The Role of Cities in Sustainability Transitions: New Perspectives for Science and Policy

Marc Wolfram

Abstract Sustainable development at a global and local scale heavily depends upon the pathways taken by cities in the near future. Within scientific research, this frequently identified "urban challenge" has been recognized and addressed increasingly in urban studies, as well as in transformation studies. However, while both fields clearly overlap and effectively complement each other in this regard, the respective epistemic communities have largely remained separate so far. Therefore, this paper elaborates on the core concepts and approaches that dominate the emerging scientific debate on the role of cities in sustainability transitions. Based on a methodic literature review, it delineates the progressive convergence of the diverse disciplines involved over four major research perspectives. It equally derives key conclusions for future research and policy, highlighting the urgent need to connect the four fields identified, to link socio-technical and social-ecological system (SES) perspectives, to conceive of holistic innovations for developing new planning approaches, and to fully embrace transdisciplinarity by practicing science in society.

Keywords Urban studies • Transformation studies • Sustainability • Epistemology • Transdisciplinarity

1 Introduction

For about a decade, a gradual convergence has taken place between the two interdisciplinary research fields of urban studies and transformation studies. While the former is dedicated to the understanding of cities and their development, the latter explores and explains profound societal and environmental change. With the steady growth of sustainability problems and under the pressure of complex challenges such as climate change and post-fossil energy supply, this convergence of the two research fields increasingly reflects what may turn out to be a necessary

M. Wolfram (✉)
Department of Urban Planning and Engineering, Yonsei University, Seoul, Korea
e-mail: m.wolfram@yonsei.ac.kr

E. Kim, B.H.S. Kim (eds.), *Quantitative Regional Economic and Environmental Analysis for Sustainability in Korea*, New Frontiers in Regional Science: Asian Perspectives 25, DOI 10.1007/978-981-10-0300-4_1

symbiosis: urban studies need to conceive of transformation dynamics, while transformation studies in turn require a better understanding of the role of cities. In order to underpin this basic hypothesis, the essential features of both research fields will first be briefly outlined.

1.1 Understanding Cities: Urban Studies

Constituted only by its shared subject – cities – the scientific field of "urban studies" is a highly interdisciplinary one with fuzzy edges. It comprises *all* scientific perspectives on cities, examining their condition and development across time and space. Thus, there has been a corresponding epistemological and methodological diversity from the outset, since the discursive construction of cities as a subject of science was driven by individual disciplines. This included not only a concern for analysis and interpretation but also for developing and implementing *new forms of intervention*, represented by the subfield of planning (cf. Fainstein and Campbell 2012; Harding and Blokland 2014). It is here that the evolving modes of urban governance and requirements for steering urban development have been discussed extensively (see, e.g., Healey 1992; Albrechts 2004; de Roo and Silva 2010).

Since the 1970s and informed by poststructuralist thinking, urban studies have gradually started to develop a more widely shared ontology, based on the perspective of *relational geography*. Cities became increasingly framed as local nodes within multiple overlapping social, economic, ecological, political, and physical networks, continuously *shaping* and *shaped by* flows of people, matter, and information across scales (Murdoch 2006; Davoudi and Strange 2009).

This poststructuralist shift acknowledged for the crucial role of places in (re) configuring "glocal" power relations and patterns of exploitation (Sassen 1991; Castells 2000; Brenner 2004). It has also been an important catalyst for a broader engagement with the normative concept of *sustainability*, following the 1992 Rio summit. Central epistemological axes in urban studies appeared to resonate particularly well with key tenets of sustainability that demanded holistic thinking and action, including the basic concern for human needs and justice ("inter-/intragenerational equity"); for social, ecological, and economic dynamics ("triple bottom line"); for power and institutions ("good governance"); as well as for place, communities, and culture ("Local Agenda 21") (UN SDSN 2013; Vojnovic 2014). Hence, a broad diversity of boundary disciplines, a relational understanding of space and place, and an orientation at intervention for sustainability are main characteristics of the field that have become important for a growing engagement with transformation studies.

1.2 Understanding System Change: Transformation Studies

Transformation studies are an equally interdisciplinary field, although a considerably smaller and younger one. Its emergence in the early 2000s has been strongly driven by sustainability concerns from the outset. Recognizing the *systemic* character of societal sustainability problems, its subjects are fundamental changes in human-environment (sub)systems that alter ways of thinking (cultures), organizing (structures), and doing (practices). Transitions are understood as coevolutionary processes through which *complex adaptive systems transform*, thus involving multiple actors and action domains. The field is demarcated by a range of conceptual frameworks that theorize on the particular dynamics of transformations, originating from different ontological and epistemological backgrounds (Gunderson and Holling 2002; Folke et al. 2010; Elzen et al. 2004; Markard et al. 2012).

One constitutive strand has been the historical study of large-scale socio-technical systems (STS), unpacking the path-dependent patterns that shape their creation and evolution (Bijker et al. 1987). This has given rise to the *multilevel perspective* (MLP), a heuristic framework that maps interactions between incumbent socio-technical configurations (regimes), alternative solutions in their infancy (niches), and developments in the system environment (landscape) (Geels 2002). Drawing on a variety of related science fields, new frameworks have been conceived to inform policy intervention for sustainability, each engaging progressively with the specificities of the local scale: *transformation management* (TM) builds on the enabling role of governance, foresight, experimentation, and learning in transition processes (Rotmans et al. 2001); *strategic niche management* (SNM) targets the formation, selection, and empowerment of promising niches (Kemp et al. 1998); and *technological innovation systems* (TIS) focus on understanding the actor constellations, institutions, and processes that help or hinder technology breakthrough and mainstreaming (Bergek et al. 2008).

