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Cities, systems and sustainability: status and perspectives of research on urban transformations

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Urban transformation research forms an emergent interdisciplinary field with open boundaries that combines complex system studies and urban studies. It explores patterns and dynamics of change linking cities and diverse socio-technical and social-ecological systems across levels and scales, and develops new forms of intervention to foster their sustainability. This paper identifies and maps out the current status in this field and derives strategic recommendations for future research. It delineates a spectrum of recurrent epistemologies concerned with either system change, urban change or urban/system interactions, linked to an emphasis on urban metabolism, resilient communities and ecosystems, grassroots innovations or urban innovation systems. Moreover, seven key factors co-shaping urban transformations are recognized (agency, politics, capacity, policy, experiments, foresight and geography). To better exploit potential synergies between existing strands and address gaps in the light of imminent urban sustainability challenges, future urban transformation research should (1) Share a relational geographical perspective that connects the above epistemologies; (2) Identify and engage with the spatial-institutional challenges of urban transformations; (3) Move towards multi-system approaches linking various sectors and domains; and (4) Focus on transformative capacity and its agency components as an empowering lever for systemic urban change.

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Introduction

Over the past decade, various disciplines concerned with sustainable development have started to address the particular role of *cities* in this through adopting complex adaptive systems thinking. Based on the recognition that sustainability problems are typically 'wicked' and that 'simple' responses to them have so far rather aggravated than ameliorated their acuteness at all scales, this research draws on concepts of *system transformation* in order to develop new forms of analysis and intervention for urban change. A shared assumption in this is that the pluralistic and messy character of sustainability problems *by necessity* demands approaches that incorporate precisely these features, thus aiming to conform with the law of 'requisite variety' [1–4].

Two different types of system perspectives have so far informed the vast majority of research addressing cities and systemic change for sustainability: socio-technical system (STS) studies [5] and social-ecological system (SES) studies [6]. Each of these strands contributes a set of concepts, frameworks and models for *system* analysis and/or intervention that have been referred to urban development in particular ways [7]. They also purport assumptions about the conception of cities as systemic configurations, or the relationships between 'cities' and 'systems', that have led to focus on a selected range of questions and issues, while at the same time neglecting others. In so doing, 'urban transformations' and 'urban transitions' have quickly become widely shared normative catch phrases in science and policy that evoke (radical) change for urban sustainability—yet without much clarification of what is meant by them. Consequently, research on cities and systemic change for sustainability involves terminological variety, epistemological disjunctions and blind spots that lack both recognition and reflection in order to inform future strategies. Therefore, this paper reviews the current status in this emerging scientific field by responding to the following questions: (1) How are 'urban transformations' framed and analyzed?, (2) Which key factors are (therefore) identified to enable or constrain 'urban transformations'?, and (3) What are the resulting gaps and synergies that need to be addressed?

Methodology

A qualitative literature review has been carried out to identify pertinent contributions and map out their characteristics [cf. 8,9]. The corpus has been selected through

