

From Situation Awareness to Smart City Planning and Decision Making

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Abstract

Urban planning under the current rapidly changing conditions requires holistic understanding of the planning ecosystem. Sustainable communities cannot be planned in silos, but ask for systems thinking, collaborative methods, and knowledge management. Smart city planning, or “expanded urban planning”, practices are developed for framing cities from a holistic and integrative perspective as a multi-scalar and multi-dimensional endeavor. The aim of this article is to describe and discuss knowledge creation and situation awareness in collaborative urban planning practice, and the question of how digitalization changes it. These subjects are approached through a case study on an urban planning process in the metropolitan area of Helsinki, Finland. Through empirical findings, this article argues that smart city planning is not only a data-driven superlinear scaling practice, but an integrative and collaborative learning process facilitated by face-to-face interaction and advanced analyses and visualizations of available data, ongoing processes, and local history and stories.

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1. Introduction

1.1 Background

Today's society is facing complex challenges like urbanization, climate change, globalization and societal differentiation. With over a half of the world's population living in cities, these all set prerequisites for sustainable urban planning, which lays the foundation for robust, livable and functioning societies. The process of developing urban areas is divided into a number of separate, fragmented and overlapping strategy, planning and implementation projects from a number of actors. Sustainable communities cannot be planned in silos. In a complex and multi-scalar system, forming an overall picture of the whole development process is challenging. Urban planning and decision making under these rapidly changing conditions require holistic understanding and ability of systemic thinking and collaborative practices.

Urban planning brings together professional, political and economic interests of various scales. Stakeholders face an overflow of information, challenging information use by making it harder to concentrate on the essential pieces of information. Planning and decision support systems bringing all available information together have been developed to assist planners and decision makers in their work. However, these rarely have the ability to filtrate, condensate or prioritize the most essential information. Along with the number of stakeholders and the amount of information, there are challenges in how to bring the various views, and ways of representing and understanding thoughts into the planning and decision making process.

Smart city planning, or expanded urban planning, practices are developed for framing cities from a holistic and integrative perspective as a multi-scalar and multi-dimensional endeavor. Smart cities are seen as systems of interwoven, ICT enriched systems ubiquitous in urban environments. Smart city planning is a practice that utilizes digital data for normative, policy based objectives like sustainable urban development.

1.2 Objectives of the Paper

The aim of this paper is to describe and discuss knowledge creation and management in collaborative urban planning practice. The paper critically analyzes the prevailing planning and decision making practice (Healey 2007, 1997; Salet & Thornley 2007) in the complex urban planning eco-

system from the viewpoint of situation awareness (Endsley & Jones 2012; Endsley 2008, 1995) adding to the understanding of planning processes, digitalization and collaborative smart city planning practices (Townsend 2014, Staffans & Horelli 2014). Consequently, the paper is interested in the two following research questions: *'How the generation of situation awareness can be assisted in a complex planning and decision making ecosystem?'* and *'How digitalization changes the practice?'*

These subjects are approached through a case study on an urban planning process in the metropolitan area of Helsinki, Finland. The paper summarizes and continues discussion from the research of Eräranta (2013), in which situation awareness in urban planning was studied. In this paper the results are further analyzed, tested through piloting, and investigated in terms of smart city planning. The case study comprises a qualitative document analysis and key person interviews, and an experimental living lab of facilitating the ongoing planning process in a novel digitally supported facility.

Based on the findings, the paper argues that *smart city planning and decision making is not only a data-driven superlinear scaling practice, but a collaborative learning process facilitated by advanced visualizations of available data, ongoing processes, local history and stories. Urban planning decision making is to a great extent about discussion and negotiation, rationalization and argumentation. Thus, the lack of overall picture and systemic understanding can be alleviated through collaboration and interaction. There is a need for developing collaborative tools and practices, as well as methods for bringing in various materials into the decision making process in order to support the discussion and understanding of the complex decisions.*

The paper will first construct the framework for shaping and studying situation awareness and smart city planning, ending up to extended urban planning practice. Then, the research methods, case study, results and piloting of the results will be described. The paper will conclude by answering and discussing the research question.