A different constitutive strand forms the study of social-ecological system (SES) and their de- and restabilization, elaborating on the concept of *resilience* (Holling 1973). Similarly, these studies have recognized the need for governance innovations, foresight, knowledge transfers, and learning-by-doing across scales, increasingly linked to urban contexts (Ernstson et al. 2010). Therefore, transformation studies to date offer a range of perspectives on societal change that emphasize different system types (STS, SES), forms of agency, scales, and dynamics of change while reflecting a growing concern for cities as strategic hotspots.

2 Urban Transformation Studies: Epistemological Trajectories

Against this backdrop, the following sections trace the trajectories along which a convergence between the two research fields outlined above has taken place so far and identify common orientations for understanding and shaping urban

transformation. To this end, first their mutual engagement is briefly reviewed, highlighting epistemological, empirical, and methodological characteristics (Sect. 2). Next, four principal perspectives are identified that currently appear to dominate and structure the emergent field of urban transformation studies (Sect. 3). Building on these perspectives, conclusions are drawn regarding future requirements in research, policy, and practice (Sect. 4).

The corpus for the literature review has been identified on the basis of a keyword search (Scopus, Web of Science, Google Scholar), concluded in November 2014. Search terms were formed combining core terminology from both fields ("system transition," "system transformation," urban, city, region, space, spatial, place, scale). Pertinent references were selected by reviewing abstracts and conclusions, thereby excluding divergent understandings (e.g., "urban transition" as *urbanization*). Further relevant sources have then been identified successively through the reference lists included, finally retaining a total of 115 references for analysis (93 journal articles, 18 books, 4 book chapters). These have each been reviewed independently by at least two different researchers to specify five basic characteristics: (1) normative position (sustainability), (2) interdisciplinarity, (3) main concepts and theories used, (4) methodology, and (5) empirical sources. On this basis, further subcategories could be established for the second and third review, thus creating a more differentiated typology from the bottom up (Table 1).

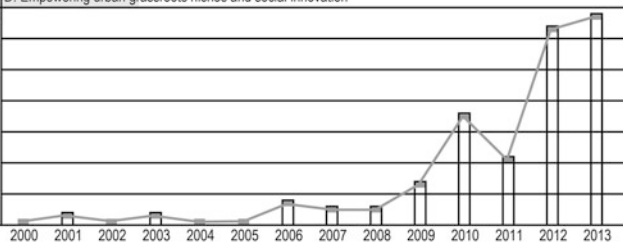
2.1 Transformation Studies and the City

The epistemological concern of transformation studies for system dynamics has increasingly also triggered research dealing with the role of cities. Most references analyzed adopt system transformation theory frameworks and concepts as a heuristic to explore patterns and dynamics of urban change. But also a normative use to develop new forms and methods for steering and intervention is frequent, given the orientation at sustainability.

The most widely used conceptual frame is the "multilevel perspective" (MLP), followed by "transition management" (TM), "resilience," and "innovation systems" (Table 1). "Coevolution" and "social innovation" concepts are hardly employed independently from these (Roggema et al. 2012; see, e.g., Mader 2013), with the combination between "social innovation" and "strategic niche management" (SNM) forming a more persevering pattern. Also, very few researchers draw on both the MLP *and* "resilience" (see, e.g., Newton 2008; McCormick et al. 2013), which reflects a clear divide between the respective epistemic communities rooted in either STS or SES scholarship. Thus, apart from the prevailing use of the MLP, two related trajectories are informed by TM or SNM/"social innovation" and two more independent ones build on "innovation systems" or "resilience" theory.

The *MLP* maps out how niche-regime interactions affect the creation and unfolding of pathways for socio-technical transitions that lead to new system configurations. By adopting the MLP, new basic questions have thus been raised

Table 1 Bottom-up categorization of references and total incidence ($n = 115$)

Category	Subcategory	No.	%
Normative	Sustainability	100	87%
Interdisciplinarity	Urban transformation studies (integrated approaches)	31	27%
	Transformation theory in urban studies	31	27%
	Urban subjects in transformation theory	20	17%
	Urban theory in transformation studies	19	17%
	Transformation subjects in urban theory	14	12%
Urban theory/concepts	Urban Governance [1)]	75	65%
	Urban Planning (incl. regional planning)	65	57%
	Urban Geography (incl. economic and political geography)	40	35%
	Urban Ecology (incl. political and industrial ecology)	31	27%
	Urban Sociology [2)]	18	16%
	Urban Design (incl. architecture, building engineering)	15	13%
	Other (urban theory) [3)]	14	12%
Transformation theory/concepts	Multi-Level Perspective (MLP)	52	45%
	Transition Management (TM)	36	31%
	SES resilience [4)]	27	23%
	Co-evolution	21	18%
	Innovation Systems (incl. regional-, local- and technological-)	20	17%
	Social innovation (incl. social practice theory, social movement theory)	19	17%
	Other (transition theory) [5)]	11	10%
	Strategic Niche Management (SNM)	7	6%
Methods	Deduction / Hermeneutics	82	71%
	Case study	75	65%
	Transdisciplinarity	7	6%
	Data mining	5	4%
	Modelling	2	2%
Empiricism	City	78	68%
	Region	49	43%
	Building / neighborhood	33	29%
	National	19	17%
	Networks (of cities or initiatives)	13	11%
	Practice	88	77%
	Policy	62	54%
	None	13	11%
Epistemology	A: Transforming urban metabolisms and political ecologies	58	50%
	B: Configuring urban innovation systems for green economies	36	31%
	C: Building adaptive urban communities and ecosystems	29	25%
	D: Empowering urban grassroots niches and social innovation	25	22%
TOTAL		35	p.a.

