Special issue editorial

Urban Analytics and City Science

EPB: Urban Analytics and City Science
2020, Vol. 47(8) 1317–1325

DOI: 10.1177/2399808320945453
journals.sagepub.com/home/epb
SAGE

What does urban informatics add to planning support technology?

Haozhi Pan
Shanghai Jiao Tong University, China

Stan Geertman
Utrecht University, the Netherlands

Brian Deal
University of Illinois at Urbana-Champaign, USA

Introduction

In the Urban Informatics session of the Computational Urban Planning and Urban Management (CUPUM 2019) conference (where we started the idea of this special issue), there were heated discussions on the fundamental meaning of the term "urban informatics". Questions revolved around its definition, its role in urban planning, and more specifically, its role in planning support technology. Some consider urban informatics a vehicle for the "seamless transitioning between the visible and the invisible infrastructure of cities" (Foth, 2011). Some see it as an extension of "big data" (Schintler, 2017), while others a field that simply "applies information technologies in urban areas" (Thakuriah et al., 2017). Although it is not our intent to provide defining terms and definitions, some lexicography will help with the discussion.

An early definition of "informatics" is provided by Mikhailov et al. (1967) as: "...the processes, methods and laws related to the recording, analytical-synthetical processing, storage, retrieval and dissemination of scientific information" (transcribed by Wellisch, 1972, p. 176). This is a wide-ranging and extensive definition that touches on almost every aspect of applied information science. Its extensiveness has created some difficulty in delineating the scope of sub-disciplinary areas of study that have emerged around the concept. The urban informatics literature is generally focused on urban computing and computer science techniques to explore, describe, predict, and to a lesser extent, explain

Corresponding author:
Brian Deal, Department of Landscape Architecture, University of Illinois at Urbana-Champaign, Champaign 61820, IL, USA.
Email: deal@illinois.edu

urban phenomena. Kontokosta (2018) describes urban informatics as the study of urban phenomena through a data science framework of urban sensing, data mining, modeling (and analysis), and visualization in order to generate insight that simultaneously advances methods in computational science and addresses domain-specific urban challenges. This description (as pointed out by our peers) contains some clear similarities with commonly used definitions ascribed to planning support and planning support systems (PSS). We agree—with one major deviation: where the field of planning support and PSS are based and deeply embedded in urban planning with urban science roots, the field of urban informatics has emerged from the computational sciences and urban computing. This subtle, but notable difference is explored in this special issue. Beginning with this editorial, we will examine the "value-added" proposition in integrating urban informatics with urban planning processes and more specifically with planning support technologies.

The use of information science in urban planning has a long and historic tradition. Since the mid-20th century, scholars have consistently and routinely presented an (overly) optimistic view of computer models and their potential for transforming the practice of urban planning. In 1959, Alan Voorhees describes a fairly comprehensive (even by today's standards), ambitious, and optimistic view of planning-oriented computer models in an introduction to a special issue on the subject (Voorhees, 1959). This was supported by Britton Harris in 1965, "... the problems of metropolitan growth and development are 'many body' problems which are best handled through extensive computations on high-speed computers" (Harris, 1965). Since then, many planning oriented computational tools have been developed and utilized in the field (see for example Lowry, 1964 and Wegener, 1982) including a more recent classification of the tools using the term, Planning Support Systems (PSS). Like previous planning tools, PSSs were purported to be able to help planners and stakeholders make wise decisions by articulating complicated information on the potential consequences of various development decisions.

Recent discussions place more emphasis on PSS applicability (Geertman and Stillwell, 2020a), usability (Pan and Deal, 2020), and usefulness (Pelzer et al., 2014; Punt et al., 2020). Throughout its evolution, it is the confluence of science (theories of urban ontology), methods of spatial analytics, and theories of planning practices that have driven PSS development and the corresponding literature. Notable steps include the science of approximating urban land-use patterns using Cellular Automata (CA) in the 1990s (White and Engelen, 1993), along with communicative planning theory advances (Klosterman, 1997), and the rapid growth of Geographic Information System (GIS) technology (Hopkins, 1999) later in the decade. In the 2000s, land-use and transportation models are re-integrated (LUTI) (Waddell, 2002), helping to bring attention to issues such as urban sprawl and carbon emissions, and helping to promote the use of planning technology in sustainability theory-guided planning practices (Deal and Schunk, 2004; Lautso, 2003). At this point, GIS-based planning support technologies also began to evolve into collaborative and web-based systems that were found useful in planning processes (Pettit, 2005).

