intersectoral planning in general as one of the key future applications, along with, for example, the optimisation of playgrounds, planning of noisy areas, valuing green spaces and the spatial monitoring of segregation. The usability of the StrateGIS tool was seen to be good: 40% of the survey respondents answered that they are highly likely *to be able* to update and repeat the process independently in their organisation, 40% answered that this was likely. 80% answered that they are quite likely to *actually* update the process in the future.

5. Discussion

Our results from using the StrateGIS tool to support planning for well-being align with previous studies which emphasise the importance of integrating scientific, local and practice-placed knowledge in spatial and environmental planning (Corburn, 2009; Frantzeskaki and Kabisch, 2016; Adem Esmail et al., 2018; Webb et al., 2018). Scientific knowledge played a dominant role as most of the well-being indicators used in the process were introduced by the researchers and identified on the basis of scientific literature. However, the practitioners also played an instrumental role in identifying criteria, drawing on both on scientific literature and local knowledge. While the latter played a less significant role, it nevertheless helped to bring up important issues that would otherwise have gone unnoticed. These criteria mainly concerned the local environmental conditions that were significant for well-being, such as the existence of a water supply and sewerage or the radon concentration. Furthermore, the city officials could adjust the academic research-driven knowledge to the context of their city/region and thereby define criteria that are the most usable in meeting their well-being objectives.

Importantly, the practitioners not only contributed to the identification of the criteria, they also participated in providing the spatial data sets and spatial operationalisation of the criteria by, for example, setting the thresholds (such as accessibility to different services). In fact, the diversity of local practitioner knowledge was particularly represented in defining these value functions, which has traditionally mostly been a researcher-oriented phase in MCDA applications (Failing et al., 2007). There is no objective ‘scientific’ way of defining, for instance, a suitable distance to different health care services, and therefore, it was essential that the practitioners who were the best experts about local conditions made these subjective judgements. For example, the proximity of waterbodies is a less crucial factor in a municipality surrounded by lakes than in a municipality with less access to waterbodies. The definitions of the criteria also depend on the objectives that the practitioners set for their value tree and for each theme, which also emphasises the role of local knowledge in defining the spatial operationalisation of the criteria according to these objectives. This is reflected in the diversity of the spatial representation of the same well-being indicator in different value trees. The subjectivity of defining the value functions is recognised in MCDA literature (Ferretti and Montibeller, 2016), but in practice, they are usually defined by researchers, often using linear value functions for the sake of simplicity (see, e.g. Mustajoki et al., 2005; Ferretti and Montibeller, 2016).

StrateGIS tool supports participation and knowledge co-creation but it also set some barriers for inclusion of practitioner knowledge. The list of the pre-selected criteria based on academic literature (Supplementary Table S1) that was used as an initial criteria pool for construction of the value trees was already quite comprehensive, covering various aspects of well-being. This left limited space for new place-based criteria, since the value trees can only include a limited number of branches and criteria to remain understandable. This may have shifted the use of local knowledge more towards the definitions for the criteria: the distance thresholds, or which exact services (e.g. health and social services) are to be included in the GIS analysis. However, adjusting the spatial descriptions for the criteria was an important task that could not be carried out solely by the researchers. Furthermore, the participants drew on their understanding of the local conditions when selecting the criteria to be included in the value tree: What are the relevant issues in our city or city region. This selection of the relevant criteria is an important part of the knowledge production in StrateGIS as well as other MC(D)A tools (Oppio et al., 2018), and it was entirely done by the participating practitioners. In general, the level of knowledge production by the practitioners was higher than expected: not so much in terms of identifying new criteria, but in terms of adjusting the definitions for the criteria.

Most of the value tree criteria provided by the practitioners emerged from scientific literature. This indicates that the city officials have strong expertise in the factors that impact on well-being, as well as the local knowledge to adjust the academic knowledge to the context of their city/region. Based on our results, the practitioners have good skills to apply academic knowledge of well-being in practical planning processes, that can lead to increasing usage of research-oriented tools and better collaboration between researchers and practitioners’, which is important given the findings that highlight the practitioners’ key role in sustainable urban planning and their ability to impact on local decision-making (Hysing, 2009; Tennøy, 2010; Bergsten and Zetterberg, 2013; Frantzeskaki and Kabisch, 2016; Gil Solá and Vilhelmson, 2019).