1) Incl. multi-level governance, neo-institutionalism, regulation theory, discourse theory.
2) Incl. organization and knowledge sociology, anthropology, culture theory.
3) Incl. policy analysis, economics, information society studies, transport studies, rural studies, environmental justice.
4) Incl. adaptive and transformative capacity, adaptive renewal cycle, panarchy.
5) Incl. actor network theory, sustainability assessment, market transformation, complexity theory, spatial transition, sustainable consumption and production, ecological restructuring, social construction of technology.

for urban policy and planning that address the role of cities as purposeful *actors* in socio-technical transitions and their possible influence on (national) regime transformation and/or as *seedbeds* for local innovation niches (Geels 2011; Raven et al. 2012), especially with a view to urban infrastructures (Bulkeley et al. 2011). But also cities themselves have been interpreted as *urban regimes*, configured through strategic work by incumbent urban actors (Quitzau et al. 2013). However, the MLP has only rarely served to directly derive new approaches for urban policy and planning that address niche-regime constellations (see, e.g., de Graaf and van der Brugge 2010), but mostly required a combination with other transformation and/or urban theory to meaningfully address intervention options (cf. Burch et al. 2014).

Here, especially *TM* has been helpful as a heuristic to examine the characteristics of urban governance and planning processes. Based on its postulations concerning actor types (frontrunners, border crossers, incumbents), interaction forms (transition arena), and activities (orientating, agenda setting, activating, reflecting) (Rotmans 2006; Loorbach and Rotmans 2010), TM has been largely employed for empirical assessment and/or development of urban policy guidance. Focused on single domains such as water management (Brown et al. 2013) or information infrastructures (Wolfram and Vogel 2012), or regarding broader development strategies such as waterfront regeneration (Frantzeskaki et al. 2013), this has provided deeper insights concerning the role of agency and leadership, as well as pilots and experiments for enabling transformative governance and social learning in urban contexts. It has equally informed the conception of action research in "urban transition labs," i.e., transdisciplinary interaction spaces that complement existing governance arenas (Nevens et al. 2012). Moreover, the specific design of foresight processes within TM has generated suggestions for modifying urban planning methods (Wiek et al. 2003; Eames and Egmose 2011).

Other studies have invoked *SNM* as a conceptual reference in order to "zoom in" on the requirements of local niches and their relations to socio-technical regimes. While this has largely confirmed the importance of general success factors identified in the SNM literature such as shared stakeholder expectations, enabling actor networks and experiential learning (Bai et al. 2010; Schreuer et al. 2010), it has also illustrated the need for a better understanding of locally *embedded* niches. Some scholars have therefore linked SNM with social innovation theories in order to also trace the implications of practical know-how, physical activities, and cultural meanings for the transformative impact of community initiatives and "grassroots niches" (Davies 2012; Seyfang and Haxeltine 2012; Smith and Seyfang 2013) – yet often without a clear differentiation of their urban and spatial contexts. By contrast, others have strongly underlined the need to acknowledge for the *place-specific* constitution of niches and related options for strategic urban planning (Quitzau et al. 2012) or a less antagonistic but more relational understanding of locally shaped niche-regime configurations (Maassen 2012). Furthermore, the focus on urban niches has also led to recognize the necessity to develop new approaches to public participation in urban planning with a view to enable civil society and private sector actors to effectively contribute to urban transformations (Aylett 2013).

A different direction has been pursued by those drawing on (technological) *innovation systems* studies and their concern for the institutions and actor networks that shape the creation, adoption, and diffusion of new technologies (cf. Hekkert and Negro 2009). As recognized by earlier approaches to managing the transformation of local socioeconomic systems (Wiek et al. 2003), embedded actor strategies and institutional structures can become vital factors for the breakthrough of "green" technologies, industries, and markets (Coenen et al. 2012). Empirical studies illustrate this for specific technologies (Carvalho et al. 2012; Dewald and Truffer 2012) or clusters of eco-innovation (Cooke 2010; Cooke 2011; Lahlou 2011; McCauley and Stephens 2012) while simultaneously highlighting the multilevel character of the processes observed. This underlines the unique position of cities as the places that connect consumers, producers, and policy, shaping global consumption patterns through urban lifestyles (Reusswig 2010).

Last but not least, *resilience theory* has generated another rich strand of research addressing urban sustainability transitions, yet starting from an understanding of cities as social-ecological systems to identify vulnerabilities, unsustainable performances, and dynamics of change. Based on the adaptive renewal cycle and the concept of panarchy, there is a very similar concern for governance innovations, experimentation, and social learning (Ernstson et al. 2010; Folke et al. 2010). This is reflected in a comparable spectrum of research interests with a view to interpret overall urban transformation dynamics and identify options for steering (Pincetl 2012; Wilson 2012; Pickett et al. 2013; Cole et al. 2013), develop orientation and practical guidance for urban planning and design (Desouza and Flanery 2013; Jabareen 2013; Lu and Stead 2013) and related foresight (Van der Voorn 2012), and explain the emergence and impact of local innovations (Boyd and Ghosh 2013), as well as related lifestyle changes (Peters et al. 2012).

2.2 Urban Studies and Transformative Change

Inversely, a number of researchers have used urban theory to explore the role of cities and regions in relation to transformations thus engaging critically with concepts from both STS studies and resilience theory. This has allowed to not only substantiate a call for better recognizing the crucial role of space in mainstream conceptions of socio-technical transitions. More importantly, it has enabled a differentiated account for the specific dynamics resulting for and from cities with a view to sustainability transitions. Four main strands need to be distinguished here by the nature of their concerns and the theoretical references used, respectively rooted in *economic geography*, *political ecology*, *sociology and anthropology*, or *planning studies*.

