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Planning First, Tools Second: Evaluating the Evolving Roles of Planning Support Systems in Urban Planning

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ABSTRACT

Planning support systems (PSS), as geo-information technology instruments, have been developed to support planning as urban planning is becoming highly complex. Recent advances in new information and communication technologies (ICTs) in the context of smart cities have provided new potentials to enrich PSS-support functions, but they do not constitute a "silver bullet;" in fact, PSS's potential roles in practice are impeded by fundamental and structural factors. This article argues that the evolving perceptions of planning together with the changing roles of PSS in supporting planning provide the foundations for solving these structural restrictions. It presents a genealogical exploration of planning thoughts and associated PSS supports over the past 70 years, which is cross-checked by the results of expert interviews. The analysis indicates that for a factual planning supportive role: (1) the focus on the urban planning issue at hand should be strengthened, since it determines the planning mode and the relevant PSS choice; (2) there is a need for a user-centered, demand-induced approach toward PSS developments in planning, aimed at better serving the real needs of PSS users and planning practices; and (3) and there is also a need for more sensitivity toward contextual factors in PSS developments and applications, since the specific contextual characteristics help to identify the complexity faced by planners and influence the relevant planning rationality and specific PSS to be applied. This article thus highlights the importance of considering planning support as a socio-technical innovation shaped through challenges in urban contexts and the relevant planning approaches applied to handle these challenges. Further recommendations are proposed for PSS developments and applications in future planning practice.

KEYWORDS

smart city; planning support systems (PSS); complexity; rationality; a sociotechnical approach; context-orientation

Introduction

Urban planning concerns the organization and design of economic and social relations in space via the various levels of government, and handling prevailing sustainability issues and/or giving directions toward future urban development (Vonk and Geertman, 2008). The goal of urban planning is usually the construction of visions and schemes for, and the

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management and governance of, metropolitan regions, local cities and towns, and neighborhoods, to better allocate or distribute physical, human resources and development rights. According to Friedman (1987), knowledge, information, skills, and creativity are required in this process to arrange, assess, and execute a range of thoroughgoing operations and actions for public goods. However, planning practitioners face the difficulty of understanding and dealing appropriately with the issues at hand (Innes and Booher, 2010) when aspects of the issues are complex and they do not possess the considerable amount of information and knowledge required to deal with them (Friedmann, 2019; De Roo and Hillier, 2016). Thus, in the urban planning field, there is a strong consensus that the information and communication revolutions can be seized by planners to support planning and create possible solutions to these urban problems (Harris and Batty, 1993; Huxhold, 1991; Geertman and Stillwell, 2004).

Geo-information technology experts and developers have long been engaged in developing planning support tools to assist urban planners in handling information and producing the knowledge needed for decision-making (Geertman, 2006; Vonk and Geertman, 2008). For instance, in the last two decades tremendous efforts have been made to integrate planning knowledge, intelligence, and skills from branches of subjects by employing planning support systems (PSS) (Pelzer, 2015). In general, PSSs are "geo-information technology instruments that incorporate a suite of components that collectively support some specific parts of a unique professional planning task" (Geertman, 2008, p. 217). Besides this general meaning, in some studies, PSSs are also deemed to be a typical type of database instrument to collect diverse data and transform it into valuable and relevant contextualized information to support resilient community planning (Deal et al., 2017). In addition, the meaning of PSS broadens as innovative technologies consistently emerge. For instance, Papa et al. (2017) treat artificial intelligence (AI) as a type of PSS to measure and model accessibility in transportation planning. According to Klosterman (1994), PSS function as "information frameworks" that form the pool of available planning support tools for assisting in distinctive planning contexts. They are developed to support different tasks of urban planning professionals, such as problem identification, data gathering and processing, spatial analysis, spatial simulation, visualization, and projection.

More recently, the exponential growth in big data infrastructures and associated information and communication technologies (ICTs) in the realm of smart cities provides the momentum for improving the planning support role of PSS (Geertman and Stillwell, 2020; Jiang et al., 2021a, 2020a, 2019). Several promising signs in the smart city planning field indicate the potentials of PSS dedicated to supporting specific planning tasks in practice. First, up-to-date and real-time (big) data collected via the Internet of Things (IoTs) sensors provide planners with new ways of measuring and monitoring the form and function of the city (Batty et al., 2012). For instance, a big-data-driven platform called City Brain is used in Hangzhou (China) to analyze, visualize, and manage the spatial-temporal behavior of car drivers. With the help of this platform, traffic flows are monitored and controlled, allowing the deployment of mobility strategies and plans (https://www.alibabacloud.com/et/city). Second, the emergence of new PSS platforms enables new ways of working and communicating in planning and provide the mechanisms through which new knowledge can be produced. An example of this is the online workbench Australian Urban Research Infrastructure Network (AURIN) (https://aurin.org.au/). By bringing together a network of researchers, planners, and policymakers from across Australia, new collaborative outcomes can foster multidisciplinary and joint research on sustainable challenges related to smart cities. Third, big data and new PSSs can be combined to tackle some routine planning tasks. For instance, by developing methods from data analytics and using large volumes of up-to-date data collected from communities, Smart Shrinkage Decision Modeling is used in Baltimore (USA) to monitor and visualize vacant or abandoned properties and provide novel insights into ways in which planners can perform vacant property redevelopment (Johnson et al., 2015). In brief, new big data and smart PSSs offer planning practitioners new PSS innovations to tackle historically grown path dependencies and address some of the still unresolved social, economic, and environmental problems (Jiang, 2021).

