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Redesigning knowledge systems for urban resilience

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ABSTRACT

While studies have suggested that climate change adaptation will require dynamic sets of knowledge types—scientific, technical, local, and tacit—about complex, interconnected problems across spatial and temporal scales, less attention has been directed to how these different ways of knowing might be used to transform specific urban knowledge systems that are currently in place, to align with diverse societal needs, and to open new pathways for designing how cities sense, anticipate, adapt to, and learn from extreme weather events. This special issue on *knowledge systems for urban resilience* explores the social practices that produce, validate, circulate, and use information, data, and expertise to enable institutions to adapt to the unpredictable and highly dynamic conditions of the Anthropocene. We are particularly interested in the relationship between the social organization of knowledge production and ways that cities can build urban resilience to extreme weather events associated with climate change. Through a combination of conceptual and case study analyses of how knowledge systems work in cities, we argue that building adaptive capacity requires changing the practices, rules, expectations, and underlying power relations in the production and use of knowledge.

1. Introduction

Faced with threats of increasingly severe and frequent extreme weather events and aging infrastructure designed to outdated weather standards, cities are on the front lines of climate change adaptation and resilience (Meerow and Newell, 2019; Miller et al., 2018). While previous studies suggest that climate change adaptation requires dynamic and diverse types of knowledge – scientific, technical, local, and tacit – about complex, interconnected problems across spatial and temporal scales, less attention has been directed to *how* these different ways of knowing might be used to transform existing urban knowledge systems to better align with societal needs (Nursey-Bray et al., 2014; Hulme, 2010; Jasanoff, 2010). Furthermore, while there is burgeoning innovation in smart city technologies (Cohen, 2012), ecological design (Childers et al., 2015), and urban governance (McPhearson et al., 2016), calls persist for deeper investigation into the social and institutional practices – including the knowledge politics – of urban resilience planning and decision-making in the face of an uncertain climatic future (Eakin et al., 2017; Grabowski et al., 2017; Newell, 2015; Meerow and Newell, 2019; Pelling and Garschagen, 2019; Miller and Muñoz-Erickson, 2018). Filling these gaps, we argue, requires innovation in how cities produce, organize, and use knowledge to enable more effective learning and transformation in climate change adaptation (Matson, 2009; Redman and Kinzig, 2003; Fink, 2011; Ernstson et al., 2010). Hence, the central question guiding this special issue on Knowledge Systems for Urban Resilience is: *what changes in knowledge practices are required to ensure resilient urban futures?*

The seventeen contributing articles offer new case studies and theoretical insights into how actors need to change to transform knowledge systems for greater urban resilience and better societal outcomes. Indeed, a highly uncertain climate future calls for re-designing how cities sense, anticipate, adapt to, and learn from extreme weather events (Park et al., 2013). By unpacking the elements of urban knowledge systems – or the social practices and institutions that produce, validate, circulate, and use information, data, and expertise to advance specific decisions and actions – this collection of articles contributes to the budding scholarship on knowledge systems innovation to change the way cities think about building resilience in the Anthropocene (Miller et al., 2010, 2018; Miller and Muñoz-Erickson, 2018).

Definitions of urban resilience should not be pigeonholed to fit within any single discipline, but rather must be continually renegotiated to reflect what is actually working to foster just and sustainable transitions (Harris et al., 2017). The articles gathered here explicitly call for working across boundaries, scales, and groups, and moving beyond technological fixes toward more explicit and robust incorporation of the socio-political aspects of urban resilience work (Grabowski et al., 2017). In this way, knowledge systems analysis (KSA) aims to reveal locked-in path-dependencies in how urban systems reproduce particular knowledge practices that have set cities on the current collision course with climate change (Chester and Allenby, 2018). To break free and change course requires stepping outside of traditional decision-making silos and developing holistic solutions in which myriad city actors will need to innovate and transform their roles, practices, and spaces through which collective knowledge-making and decision-making happens (Miller and Muñoz-Erickson, 2018).

Thus our goal is to broaden the range of approaches that might contribute to KSA in relation to the growing field of urban resilience and to show the relevance of KSA to a wider readership already working on issues of urban governance (e.g., Frantzeskaki et al. (2016)). First, this editorial discusses three different ways the core theme of redesigning knowledge for urban resilience is taken up in this special

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issue (Section 2). Next, we outline the implications of these insights for knowledge systems research (Section 3). Finally, we propose new research directions (Section 4).