Research informed by *economic geography* has been particularly instrumental to acknowledge for the spatial implications of transitions and to also provide adequate concepts to capture these. Following earlier calls for a "geography of sustainability transitions" (Smith et al. 2010), the endeavor has here been to foreground the role of

place and scale in transitions, thereby enhancing the utility of the MLP. Drawing on relational geography, regime and niche actors have thus been framed within cross-scale spatial and institutional contexts that produce enabling and constraining effects for socio-technical transitions in terms of identity, legitimacy, actor coalitions, and resources. Consequently, the impacts of embeddedness and territorial power relations on creating multi-scalar trajectories and patterns of uneven distribution have been disclosed (Coenen et al. 2012; Truffer and Coenen 2012), especially looking at energy systems (Essletzbichler 2012; Bridge et al. 2013). Regarding cities, this has served to illustrate their ambivalent role in shaping transitions both as places of innovation and as a local manifestation of multi-scalar socio-technical regimes.

A second central motive for using urban theory in transformation studies has been the *political ecology* of resource flows underpinning urban development. Through the lens of urban governance and regime theory, new insights have been obtained into the ongoing reconfiguration of the networked infrastructures that mediate those flows (Guy et al. 2001; Monstadt 2009). Focused on the public and private key stakeholders, their interactions, and the institutional shifts they create, this perspective has illustrated the multilevel and multi-sectoral character of urban socio-technical change (Späth and Rohracher 2012; Uyarra and Gee 2012; Burch et al. 2013), but also the crucial role of strategic local planning processes and new intermediaries (Truffer et al. 2010; Hodson and Marvin 2010; Guy et al. 2011; Bulkeley et al. 2011, 2012; Hamann and April 2012). It has equally underlined how urban experiments and civil society participation contribute to articulate new system configurations in concrete settings (Castán Broto and Bulkeley 2013; Rydin et al. 2013). In order to orient transitions toward sustainability and avoid new elitist forms of steering (Khan 2013), different new requirements have been identified for urban governance and planning (Domènech and Saurí 2010; Young 2010; Scerri and Holden 2013). Especially participatory foresight and novel forms of intermediation turn out to be critical elements in transition processes grounded in urban contexts with a view to their contribution to create shared visions, operational capacity to act, and opportunities for social learning (Späth and Rohracher 2010; Hodson et al. 2013).

Third, increasing attention has been paid to the influence of social practices, communities, and grassroots initiatives on socio-technical transitions, drawing on *sociology and anthropology*. While recognizing the steering attempts of urban regime actors, this perspective acknowledges especially for the time- and space-specific constituents of everyday practices as equally basic conditions for system innovations (Shove and Walker 2010). Hence, differences between places in terms of discourses, cultural frames, and identity result to be critical factors for transformative governance that require attention through foresight, community participation, and empowerment approaches (Mulugetta et al. 2010; Cooke and Rehfeld 2011; Marsden 2012; Späth 2012). The case of the UK Transition Town movement and its diffusion has received much attention from this perspective, giving rise to critical questions regarding transition visions, politics, and culture (Brown et al. 2012; Mason and Whitehead 2012; Neal 2013). These studies clearly recognize that

cities provide far better opportunities for scaling up the impacts of grassroots initiatives than the villages and small towns that currently prevail in this particular movement. Especially the capacity to empower communities and to draw on translocal and cross-scale networks appears to be a crucial asset of cities (Taylor 2012; North and Longhurst 2013).

Finally, *planning studies* have increasingly turned toward urban transformations as well, both conceptually and empirically. Starting from earlier engagements with complexity theory and its lessons for planning in terms of handling uncertainty, thresholds, and emergence (Innes and Booher 1999; de Roo and Silva 2010), requirements for planning processes to explicitly address transitions have gradually become further specified. This has underlined the pertinence of the theoretical debates on collaborative, adaptive, and/or strategic urban planning, especially regarding their emphasis on participation, knowledge co-creation, long-term foresight, experimentation, and flexibility (Healey 2007; Truffer et al. 2010; Rauws and de Roo 2011). While some authors have sought to substantiate their conceptual considerations through the strategies and measures recognized in current planning practice (Portney 2009; Hagelskjær Lauridsen and Stissing Jensen 2013), others have discussed conceptual ambiguities when applying transformation theory to cities. This concerns especially the constitution of cities out of multiple coalescing subsystems, both socio-technical and social-ecological, that require to conceive of "multi-regimes" and to develop different strategies for managing place-based niches in a highly inert built environment (Næss and Vogel 2012; Quitzau et al. 2012).

2.3 Methods, Empiricism, and Transdisciplinarity

Regarding the research designs used across all references analyzed, it is first of all the high proportion (1/3) of purely deductive and/or hermeneutic approaches that calls the attention, apparently reflecting lively and ongoing theory development in this field. The empirical work is almost exclusively based on qualitative case studies, with only a few methodological exceptions (surveys, modeling, data mining). Although the majority of these case studies focus on the scale of the city, there are also a number of cross-scale studies that address either relations between the urban/regional and urban/national scales or relations within cities and their subscales of districts, blocks, or buildings. To speak of "urban" transformations is therefore by no means an attempt of spatial delimitation, but rather a necessary focus in the perspective of relational geography, which recognizes the particular importance of cities.