Nevertheless, critics say that PSS's potential in augmenting the planning of cities has been hindered by various fundamental and structural factors (Geertman and Stillwell, 2020; Jiang et al., 2019; Pettit et al., 2018). In practice, many smart PSSs developed by private companies outpace the ability of planners and societies to adapt to the changes. For instance, although many smart PSSs have been developed—such as cloud computing, artificial intelligence (AI), and the Internet of Things (IoT)—when they are applied to support planning (as PSS), insufficient technical skills, knowledge, and training hinder their acceptance by practitioners (mainly planners) as tools to improve their problem-solving potential (Geertman and Stillwell, 2020). Then, due to a lack of quality in utility, user-friendliness, and ease of use, some PSS advances do not satisfy the real needs of users and planning tasks, such as spatial scenario building, interpersonal dialogue, collaborative decision-making, and consensus building (Flacke et al., 2020). Furthermore, some PSS are developed by small teams of academic researchers (i.e., through expert-led systems engineering approaches); consequently, the innovation processes are seldom co-created and practiced by practitioners or ordinary people (Vonk and Ligtenberg, 2010). It, therefore, becomes increasingly difficult to integrate PSS for e-participatory planning that can support citizen-specific and context-based decision-making (Afzalan and Muller, 2018).

Thus, although the emergence of new PSSs has created new opportunities for planners to embrace the shift toward the digital paradigm and increase their awareness and uptake of PSS-based toolkits, the identified fundamental and structural restraints in practice significantly hinder the promising role of PSS in supporting planning and in handling the planning issue at hand. Innovative approaches to PSS developments are, therefore, needed to effectively integrate smart PSSs into supporting planning (Geertman and Stillwell, 2020; Jiang et al., 2019). According to Klosterman (1994), the continued failure of practitioners and researchers to use smart technologies to augment the planning process and deal with planning issues in the realm of smart cities, results less from the limitations of hardware and software and more from a limited understanding of the difficulties and decision-making process of planning in determining the proper role these tools should or could play. This statement suggests that the evolving views of PSS in supporting planning are closely related to the evolutionary perceptions of planning. For this reason, the following question was used to guide the present study: How can the role of PSS be conceptualized from a planning evolutionary perspective?

The rest of this article is structured as follows: the next section introduces the research strategy and method. That is followed by a section that presents a genealogical investigation of the evolving views on PSS in planning. Then we discuss which lessons can be learned for an up-to-date and factual planning support, which is crosschecked by the results of interviews with experts. Finally, we present some conclusions and recommendations for future PSS innovation and application.

Research Strategy and Method

Strategy

To explore the evolving roles of PSS in supporting planning, a framework was developed to target challenges related to the urban context, the perception of planning, and the supportive role of PSS in planning over the past 70 years (See Figure 1).

It should be noted that the figure is chiefly based on the theoretical argumentation of Klosterman (1994) and Hartmann and Geertman (2016). According to Klosterman (1994: 45), "the evolving perceptions of planning together with the evolution of computer-based information and techniques provide the foundations for a new perspective on computer-aided planning." The underlying assumption is that the planning difficulties faced by planners are quite profound and vast, thus decision-makers and planners are in serious need of more or better planning support instruments to be able to handle the ever-increasing complexity of real-world planning practice (Chadwick, 1971; Klosterman, 1994). Other authors highlight that planners' faith in the role of PSS in supporting planning, results from the efficacy and usefulness that such new computer-based tools have contributed to improving the appropriateness of planning (Pelzer, 2015; te Brömmelstroet, 2013; Vonk, 2006). However, what is worth noting is that the cognitive and decision-making processes of planning significantly influence how PSS are developed, organized, applied, and evaluated (Vonk and Ligtenberg, 2010). For instance, centralized planning often requires PSS to be organized in a hierarchical way to transmit information from a high level to a low level, whereas participatory and collaborative planning usually asks for more communicative PSS tools distributed among different stakeholders to support mutual information exchange.

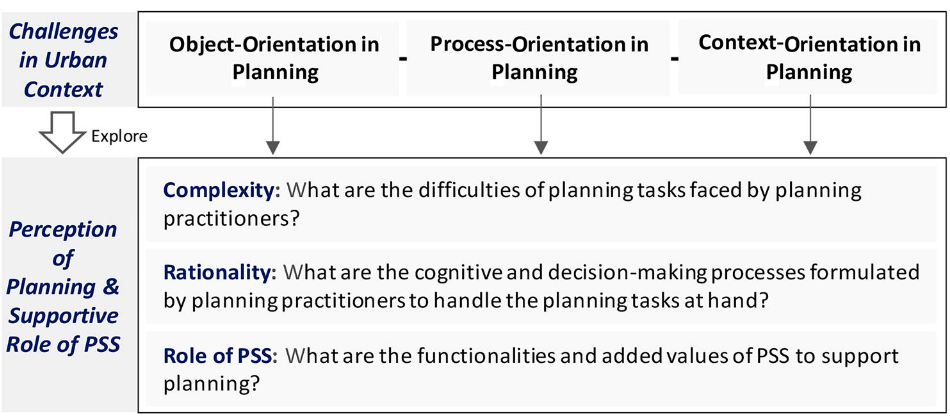

Figure 1. A framework for exploring the evolving role of PSS in supporting planning, based on Klosterman (1994) and Hartmann and Geertman (2016)

Following Klosterman, three key concepts—namely the complexity, rationality, and role of PSS—were used to explore the role of PSS in supporting planning. Each concept was explicated in the form of a question. The question in the case of "complexity" was, "What are the difficulties of planning tasks faced by planning practitioners?" Complexity refers to the substantial issues, technical or non-technical works, contents, questions, and themes that are the prime concerns of planning. "Rationality" concerns how decision-making is understood, judged, and made by a process of logic—in other words, the process, mode, method, and way that planners make choices through problem identification, information collection, and the evaluation of alternatives. The question in the case of "rationality" was, "What are the cognitive and decision-making processes formulated by planning practitioners to handle the planning tasks at hand?" Then, the supportive role of PSS in planning was explicated by answering the question, "What are the functionalities and added values of PSS for supporting planning?" Here, functionalities concern whether the [range of operations] that can be run on a [computer] system in principle can do what is needed (Nielsen, 1993; Pelzer, 2017). It is assumed that only if the range of operations of systems fit the planning task, can the functionality of PSS be fulfilled. The outcome produced by the functionality is the added value of PSS for planning. The three concepts were used to conduct a genealogical investigation into the evolving roles of PSS in supporting planning in an explorative way.