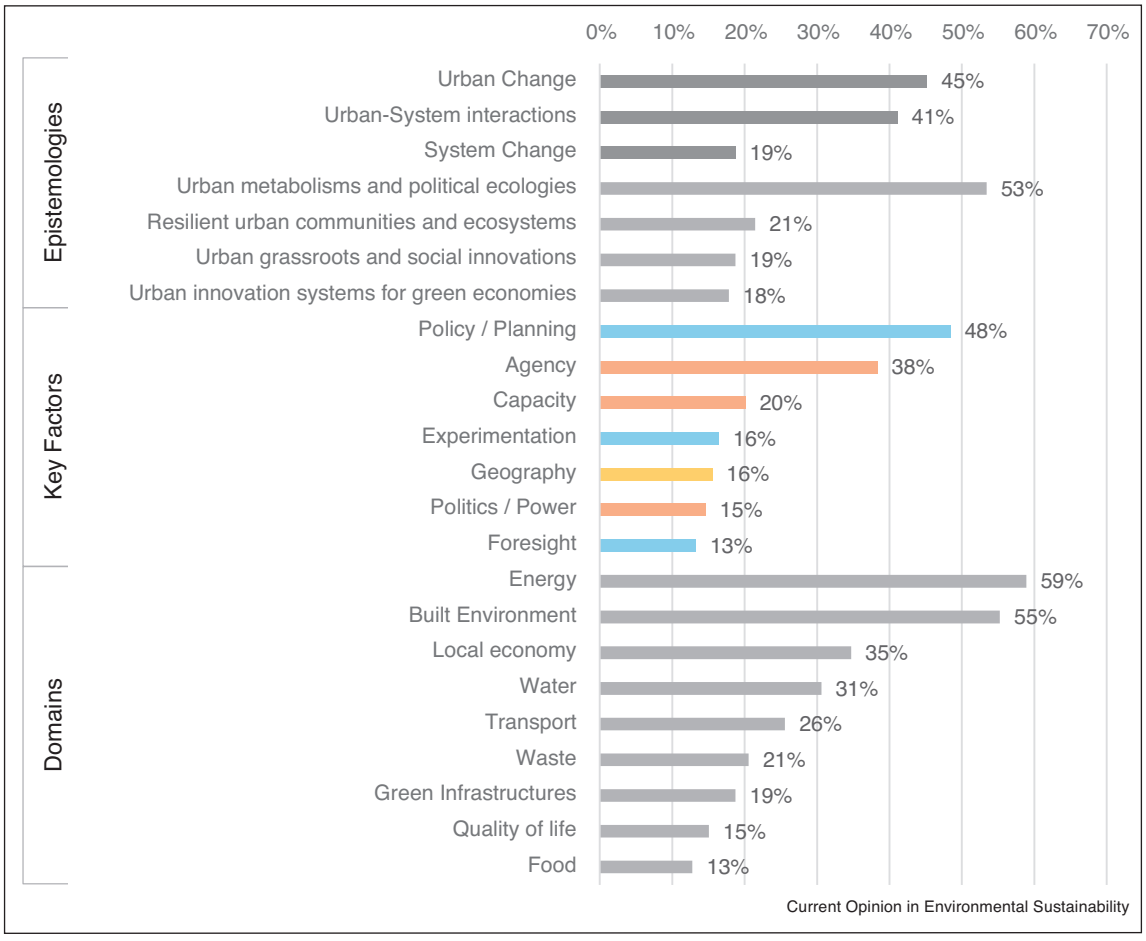
a keyword search in three scientific literature databases (Scopus, Web of Science, Google Scholar), covering publications until 2015. Boolean search terms were formed to capture an explicit concern for cities *and* systemic change, as well as sustainability ('system transition' OR 'system transformation' OR 'sustainability transition' OR 'sustainability transformation' AND urban; city; cities). This narrow filter has been necessary to effectively distinguish the field of interest here from the abundant literature on cities and sustainability, or on systemic change in general, while also tracing distinct notions of 'transition' versus 'transformation'—as discussed below.

Among all references identified, those that did not *conceptually* engage with the search terms and/or used them with a non-pertinent meaning were excluded. Additional sources have been included through reviewing the reference lists (backward analysis) and on the basis of the author's expertise, thus partly compensating for the narrow search terms. Finally, a total of 214 references have been retained for analysis (see Supplementary material Table 1). Focusing on the above questions, a bottom-up classification then resulted in 23 categories for differentiation (Figure 1). The search has been conducted without restriction of the time period, but did not identify contributions from before 2001. Thus, urban transformation research represents a still recent turn, presumably driven by growing local to global sustainability pressures, and embedded in the much wider debate on sustainability transformations that has gained momentum since the turn of the Millennium.