2. Core themes and contributions

Knowledge practices are central to urban resilience work, yet they often remain obscured, understudied, or taken for granted within urban resilience planning processes. We suggest three main ways that knowledge systems research contributes to opening up different layers of work that go into producing urban resilience. First, by mapping current knowledge practices, the articles ask: what is the actual institutional work that goes into producing resilient infrastructure? The articles reveal the social dynamics behind what might otherwise appear as stable infrastructures, while mapping some of the complex – and often contradictory – historical trajectories of resilience-building efforts in the face of extreme weather events.

Second, in examining the opportunities and constraints for changing the existing roles of various administrators, managers, specialists, and other designated decision-makers with a professional stake in current institutional practices, the articles ask: how are knowledge professionals' innovations enabled and/or constrained? In addition to mapping current institutional practices in different contexts, here we explore the potential for challenging siloed and institutionalized practices with more hybridized knowledges constructed through collaborative, cross-disciplinary, and participatory approaches.

Third, along with the practical work of creating new hybridizations and experimental spaces for bridging different knowledges, there is a need to understand how the current organization of ideas and practices within existing disciplinary, institutional, and professional silos came to be—and what is required to fundamentally open up new structures and meanings of urban resilience. Through a combination of theoretical and case study insights, the articles examine what a radical reordering of the knowledge practices underlying urban resilience might entail, pointing toward the need for a greater focus on reflexivity, power-shifting, and justice in challenging and transforming dominant trajectories of urbanization.

As will become apparent and taken up after this discussion, these three sets of insights harbor key complementarities and distinctions regarding the strategies for changing core knowledge practices for urban resilience innovation, raising critical questions for knowledge systems theory.

2.1. Mapping current institutional practices

Urban infrastructure is often designed to appear stable: there is an expectation that the lights in your home will turn on at the flick of a switch, that water will run through the pipes and out of your faucet when needed, and that roads and other transportation infrastructure will continue to connect your home to all of the services you depend upon daily. Extreme weather events interrupt this stability, revealing how the seemingly permanent appearance of roads, pipes, and powerlines is actually made possible through ongoing investments in workforce training, infrastructure development, maintenance, and repair work—a whole series of activities and decision-making processes that generally take place outside of public view (Miller et al., 2013).

Several articles in this special issue build on the idea that the apparent *stability* of urban infrastructure is actually an outcome of the social dynamics of institutional decision-making, and that building resilience to extreme weather events therefore requires looking in detail at how that stability is produced through specific kinds of institutional work over time, and in connection with various other contexts. For example, Gim et al. (2019) describe the various constitutional, regulatory, and operational work of institutions at the intersection of water and energy infrastructure in Arizona, arguing that strict engineering perspectives on infrastructure resilience limit our understanding of the technical, social, and environmental changes at different scales within critical infrastructure management. In the case of green infrastructure and financial asset management in Portland, however, Matsler (2019) shows how these kinds of dynamics are subjected to deeply entrenched rules, norms, and routinized procedures, which do not recognize trees, soil, and vegetation as bookable assets, thus inhibiting the mainstreaming of green infrastructure, despite potential cost-saving and stormwater management benefits. Nonetheless, intentionally redesigning institutionalized knowledge practices for greater urban resilience is both possible and desirable: in their study of the history of flooding in the Monterrey Metropolitan Area, Aguilar-Barajas et al. (2019) suggest that significant improvements have been accomplished, despite a complex and sometimes contradictory process of infrastructure planning and implementation, and the region's resilience could be further enhanced with better inter-institutional coordination.

There is, therefore, an unevenness and diversity of urban histories and institutional practices in city responses to extreme weather events, raising questions about how these differences might become key sources of learning and innovation. For example, Rosenzweig et al. (2019) compare responses to sudden cloudburst rainfall events in Phoenix, New York City, and Copenhagen, showing considerable variability in what kinds of policies are developed, while documenting clear and intentional cross-city learning between New York and Copenhagen, with potential expansion to other cities. Also focused on Copenhagen, the interviews with climate adaptation professionals conducted by Madsen et al. (2019) suggest that the public's direct experience of pluvial flooding has helped professionals advance greater technological adaptation pathways, compared to the seemingly more distant threat of coastal flooding. Interestingly, Friedman et al. (2019) compare Boston and New York's response to Hurricane Sandy, arguing that New York's direct hit has led to a much more reactive policy response, whereas Boston's near miss sparked a more robust and proactive approach. These results would seem to confirm the argument presented in Huck and Monstadt (2019) that although resilience is often celebrated as a boundary object permitting different institutions and communities of decision-makers to work together, there remain significant differences in how resilience work is interpreted and acted upon in different contexts and across cities, suggesting a need to further explore how cross-sector, interdisciplinary, and collaborative participation of different actors could lead to new capacities for urban resilience.