These advances, however significant, had not yet satisfied the overly optimistic perspective laid out earlier in the previous century. For example, Geertman (2006) and Vonk et al. (2005) each found a notable failure in PSS technology adoption and use among planners (and non-expert stakeholders in planning processes). They attributed the failure to a lack of "fit" between the technological "supply" (what the models could deliver) and the field's "demand" (what questions planners required the answers to). They also found that the technologies were excessively complex and not understandably communicated. The noted "implementation gap" is only aggravated by the highly theoretical nature of some of the models (CA and LUTI). A bright spot in that period is the emergence of web-based technologies, such as web-based GIS that begin to be used to facilitate planning practice (Kingston et al., 2000).

More recent PSS research is situated at the intersection of complex urban system science (Batty, 2013; Deal et al., 2017a; Meerow et al., 2016), spatial data science (Lim et al., 2018), and the science of smart cities (Pettit et al., 2018). This triangular intersection represents a unity of ideas. Each is strong where the others are weak, and each has the potential to address critical knowledge gaps in PSS development. Urban informatics is the peculiar term that merges these sciences. It incorporates the data manipulation focus of spatial data science, the theoretical focus of urban system science, and the smart city emphasis on information and communications technologies (ICT). Urban informatics does not just present a siloed ontological, technical, or practical orientation; it represents an unprecedented opportunity. In conjunction with PSSs, urban informatics represents "a whole system design" that links complicated data and models to the end-use (information dissemination, policy deliberations, planning processes) and the end-users (citizens, planners and other stakeholders of planning).

This special issue aims to set the research agenda for the application of urban informatics in support of urban planning with an emphasis on PSS and PSS technologies. We do this with a diverse collection of papers. Topics range from computationally large-scale urban models, to combinations of traditional and new sources of data, to a more pragmatic user-interface, whole system developments, and applications of PSS in urban planning processes. It is our intention to advance the literature on computer model-based PSSs to a new state-of-the-art that includes demonstrations of planning support technologies that might be applied everywhere and anywhere, i.e. in cities and in the living trajectories of its citizens. This special issue represents a considerable effort in this direction. It represents years of work from a host of highly regarded colleagues. We appreciate their efforts and their willingness to participate in this notable endeavor. In the following, we showcase selected papers from a substantial amount of short and full paper submissions to this special issue.

From PSS to PSScience

In the first paper of this special issue, Geertman and Stillwell (2020b: 1326) provide an update of recent developments and potential challenges for the field of PSS. This follows their similar reviews from 2003 and 2009 (Geertman and Stillwell, 2003, 2009). In this paper, they note the rapid development of information and communication technologies and their impact on PSSs and PSS applications. Synthesizing the experiences and views of a global sample of 88 PSS experts, the authors argue that a fundamental transformation is taking place – a paradigm shift – wherein the field of PSS is maturing into a field of 'Planning Support Science' (PSScience). From their perspective, PSSs will become indispensable instruments in the planning process in the not too distant future. They describe the visible signs of this maturation in the current literature, research, education and practice.

Large scale urban models

Progress in large-scale models that serve as the core of many PSSs also serve as a core to this collection. Four different papers demonstrate the range and variability in current planning support model approaches. They include models of urban landscape patterns (Xu et al., 2020: 1361), a land use change scenario modeling approach (Cai et al., 2020: 1380), a new land use and transport interaction model (Basu and Ferreira, 2020: 1397) focusing on residential location and vehicle ownership choices, and a new approach to urban cellular automata (CA) modeling that takes into account future points-of-interest (POI) density distributions on urban streets (Jia et al., 2020: 1418).

Translating various sources of data into useful and relevant information is the essence of the "informatics" part of the urban informatics/planning support integration. PSS models have traditionally been constructed to provide information on land use forecasting or impact assessment – two of the most challenging tasks facing urban planners. In this issue, Xu et al. (2020: 1361) assess urban landscape pattern shifts under multiple scenarios of housing demand, spatial structure, and growth with combined CA and optimization models. Cai et al. (2020: 1380) integrate a spatially dynamic CA land use model with preset policy scenarios (different roads, no-growth planning, and population/employment projections) that are derived from real-world planning documents to provide local policy-makers with the capability to test and evaluate "what-if" consequences. Basu and Ferreira (2020: 1397) propose an agent-based simulation framework that uses "econometrically robust behavioral models" to model "the potential impacts of accessibility changes in 'car-lite' communities on the choice of housing-mobility bundles". They find that LUTI models can be useful for helping to align current transportation policies (autonomous vehicles) with current market conditions (car lite communities). Jia et al. (2020: 1418) adopt the street scale as the unit of analysis (also utilizing CA), but in this case to simulate POI density. The conceptual framework and analysis "lay a foundation for potential investigations into the relation(ship) between the micro-scale built environment (and) macro-scale socioeconomic attributes in urban public space(s)". These papers represent a continued trend in agent-based or CA model for planning analysis and support. Although somewhat familiar in approach, the methods and objects of the investigations are novel and present important emerging urban phenomena (such as autonomous vehicles and POI).