2. Conceptual Framework

2.1 The Changing Environment of Urban Planning Processes

Cities are in a constant fluctuation of various flows: people, goods, information etc. According to Healey (2007, 2), the places of cities cannot be understood as integrated unities with a singular driving dynamic, but are complex constructions created by the interaction of actors in multiple net-

works. More stakeholders from various spatial scales are taking part in the urban development processes, raising a question of how much *multi-scalarity* can be coordinated in the context of institutional fragmentation (Salet & Thornley 2007, 190). More connectivity between the traditional planning and decision making silos is needed. In addition, urban planning has also become *multi-actor* with new actors actively involving in urban development processes. According to van 't Verlaat & Wigmans (2011, 31), urban area development occurs within a complex context and a long time-scale, combining a sum of complex processes performed by many individual actors and organizations with their own interests and claims.

This creates a demand for a sustainable and smart planning process, which understands the dynamic and systemic nature of a city. The traditional way of planning cities in separate silos cannot be seen to survive under the changing circumstances. The complexity of tasks exceeds the complexity of the planning system, and some tasks fall in between various departments. Systems thinking entails that there are emergent properties of systems that do not exist when systems are decoupled into smaller parts (Rubenstein-Montano 2000, 161). Urban planning is seldom linear and easily structured. As actors involved have different information and knowledge of the problems, complex decisions should be exposed to negotiation in various phases of the process. De Bruijn et al. (2010, 21) say that testing different sources of information against each other may, indeed, improve the quality of the information used.

2.2 Situation Awareness in Complex Urban Ecosystems

Urban planners and decision makers face a constant overflow of information. After entering the information age, the rate of producing and accessing information has grown rapidly. There is an enormous gap between the data being produced and disseminated, and the human ability to find the bits that are needed and process them together with the other bits to arrive at the actual needed information (Endsley & Jones 2012, 3). Urban systems differ from many other systems as usually no sudden error will follow the decisions, but consequences will be seen after several years, challenging the understanding of decision-consequence loop. This increases the significance of information use and systemic understanding in urban planning practice.

Developing the steps leading to the desired future, planners and decision makers should have an awareness of what the situation is and how the various parts of the society are interconnected. This can be called situation awareness, defined as “*the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning,*

and the projection of their status in the near future” (Endsley 1995, 36-37). More specifically, situation awareness in urban planning can be understood more as *holistic understanding of the urban elements and subsystems, and their complex relationships and influence on each other*.

Acquiring and maintaining situation awareness becomes increasingly difficult as the complexity and dynamics of the environment increase (Endsley 1995, 33). According to Artman (1999, 15), controlling large dynamic systems is beyond the competence of one single individual, and should be coordinated by a team working co-operatively. The challenge in urban areas is that a city is not a ‘thing’, but an imagined phenomenon, understood differently by different people (Healey 2007, 27-27). A city changes all the time, and so does the mental representation of the city. Accordingly, interactive methods can increase the understanding of systemic urban complexity.

2.3 Digitalization and Participation Call for Smart City Planning

Rational planning thinking basing planning solutions on scientific reasoning arose in Europe in the 1960s (Taylor 1998). The modernist paradigm of scientific reasoning dominated until the 1970s, when the communicative turn transformed planning thinking (Healey 1997). Communicative planning theory (e.g. Habermas 1984) acknowledges the role of various stakeholders, emphasizing the planning process and content (Healey 1997). Today many instances call for participation and collaborative processes, and the move towards communicative and participative planning practices remains ongoing. It has, though, been largely acknowledged that in order to get satisfactory results, stakeholders should have a possibility to participate in the planning process as early on as possible. This, together with the rise of digitalization, has challenged urban planning and decision making practice to adopt new transdisciplinary methods and technologies for working together with various stakeholders (Silva 2010).

As a reaction to this, smart city planning practice has evolved in many parts of the world. According to Manville (2014, 88), a “*smart city uses ICTs to optimize the efficiency and effectiveness of useful and necessary city processes, activities and services by joining up diverse elements and actors into a seamlessly interactive intelligent system*”. A report on smart cities by the European Union distinguishes six dimensions of smart cities: people, government, mobility, economy, environment and living (Griffinger et al. 2007). Based on this, Staffans and Horelli (2014) suggest that smart cities enhance the collective intelligence of their citizens and communities, as well as their well-being and quality of life.

The smart city phenomenon has, though, also been severely criticized for instance for creating a city machine in which citizen can only passively act with ready-made optimizations and choices (Sennet 2012). Vanolo (2014) contests the smart city mentality by focusing on power and knowledge implications of distinguishing between 'good' and 'bad' cities. Viitanen & Kingston (2014) state that the ICT-focused smart city paradigm creates too much influence for multinational technology firms. Accordingly, the problem is how to deal with the smart city notion, which is still under social and political construction (Staffans & Horelli 2014, 3).