Hartmann and Geertman (2016) identified three major periods in planning thoughts —namely an object-oriented period, a process-oriented period, and a context-oriented period—during the previous half century in Western Europe and North America. Broadly speaking, each of these periods has distinctive characteristics (e.g., time span, the task at hand, actor interaction) that result in distinctive perspectives on the role of planning and that of the PSS in supporting that planning. The underlying argument of this view is that instead of an object "out there," the planning of solutions to urban challenges requires an understanding of how planning is integrated in larger urban networks and circumstances and what this means for the role of PSS. For instance, the object orientation indicates that the focus of planning is clearly on the object—space, built structures, economic effects—whereas the process orientation implies that planning moves toward governing the process of decision-making, with an emphasis on actor interaction and deliberation. Finally, the context orientation highlights the importance of contextual factors in analyzing and designing urban developments and in the implementation of specific planning measures, so in that sense it also integrates the object and process orientation. Each planning orientation relates to a certain type of decision-making (and relevant planning rationality) to deal with the specific planning task (and its complexity). And likewise, each planning orientation requires certain PSS tools if its support is to be able to deal with the identified planning tasks and decision-making processes.

Method

The present study applied a combined research method. First, since the different roles of PSS in supporting planning are well recorded in the scientific literature (Vonk, 2006), a literature review was carried out. The selection of suitable literature was based on the general definition given in the first section of the article. By referring to the method proposed by Wolfswinkel et al. (2013) for a rigorous literature review, the search was conducted in March 2018 and updated in November 2019. Since computer-based information technology began to play an important role in planning especially after World War II (Geertman, 2006), the review was limited to literature published since 1945. Only peer-reviewed journal articles and scientific books were included in the literature review to ensure the inclusion of only high quality research. Scopus, a comprehensive and multidisciplinary database, was then searched for appropriate academic journal papers. A total of 253 scientific publications on the role of PSS in supporting planning were identified in the first phase, but after reading the details of the articles, only 47 key publications were used in the study. Figure 1 was then used to guide an explorative analysis of the identified documents. The major thematic fields elaborated in the literature are presented in Table 1, which shows that the 47 publications encompass a wide range of topics regarding PSS. Some focus on how to improve the usefulness of PSS in practice, others pay attention to developing new instruments to enrich PSS toolboxes, and yet others conceptualize and assess the performance of PSS. These multiple topics indicate that PSS have been receiving considerable attention because of their perceived potential to support urban planning.

Second, to substantively cross-validate the results obtained from the genealogical investigation, a questionnaire was designed to explore the actual application of PSS in planning practices. Questionnaires were delivered to 1,300 members of the Computers in Urban Planning and Urban Management (CUPUM) research community; 268 completed the questionnaire (≅ 20% response rate). The reason for selecting these experts was that they possess considerable skills at, knowledge of, and experiences with the application of PSS in urban planning. Analysis of the questionnaire showed that PSS have been widely applied to deal with a range of urban issues and support multiple planning processes in different contexts, and that the fit of task-technology and user-technology and contextual factors indeed influence the role of PSS in supporting planning (Jiang et al., 2020a, 2020b; Jiang, 2021). To improve the roles of PSS in planning, they should be attuned to satisfy the real needs of users and planning practices, while considering the importance of context in designing, developing, and implementing PSS.

Based on this background information, interviews were held with 12 high-impact experts in the field of PSS from Australia, the United States, China, the Netherlands, Brazil, the United Kingdom, and Japan (see Appendix Table A1). Although the sample of interviewees was limited and selective, the majority of the experts had worked in

Table 1. Major thematic fields elaborated in the literature

Main Themes	Number of Articles	Key References
Novel functionalities or instruments for planning support	15	Harris (1989);Rugg (1992); Webster (1993); Geertman (2002); Pettit et al. (2018)
Usability of PSS	3	Pelzer (2017); te Brömmelstroet (2017a); Russo et al. (2018)
Innovative methods and ways to improve PSS's potentials	10	Harris (1960); Vonk and Geertman (2008); te Brömmelstroet (2010); Flacke et al. (2020)
Contextual factors influencing PSS's implementation	6	Lee Jr (1973); Geertman (2006); Vonk et al. (2007)
Performance or usefulness of PSS	5	Te Brömmelstroet (2013); Pelzer (2017); Pan and Deal (2020)
Development trends in PSS	8	Openshaw (1986); Bishop (1998); Hopkins (1998); Klosterman (1997); Geertman (2017)

the PSS field for over 20 years, and some for more than 50 years. It was thus a very important sample of key experts in the field, who provided valuable insights and opinions.

Three sets of semi-structured interviews were held in the period June–October 2019. The aim was to gain empirical insights from the debates concerning the role of PSS in supporting planning. The first set of interviews was conducted during the 2019 Wuhan CUPUM[1] Conference (July 8–12, 2019) in China with eight internationally highly recognized experts from the field of PSS and urban planning. The second set of interviews was conducted in August, 2019, in Beijing (China); however, only one expert from the PSS field was available for interview. In September–October 2019, three additional experts from both the fields of PSS and smart city governance were interviewed. Each interview lasted about one hour.

The semi-structured interviews were audio-recorded, with the informed consent of the interviewees. After the interviews, the audio-records were manually transcribed. The texts were then coded and analyzed to generate themes to address the research question. The aim of analyzing the data was to obtain the conceptual and visionary opinions and comments of the experts on the potential and actual contributions of PSS in supporting planning. By taking an unbiased stance during the data analysis process, the subjective inferences or comments derived from the interviews were applied to demonstrate the statements.