However, there are a number of significant empirical gaps emerging. The case studies invariably deal with *individual* cities – comparative research dealing with several cities has hardly been undertaken, although this would be particularly informative (esp. if realized within the same nation-state to control context variables). Also studies on translocal relations of cities and the role of city networks

have been rare so far. Moreover, regarding the geographical location of the cities studied, the empirical basis appears to be largely concentrated in Western Europe, thus (implicitly) assuming specific political, cultural, and socioeconomic conditions. Likewise, despite all interdisciplinarity, there is still a lack of genuine contributions from key fields in urban studies such as planning, engineering, political science, economics, or sociology. These disciplines could however contribute to examine important facets of urban transformations in more depth (or have already done so – yet without invoking transformation theory).

Above all, the proportion of *transdisciplinary* research – i.e., interdisciplinary studies defined and realized together by science and society stakeholders – is surprisingly low. Although the crucial importance of transdisciplinarity for collective knowledge production and learning processes in transitions has been repeatedly emphasized and illustrated (Wiek et al. 2006; Scholz 2011; Mieg and Töpfer 2013; North 2013), and although the urban context provides ideal conditions for transdisciplinary research, practical implementation falls short of meeting this requirement. The case of an international "network for sustainable urban development" recently formed by research institutes and cities represents a pioneering exception here (Childers et al. 2014), but also points to the continued lack of adequate concern in mainstream policy and research.

3 Mapping Perspectives on Urban Transformations

Drawing on the trajectories outlined above, this section provides a more foresighted reading of the references analyzed with a view to inform a future agenda for research, policy, and practice. It highlights four research perspectives that have so far dominated the debate and are therefore also well substantiated both empirically and conceptually. These perspectives are characterized by their emphasis on *distinct drivers of change* (cf. McCormick et al. 2013; Mieg 2013) and their role in shaping urban transformations which implies a particular epistemology (questions, subject, theory, methods). By focusing on a consistent combination of drivers in terms of *agency* (public sector, civil society, private sector) and *system dynamics* (social, economic, ecologic), each perspective thus anticipates a distinctive *urban transformation pathway*, identifying pertinent action domains, stakeholders, and interactions that in turn require corresponding forms of intervention. Without claiming comprehensive coverage or unique attribution of references, the following four salient research perspectives and related pathways have been identified.

3.1 Transforming Urban Metabolisms and Political Ecologies

This perspective highlights the strategic responses that powerful urban actors create to the challenge of a shifting political ecology and economy of cities in times of global resource scarcity and climate change. It recognizes that especially local governments and major infrastructure and technology providers increasingly engage in novel forms of place-specific interaction and socio-technical experimentation concerning urban energy, water, waste, or transport. To secure long-term access to vital resources for continued economic growth and safeguarding local assets and living standards, these actors form new alliances that aim to significantly reduce a city's carbon and ecological footprints. New technologies, services, and usages are therefore trialed in urban settings, involving various stakeholders – from industry to NGOs and citizens. Studies adopting this perspective are also wary of scalar relations and multilevel interactions in this, with a view to state institutions, resource markets, or (inter)national companies, and often account for the role of intermediaries and their capability to facilitate change by supporting new visions, discourses, networks, and coalitions. Particular attention is paid here to emerging deficits in terms of legitimacy, accountability, and openness. Hence, this research strongly focuses on STS that condition the urban metabolism and its changing (multilevel) governance. Drawing on the MLP, cities represent complex socio-technical *niches* that can challenge large-scale resource regimes, but also place-based *urban regimes* for small-scale experiments. Together, the forms of agency involved in both constellations are deemed to enable or constrain wider sustainability transition dynamics. This also suggests particular forms of intervention, like strategic networking, intermediation, and/or participatory foresight in order to influence or counterbalance the direction and speed of these processes.

3.2 Configuring Urban Innovation Systems for Green Economies

While the central motif of the key actors in this perspective is similar to the previous one (i.e., adjustment to global environmental change in order to stay competitive), "transitions" primarily concern production and consumption patterns here, not (only) infrastructures. Yet, cities are equally vital for this: the focus is on private companies, consumers, and markets for high-/low-carbon products and the place-specific requirements, strategies, and networks for "greening" the related parts of the economy. Actor constellations are recognized that bring together government agencies, industry, SMEs, and academic institutions, jointly initiating and driving innovation processes that improve their competitiveness, while also contributing to reduce the resource intensity of certain products and services. In this, knowledge transfers and innovation activities are conditioned by the formal and informal

networks among these actors and the associated formation of shared value systems and cooperation cultures. However, issues of legitimacy or accountability are not necessarily a particular concern here. In this perspective, change for sustainability thus takes place through innovation systems for selected markets and socio-technical practices anchored in cities. This points toward a proactive pursuit of local "public-private-research" cooperations facilitated through certain types of intermediaries (e.g., economic promotion agencies, cluster managers), as well as specific forms of experimentation and open innovation (e.g., Living Labs).

3.3 Building Adaptive Communities and Ecosystems

Climate change, resource scarcity, and biodiversity loss form the combined drivers in this perspective, yet especially with a view to the resulting vulnerabilities of cities. Diverse urban stakeholders respond to this challenge, aiming to create a dynamic social-ecological system balance while controlling the local impacts of global environmental change. System relations and contexts considered are thus defined essentially through ecosystem services. Therefore, water supply and catchment areas, building material imports and exports, food provision and agriculture, or green infrastructures and their different functions (carbon sink, water resorption, species protection, shading, recreational space, etc.) are important starting points for future pathways. In this, also a broad variety of locations and typologies needs to be considered (e.g., for green infrastructures: riverbanks, parks, gardens, brownfields, roofs, facades, streets, squares). Correspondingly, the social-ecological interactions and actor constellations are rather diverse but highly inclusive, ranging from the vegetable garden at the scale of the block to material recycling and urban mining in metropolitan areas. Pertinent communities may thus include citizens (as dwellers, owners, users) and civil society groups (local), government agencies as well as private companies, and research institutions. New system configurations can be enabled through fostering self-organization capabilities and creating diverse and redundant solutions. Thus, participation, knowledge, co-production, learning by doing, and adaptive governance become necessary cornerstones of urban policy making and planning.