Big data analytics and decision support

The current revolution in (big) data and data availability is also driving the current PSS evolution. In this case, urban informatics represent the deductive methods used for understanding the dynamic laws that drive urban change and inform plan-making. Voluminous data – on its own – can help uncover complex urban patterns. Two papers in this issue feature the use of big data in support of planning decisions. Yang (2020: 1440) integrates mobile phone data and conventional statistics into a computable general equilibrium framework, "for incorporating shared mobility big data into transportation planning and decision-making processes". They suggest that "complementing big data with survey data create(s) considerable added analytical capacity for planning support". Pan et al. (2020: 1456) use a multi-dimensional spatial scan technique to discover household movement patterns in Chicago from millions of household address records. They demonstrate "urban informatics techniques to the problem of urban mobility in underserved areas". They use "voluminous and diverse data sources ("big data") to understand the science of (the city)" and construct "visualized and interactive interfaces to communicate the information in understandable and useful" ways. These big analytic studies use experimental, counterfactual analytical techniques to examine the potential successes or failures of specific planning policies.

The PSS user interface

The focus on users and user experiences is one key characteristic that distinguishes PSS from urban informatics. Unlike typical urban informatic approaches, PSS interfaces are typically constructed to both visualize the data and make it useful in a planning process. This requires that visual information should be accessible to a range of users, interactive, and easy to use in a group deliberation setting, with the potential for feeding information back into the PSS model. Pan et al. (2020: 1456) have developed a visualized planning support interface and feedback portal with user survey functionality. The interface aims to improve both the understandability of the analytical results and their use in public planning and policy formation. Yang et al. (2020: 1474) developed a web-based visualization platform for urban design—*Plugs-web*—which can replicate their modeling process and also facilitates visual communication and collaboration between PSS developers, stakeholders and users. The RAISE tool developed by Pettit et al. (2020: 1490) provide users with a deliberate access to complex models and the ability to create and explore a range of 'what-if' scenarios.

From the papers in this issue, the role of PSS interfaces in revealing the "value added" by urban informatics is to: (a) communicate complex models and data to users (Pan et al., 2020: 1456; Pettit et al., 2020: 1490; Yang et al., 2020: 1474); (b) prototype models to generic processes that can be run by any user (Pettit et al., 2020: 1490; Yang et al., 2020: 1474); and (c) solicit contextual feedback or inputs from users to improve the analysis (Pan et al., 2020: 1456; Yang et al., 2020: 1474). We expect further use-based tests on the design features of these interfaces to examine whether they have adequate user-friendliness to realize these claimed benefits.

Process and applications

A string of literature from the mid-late 2000s argued (in various ways) that the main bottleneck to PSS advancement was an inordinate focus on tool and technical development at the expense of more practical research and application to planning practice (Geertman, 2006; Pan and Deal, 2020; Pelzer et al., 2014, 2016; Vonk et al., 2005). There are three papers in this special issue with empirical or bibliographic evidence for how the information generated from a PSS can be usefully applied to practical planning processes or smart city applications. Page et al. (2020: 1508) employed a collaborative approach that integrates scientific knowledge, policy and engagement by planners in Stockholm, Sweden. The aim of their work is to make an open source PSS, "more easily useable for local planners, and thereby facilitate its adoption by planning authorities" making it "possible to integrate scientific knowledge, policy and stakeholder engagement in the complex process of planning for sustainable urban development". Pettit et al. (2020: 1490) investigated a use case in Western Sydney, Australia to determine, "whether a rapid analytic scenario planning approach can be encapsulated in a tool that supports data-driven planning and decision-making". The main purpose of the work is to "support government land valuers in understanding changes in land and property dynamics" and to "support urban planners and policy-makers in exploring the potential value uplift from new public transport infrastructure". Jiang et al. (2020: 1343) explore whether "the rich debates" that surround the PSS implementation gap, "can provide insights that can enrich smart governance". They interview experts from both the PSS and smart governance fields to show that PSS can provide a useful analytical perspective for smart governance developments by helping to, "envision technology as the means and urban practice as the goal in which to attain improvement". These studies help support the notion that a well-designed and implemented PSS can enhance the information quality and usefulness for both PSS modeler and PSS user. The concept of urban informatics, in this case, is extended to the whole process of creating and utilizing information – from creation to use in a planning context. This is the literal definition of a 'whole system of information capture and dissemination".