Evolving Roles of PSS in Supporting Planning

The conceptual framework presented in Figure 1 is positioned and comprehended in a set time frame, even though this should be accounted as merely a rough track. Geertman (2006) stated that in reality the associated time frame differs from place to place, from one planning field to another (e.g., transportation vs. urban design), between distinctive planning professions (e.g., data analyzer vs. designer), etc. Thus, the transformation in thinking about the supporting role of PSS will not be revolutionary (hard breaks between stages) but evolutionary, with a continuous influence on the next stage. Following the scrutiny of planning literature, this section conducts a genealogical investigation into the evolving roles of PSS in supporting planning in four areas, namely: (1) challenges in the urban context; (2) planning complexity and PSS functions; (3) planning rationality and PSS development/application; and (4) PSS implementation problems.

The Role of PSS in Supporting Object-Oriented Planning

The idea of using information technology to deal with troubling urban challenges, such as overcrowding, slums, unhealthiness, and the deterioration of cities, was first introduced in the second half of the twentieth century (Huxhold, 1991). Up until 1951, when the first computers for commercial use were introduced in the public sector, planners had reluctantly started to embrace computer-based information technologies to support their planning activities (Shiode, 2000; Brail, 1987). Planners in Western countries started to use computer-based information technologies in this period in response to the intensive urban renewal and reconstruction after World War II. With a deepening of the division of labor caused by large-scale urban development, planning was divided into a multitude of specialties—for example, transportation planning, environmental planning, health planning, land-use planning, regional planning, and social planning—each requiring specific skills and professional knowledge (Beauregard, 1986, 1987). The difficulty (i.e., complexity) faced by planners in this period was how to employ multiple theories and tools from different disciplines to foresee, specialize, generalize, and explain specific urban problems and combine these understandings to formulate a final picture of the future state; this is known as blueprint planning (Faludi, 1973). In these sectoral planning domains, planners are assumed to be working in a rational–comprehensive way (also known as instrumental, substantive, unbounded, or synoptic rationalities), indicating that planners have all the knowledge about past, present, and future events, items, or performances and the knowledge required in the whole process of plan-making and coordination (Kiernan, 1983).

Influenced by this, computer-based information technologies were mainly required to facilitate planners to collect, process, and analyze information and data and make intrinsically value-free plans that would be appropriate for everyone who lived in the city. A remarkable feature of planning-supportive tools in this period was its task orientation. Some large-scale system models were developed (e.g., urban transportation models, large-scale metropolitan land use, and integrated municipal information systems) to deal with some large and urgent urban issues (Chadwick, 1971; Klosterman, 1994; Lee Jr, 1973). In the process, the city was treated as a complex dynamic system, comprised of various interconnected components in a hierarchical order. Technology developers and specialists hoped that these system models could collect and store the required data, and define problems, identify goals, generate alternatives, and select the best plan. Underlying this was the influence of the rational–comprehensive model on the value of technology, postulating that technology's usefulness is judged in terms of achievement of the ends (i.e., instrumental value).

However, it should be noted that the use of large-scale system models, despite being deemed a rational behavior, failed to optimize the overall urban system. As Lee Jr (1973) proposed, seven shortcomings blocked the potential of earlier computer innovations to support and revolutionize tools like large-scale models in a policy environment. According to Lee Jr, these models were designated to replicate too complex a system in a single shot and serve too many purposes at the same time. Then, simple algorithms and low computing capabilities did not match the needs of complex urban issues. In general, the actual support needs of planners and planning practices were far ahead of what computer-based information technologies could provide. As a result, a key challenge facing the application of computer-based information technologies in that period was the undersupply problem of planning-supportive tools (Webster, 1993).

Accompanied by the intensive criticism of the rational–comprehensive model, planning processes were no longer treated as politically neutral but seen as inevitably linked with power relations and political contestation (Hudson et al., 1979). Large-scale system models, once presumed to offer value-free information and plans that would satisfy everyone, were no longer suitable for more open and participatory policymaking processes. Thus, the period following this saw the emergence of more specialized information technologies that were developed to aid a different, more open, planning process.

The Role of PSS in Supporting Process-Oriented Planning

From the 1970s through to the early 1990s, the general political and social evolution of Western society challenged the conventional unitary public interest, which led to a "paradigm breakdown" in planning (Alexander, 1984). Planning was no longer deemed a closed system that included only the state and its planner; instead, it was treated as a process-oriented open system to meet the need of engagement with non-state actors; this is process-orientation in planning (Faludi, 1973). The complexity faced by process-oriented planning is how the state/planner can build rich connections with different stakeholders to operate on the edge of social uncertainty and instability to articulate important urban problems and realize the pluralist interests in outcomes. Furthermore, due to the identified wickedness of many urban problems (Rittel and Webber 1973), bounded rationality (incrementalism and mixed-scanning), advocacy, and transactive and radical rationality were proposed (Lane, 2005), emphasizing the importance of politics and social interaction in collectively shaping the planning process. Knowledge, discourse, ideas, and lived experiences endowed with power among different stakeholders can all exert particular influence on the content, strategic directions, and outcomes of certain plans (Friedmann, 1987). This change in the perception of planning largely altered the primary concern of technology in planning.

First, conflicting values and interests arising in the 1970s greatly increased the data and information input in the planning process (Klosterman, 1994). It was argued that better computer-based information systems would be useful for managing information and revealing unrecognized controversies and faults in planning processes (Huxhold, 1991). When the minicomputer was developed and introduced, computer-based information technologies were mainly developed to deal with information management in planning. Except for traditional functions (such as data collection and input, data transmission, data storage, data processing and output), new information systems were considered to help planners to reasonably arrange the plans of each functional department. For instance, computer-based mapping was created to better craft representations of urban space, while relational database management systems (DBMS) were employed to transmit and share this mapping information within planning systems (Klosterman, 1994). However, it should be noted that the previous rational–comprehensive model still had an enduring influence on the development of these systems. Although some techniques were deemed useful for narrowly-defined technical problems, they could hardly offer the rigorously tested and empirically confirmed knowledge required to guide policymaking processes (Bernstein, 1976).