3.4 Empowering and Harnessing Urban Grassroots Niches

In this perspective, change for sustainability is driven by heterogeneous approaches and initiatives of civil society actors in cities. Global environmental change plays an equally crucial role, but responses are rather justified ethically and also need to be seen in relation to other individual and group-specific needs (e.g., employment, housing, mobility) and motives (e.g., identity, self-achievement, recognition, cohesion, solidarity). Correspondingly, there is a wide range of activity fields addressed,

including food, education, health, and also green space or renewable energy. This implies that characteristics of urban structure and design such as density, typology, functional mix, and accessibility are of considerable importance since they have a direct or indirect bearing upon stakeholders' means and ends. On the other hand, this interweaving with the built environment also conditions an integrated handling of socio-technical and social-ecological problem dimensions (e.g., as in street rehabilitation or residential- and roof gardens). The focus is on the ability and opportunity of the respective initiatives to promote and scale their innovative practices, both through replication and through translation into policies and regulation, or new markets. The transformative potential of such urban niches is seen to depend on the local institutional cultures and practices, but also translocal relations (peer to peer). Cities may thus appear as innovation incubators, actively empowering and promoting grassroots initiatives and networks, or as regimes that offer structural resistance, and most likely are both at once.

4 Conclusions and Outlook

Based on a methodic literature review, this chapter has discussed why and how the two interdisciplinary fields of urban studies and transformation studies are converging toward research into the urban dimension of complex system changes for sustainability. It has described the emergence of a certain range of epistemological trajectories that have required and fostered an increasing interconnection between both fields. These underline the need to conceive of and study *urban sustainability transformations* with a view to both the characteristic immediacy, imbrication, and variety of innovation dynamics in cities and their strong implications for global (un) sustainability on a fast urbanizing planet. However, it has also recognized a predominant orientation of research at four salient pathways and the corresponding combinations of agency and system dynamics. Based on these findings, and considering earlier roadmap suggestions for transition studies (STRN 2010), future action in science, policy, and practice dealing with urban sustainability transformations would strongly benefit from addressing the limitations and gaps of the pattern identified. Hence, the following issues should inform a shared future agenda in order to move from convergence to synergy and to focus limited resources on high-impact challenges:

1. Studies that have engaged with urban transformations have so far largely drawn on *selected* theoretical constructs to conceive of and explain change. This necessarily implied a more fragmented account for the urban and its role in transformations. While these perspectives remain valid and useful, much could be gained from conceptualizing and exploring interdependencies between the different change dynamics they address, without aspiring to create a "great unified theory." For this, relational geography and (multilevel) governance theory provide shared frameworks that enable a crossover, including between

the various underlying ontologies (cf. Geels 2010). Such a multifaceted theoretical framework could help to create a more adequate understanding of how "places produce transitions and transitions produce places" (STRN 2010, 18). Particular attention should then be paid to emerging synergies and conflicts between pathways and their respective drivers, between orientations at resilience or transformation (cf. Smith and Stirling 2010), and between phasing out *old* and building up *new* regimes (Loorbach 2014). It would equally allow to identify *new tipping points* that effectively couple various innovation dynamics.

2. Knitting the above theoretical framework necessarily entails a shift in terms of the subjects and questions dealt with. As recognized by various authors, looking at cities requires to acknowledge for "multi-regime" configurations that interconnect various STS. However, cities can equally be depicted as a set of coalescing SES that govern diverse stocks, flows, and ecosystem services. Therefore, it becomes crucial to empirically explore how institutions, discourses, actor constellations, and practices avoid or embrace this "hybrid" reality of cities as *social-ecological-technological systems* (SETS) (cf. McGinnis and Ostrom 2014) – and with what implications for transformations. More emphasis needs to be put on the role of *urban place* as a key entity in this, since it is through particular physical landscapes, built environments, identities, and sociocultural practices that such hybrid configurations become manifest in cities. Across the spectrum of epistemological trajectories identified, this raises new questions about how multiple transformation dynamics play out in different places, accounting for their local constitution, as well as translocal and scalar relations.
3. Having recognized the critical role all pathways attribute to agency, leadership, and intermediation, particular efforts need to be undertaken with a view to develop suitable urban approaches for intervention to help initiate, accelerate, and navigate sustainability transformations. Transition management and its local adaptations provide only first orientations here. In addition, capacity building and civil society empowerment form equally important approaches, especially considering the diversity of context conditions and starting points of cities from across the globe. Most importantly, the gap toward urban planning and policy making must be closed in theory and practice. Instruments and techniques applied in this domain (e.g., strategic planning, SEA, foresight, community participation, urban regeneration) offer considerable potential regarding their integrative, governance, and experimental functions, but would require more tailored modifications. Therefore, transcending the available approaches to develop new forms of transdisciplinary "up-down" governance, intermediation, and institutional entrepreneurship in cities is a necessity that would also help in facing the legitimacy challenge of transformation-oriented intervention.
4. The current empirical basis and range of research methods require strategic extensions in various directions. Identifying lessons and patterns regarding the multitude of individual case studies carried out so far seems an immediate requisite. Correspondingly, more emphasis needs to be put on *comparative research*, including both qualitative case study and quantitative analysis of

larger urban data sets, while also looking at failed or locked-in transition pathways. This should be included to widen and balance the empirical basis toward the global South and East, enabling an exploration of the influence of key context variables, but also interconnections between cities and/or regions. Last but not least, the role of transdisciplinarity needs to be strengthened substantially, using especially research policy and programs as a lever to codevelop and mainstream (new) methods for targeted urban interaction between science and society.