2.2. Innovation in professional practice: opportunities and constraints

The examples discussed above document the current resilience work of specific institutions and reveal what knowledge practices need to change to improve urban resilience to extreme weather events. This points to another question, namely, how much flexibility do professional actors have to innovate in their existing roles?

A number of articles address this question by situating the formalized practices of specific institutional actors within various informal or otherwise separate knowledge systems, shedding light on the potential for constructing hybridized knowledge and co-produced solutions. In their study of urban flood management in San Juan, Puerto Rico, Ramsey et al. (2019) suggest that, separately, the knowledge practices of municipal managers and citizens are inadequate for building greater anticipatory capacities for flood resilience: while managers continue to rely on outdated climate data and static flood maps, citizens' and residents' experiential knowledge is limited to localized flood events, and thus does not typically take into account the potential changes in magnitude brought into play with climate change. However, if combined within a holistic reframing of flood management, the authors suggest that citizens' more granular and localized knowledge of flooding could complement an upgraded municipal flood

knowledge system based more on the tracking and monitoring of actual flooding events, rather than historical maps and past climate data. Similarly, in their case study of mapping informal settlements in Nairobi and Cape Town, Borie et al. (2019) suggest some potential for municipal planners and residents to work across very different approaches to resilience by opening deliberative spaces for conversation, in which experiential knowledge and quantitative techniques can actually work together to produce more socially just outcomes. In studying the dynamics of water management across the urban/rurla divide in Peru, Ostovar (2019) suggests that new incentives can increase agreement on, and the implementation of, ecosystem-based approaches to watershed protection, bridging the seemingly incongruent worldviews and epistemologies of *campesino* communities and state-led water governance actors. In other words, these articles reveal how stepping outside of institutionalized knowledge practices can help overcome the limitations of current knowledge systems, leading to unconventional opportunities for improving urban resilience.

The articles also demonstrate the need to balance such opportunities for innovation with an understanding of the persistence of dominant institutionalized knowledge practices. For example, in their study of flood and climate risk governance for sea level rise in Vancouver, Canada, Yumagulova and Vertinsky (2019) suggest that "shadow spaces" – informal working groups, networks, and places where professionals can interact outside of the their officially mandated function – contribute significantly to learning across different governance levels – yet the learning emerging from these spaces remains largely contained within the traditional engineering paradigm and techno-rational forms of expertise and decision-making. This would seem to support the assertion made by Moore et al. (2019) that "the Modern division of labor is also the division of knowledge," posing the real need for new hybridized knowledges contructed through experiments with a new division of labor. As Rodina (2019) finds in her study of water governance in Cape Town, despite some significant overlap between engineering and hydro-ecological frameworks, the distribution of resources and siloed management practices continue to favor the dominance of engineering solutions, even if these are increasingly understood as inadequate for addressing future climate change risks. This is not to say that professionals have no room to maneuver—in their study of professionals' roles in framing climate change and flood risk in Copenhagen, Madsen et al. (2019) suggest that opportunities for innovation are expanded when professionals use the public's experience of actual flooding events to move beyond regulatory institutional framings of risk. But as Dobson (2019, p. 133) argues through a case study of three urban organizations in northern England, professionals' ability to expand their engagement into wider epistemic networks is "a necessary, but not sufficient, condition for institutional reinterpretation" of their roles.

2.3. Changing the starting points for resilient futures

Recognizing these opportunities and constraints, several of the articles inquire about the origins of particular dominant knowledge systems in an effort to identify radically different seeds of change that could lead to new trajectories for socially just and resilient urban futures. For example, Wijsman and Feagan (2019) argue that feminist and decolonial environmental knowledge politics have much to offer urban resilience planning, reframing it around different epistemological and ontological starting points. These perspectives have been systematically undervalued and ignored since the beginning of urbanization in North America (and continue to be excluded in current urban resilience planning, see Yumagulova and Vertinsky (2019). Grabowski et al. (2019) connect the challenge of urban resilience planning to the context of social alienation, in which the general public lacks meaningful opportunities to participate in – and shape – the (un)democratic processes governing life in the city. The authors advocate for the value of epistemic pluralism, and suggest ways that researchers can better recognize their privilege, while valuing diverse forms of experiential knowledge emerging through ongoing social struggles in the city. Rozance et al. (2019) use case study findings from the Pacific Islands and coastal areas of Florida to show how different groups are positioned within dominant framings of the problem of sea level rise. They propose a framework around the scalar politics of risk to help researchers identify and become more intentional about the implicit and explicit choices they make in framing sea level rise, and in developing strategies to overcome long-standing barriers to effective and inclusive urban adaptation.