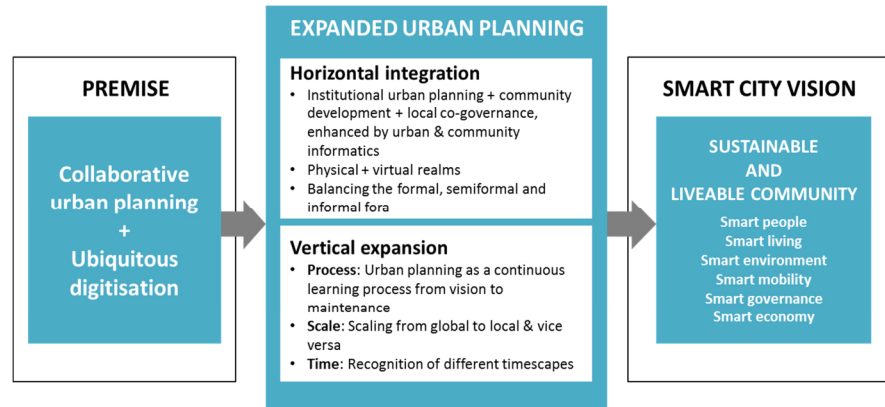
2.4 Expanded Urban Planning

Staffans & Horelli (2014) have developed a concept of *expanded urban planning*, which frames smart city planning in complex urban ecosystems from a holistic and integrative perspective as a multi-scalar and multi-dimensional endeavor, stressing planning as a participatory knowledge building, management and coordination process (Staffans et al. 2010, Horelli 2013). The expanded urban planning approach is based on theory of complex co-evolving systems, and communicative and post-structural planning theories, comprising methods of monitoring and evaluating planning processes iteratively, and identifying and mobilizing various stakeholders (Staffans & Horelli 2014, 1; Horelli 2013).

Expanded urban planning comprises of the characteristics of horizontal integration, vertical expansion and multiple participations (Fig. 1). Horizontal integration enhances systemic integration of institutional planning silos and local practices of everyday life. Vertical expansion sees planning as a continuously scaling learning process covering the whole trajectory from the setting of the political agenda and policy targets, strategies with ex-ante evaluation, statutory planning and implementation to the ex-post evaluation of outcomes. Vertical expansion refers also to the continuous scaling between the local and the global in all planning practice. Multiple participations enhance urban planning by urban and community informatics, balancing the formal, semiformal and informal activities, processes, partnerships, discourses, spaces and spheres. (Staffans & Horelli 2014, 8)

As Väyrynen (2010) states, urban knowledge is scattered and the challenge is to successfully bring together and incorporate in the planning process knowledge produced by various stakeholders. The expanded urban planning approach offers a multi-dimensional, multi-scalar and multivocal integrative practice, bringing together the formal, semi-formal and informal spheres and involving the variety of public-private-people partnerships (Staffans & Horelli 2014, 18).

Fig. 1. The expanded urban planning framework for understanding and shaping smart cities (modified from Staffans & Horelli 2014, 8)



3. Methodology

This paper is based on data and material collected during a case research in 2013 (Eräranta 2013) and on a following ongoing pilot project. In this paper, the findings are discussed and tested through piloting. The scope of this paper is to approach the subject in the light of a case study on an urban planning process in the metropolitan area of Helsinki. One of the key aims has been to document and evaluate the process, and to assess the most critical steps and factors of assisting the generation of situation awareness in a complex planning ecosystem. For this paper the two key questions were: *'How the generation of situation awareness can be assisted in a complex planning and decision making ecosystem?'* and *'How digitalization changes the practice?'*

This paper analyses the mobility planning and decision making process in Aalto University Otaniemi campus area (Espoo, Finland). The piloting project focuses on various planning projects dealing with the campus area. The case area is part of a nationally acknowledged T3 area (Tapiola–Otaniemi–Keilaniemi) aiming to integrate science, culture and business for creating a global innovation ecosystem. T3 area serves as the location for several research institutes, and many national and international companies. The west metro project (first phase scheduled to be completed in 2016), as well as Aalto University's campus development projects, will have various effects on the development of the area, which makes mobility planning within the area a topical and multi-scalar theme for the research.