Several scholars have recognised the “rigour-relevance dilemma” (e.g. Fincham and Clark, 2009; Silva et al., 2017), which results from the fact that the developers of planning-support systems are mainly concerned with scientific rigour of the methods while the users are mainly interested in practical relevance of the results. This leads to diverging paths where planning support systems are not used, since the practitioners are unaware of or inexperienced in using the tools and the developers of these tools are not familiar with the user demands for the tools. According to our results, StrateGIS has many opportunities to bridge this gap by knowledge co-production. There were certain qualities in the StrateGIS tool that especially supported the co-production of knowledge in the process. Firstly, along with the scientific framework of the tool, the importance of considering local conditions and strategies in discovering the well-being indicators was emphasised in the workshops from beginning to end, which encouraged the practitioners to actively participate in knowledge production. This relates to the findings of Lemos and Morehouse (2005), who argued that establishing credibility and trust through the co-production processes makes results more likely to be implemented in policies. Secondly, the fact that the tool was particularly designed to serve a widely recognised planning problem (the absence of built-environment-related well-being indicators in the planning and reporting of well-being) gave the practitioners the motivation to apply the tool and embed their real-life objectives into the process. This relates to the findings that transdisciplinary knowledge co-production processes should create solution-oriented knowledge (Lang et al., 2012). Thirdly, the use of academic knowledge and tools in planning practices also depends on the understandability and usability of the information (Frantzeskaki and Kabisch, 2016; Tennøy et al., 2016), which is why particular interest was paid to the cognitive simplicity of the method (compared with many computerised decision-support system processes) in order to increase the probability that the case-study municipalities could actually embed the tool as a part of their planning processes in the future.

In previous studies, concerted collaboration and co-creation between researchers and policy officers has led to mutual learning, the establishment of relationships and trust (Frantzeskaki and Kabisch, 2016) and helped to reduce the silo effect between sectoral administration (as discussed by, e.g. Karppi and Vakkuri, 2019). In our case of the StrateGIS tool, the discovery phase (the construction of the value tree and identification of spatial data) was well-suited for supporting intersectoral discussion on human well-being among practitioners in different administrative sectors. Silva et al. (2017) found that workshop discussions themselves are also valuable in promoting the use of planning-support tools. The challenges in our case studies were related to finding a common language among practitioners. This is a well-acknowledged problem in transdisciplinary co-production processes concerning communication among both researchers representing different disciplines and stakeholders with diverse backgrounds, and in researcher–stakeholder interaction (Djenontin and Meadow, 2018). Based on our case studies, the local GIS experts had the ability to bridge the gaps in understanding the spatial indicators in a local context in the workshop discussions. Building shared understandings takes time that is often considered a scarcity in knowledge co-production processes (Lemos and Morehouse, 2005). Our results also indicate that knowledge co-production takes time and requires commitment from the participating actors.

Knowledge is rarely transferable between different projects and contexts (Westberg and Polk, 2016). In our case of the StrateGIS tool, the knowledge related to specific well-being indicators was not directly transferable to other areas since the spatial data that was used to describe the criteria was, in many cases, place specific. However, many of the well-being indicators that were found from the scientific literature could be used or adjusted to different case study areas if adequate spatial data was available. This also highlights the role of local GIS experts in the process having the knowledge of the diverse local datasets that can be used to describe the well-being indicators.

This article focused on the preparatory and discovery phases of knowledge co-production. However, the procedure also includes the knowledge consolidation phase (Frantzeskaki and Kabisch, 2016), which in our case would mean the processing and interpretation of the data that was co-produced. Most municipalities had not reached that phase while writing this article, but the consolidation is undoubtedly a key phase that also defines the applicability of the method in the future: How beneficial are the resulting maps? Is the shared understanding of the well-being indicators indicated well by the maps? Are they easily communicable to other practitioners / decision makers outside the process? It is also important to acknowledge how planning-support tools like StrateGIS support long-term understanding and learning for the integrated planning of well-being. Obviously, learning does not directly result in desired outcomes (Westberg and Polk, 2016).

6. Conclusions

In this paper, we have studied the knowledge co-production process and intersectoral interactions facilitated by a SMCA-based tool called StrateGIS for planning for well-being in eleven Finnish municipalities and one city region. Our research contributes to literature on MCDA, which has been lacking studies that address the contribution of different types of knowledge in the process (Langemeyer et al., 2016). From the methodological perspective, the tool provides a flexible and transparent way to combine both academic knowledge and local expertise that can enhance the planning of well-being.

In constructing the value tree, most of the selected criteria originated from the scientific literature. However, in many of the study areas, the practitioners also included city-specific criteria originating from their own expertise and needs. The municipalities' local conditions were particularly considered in defining the actual calculation methods (the value functions) for the criteria – for example, the acceptable distances for services in different urban, peri-urban or rural environments. Based on our experiences, the knowledge co-production, especially at this traditionally researcher-oriented stage of the process, was beneficial in order to find the best way to describe each criterion in different contexts. According to the participating practitioners' view of the process, the tool helped to find shared understandings concerning the indicators of well-being, and it was also helpful in evoking discussion across sectoral silos. In spatial planning-support tools like StrateGIS, the local GIS experts have both the role of an informant with knowledge of the diverse local datasets for the planning of well-being and an intermediary role between practitioners in which they have the ability to explain how the selected indicators result in a map.