These articles (among others already discussed) point to a tension between the embedding of urban resilience work within existing structures and power relations and intentionally reforming and opening up resilience knowledge systems in an effort to shift toward more radical trajectories. Likewise, we need to challenge the assumption that the primary agents of change in resilience work are limited to those professionals currently closest to the centers of power, since transformative social change has often come from the margins of society.

3. Implications for knowledge systems research

Reading across the nuances of the articles just discussed, at least three core ideas emerge:

- redesign/change of knowledge systems is necessary and possible;
- experiential knowledge, especially knowledge developed through informal networks, marginalized groups, or practices that extend beyond established disciplinary routines, have the potential to add considerable value in designing holistic solutions; and
- urban resilience planning is inherently political – there is no apolitical space in which transitions toward greater resilience occur.

The papers nevertheless offer divergent arguments and pathways toward redesigning urban knowledge systems: institutions can act as spaces of professional knowledge exchange and codification, or can amass and distribute alternative or marginalized knowledges; informal spaces within and around institutions are critical to their functioning, but changing dominant institutional structures may require radically re-examining the available starting points through a wider diversity of theoretical standpoints; and both the scale and the direct experience of extreme weather events can fundamentally influence all of these interactions.

What are the implications of these findings for knowledge systems research? We recognize that multiple realms of scholarship utilize the 'knowledge systems' concept—from anthropologists studying the relationship of knowledge to different cultural belief systems (Barnhardt and Kawagley, 2005) to computer scientists working on the mathematical representation of knowledge (Wille, 1992). While this special issue was launched through an interdisciplinary conception of knowledge systems (Miller and Muñoz-Erickson, 2018), the contributions reach beyond this conception, adding further diversity to the number and type of available starting points for knowledge systems research and for interdisciplinary collaboration. For instance, the authors usefully combine knowledge systems with additional theoretical frameworks and methodologies, from critical pragmatism to participatory mapping, and from theories of risk to the politics of working across epistemic communities. Does the malleability of the forms of engagement with the concept of knowledge systems enrich or undermine the value of research contributions? Since no one paradigm contains the solution to the re-design of knowledge systems to promote urban resilience, we are persuaded that learning across different paradigms helps expand the options for producing resilient futures and understanding current trajectories. Nonetheless, what are productive research trajectories, to what extent can knowledge systems analysis be combined

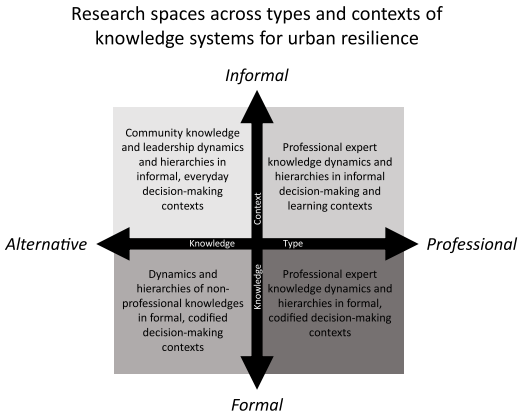

Fig. 1. Four cross-over research spaces were identified by organizing studies along a professional to alternative knowledge type axis (horizontal axis) and an informal to formal knowledge context axis (vertical axis): Professional/Formal, Alternative/Formal, Professional/Informal, and Alternative/Informal.

with different theoretical and analytical frameworks, and what refinements could improve knowledge systems theory moving forward? These are useful questions to keep in mind as we explore future research trajectories in Section 4.

A final key implication is the need for reflexivity across the knowledge systems research community, to acknowledge our own positionality, motivations, limitations, and opportunities in using the knowledge systems concept to approach urban resilience. To this end, the editorial team hosted a virtual, two-hour authors' dialogue to allow contributors to the special issue to connect in real-time and directly hear each other's contributions and comments. Not only was the intention to support opportunities for new research collaborations, but also to gain greater reflexivity – to hold up a 'mirror' to our own scholarship – and better understand where we each are embedded in particular disciplinary knowledge systems, norms, and other processes for vetting and legitimating knowledge claims across and beyond different expectations.