References

Albrechts, L. 2004. Strategic (spatial) planning reexamined. *Environment and Planning B: Planning and Design* 31: 743–758. doi:10.1068/b3065.

Aylett, A. 2013. Networked urban climate governance: Neighborhood-scale residential solar energy systems and the example of Solarize Portland. *Environment and Planning C: Government and Policy* 31: 858–875. doi:10.1068/c11304.

Bai, X., B. Roberts, and J. Chen. 2010. Urban sustainability experiments in Asia: Patterns and pathways. *Environmental Science & Policy* 13: 312–325. doi:10.1016/j.envsci.2010.03.011.

Bergek A., Jacobsson S., Carlsson B., et al. 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy 37:407–429. doi: 10.1016/j.respol.2007.12.003.

Bijker, W., T.P. Hughes, and T. Pinch (eds.). 1987. *The social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, MA: MIT Press.

Boyd, E., and A. Ghosh. 2013. Innovations for enabling urban climate governance: Evidence from Mumbai. *Environment and Planning C: Government and Policy* 31: 926–945. doi:10.1068/c12172.

Brenner, N. 2004. *New state spaces: Urban governance and the rescaling of statehood*. Oxford: Oxford University Press.

Bridge, G., S. Bouzarovski, M. Bradshaw, and N. Eyre. 2013. Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy* 53: 331–340. doi:10.1016/j.enpol.2012.10.066.

Brown, G., P. Kraftl, J. Pickerill, and C. Upton. 2012. Holding the future together: Towards a theorisation of the spaces and times of transition. *Environment and Planning A* 44: 1607–1623. doi:10.1068/a44608.

Brown, R.R., M.A. Farrelly, and D.A. Loorbach. 2013. Actors working the institutions in sustainability transitions: The case of Melbourne's stormwater management. *Global Environmental Change* 23(4): 701–718. doi:10.1016/j.gloenvcha.2013.02.013.

Bulkeley, H., V. Castán Broto, M. Hodson, and S. Marvin (eds.). 2011. *Cities and low carbon transitions*. New York: Routledge.

Bulkeley, H., V. Castán Broto, and G. Edwards. 2012. Bringing climate change to the city: Towards low carbon urbanism? *Local Environment* 17: 545–551. doi:10.1080/13549839.2012.681464.

Burch, S., H. Schroeder, S. Rayner, and J. Wilson. 2013. Novel multisector networks and entrepreneurship: The role of small businesses in the multilevel governance of climate change. *Environment and Planning C: Government and Policy* 31: 822–840. doi:10.1068/c1206.

Burch, S., A. Shaw, A. Dale, and J. Robinson. 2014. Triggering transformative change: A development path approach to climate change response in communities. *Climate Policy* 14(4): 1–21. doi:10.1080/14693062.2014.876342.

Carvalho, L., G. Mingardo, and J. Van Haaren. 2012. Green urban transport policies and cleantech innovations: Evidence from Curitiba, Göteborg and Hamburg. *European Planning Studies* 20: 375–396. doi:10.1080/09654313.2012.651801.

Castán Broto, V., and H. Bulkeley. 2013. A survey of urban climate change experiments in 100 cities. *Global Environmental Change* 23: 92–102. doi:10.1016/j.gloenvcha.2012.07.005.

Castells, M. 2000. *The rise of the network society*. Oxford: Blackwell Publishers.

Childers D.L., Pickett S.T.A., Grove J.M., et al. 2014. Advancing urban sustainability theory and action: Challenges and opportunities. Landscape and Urban Planning 125:320–328. doi: 10.1016/j.landurbplan.2014.01.022.

Coenen, L., P. Benneworth, and B. Truffer. 2012. Toward a spatial perspective on sustainability transitions. *Research Policy* 41: 968–979. doi:10.1016/j.respol.2012.02.014.

Cole, R.J., A. Oliver, and J. Robinson. 2013. Regenerative design, socio-ecological systems and co-evolution. *Building Research and Information* 41: 237–247. doi:10.1080/09613218.2013.747130.

Cooke, P. 2010. Regional innovation systems: Development opportunities from the "green turn.". *Technology Analysis & Strategic Management* 22: 831–844. doi:10.1080/09537325.2010.511156.

Cooke, P. 2011. Transition regions: Regional–national eco-innovation systems and strategies. *Progress in Planning* 76: 105–146. doi:10.1016/j.progress.2011.08.002.

Cooke, P., and D. Rehfeld. 2011. Path dependence and new paths in regional evolution: In search of the role of culture. *European Planning Studies* 19: 1909–1929. doi:10.1080/09654313.2011.618685.

Davies, A. 2012. *Enterprising communities: Grassroots sustainability innovations*, Advances in ecopolitics 9. Bingley: Emerald.

Davoudi, S., and I. Strange (eds.). 2009. *Conceptions of space and place in strategic spatial planning*. New York: Routledge.

de Graaf, R., and R. van der Brugge. 2010. Transforming water infrastructure by linking water management and urban renewal in Rotterdam. *Technological Forecasting and Social Change* 77: 1282–1291.

de Roo, G., and E. A. Silva. 2010. *A planner's encounter with complexity*. Farnham (UK)/ Burlington (US): Ashgate.