The knowledge co-production process introduced in this article covered the information needs and values of municipality practitioners representing different sectors. Future research is needed on how the knowledge production in StrateGIS could be expanded from researchers and city officials to other members of society such as local residents. The need to address challenges related to power and equality in knowledge integration has long been recognised (Raymond et al., 2010); however, given the technicality of the method and the substance, scientific and expert dominance is likely to remain, which calls for future research on how other types of knowledge (e.g. the knowledge of local residents) can be better considered in the co-production process.

CRediT authorship contribution statement

Maija Tiitu: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing, Project administration. **Arto Viinikka**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Maria Ojanen**: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Heli Saarikoski**: Conceptualization, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Annex A. The questions of the Webropol survey

Question	Type of question and the answer options for the multiple choice questions
1. What authority do you represent?	Closed A list of the participating municipalities and city region authority
2. What is your field of expertise?	Closed Health and well-being; environment/nature; land use and urban planning; housing; transportation; education; sports; cultural services; regional development; management and administration; GIS or information production; other
3. What kind of experience has it been to participate in testing the StrateGIS tool?	Closed
a. How well did you understand the concepts and criteria?	a) 1 = *very weakly*, 2 = *weakly*, 3 = *not particularly weakly or well*, 4 = *well*, 5 = *very well*, 6 = *I can't say*
b. How was the intersectoral discussion in the workshops and internal meetings?	b) a) 1 = *very weakly*, 2 = *weakly*, 3 = *not particularly weakly or well*, 4 = *well*, 5 = *very well*, 6 = *I can't say*
c. Was the discussion unified or were there differences in views between the sectors?	c) 1 = *very contradictory*, 2 = *quite contradictory*, 3 = *not particularly unified or contradictory*, 4 = *quite unified*, 5 = *very unified*, 6 = *I can't say*
d. Did you get enough information of the method before the criteria weighting?	d) 1 = *not at all enough*, 2 = *not enough*, 3 = *somewhat enough*, 4 = *enough*, 5 = more than enough, 6 = *I can't say*
e. Did you get enough support for conducting the GIS analyses?	e) 1 = *not at all enough*, 2 = *not enough*, 3 = *somewhat enough*, 4 = *enough*, 5 = *more than enough*, 6 = *I can't say*
4. What has been the easiest / the most beneficial aspect in applying the method?	Open
5. What has been the most difficult/challenging aspect in applying the method?	Open
6. How is your municipality going to utilise the method and its results in the future?	Open
7. What other planning questions could the method be applied to in your organisation?	Open
8. The repeatability of the method:	Closed
a. How probable is it that you are able to repeat the method independently in your organisation?	a) 1 = *highly unlikely*, 2 = *quite unlikely*, 3 = *not particularly unlikely or likely*, 4 = *likely*, 5 = *highly likely*, 6 = *I can't say*
b. How probable is it that you will repeat the method in your organisation?	b) 1 = *highly unlikely*, 2 = *quite unlikely*, 3 = *not particularly unlikely or likely*, 4 = *likely*, 5 = *highly likely*, 6 = *I can't say*
9. What would you name as the most significant barriers for utilising the method in the future?	Open
10. What kinds of benefits does the method bring to planning and/or decision-making in your opinion?	Open
11. What kinds of weaknesses or risks are related to the method in your opinion?	Open
12. How the method could be developed in your opinion? You can leave free feedback on the method in this field.	Open

Annex B. Workshop participants in each of the case study areas

Study area and type	The expertise of participating practitioners (the number of participants)
City 1 Urban	Environmental protection (1) Housing development and service networks (1) Well-being coordination (1)
City 2 Urban	Land use and urban planning (3) Land use, urban planning and GIS (1) Sports services (3) Education and inclusion coordination (2) Adult social work (1) Basic security (1) Health services (1) Transportation (1) Well-being coordination (1)
City 3 Urban	Land use and urban planning (5) Land use, urban planning and GIS (1) Development services (1) Inclusion and well-being services (1) Regional well-being coordination (1) Transportation (1) Well-being management (1)
City 4 Urban	Civic activity services (2) GIS (1) Housing (1) Municipality management (1) Promotion of well-being (1) Self-directed well-being services (1) Transportation (1)
City 5 Peri-urban	

(*continued on next page*)

(*continued*)

	Education (1)
	Land use and urban planning (1)
	Management of the living environment (1)
City 6	Land use and urban planning (1)
Peri-urban	GIS and environmental protection (1)
	Well-being and inclusion coordination (1)
City 7	GIS (1)
Peri-urban	Well-being (1)
City 8	Well-being coordination (1)
Peri-urban/rural	Municipal vitality services (1)
Joint group of Cities 9, 10 and 11	Well-being coordination (2)
Peri-urban/rural	Education (1)
	Land use and urban planning (1)
City region	GIS (3)
Urban/peri-urban/rural	Land use and urban planning (3)
	Environmental protection and policy (2)
	Transportation (2)
	Business (1)
	Management of the living environment (1)
	Municipal management (1)
	Regional management (1)
	Well-being management (1)

Appendix C. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2021.09.028.

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