4. Emergent research gaps, directions, and strategies

Lastly, we turn our attention to the future of knowledge systems research by highlighting key gaps and proposing new directions and strategies that fall along two axes: the first is a spectrum of formal to informal knowledge-making contexts (the vertical axis in Fig. 1), while the second proposes a spectrum of knowledge types spanning from professional to alternative (the horizontal axis in Fig. 1). Currently, we find an uneven distribution of research across these two spectrums of knowledge types and contexts, and we posit that a balance of approaches is critical to a holistic understanding of knowledge systems for urban resilience.

For instance, professional fields, such as engineering and economics, have tremendous power and influence in conceptualizing urban risk, and therefore often drive urban resilience discussions on-the-ground. It is therefore critical to analyze the ways that formalized professional knowledge systems operate in order to re-design knowledge systems for urban resilience. We place studies that do this type of analysis in the bottom right quadrant of Fig. 1 – an overlap between a focus on Formal knowledge contexts and Professional knowledge types. Many of the papers in this special issue fit this category. A second set of papers point to the importance of informal contexts to knowledge production and circulation, as well as the legitimacy of alternative and experiential knowledge types alongside or integrated with professional knowledge. These papers fall in the bottom left (Alternative/Formal) and the upper right (Professional/Informal) quadrants of Fig. 1. Third, the upper left (Alternative/Informal) quadrant of Fig. 1 is the most sparsely populated; this highlights a lack of research studies examining the everyday, informal contexts in which non-expert knowledges are being made, vetted, circulated, and put to use towards resilient outcomes.

Using Fig. 1 as a heuristic to organize our recommendations for a Knowledge Systems Research Agenda moving forward, we argue that *a balance* across the four quadrants is key to developing a robust theory of knowledge systems. As described above, much existing KSA scholarship centers knowledge systems innovation on decision-makers and the organizations they work for—a commitment to helping those most invested in official knowledge systems become better equipped at changing those systems. Our first suggested avenue for future knowledge systems research focuses on empowering knowledge professionals to reposition themselves as active designers of institutional decision-making norms and practices—to develop their abilities as knowledge systems innovators. However, many of the analyses presented in this issue show the limitations of this approach, as existing incentive structures and normalized practices reinforce the status quo. While more work is needed that explores opportunities for professional knowledge innovation, there is also a need to explore radical alternatives to existing institutionalized decision-making practices, taking seriously the constraints the professional class of urban managers and decision-makers face. This suggests a second direction for future research, away from a focus on professionals as the primary agents of knowledge systems innovation, towards a better understanding of how marginalized communities and informal knowledge spaces can be the agents and loci of change, shifting the power relations of decision-making for urban resilience. These two research directions combine into a third: studying the relationship between different professionalized and non-professional intervention points globally, across cities. Indeed, given the globalized reality of increasing urbanization, knowledge systems innovation for urban resilience will require cross-city global networks to share new approaches for mitigating the effects of extreme weather events and redesigning urban knowledge systems.

These three strategic research directions build on the core themes developed in Section 2. They respond to the current research gathered here by focusing on innovation *with*, *from*, and *across* decision-making contexts and knowledge types.

4.1. Strategic research direction 1: Innovation with institutional professionals

Since various knowledge professionals are responsible for managing urban systems, they can become key actors for knowledge systems innovation through experimenting with cross-sector learning, changing institutional decision-making practices, and coming to better

understand the limitations and flexibility in reinterpreting their roles in urban resilience. In short, this research stream asks how can we do a better job of understanding how professional "epistemic communities" operate in urban resilience settings, and how can their resilience work be improved?

4.2. Strategic research direction 2: Innovation from the margins to shift power

Professionals encounter deeply entrenched constraints to their knowledge-making practices, which limits their ability to innovate. This suggests that alternative approaches outside the professional class may be required. These alternatives include knowledge from informal spaces and underrepresented groups, and provide a potential avenue for future innovative research that documents marginalized communities' expertise by listening to and learning from those leaders who are excluded from formal municipal decision-making processes. A wide range of ethnographic methods, such as interviews, participant observation, textual and intertextual analysis, oral histories, and digital storytelling, among other approaches could be useful here.

4.3. Strategic research direction 3: Innovation across city networks

Given the urgent need to enhance learning across different cities, this third research direction would support a 'network of networks' approach to share what is working (and not working) across regional and global scales. How do research and practice align globally across uneven processes of urban development? This research would help connect existing city networks to accelerate the identification and sharing of lessons learned regarding urban resilience.

We are left with the impression that not just institutions, but the constellation of socio-political organizations, actors, and discourses that support and resist them, *matter* for transformation towards urban resilience. In other words, an expanded understanding of knowledge systems is crucial to improving urban resilience—and we believe that the three research directions presented here can support this innovation.

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