The approach of this research is descriptive and focuses on multiple sources. The analysis process was divided into three parts, all supporting each other: planning ecosystem analysis; mobility planning and decision making documentation analysis; and key person interview analysis. In the first and second part of the analysis, various mobility planning and decision making materials were used to form a perception of the local mobility planning ecosystem, and pointing out the main themes in the related discourses. The material consists of altogether 42 documents (2006-2013). For a deeper understanding of the planning and decision making process, 17 semi-structured key actor interviews were performed, representing the main stakeholders influencing the planning and decision making process in the case area. The interview analysis was performed through discourse and content analysis, pointing out main themes and development needs based on the interviews.

It is not feasible to create a general description of situation awareness and smart city planning in urban planning and decision making processes within the scope of this paper. However, with a clearly defined case and piloting projects it is possible to describe the most important aspects of generating situation awareness within a certain development process.

4. Findings: Situation Awareness in a Complex Planning Ecosystem

4.1 Varying Information Use and Scale of Conceptualization

Various actors have differences in what kind of material they can easily understand and absorb. Accordingly, they use planning information in diverse ways based on their own background, interests and objectives. Whereas some find it more natural to use quantitative or textual information, others find it easier to use visualizations and qualitative information. Also Te Bömmelstroet & Bertolini (2008, 252) describe that various professionals seem to have established traditions of information use.

In addition, the stakeholders approach urban planning ecosystem on different scales of conceptualization. When one approaches it from the viewpoint of technology oriented small-scale solutions, another sees the area as being a part of a larger entity. As Healey (2007, 3) describes, stakeholders in planning ecosystems are struggling to grasp the diversity of scales and subsystems that transect and intersect an urban area. The challenge is how to make these communicate with each other from the higher level strategic views to the more detailed local solutions.

Urban development processes and decisions take time, and speed up suddenly. Townsend (2014, 305) argues that smart cities need new agile and fluid practices, as the reality changes constantly. Even if there wouldn't be hectic development going on all the time, actors should still be aware of the overall picture for being able to react to, and proactively influence the process when it accelerates. This together with the availability of increasing amounts of information and varying scales of conceptualization among the actors challenges situation awareness in urban planning and calls for digital methods of bringing together and visualizing various kinds of information during planning and decision making processes.

4.2 Information Filtering, Selection and Report Overflow

Information use, understanding of systems and network relations, prioritizing information and arguments are all formed by ongoing interaction, reasoning and visioning on for instance personal, organizational, regional and municipal levels. From the first phases on, decisions are made on what to highlight, what to downgrade, and what to communicate further. As Healey (2007, 26) argues, concepts and priorities emerge not just from the codified knowledge of science, but from experience, ideology, professional concepts and political fixes. The strategy formation process is a product of several filtering phases (Healey 2007, 188). The interviews suggest that several filtering phases take also place on all levels of planning and decision making process, both intentionally and unintentionally. Arguments are justified according to the actor-contextual rationality, which supports selected objectives. Opposing arguments are seldom offered, reducing the possibility of evaluating the ready given truth.

Transparency and openness of the process become important already from the earliest phases onwards. Long planning and decision making chains cause the information to be selected and filtered several times before reaching the final phase of planning and decision making process, if ever ending up so far. In the interviews, it was pointed out that urban planning is very report oriented. There is an overflow of reports, making it difficult to concentrate on finding the essential in them. Planning and decision making are based on readily processed information in reports and documentation, but the information processing itself cannot be validated very easily. So the information processor actually holds much power and responsibility in collecting, filtering and selecting the information further. As people change, much process information and tacit knowledge is lost due to incomplete and vague process documentation.

According to the interviews, the importance of co-created documents is high. As the planning and decision making process may seem non-linear,

and sometimes even irrational for the outsiders, it is easier to commit on something one has been involved in for understanding the reasoning behind them. There cannot be a shared understanding of the systemic relations between processes unless it is co-created with the various actors and clearly reasoned. Van Hoek & Wigmans (2011, 57) state that sustainable urban development cannot even exist without an integrated and cohesive development vision. The more people contribute to the process of creating a vision, the more people devote themselves to the vision, and the active participation of the related parties is vital for being able to go beyond just an intention or a dream (Dogon 2011, 86).

There is a need to develop the planning and decision making process documentation in the beginning of the process (for creating a shared overall picture and vision of the desired development path), during the process (documenting and visualizing the rationalization of the decisions made during the way), and in the end of the process (documenting and visualizing the process knowledge so that it is easy to comprehend).