Urban transformations: main epistemologies

Although semantically 'transformation' indicates both the process *and* the outcome of attaining a different system configuration, while 'transition' refers only to the former, there is little reflection of this distinction in the literature yet. Regardless of the systemic ontology adopted, both terms are used indistinctively and appear to delineate particular epistemic communities rather than a substantive difference in meaning. While 'transition' continues to be the preferred term in STS studies, 'transformation' is adopted in more diverse fields, thus forming a boundary object that enables dialogue across a wider range of

Figure 1



Bottom-up classification of references and total incidence (including multiple attribution; n = 214).

disciplines [10]. In light of this quality, 'transformation' lends itself as a more open and encompassing concept. It also aligns well with an understanding of 'sustainable development' as both a normative goal and process, reflecting the open-endedness of sustainability. We therefore adopt 'urban transformation' as a suitable descriptor for the emergent interdisciplinary field explored here, acknowledging that the vast majority of research identified is explicitly sustainability-oriented. 'Urban transformation' thus refers to the process and the outcome of changing the systemic configuration of urban areas, and is mostly studied with a view to its sustainability performance or achievements.

A more important distinction between studies than terminology, however, appears to be the underlying *motive* for engaging with cities and systemic change for sustainability. We distinguish three perspectives for framing urban transformations, depending on whether the concern is for:

System change (i.e., new system configurations), recognizing an important role of/for cities in this—such as being 'seedbeds' [11], local/regional 'innovation systems' [12] or contested sites of implementation [13]. This forms a minority but increasing approach overall (18%) that partly tends to 'black-box' cities and their particular physical, cultural, institutional and governance characteristics [14]

Urban change (i.e., new urban structures and processes) that attributes a key role to certain system dynamics and develops (possible) responses to them. Almost half of the studies (45%) adopt this perspective, resulting in diverse propositions for local [15], trans-local [16] or multi-level approaches [17], but partly also risk to underpin localism [18];

Urban/System relations linking urban change and system reconfiguration as simultaneous and mutually dependent processes across levels and scales. This approach is shared by 42% of the studies and largely dominated by analyses [19••], but increasingly also suggests differentiated forms of intervention [20•,21•].

Taken individually, these three perspectives all reflect certain insufficiencies for addressing the complex subject of urban transformation. But *together* they form a rich epistemological spectrum that provides perfectly complementary insights—a potential that remains largely unexploited so far.

Within this spectrum, specific orientations are derived in particular from STS and SES studies, since most scholars (89%) focus on one of the following four issues: (1) *Urban metabolism and political ecologies* (53%), (2) *Resilient communities and ecosystems* (21%), (3) *Urban grassroots and social innovations* (19%) or (4) *Urban innovation systems for green economies* (18%). These four prevailing epistemologies confirm earlier review results [cf. 7] and combine with the above perspectives in characteristic ways (Figures 2a, b and 3):

System change is almost exclusively addressed by STS studies concerned with urban infrastructures [22], thus still reflecting the original focus on sectoral (national) STS and relative disregard of the role of *place*;

Urban change is also mainly addressed by STS studies regarding urban metabolism (energy, water, built environments, transport, waste) [23], but also with a view to the corresponding potential of grassroots initiatives [24] and urban innovation systems [25]. In addition it involves a significant share of SES-based studies [26•] dealing especially with green infrastructures.

Urban/System relations form an even stronger focus of STS studies, mainly linked to the political ecology of urban infrastructures and climate change [27], and to some extent also regarding the role of grassroots and urban innovation systems [28••], while SES studies explore panarchy and ecosystem service provision across scales and across geographies [29].