Then, in the 1980s, the primary concern of planning support shifted to facilitating the creation of knowledge and helping planners make decisions (Geertman, 2006; Klosterman, 1994). This transition reflected the importance of knowledge in policymaking. Stimulated by an article by Gorry and Scott Morton (1971), the notion of decision support systems (DSS) was introduced to help managers to formulate decisions. According to Gorry and Scott Morton, DSS would allow decision-makers to systemically produce and assess a number of alternative solutions and help them to incorporate substantive knowledge along with quantitative data offered by the models. In the later 1980s, the underlying principles of DSS were incorporated into spatial decision support systems (SDSS) (Densham and Rushton, 1988). However, a key problem for SDSS was that it limited its capability to exclusively support short-term decision-making by isolated organizations or individuals, and did not extend to longer-term planning (Geertman et al., 2013).

In the early 1990s, earlier views of planning as a conflicting process were replaced by a perspective on planning as an ongoing process of interactive dialogue and debate in which different stakeholders can collaborate with each other to collectively identify and solve issues (Healey, 1997). Innes (1995) summarized this new approach as "communicative planning," although it was also called "planning through debate," "argumentative turn," "communicative turn," "collaborative planning," and "deliberative planning" (see Healey, 1997). With this came the realization that the development of computer-based PSSs should facilitate interpersonal communication and collective design, and focus more on long-term urban challenges and strategic planning issues. To do so, the notion of PSSs was put forward to provide participatory and integrative procedures for tackling poorly structured decisions (Harris, 1989; Harris and Batty, 1993). According to Klosterman (1994), PSSs are intended to integrate various computer-based ICTs useful for planning and provide the information infrastructure for planners and planning practices.

Nevertheless, planners seemed to regard the developed PSS as unsatisfactory (Geertman, 2006). Although a lot of PSS were developed and supplied, their application was primarily dominated by an apparent mismatch between the supply of available planning-support instruments and the time-bound demand for support by planning practice; this is the so-called PSS implementation gap (Geertman, 2006; Vonk, 2006; Silva et al., 2017; te Brömmelstroet and Schrijnen, 2010), namely the discrepancy between the various PSSs developed by experts in laboratories with a traditional systems engineering approach, and the real needs of users (planners) in planning practices (Vonk and Ligtenberg, 2010). For instance, the lack of sufficiently attuned communication functionalities made it difficult to facilitate interpersonal communication and community-based debate in participatory planning. Focusing too much on strict rationality, some computer-based PSSs were too complex, inflexible, and incompatible with real planning tasks (Vonk, 2006). Therefore, strong recommendations were made that future PSS developments should move beyond the demonstrated collaboration among PSS experts toward a user-centered PSS-development approach (Pelzer, 2015; Geertman, 2006; Vonk and Ligtenberg, 2010).

The Role of PSS in Supporting Context-Oriented Planning

Since the late 1990s, the capitalist expansion has integrated local and national economies into a global, unregulated market economy (Fainstein, 2010). Cities worldwide are becoming more exposed to the challenges or tensions between the increasing significance of globalization and the escalating salience of local communities (Newman and Thornley, 2011). For a proper working of planning, arguments are made that planning should focus more on the context-specificities (Alexander, 2017; Fainstein, 2000, 2010). Hartmann and Geertman (2016) identify this as context orientation in planning—focusing on the specific role of the planning object in its wider environment, reflecting on the political dimension of the planning process, and theorizing on the specificities of the planning context. The complexity faced by planning in this period is how to produce more open and inclusive processes and better outcomes in specific urban contexts as its legitimacy claim (Fainstein, 2000, 2010). Then, communicative rationality and pragmatic rationality were correspondingly proposed to frame planning behavior and practice (Holgersen, 2015; Healey, 1997, 2009; Alexander, 2000, 2017). Such rationalities emphasize the importance of different planning methods and paradigms associated with the situations to be interpreted through either personal and individual deliberation or collective communicative action (Alexander, 2000).

Consequently, enquiry into the supportive role of PSS in planning has recently advanced to embrace such a question: What kinds of PSS are or should be implemented by what kinds of stakeholders in which types of planning situations, contexts, or circumstances? (Russo et al., 2018; Pelzer, 2015; Biermann, 2011; Vonk, 2006). Rather than taking a normative view, these questions help to embrace a more pragmatic attitude toward the role of PSS: To what extent can the implementation of PSS in planning become more effective and useful? (Deal et al., 2017; te Brömmelstroet, 2017a). This perspective indicates that: (1) The design of one typical PSS functionality should be related to its application situation—real needs of users and planning practices—rather than to the technology itself (Pan and Deal, 2020; Pelzer, 2017); (2) rather than being complex, objective or value neutral, PSS should be more flexible, integrated, and user-friendly (Russo et al., 2018; te Brömmelstroet, 2017b); and (3) all available PSS instruments suitable for serving the specific needs of planning should be employed—providing the "information infrastructure" for planning (Klosterman, 1994; Pelzer, 2015).

Thus, rather than following a traditional systems engineering method, a much more human-induced socio-technical approach should be employed, one that is sensitive to the specific characteristics of the context to facilitate and optimize PSS's potential role in planning practice (Geertman, 2006; Jiang et al., 2021b; Vonk and Ligtenberg, 2010; Pelzer, 2017). Such a transformative approach assumes that a system is only optimal for dealing with a particular planning task when it is attuned to the specific characteristics of that specific planning context. To do so, a range of authors have urged that thorough research into the potential added value or usefulness of PSS for planning in specific contexts will facilitate this socio-technical transformation and unblock the bottlenecks that prevent the widespread use of PSS in planning (Geertman, 2006; McEvoy et al., 2019; Russo et al., 2018; Pelzer, 2017; Silva et al., 2017; te Brömmelstroet, 2017b; Vonk and Ligtenberg, 2010).