4.3 Interaction and Process Documentation Are Important Features of Support Systems

Urban development projects are examples of systems where various actors, scales and subsystems have to be aligned for the envisioned development to take place. Planning support systems bringing all available information together have been developed to assist in information acquisition. However, they are usually not capable of information condensation and prioritization. In a complex multi-actor environment ways of facilitating the understanding and comparison of various kinds of information formats and sources is important. The interviews suggest that it is not solely planning and decision making support systems that are enough to support information comprehension, systemic understanding and situation awareness, but possibilities for human interaction and discussion are needed as well.

Urban planning and decision making are to a great extent about co-creation, discussion and negotiation, rationalization and argumentation. Various working groups and round-table meetings of local actors are seen as important support systems, where information is shared and discussed. The round-table information-sharing enables open discussion between various perspectives and arguments, testing the justification and rationalization behind the argumentation. Opposition and difference are important in creating new practices and innovations. The presence of diverse values can aid creativity, commitment and coordination (Deetz 2007, 276).

In complex urban settings decisions which are optimal for all actors can rarely be made. Accordingly, the value of co-creation is in understanding

the various views and making well-reasoned decisions. Over-intellectualization and inaccessibility of validated information can distance stakeholders from the planning and decision making reality creating more resistance against the decisions. There is a need for developing round-table and co-creation methods in order to facilitate the generation of situation awareness and overall view, and reducing the amount of uncoordinated and unconsciously overlapping projects in the urban development processes. Co-creation methods and practices, as well as methods for bringing in various types of background information and argumentation, need to be developed for reaching new innovations and solutions to the complex challenges of urban planning ecosystems.

According to van Hoek & Wigmans (2011, 27), co-operation should take place in a context which invites actors to address their differing opinions in a constructive manner. Round-table meetings can create a platform for discussing the various objectives and development plans of the local actors, as well as their impacts on the objectives and plans of the other actors. Urban development entails perspectives from at least urban design, planning, transportation planning, traffic engineering, real estate theory, management and organization theory, economics, law, policy studies, sociology etc. A physical and digital platform, bringing together various types of information and facilitating discussion about them, is needed. This also calls for a process facilitator assisting and managing the co-creation process.

4.4 ABE - a Living Lab for Boundary-crossing Co-creation

According to the case study, the urban planning ecosystem is complex, and the amount of available information is vast and in various formats. Reports keep coming in, and only a part of the information can be absorbed. In such a complex system, forming an overall picture of the whole development process is challenging. However, developing the steps leading to the desired future, there should be an awareness of what the overall situation is, and how the different projects and objectives fit into the overall picture. As unless the actors are conscious of the prevailing situation and the social complexity, also benign planning decisions might have undesired and surprising outcomes.

The research pointed out two clear needs for developing methods in order to assist the generation of situation awareness. First, process knowledge documentation, as well as reports and visualizations, should be developed to better meet the needs of the actors, who constantly face an overflow of information. Second, the methods for round-table meetings as a way of facilitating the discussion and interaction, and the generation of

systemic understanding within the planning ecosystem, should be developed. Digitalization brings notable opportunities for developing these methods for smart city planning. As an answer to these findings, this paper presents a pilot case study project of Aalto Built Environment Laboratory (ABE, www.abe.aalto.fi), which is a work in progress operated by a multi-disciplinary research team from Aalto University, Finland.

ABE comprises of a physical space with visualization technology and methods aiming at multi-actor co-creation and co-working processes. It serves built environment research and development on all scales from building design to strategic urban planning. ABE offers a living lab for Aalto University campus development processes, academic courses and lectures, and urban development co-creation events. The facility consists of an 80 m² room and can host a group of 25-30 people. It is situated in the heart of the campus, in an urban planning themed co-working space Urban Mill, which offers additional spaces and services for the ABE users (www.urbanmill.com).

In addition to the physical space, ABE embeds user-centered boundary-crossing participatory traditions, bringing together mixed information sources and finding ways to visualize and communicate them. Instead of focusing only on the outcomes, ABE project gives attention to the visualization of the underlying processes by providing the stakeholders understanding of the process and interconnections. Visualization is a strong means of communication in urban planning and much work is done with drawings, plans and images. Consequently, ABE supports the testing of new techniques for urban planning visualization. For example methods of 3D modeling and rendering, agent based modeling and process visualization have been tested in order to alleviate the understanding of complex spatial problems.

ABE gives support and facilitation for round-table information-sharing and co-creation processes, enabling open discussion between various perspectives and arguments, which are important prerequisites for systems understanding and situation awareness. ABE is a university project without a formal position in urban planning system, but the first pilot experiments since March 2014 suggest that it has potential to become a collaborative semi-formal meeting place for various urban planning and decision making related stakeholders. The results of ABE pilots have been encouraging in developing ways of project documentation and round-table facilitation.