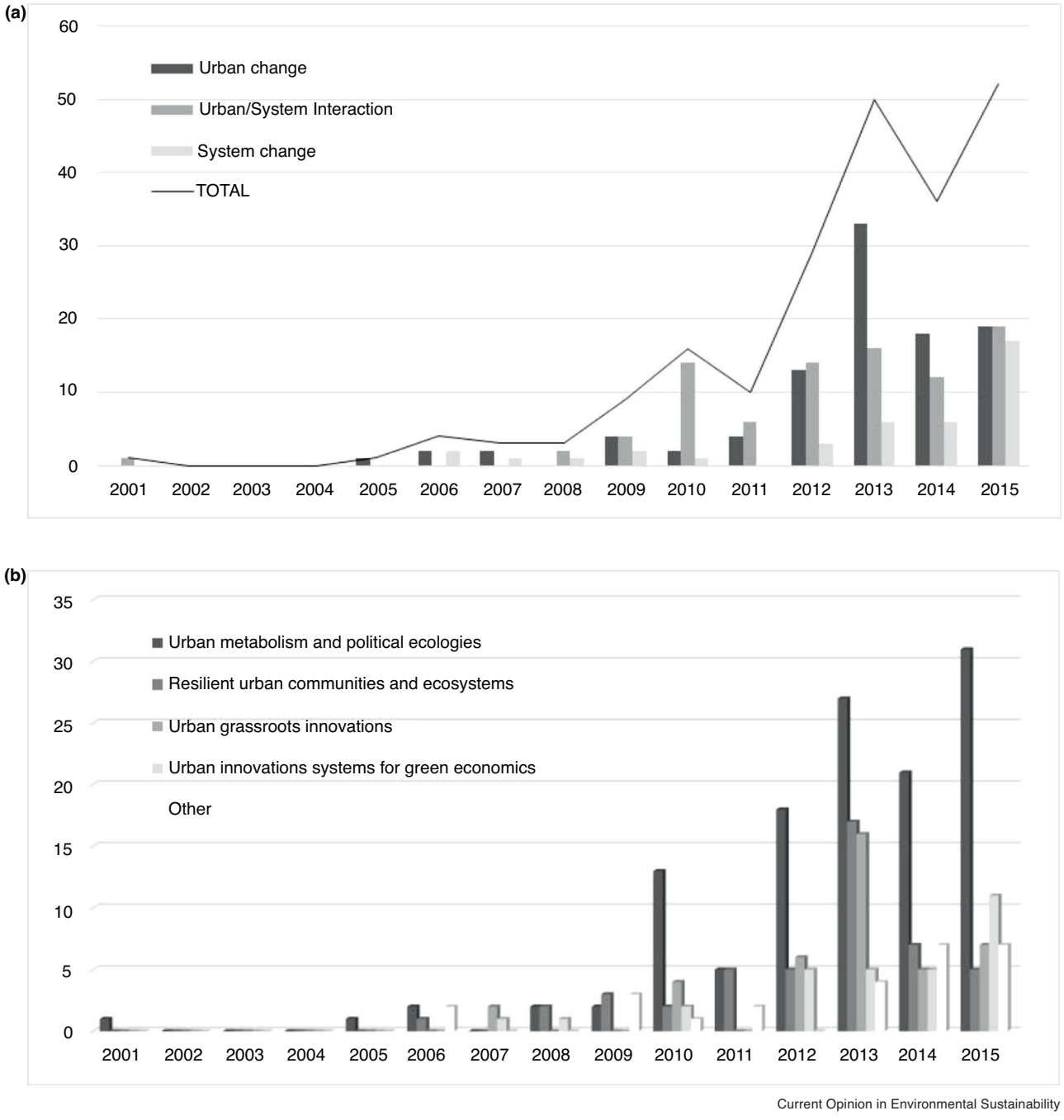
Over time, these epistemologies appear to form a stable spectrum that reflects a relative dominance of STS discourses linked to energy, water, transport and low carbon transitions. Nevertheless, a growing share of 'other' perspectives also indicates ongoing diversification of the field and increasing epistemological pluralism.

Urban transformations: enabling factors and constraints

Across epistemologies, attention is drawn to particular key factors co-shaping urban transformations. Given the common concern for dealing with complexity, uncertainty and emergence, there is an emphasis on forms of social interaction and collective decision making and their cognitive and normative implications. STS and SES theory both coincide in emphasizing the central importance of inclusive governance, intermediation, knowledge brokerage and social learning as basic conditions for effectuating systemic change towards sustainability [30]. Studies thus also frequently explore novel forms of intervention for purposefully navigating urban transformations.