Conclusions

This special issue presents a collection of studies that connects planning scholars to the new horizons of planning support in the era of urban informatics and smart cities. It supplements decades of PSS literature presenting novel approaches to core model development (Basu and Ferreira, 2020: 1397; Jia et al., 2020: 1418) with an increasing focus on the integration of the planning process and the applications of PSS technologies (Jiang et al., 2020: 1343; Page et al., 2020: 1508). User interface developments are also presented (Pettit et al., 2020: 1490; Yang et al., 2020: 1474) as are urban analytics that utilize recently available big data sets (Pan et al., 2020: 1456; Yang, 2020: 1440). These additions help demonstrate new opportunities for the integration of planning support research, urban informatics, and smart cities. For example, Yang (2020: 1440) combines a theoretical economic model with mobile phone data, while Pettit et al. (2020: 1490) integrate a use-case evaluation with land value models and a user-interface application.

The most often mentioned term in the "value-added" discussion (from urban informatics to planning support technology) is "participation"—participation of both planners in the modeling processes (Page et al., 2020: 1508) or modelers in the planning processes (Jiang et al., 2020: 1343; Pettit et al., 2020: 1490; Yang et al., 2020: 1474). Urban informatics and smart city technologies can contribute to improved participatory planning infrastructure with better communication technologies and faster prototyping of PSS models that allow the automation of model updates (in real time) during participatory deliberation (Cai et al., 2020: 1380).

Participatory processes can provide both instrumental and normative value in PSS development. Instrumental value is produced by enabling feedback solicited from planners and local stakeholders directly implicate PSS model outcomes and improvements (Cai et al., 2020: 1380; Pettit, 2020: 1490; Page et al., 2020: 1508). Planner and stakeholder inputs help to create multiple scenarios that can inform planning consequences and policy decisions (Yang, 2020: 1440; Yang et al., 2020: 1474; Xu et al., 2020: 1361). The normative value of participation is realized in the smart city ideal of transparent, participatory, and collaborative open government and data (Deal et al., 2017b; Pereira et al., 2017). Pan et al. (2020: 1456) and Jiang et al. (2020: 1343) propose equitable and collaborative governance through ICT technology and web-interfaces created for stakeholders from all social spectrums.

The urban informatics value-added proposition is also realized in an enhanced understanding of the science, complexity and dynamics of cities. Pan et al. (2020: 1456) and Jia et al. (2020: 1418) use large, voluminous, and diverse data sources (address change data from postal records and POI data from navigation systems) to better understand the science of cities and advance the theories of complex urban systems. Xu et al. (2020: 1361) and Yang (2020: 1440) contribute to the understanding of urban dynamics, urban mobility and their resulting impacts. Though these theoretical findings do not immediately, nor intuitively support practical planning, understanding complex urban phenomena is the first step toward future iterations that will ultimately become useful for planning practice.

In general, we find a limited set of literature on the integration of urban informatics, smart cities, and planning support. Most previous contributions come from the information sciences, engineering or land management domains (Arroub et al., 2016; van den Buuse and Kolk, 2019; Yeh, 2017). One difficulty for urban planning scholars may be the technical barriers in conducting complex communication or network studies. Another might be the difficulty that the "hard sciences" have in engaging social science related questions. We propose cross-domain studies on urban informatics and planning support.

These types of studies should not be limited to planners, geographers, or computer scientists but also include information engineers and a range of other hard and soft scientists to help engage the human, "user" dimension. We argue that these types of collaboration will enhance and speed progress for the future of urban informatics and planning support technology research.