5 Discussion and Conclusions

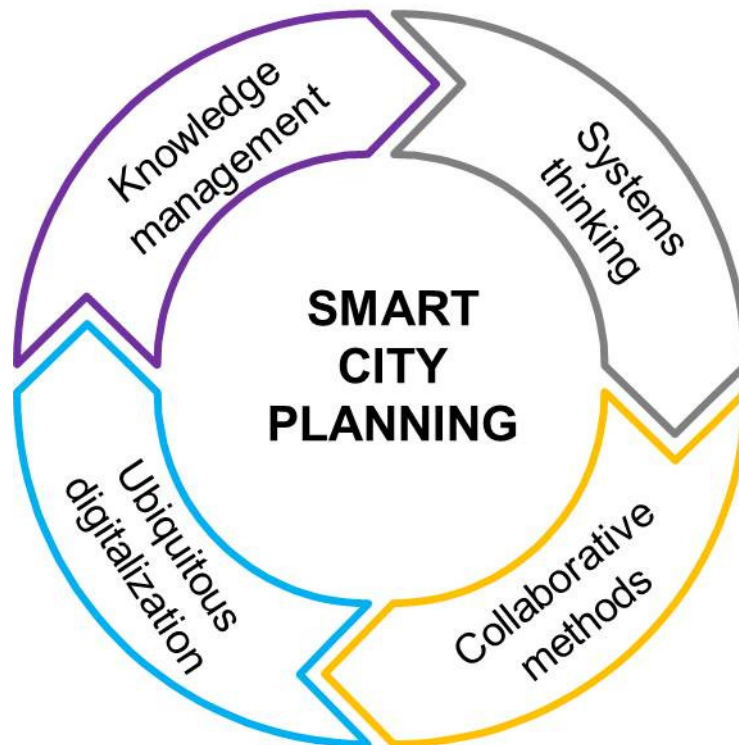
In a complex and multi-scalar urban planning ecosystem, forming an overall picture of whole development processes is challenging. Even the process of developing a single, quite clearly defined area is divided into a number of separate, fragmented and overlapping processes. The amount and quality of information that the planners and decision makers meet is vast, challenging the ability to keep up with updated situation awareness of the planning ecosystem, and the systemic relations between various processes. However, developing the steps leading to the desired future, planners and decision makers should have an awareness of what the overall situation in the area is, and how their own projects and objectives fit into the overall picture.

The research suggests that process documentation and methods of user information utilization should be developed to better meet the needs of the planners and decision makers, who face an overflow of information. This indicates that the meaning of knowledge management processes should be increased in planning. It was found that the lack of overall picture and challenges of systemic understanding can be alleviated by interaction and discussion. Consequently, a focus should be put on developing the methods of round-table co-creation as a way of facilitating discussion and interaction, and the generation of systemic understanding. In addition to knowledge management, collaborative methods need to be further developed. In response to the need of improving the situation awareness in planning practice, smart city planning methods of knowledge management and collaborative working were piloted and tested in Aalto Build Environment laboratory projects, suggesting encouraging results.

The *ubiquitous digitalization* of planning environment, the smart city, has exploded the amount of data in planning practice. Based on the findings, expanded urban planning in order to reach the normative objectives of smart cities demands methodology, which emphasizes the integration of knowledge management, systems thinking and collaborative methods (Fig. 2). *Systems thinking* entail the perspectives of learning and feedback loops, which help the generation of situation awareness. In addition, the understanding of complex ecosystems, systemic change and resilience make a foundation for systems understanding. *Knowledge management* in smart city planning integrates the importance of modeling, simulations and visualizations, process documentation and adequate planning and decision support systems bringing together data, information and knowledge from various perspectives. Finally, the smart city is all about communication, and the smart city planning is based on *collaborative methods*, involving

stakeholders into the development processes, bringing diverse thinking into the process through various channels and platforms, and generating a human- and user-centered focus on planning.

Fig. 2. Methodological framework for smart city planning



The urban planning and decision making processes go on at political, institutional, and inter-personal levels. Even though the planning and decision making processes might sometimes feel distant and vague when observed from outside, they affect the sustainability, livability, functionality, and accessibility of the living environments. The complex urban development processes can be supported by smart city planning practices, which lay the foundation for situation awareness and systems understanding. The paper argues that smart city planning consists of values and judgments, generating a need for discussion and co-creation.

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