In particular, we identify seven key factors that scholars from across strands recognize as enabling and/or constraining more sustainable urban transformations: A strong concern is shared for *policy and planning* (*1*) at various levels and scales, focusing on the design, and implementation of state action for urban/system change to assess its effects on the above conditions (e.g., planning paradigms, policy mobility) [31,32], but also for

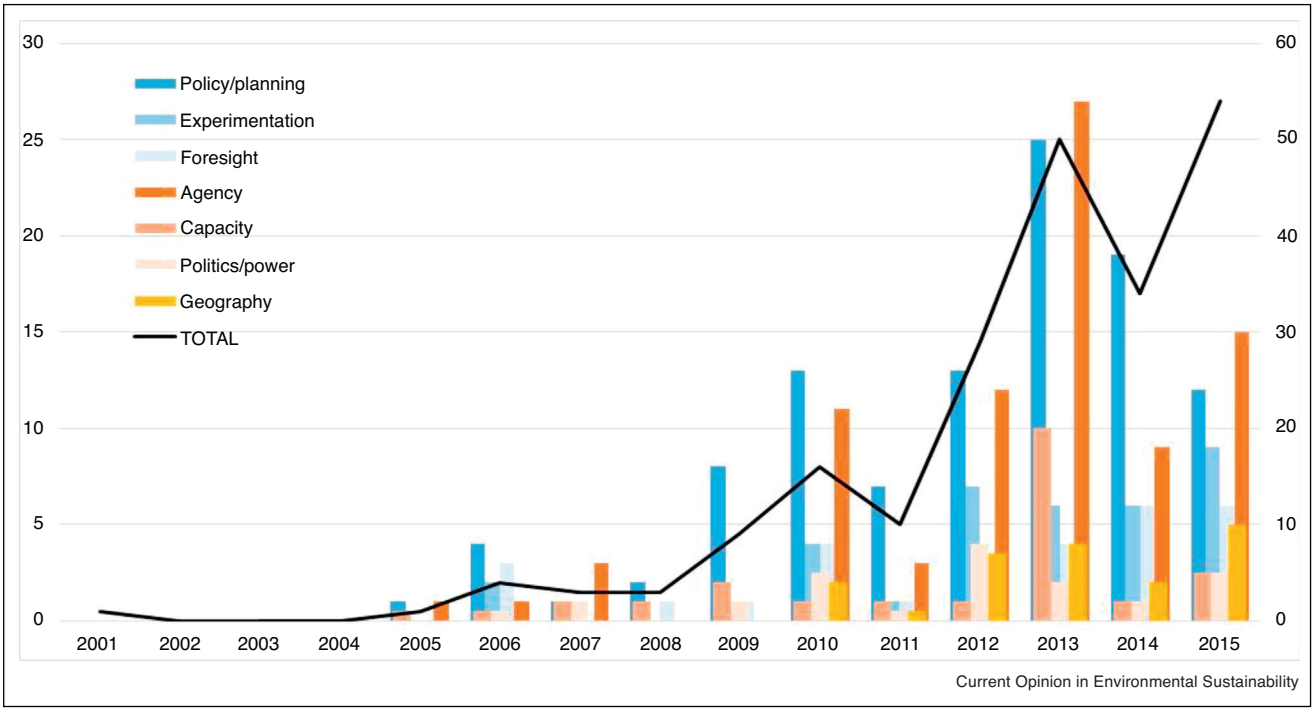
Figure 2



(a) and **(b)**: Evolution of urban transformation research—total no. of references per year and share of main epistemologies (includes multiple attributions; n = 214).

conceiving new approaches, techniques and tools (e.g., urban transition management, complexity mapping) [33,34]. Furthermore, processes of *experimentation* (*2*) i.e., innovative practices for co-developing and implementing more sustainable urban solutions are emphasized increasingly, empirically disclosing their ability to catalyze joint learning and to scale up and embed innovations, but also conceptually exploring place-based and governance experimentation as novel ways to steer transformative change (e.g., through urban living labs, networking grassroots initiatives) [35,36,37•,24,38]. Moreover, the specific characteristics of participatory *foresight*

Figure 3



Evolution of urban transformation research—total no. of references per year and share of key factors identified (includes multiple attributions; n = 214).