Acknowledgements

We thank the editors of *Environment and Planning B: Urban Analytics and City Science*, Dr Linda See and Prof. Michael Batty in helping to make this Special Issue possible. We especially thank Linda for her support and help in the entire process of editing and producing the issue. We also thank all authors submitting short or full papers and those attending the special session of CUPUM in Wuhan, China. We found the process engaging and illuminating. We also appreciate the CUPUM organizers and volunteers from Wuhan University who provided the platform for sharing and communicating with the many scholars interested in the topic of planning support with urban informatics. Finally, we wish all a safe and healthy post COVID-19 recovery.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Arroub A, Zahi B, Sabir E, et al. (2016) A literature review on Smart Cities: Paradigms, opportunities and open problems. In: *2016 International conference on wireless networks and mobile communications (WINCOM)*, pp. 180–186. Fez, Morocco: IEEE.

Basu R and Ferreira J (2020) A LUTI microsimulation framework to evaluate long-term impacts of automated mobility on the choice of housing-mobility bundles. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1397–1417.

Batty M (2013) *The New Science of Cities*. Cambridge, MA: MIT Press.

Cai Z, Wang B, Cong C, et al. (2020) Spatial dynamic modelling for urban scenario planning: a case study of Nanjing, China. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1380–1396.

Deal B, Pan H, Pallathucheril V, et al. (2017a) Urban resilience and planning support systems: the need for sentience. *Journal of Urban Technology* 24(1): 29–45.

Deal B, Pan H, Timm S, et al. (2017b) The role of multidirectional temporal analysis in scenario planning exercises and planning support systems. *Computers, Environment and Urban Systems* 64: 91–102.

Deal B and Schunk D (2004) Spatial dynamic modeling and urban land use transformation: a simulation approach to assessing the costs of urban sprawl. *Ecological Economics* 51(1-2): 79–95.

Foth M (2011) *Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City*. Hershey, PA: Information Science Reference.

Geertman S (2006) Potentials for planning support: a planning-conceptual approach. *Environment and Planning B: Planning and Design* 33(6): 863–880.

Geertman S and Stillwell J (eds.) (2003) *Planning Support Systems in Practice (Advances in Spatial Science)*. Heidelberg: Springer Verlag, 578 p.

Geertman S and Stillwell J (eds.) (2009) *Planning Support Systems: Best Practice and New Methods (Advances in Spatial Science)*. New York: Springer Publishers, pp.511.

Geertman S and Stillwell J (2020a) *Handbook of Planning Support Science*. Cheltenham, UK: Edward Elgar Publishing, pp.555.

Geertman S and Stillwell J (2020b) Planning support science: Developments and challenges. *Environment and Planning B; Urban Analytics and City Science* 47(8): 1326–1342.

Harris B (1965) New tools for planning. *Journal of the American Institute of Planners* 31(2): 90–95.

Hopkins LD (1999) Structure of a planning support system for urban development. *Environment and Planning B: Planning and Design* 26(3): 333–343.

Jia Z, Chen L, Chen J, et al. (2020) Urban modeling for streets using vector cellular automata: Framework and its application in Beijing. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1418–1439.

Jiang H, Geertman S and Witte P (2020) Does the PSS discourse have something to offer to the smart governance debate? *Environment and Planning B: Urban Analytics and City Science* 47(8): 1343–1360.

Kingston R, Carver S, Evans A, et al. (2000) Web-based public participation geographical information systems: an aid to local environmental decision-making. *Computers, Environment and Urban Systems* 24(2): 109–125.

Klosterman RE (1997) Planning support systems: a new perspective on computer-aided planning. *Journal of Planning Education and Research* 17(1): 45–54.

Kontokosta C (2018) Urban informatics in the science and practice of planning. *Journal of Planning Education and Research* 1–14, https://doi.org/10.1177/0739456X18793716

Lautso K (2003) The SPARTACUS system for defining and analysing sustainable urban land use and transport policies. In: *Planning Support Systems in Practice*. Berlin, Heidelberg: Springer, pp.453–463.

Lim C, Kim KJ and Maglio PP (2018) Smart cities with big data: Reference models, challenges, and considerations. *Cities* 82: 86–99.

Lowry IS (1964) *A Model of Metropolis*. Santa Monica, CA: The Rand Corporation, RM-4036-RC.

Meerow S, Newell JP and Stults M (2016) Defining urban resilience: a review. *Landscape and Urban Planning* 147: 38–49.

Mikhailov AI, Chernyi AI and Giljarevskij RS (1967) Informatics–new name for the theory of scientific information. *FID News Bulletin* 17(7): 70–74.

Page J, Mörtberg U, Destouni G, et al. (2020) Open-source planning support system for sustainable regional planning: A case study of Stockholm County, Sweden. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1508–1523.