Findings

Table 2 summarizes the evolutionary perspective on planning along with the evolving roles of PSS in supporting these distinctive planning perspectives in the three main planning periods. It shows that challenges in the urban context have become more extensive while the complexity of planning has been consistently increasing. In succession, the way planning is performed turns out to be more collaborative and pragmatic. However, it should be noted that although the acceptance and use of PSS in planning practice is increasingly widespread, there is still a long way to go before they are fully and effectively incorporated into supporting planning. Implementation problems consistently appear in each period (e.g., undersupply of planning-supportive PSS in object-oriented period; a

Table 2. Evolving roles of PSS in supporting planning

Dimensions	Object-Orientation in Planning: 1950s to 1960s	Process-Orientation in Planning: 1970s to earlier 1990s	Context-Orientation in Planning: late 1990s to now
Challenges in urban context	• Urban renewal and urban sprawl; population growth and various urban problems	• Government crisis; plurality of actors; urban inequality	• Tensions between globalization and localization; aggravated socio-spatial inequality; the information revolution and technological society
Planning complexity and PSS functions	• Blue-print; survey-analysis-implementation; master planning	• Wicked problem and uncertainty; participatory planning	• New urbanism; the just city; communicative planning; smart urbanism
	• Electronic data processing and large-scale system models to improve task operation	• MIS to improve management ability; DMS and SDMS for policy-making process; PSS for interpersonal communication and collective design	• Various techniques, methods, and tools focusing on real added value they can generate to users and planning practices • Planning Support Science (PSScience)
Planning rationality and PSS development & application	• Rational comprehensive; instrumental rationality	• Transition from rational comprehensive to bounded rationality, advocacy, transactive and radical rationality	• Communicative rationality; pragmatic rationality
	• Task-oriented development • Very limited application	• Expert-led development • Supply-oriented application	• Towards a user-oriented, socio-technical approach for PSS innovation • Demand-induced application
PSS implementation problems	• Strong support needs but immature planning-supportive PSS; undersupply of planning-supportive PSS	• Technological determinism; a discrepancy between PSS supply and PSS demand	• Transition challenges from technology-driven, supply-pushed to socio-technical, demand-induced practices; context awareness • To solve digital inequality regarding PSS use

discrepancy between PSS supply and PSS demand in process-oriented period; and transition challenges in context-oriented period) (analyzing Row 5).

Nevertheless, some insightful findings are both operative and useful. First, challenges in the urban context influence the perceptions of planning (i.e. planning complexity and planning rationality) and ultimately affect the choice of PSS-support functions and the way PSS are applied (analyzing Row 2–4). Second, there is a trend toward transforming the current expert-led PSS innovation into a more user-oriented, demand-induced PSS development in order to offer high-quality PSS that can meet the actual needs of users in planning practices (analyzing Column 5 and Row 5). For instance, PSS developers are expected to have more collaborations with PSS users (often urban planners and designers) to optimize the functions of PSS (Vonk and Geertman, 2008). Then, more web-based platforms and open innovation activities can be initiated to kickstart PSS innovations among policymakers, technology aficionados, and even citizens (Jiang, 2021). Third, increasingly attention has been paid to contextual factors, because of their influential role in the effective integration of PSS into planning practice (analyzing Column 5). For instance, there is often ignorance of the impact of digital inequality on PSS's role in planning (Otioma et al., 2019). In reality, aspects of digital inequality include unequal access to digital devices, disparity in digital skills and knowledge, and the varied results of people's attempts to use PSS to solve a task (Jiang, 2021; Jiang et al., 2021b). Therefore, raising awareness of digital inequality and taking all-embracing efforts to reduce it would be preferred from a policy point of view (Pick et al., 2015, Otioma et al., 2019).

Toward an Up-to-Date and Factual Planning Support

Geertman (2006: 870) argues that "[previous views of PSS] do not end with the arrival of the next one (no Kuhnian paradigm shifts); instead, equally-as-worthy indicated elements of previous traditions continue alongside and/or intermingled with, and/or adapted to following [views of PSS in supporting planning]." Taking this point into consideration, this section links the findings obtained from the previous genealogical investigation to the expert interviews and distils those dimensions that are currently overlooked and undeveloped but could contribute significantly to an up-to-date and factual planning support.

First, analysis of the expert interviews indicated the desire that PSS development capable of supporting factual planning should focus more on the sustainable urban challenges—the acknowledgement that the "urban" is the object that planning support is intended to support. As previously argued, while smart city technologies can become directly operational in planning practice, critiques show that the direct deployment of advanced PSS in practice often fails due to an inadequate link between PSS developments and planning issues. When we turned to expert views, all of the 12 experts emphasized the importance of changing urban problems into stimulating PSS innovations. For example: "In the past few decades, urban issues have been an important driving force for technological innovations in urban planning" (Expert 3); "It is not just about developing so-called PSS and implementing them, but more about the problems to be solved and the positive outcomes to be produced to cities" (Expert 9).

However, the experts were not quite satisfied with the supportive role of PSS in handling the planning issues: "The main urban issues are currently pretty much the same as they were 20 years ago … [that is], affordable housing, transportation issues and public education, etc." (Expert 3); "Many of these tools, techniques, and models didn't work well enough … they were not really oriented to what [users] are looking at" (Expert 8). Further: "Planning support techniques were only used to solve some urban transportation and land use problems and do some simple analysis such as traffic flow analysis, land use evaluation, mapping and visualization … it was hard to confront social issues like segregation, inequality, and slums" (Expert 6); "Planning support tools have changed relatively fast over the past few decades, but our understanding of the city itself is quite inadequate; thus, the role of planning support tools is vague" (Expert 9). As a response, experts highlighted that we should think about accurately what kinds of transitions cities are encountering and what kinds of planning modes are needed. As one expert concluded:

> … I personally do not care much about the smart city technologies … the important thing is about cities and providing education, good roads, and things like that … for the supportive role of technologies to be effective, you should ask: who does what, how, when, and to what effect? … I would start with planning and then think about what technologies can best support planning. (Expert 10)

Second, the experts confirmed that PSS advancements in supporting planning should be closely attuned to the planning process, highlighting a shift from an expert-led, supply-pushed strategy to a user-centered, demand-induced innovation. At present, while basic PSS can become directly operational in planning practice, the direct deployment of advanced PSS in planning practice often fails because the support functions do not fit the characteristics of the planning processes or the demands and skills of the users (Pelzer, 2015; Vonk, 2006). PSS developments are over-reliant on the ability of the private sector and experts to design, launch, and implement technologies; however, the extent to which the functions and capabilities of various PSS are properly attuned and can be applied to real-world issues has not been adequately examined (Pelzer, 2017).