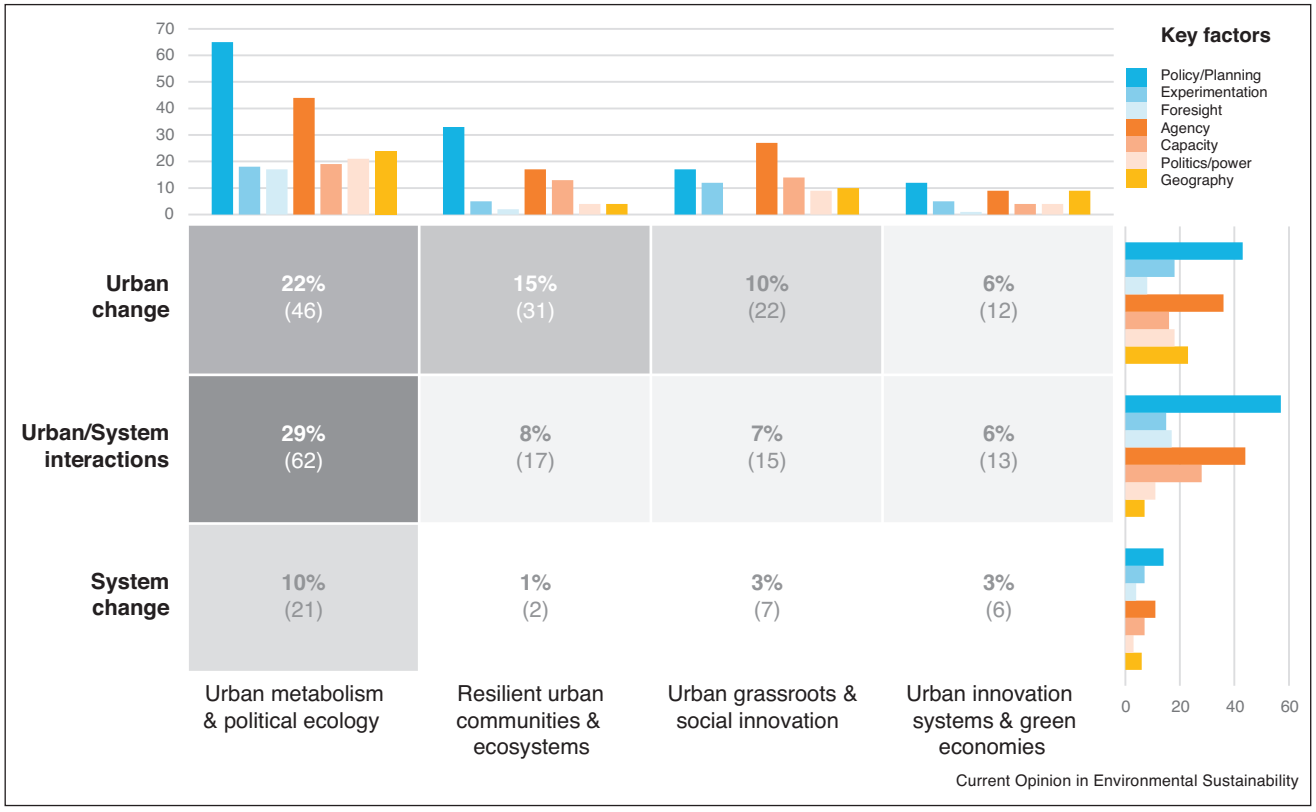
(*3*) processes and techniques and their role in developing shared system knowledge and sustainability visions among urban stakeholders are a frequent concern (e.g., backcasting, scenario planning) [39,40].