Pan H and Deal B (2020) Reporting on the performance and usability of planning support systems—towards a common understanding. *Applied Spatial Analysis and Policy* 13(1): 137–159.

Pan H, Chen S, Gao Y, et al. (2020) An urban informatics approach to understanding residential mobility in Metro Chicago. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1456–1473.

Pelzer P, Geertman S, van der Heijden R, et al. (2014) The added value of planning support systems: a practitioner's perspective. *Computers, Environment and Urban Systems* 48: 16–27.

Pelzer P, Geertman S and van der Heijden R (2016) A comparison of the perceived added value of PSS applications in group settings. *Computers, Environment and Urban Systems* 56: 25–35.

Pereira GV, Macadar MA, Luciano EM, et al. (2017) Delivering public value through open government data initiatives in a smart city context. *Information Systems Frontiers* 19(2): 213–229.

Pettit CJ (2005) Use of a collaborative GIS-based planning-support system to assist in formulating a sustainable-development scenario for Hervey Bay. *Environment and Planning B: Planning and Design* 32(4): 523–545.

Pettit C, Shi Y, Han H, et al. (2020) A new toolkit for land value analysis and scenario planning. *Environment and Planning B: Urban Analytics and City Science*47(8): 1490–1507.

Pettit C, Bakelmun A, Lieske SN, et al. (2018) Planning support systems for smart cities. *City, Culture and Society* 12: 13–24.

Punt E, Geertman S, Afrooz A, et al. (2020) Life is a scene and we are the actors: assessing the usefulness of planning support theaters for smart planning. *Computers, Environment and Urban Systems* 82: 101485.

Schintler LA (2017) The constantly shifting face of the digital divide: Implications for big data, urban informatics, and regional science. In: Schintler, L.A. and Chen, Z (eds) *Big Data for Regional Science*. UK, London: Routledge, pp.336–346.

Thakuriah PV, Tilahun NY and Zellner M (2017) Big data and urban informatics: innovations and challenges to urban planning and knowledge discovery. In: *Seeing Cities through Big Data* (pp. 11–45). Cham: Springer.

van den Buuse D and Kolk A (2019) An exploration of smart city approaches by international ICT firms. *Technological Forecasting and Social Change* 142: 220–234.

Vonk G, Geertman S and Schot P (2005) Bottlenecks blocking widespread usage of planning support systems. *Environment and Planning A: Economy and Space* 37(5): 909–924.

Voorhees AM (1959) "The Nature and Uses of Models in City Planning." *Journal of the American Institute of Planners* 25(2): 57–60.

Waddell P (2002) UrbanSim: Modeling urban development for land use, transportation, and environmental planning. *Journal of the American Planning Association* 68(3): 297–314.

Wegener M (1982) Modeling urban decline: a multilevel economic-demographic model for the Dortmund region. *International Regional Science Review* 7(2): 217–241.

Wellisch H (1972) From information science to informatics: A terminological investigation. *Journal of Librarianship* 4(3): 157–187.

White R and Engelen G (1993) Cellular automata and fractal urban form: A cellular modelling approach to the evolution of urban land-use patterns. *Environment and Planning A: Economy and Space* 25(8): 1175–1199.

Xu C, Haase D, Su M, et al. (2020) Assessment of landscape changes under different urban dynamics based on a multiple-scenario modeling approach. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1361–1379.

Yang PP-J, Chang S, Saha N, et al. (2020) Data-driven planning support system for a campus design. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1474–1489.

Yang T (2020) Understanding commuting patterns and changes: Counterfactual analysis in a planning support framework. *Environment and Planning B: Urban Analytics and City Science* 47(8): 1440–1455.

Yeh H (2017) The effects of successful ICT-based smart city services: from citizens' perspectives. *Government Information Quarterly* 34(3): 556–565.

Haozhi Pan is an Assistant Professor at the School of International and Public Affairs; China Institute for Urban Governance; School of Design, Shanghai Jiao Tong University Shanghai Jiao Tong University, Shanghai, China. His research interest includes land use, urban informatics, urban sustainability and urban governance

Stan Geertman is Professor of Planning Support Science at the Faculty of Geosciences, Utrecht University in the Netherlands. His research interests include urban and regional planning and the supporting role of information and communication technology

Brian Deal is a Professor at the Department of Landscape Architecture, University of Illinois at Urbana-Champaign. His research interests include complex urban systems and planning support systems.