During the expert interviews, it was stated that linking PSS developments to planning processes (or users) is insufficient in practice: "Over the last decade, more tools were developed and created by [private] companies … but it is just a 'dark chamber' … it's too complex" (Expert 9); "Urban technologies are largely provided by private [companies] … but it's better to have technology that is easy to operate and user-friendly" (Expert 1).

Despite the technology push, experts said that there had recently been a surge in scholarly attention to cooperation between technology developers and users on PSS development. For instance: "Instead of focusing on the expert-led development of technologies, it's better to engage the public and make them smarter … focusing on the political process" (Expert 10); "The best thing for us is to understand the need and demand of [practitioners]" (Expert 2). In brief, experts considered that successful implementation of PSS into supporting planning requires user involvement in and increased communication to practice, as that helps to develop PSS into tailor-made instruments for the relevant planning practices.

Third, the interviews revealed that particularly the importance of context in analyzing the supportive role of PSS in planning should be considered. Fainstein (2010: 2) argued that "much of planning theory dwells on planning processes and the role of the planner without analyzing the socio-spatial constraints under which planners operate." Hence, it is recommended to center on the practical realities of urban planning and urban policy within cities' local and global contexts. Analyzing the comments of experts showed that contextual factors have consistently influenced the way PSS are developed and integrated into planning practices. It should be noted that context was interpreted multidimensionally by the experts to include technological advancements, political institutions, planning styles, user characteristics, or even the planning issue itself (Geertman, 2006; Tomor and Geertman, 2020).

For instance, political systems play a crucial role in the PSS diffusion and adoption in planning organizations. As one Chinese expert said: "The government threatened the planning institutions … if the computer-based plotting rate doesn't reach 50 percent, their institutions will be degraded to a lower level" (Expert 7). Experts from the United States also commented on the influence of government on technology spread: "The census bureau since 1997 has done a lot to promote the standardization of data … like time file, TIGER file, and street network file … so planners can make use of it" (Expert 4). Then, process-wise factors (roles of governments and non-state actors and technologies) were argued to influence the organization and usefulness of PSS in practice (Tomor and Geertman, 2020). One Australian expert said that: "In Australia, certain councils and state government agencies mandate that the planning of smart cities projects should be more proactive … then, open dashboards like CITY VIEWS are used to provoke community engagement" (Expert 2). It was said that in another participatory project: "the tool in the project is not quite helpful … not many people know about it … the participation rate is low" (Expert 7).

Besides the above context factors, the technology itself was argued to be an important contextual factor:

> During the past decade, the rapid development of digital technology has enabled us to build more than 2000 GIS [geographic information system] layers of Wuhan city [China]. These layers largely enhance our capabilities to plan and solve the urban issues in our city. (Expert 7)

> The high cost and relatively low penetration rate of minicomputers hindered the adoption and use of planning support technologies in the past several decades. (Expert 9)

Finally, experts highlighted that some other contextual factors—such as skills, training, and education could—significantly influence the future use of PSS in planning. The experts' views show that valid and convincing familiarity, awareness, or understanding of the specific contexts is clearly needed to help identify the complexity faced by planners, select the relevant planning rationality, and decide on the form of PSS to be used.

Conclusions and Recommendations

Urban planning is recognized as a very complex activity; thus, PSS have been developed to support planning in the performance of its tasks. More recently, advances in new PSSs in the context of smart cities have opened up new opportunities to enrich PSS-support functions—but they are still not a "silver bullet;" in fact, in practice the potential roles of PSS have been largely impeded by fundamental and structural factors.

The study explored how the role of PSS can be conceptualized from a planning evolutionary perspective. First, studies that have elaborated on the evolving roles of PSS and put forward trends for improvements were examined. This was followed by an analysis of both questionnaire outcomes and expert interviews to cross-check the actual roles of PSS in planning practices. The results indicate that: (1) challenges in the urban context influence the perceptions of planning (i.e., planning complexity and planning rationality) and further affect the choice of PSS-support functions; (2) there is a trend toward transforming the current expert-led PSS innovation into more user-oriented, demand-induced PSS developments, aimed at offering high-quality PSS that can meet the actual needs of users in planning practices; and (3) increasing attention has been paid to contextual factors, as the specific contextual characteristics help identify the complexity faced by planners and ultimately influence the relevant planning rationality and specific PSS to be applied.

Table 3. Summary of expert interviews

Urban Problems and PSS roles	Number of Experts	Planning Process and PSS Roles	Number of Experts	Context Influencing PSS's roles	Number of Experts
• Urban issues do drive increasingly PSS innovation	12	• PSS innovation over-relies on private companies	3	• Data availability	3
• ICT developments are vital for PSS advancements	2	• Need for easy-to-operate and user-friendly PSS	2	• Political system	4
• PSS have limitations in handling social issues	5	• Knowledge, needs and pursuits from communities can facilitate PSS development	3	• Planners' knowledge and awareness	3
• PSS should focus on solving strategic and long-term urban issues (e.g. sustainable mobility)	4	• Participatory PSS are increasingly vital	2	• Internet penetration and digital capability of citizens	4
• Urban problems influence PSS's practical usefulness	1	• Partnerships between different stakeholders would help improve PSS usefulness	3	• Technical accessibility and usability	2
		• Universities are important in PSS diffusion and innovation	4	• Characteristics of urban problems	2
		• The way to collect multi-dimensional data is beneficial for PSS development	3	• Planning institution culture	1