A principal contribution of urban transformation research resides in the depth of analyses regarding the forms of *agency* (*4*) involved, identifying the particular motives, discourses and coalitions of (embedded) actors engaging in urban and/or system change. This often foregrounds existing divides between different aspirations linked to 'urban transformation', conflicting orientations of urban policies, and the pivotal role of intermediaries, institutional entrepreneurs and/or polycentric leadership in enabling alliances [41,42••,43]. Thereby, two related issues are further substantiated: First, the emerging *politics* (*5*) of urban transformations and related experimentation become exposed. Although largely referring to STS, this has served to underline how novel frames, concepts and approaches are shaped by and reshaping actor positions, power relations and institutions [44,45]. Second, the systemic *capacity* (*6*) of stakeholders is highlighted by both STS and SES studies as a critical precondition and driver for transformative change. The concept of 'transformative capacity' thus accounts for the diverse forms of institutions, resources, skills and interactions required to effectively empower actors individually and collectively for effectuating systemic change [46,47]. Finally, the crucial influence of *geography* (*7*) on the patterns and dynamics of urban transformations has gradually received wider recognition since 2010 [48]. Besides providing genuine insights into the places, spatiality and multi-scalar embeddedness of systemic (re-) configurations, however, a perspective of *relational geography* [49,48••] apparently also offers a useful bridge between the epistemologies identified above as it views system- and urban change as necessarily intertwined, while encompassing both STS and SES. It equally suggests to examine the role of agency in transcending spatial-, sectoral- and/or system-boundaries, and thus to obtain a multi-perspective view of how urban transformations unfold across space and time (Figure 4).

Urban transformation research: future orientations

Regarding the above picture of current urban transformation research, there is a need to more consciously connect between the epistemologies and strands identified, as well as to address critical blind spots. In particular, research in this field does not (yet) engage with the complex challenges identified in key urban sustainability policy debates (e.g., Habitat III, EU New Urban Agenda, Basque Declaration)—such as the necessity to transcend sectoral action (energy, water, food, transport, etc.), to drive socio-cultural and socio-economic change, and to effectively connect between diverse spaces, places and

Figure 4



Mapping of epistemologies identified in urban transformation research (n = 214). For each column and row, the bar charts indicate the number of references addressing the seven key factors identified.

agents of change. In view of the disjunctions and gaps encountered in the literature, we therefore suggest that future urban transformation research should engage with the following four priorities:

1) Share a *relational perspective* that embraces all three epistemologies identified, thus more consistently exploring urban/system interdependencies across spatial scales, and incorporating deeper insights for both urban change and particular system change dynamics (e.g., linking building retrofitting and urban regeneration to energy- and water system transitions). Present complementarities between these perspectives should thus be exploited for synergies to better explain the ongoing mutual reconfiguration of urban places and systems, as well as the role of policy, planning and politics in this.
2) Address the *spatial-institutional challenges* faced by ongoing and accelerating urban transformations regarding e.g., urban/rural dependencies, metropolitan areas, cross-border urban development or urban teleconnections—issues so far figuring mainly in other literatures as they transcend particular STS or SES [50,51]. To unpack and question the territorial institutional settings that currently govern the systemic configuration of urban areas across multiple sectors, from municipalities to nation states represents a much needed focus. Foresight studies could offer valuable insights and orientations here, especially regarding the politics and power issues confronted.
3) Move from the prevailing concerns for single systems and urban metabolism (energy, water, waste, transport) towards *multi-system* or *nexus approaches* and explore system interaction dynamics (e.g. energy/transport), as well as vital cross-cutting domains such as *land use*, *urban form*, *biodiversity*, *food* or *health*—hardly addressed in urban transformation research to date. This demands an integrated account for urban infrastructures, built environs and ecosystems, and thus to bridge the divide between STS and SES. Yet, it is presumably through such multi-system transformations in cities that current forms of human needs fulfilment, local qualities of life and identities become tangibly reshaped, and that new constellations in urban politics emerge—motivating or deterring wider engagement of people in sustainability pathways [52];
4) Focus on *transformative capacity development* as a prerequisite and key driver of urban transformation, in particular with a view to its agency components (empowered communities, transformative leadership,

inclusive collective action, etc.) and their relations in urban areas and across scales [47]. A transformative capacity perspective can offer differentiated orientation concerning specific stakeholder needs and potentials, as well as regarding the use of sustainability foresight and practical experimentation, or (novel) institutional designs and governance modes to develop such capacity. As an action-oriented and empowering concept, it may thus help to identify requirements, design policies and devise purposive interventions to guide urban transformation.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cosust.2017.01.014.

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- •• of outstanding interest

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