These findings acknowledge that PSS-enabled planning support must go beyond the technology-driven approaches and move toward the development, implementation, and use of PSS in close connection with the urban socio-technical processes at hand. The results of the aforementioned questionnaire reveal that PSS developments should enhance the extent to which a technology helps potential users to perform their planning tasks. In addition, both the literature review and the expert interviews show that planning support tools should be integrated in larger urban contexts and planning frameworks as well as what this means for planning support innovations. This supports recent studies that emphasize the role of planning embedded in shaping the usefulness of digitally-assisted analytics and platforms in practice (Anttiroiko, 2021). As Stratigea et al. (2015: 1) urged, we should "match different types of 'smartness' (technologies, tools, and applications) with different types of urban functions and contexts." The results of the expert interviews also echo arguments for a coproduction process of PSS development. This is because technical innovations require outside inputs like novel functional needs and propositions of new algorithms and models from wider practitioners (Vonk and Ligtenberg, 2010; Jiang et al., 2020a). Furthermore, the views of experts on an improved level of digital capability accords with the statement that overcoming digital inequality will remove barriers to approaching digital devices and is a manifesto for urban justice in the "smart" era (Jiang, 2021). From this, this article highlights the importance of considering planning support a socio-technical innovation of transformation shaped through contingent challenges in urban contexts and the relevant planning approaches applied to handle these challenges.

To improve planning support, the following is a relatively detailed description of key steps in the development of better or more useful or more robust PSS in practice.

First, we recommend that system experts and developers actively focus on examining support tasks and the application context. Relating PSS's developments to support tasks enables system experts and developers to engage in dialogues with practitioners and establish processes of interactive learning among stakeholders in the innovation network of PSS (e.g., improved communication between systems experts and practitioners; enhanced collaboration between actors in the PSS supported planning). Besides, it is also beneficial for systems experts and developers to be more sensitive to contextual factors (e.g., funding, organization structure, organization culture, etc.) that limit and/or boost technological applications. Thus, in new planning practices (e.g., smart cities, emergency planning), PSS developers and users will be more capable of identifying unsolved technical problems and testing and enhancing the support capability of PSS.

Second, we recommend making use of various bottom-up, user-oriented ways of PSS innovation. It is widely accepted that smart cities are closely aligned with adopting a range of innovative collaborative spaces, where online participation is integrated with offline engagement, and through which technology scientists, technology aficionados, high-tech companies, and local governments are able to participate in processes for the co-design and co-creation of technological products. Practical examples of these spaces are urban living labs, smart citizens labs, maker spaces, hackathons, citizen dashboards, and gamification. Systems experts should make full use of these bottom-up, user-oriented ways to innovate and improve PSS.

Third, the findings in this article agree with Klosterman (1994: 51) that "[we] should use all available tools appropriate for serving the particular needs of planning;" thus, we further recommend practitioners to be more pragmatic in implementing PSS. In fact, PSS should be envisioned as information frameworks that combine the different support functionalities useful for planning. Rather than starting with particular systems and operations, it is the particular needs and demands of planning practices and users (= tasks) that determine the requirements PSS should meet. Thus, we could pragmatically and functionally select the suitable tools from the PSS toolbox to deal with the specific planning tasks.

Note

1. CUPUM stands for Computational Urban Planning and Urban Management. It is a worldwide research community that organizes a biennial international conference.

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Appendix

Table A1. Details about the expert interviews

Experts	Expertise	Date(s) Undertaken	Places	Purposes
Expert 1	Around 25 years' experience in decision-aiding systems	July 9, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	Semi-structured interviews with PSS/Smart Governance experts to infer the conceptual and visionary insights on the mutually potential contributions between PSS and Smart governance
Expert 2	More than 25 years' experience in urban informatics	July 9, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 3	More than 30 years' experience in urban and transport planning	July 10, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 4	More than 40 years' experience in Urban Information Systems	July 10, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 5	More than 35 years' experience in urban modeling	July 10, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 6	Around 20 years' experience in digital city and Planning Support Systems	July 11, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 7	More than 25 years' experience in transport, urban, and regional planning	July 11, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 8	More than 50 years' experience in developing computer models of cities and regions	July 12, 2019	Face-to-Face at 2019 CUPUM Conference, Wuhan (China)	
Expert 9	Around 15 years' experience in urban informatics	August 22, 2019	Face-to-Face in Beijing (China)	
Expert 10	More than 50 years' experience in planning theory, planning methods, and computer applications in planning	September 9, 2019	Online Video	
Expert 11	Around 10 years' experience in new information technologies applications in urban governance / planning	September 11, 2019 and September 30, 2019	Online Video	
Expert 12	More than 20 years' experience in ICT-enabled governance	October 10, 2019	Face-to-face in Utrecht (Netherlands)	

Questions in Semi-Structured Expert Interviews:

Past

In general, what were the main urban problems twenty years ago in the project(s) in which you were involved?

Who were the main stakeholders in handling these problems?

What kind of roles did government/the private sector/citizens play? (asked separately)

How about the role of planning support technologies at that time (informing, communicating, or analyzing)? / How was technology used to deal with these urban problems?

Who were the main stakeholders (state, government, citizen) who promoted the uptake of technology in planning practice at that time?

What were the factors that influenced the uptake and usefulness of technology at that time?

Present

In the present era of smart cities, what are the tricky urban problems in the project(s) in which you are involved?

Who are the main stakeholders in handling these problems?

What kind of roles do government/the private sector/citizens play? (asked separately)

How are technologies used to deal with these urban problems?

What are the new technological functions applied to deal with these urban problems?

Which stakeholders do you consider of importance to promote the uptake of technology in planning practice?

Which factors are influencing the uptake and usefulness of technology in planning practice now?

Future

In the upcoming 10 years, what are the main problems we will face in your view?

What can government/the private sector/citizen do to deal with these problems? (asked separately)

How can technology help us imagine the future city?

What expectation do you have about the application of technology in the upcoming 10 years (positive or negative)?

What can government/technology-companies/academic researcher/citizens do to meet these expectations in planning practice? (asked separately)

What factors do you think will influence the uptake and usefulness of technology in planning practice in the upcoming 10 years?