Desouza, K.C., and T.H. Flanery. 2013. Designing, planning, and managing resilient cities: A conceptual framework. *Cities* 35: 89–99. doi:10.1016/j.cities.2013.06.003.

Dewald, U., and B. Truffer. 2012. The local sources of market formation: Explaining regional growth differentials in German photovoltaic markets. *European Planning Studies* 20: 397–420. doi:10.1080/09654313.2012.651803.

Domènech, L., and D. Saurí. 2010. Socio-technical transitions in water scarcity contexts: Public acceptance of greywater reuse technologies in the Metropolitan Area of Barcelona. *Resources, Conservation and Recycling* 55: 53–62. doi:10.1016/j.resconrec.2010.07.001.

Eames, M., and J. Egmose. 2011. Community foresight for urban sustainability: Insights from the Citizens Science for Sustainability (SuScit) project. *Technological Forecasting and Social Change* 78(5): 769–784.

Elzen, B., F.W. Geels, and K. Green. 2004. *System innovation and the transition to sustainability: Theory, evidence and policy*. Cheltenham: Edward Elgar Publishing.

Ernstson, H., S.E. van der Leeuw, C.L. Redman, D.J. Meffert, G. Davis, C. Alfsen, and T. Elmqvist. 2010. Urban transitions: On urban resilience and human-dominated ecosystems. *AMBIO* 39: 531–545. doi:10.1007/s13280-010-0081-9.

Essletzbichler, J. 2012. Renewable energy technology and path creation: A multi-scalar approach to energy transition in the UK. *European Planning Studies* 20: 791–816. doi:10.1080/09654313.2012.667926.

Fainstein, S.S., and S. Campbell (eds.). 2012. *Readings in planning theory*, 3rd ed. Malden: Wiley-Blackwell.

Folke, C., S.R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. 2010. Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society* 15: 1–9.

Frantzeskaki, N., J. Wittmayer, and D. Loorbach. 2013. The role of partnerships in "realising" urban sustainability in Rotterdam's City Ports Area, the Netherlands. *Journal of Cleaner Production* 65(10): 406–417. doi:10.1016/j.jclepro.2013.09.023.

Geels, F.W. 2002. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy* 31: 1257–1274. doi:10.1016/S0048-7333(02)00062-8.

Geels, F.W. 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy* 39: 495–510. doi:10.1016/j.respol.2010.01.022.

Geels, F.W. 2011. The role of cities in technological transitions – Analytical clarifications and historical examples. In *Cities and low carbon transitions*, ed. H. Bulkeley, V. Castán Broto, M. Hodson, and S. Marvin, 13–28. New York: Routledge.

Gunderson, L.H., and C.S. Holling (eds.). 2002. *Panarchy: Understanding transformations in human and natural systems*. Washington, DC: Island Press.

Guy, S., S. Marvin, and T. Moss (eds.). 2001. *Urban infrastructure in transition: Networks, buildings, plans*. London/Sterling: Earthscan Publication.

Guy, S., S. Marvin, W. Medd, and T. Moss (eds.). 2011. *Shaping urban infrastructures: Intermediaries and the governance of socio-technical networks*. London/Washington, DC: Earthscan.

Hagelskjær Lauridsen, E., and J. Stissing Jensen. 2013. The strictest energy requirements in the world: An analysis of the path dependencies of a self-proclaimed success. *Energy Policy* 53: 97–104. doi:10.1016/j.enpol.2012.10.014.

Hamann, R., and K. April. 2012. On the role and capabilities of collaborative intermediary organisations in urban sustainability transitions. *Journal of Cleaner Production* 50: 12–21. doi:10.1016/j.jclepro.2012.11.017.

Harding, A., and T. Blokland. 2014. *Urban theory*. Thousand Oaks: SAGE.

Healey, P. 1992. Planning through debate: The communicative turn in planning theory. *Town Planning Review* 62: 143–162.

Healey, P. 2007. *Urban complexity and spatial strategies: Towards a relational planning for our times*. London/New York: Routledge.

Hekkert, M.P., and S.O. Negro. 2009. Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change* 76: 584–594. doi:10.1016/j.techfore.2008.04.013.

Hodson, M., and S. Marvin. 2010. Can cities shape socio-technical transitions and how would we know if they were? *Research Policy* 39: 477–485. doi:10.1016/j.respol.2010.01.020.

Hodson, M., S. Marvin, and H. Bulkeley. 2013. The intermediary organisation of low carbon cities: A comparative analysis of transitions in Greater London and Greater Manchester. *Urban Studies* 50: 1403–1422. doi:10.1177/0042098013480967.

Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1–23.

Innes, J.E., and D.E. Booher. 1999. Consensus building and complex adaptive systems: A framework for evaluating collaborative planning. *Journal of the American Planning Association* 65: 412–423. doi:10.1080/01944369908976071.

Jabareen, Y. 2013. Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities* 31: 220–229. doi:10.1016/j.cities.2012.05.004.

Kemp, R., J. Schot, and R. Hoogma. 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management* 10: 175–198. doi:10.1080/09537329808524310.

Khan J. 2013. What role for network governance in urban low carbon transitions? Journal of Cleaner Production 50:133–139. doi: 10.1016/j.jclepro.2012.11.045.

Lahlou, S. 2011. *System innovation for sustainability 4: Case studies in sustainable consumption and production – Energy use and the built environment*. Sheffield: Greenleaf Pub.

Loorbach, D. 2014. *To transition! Governance Panarchy in the new transformation*. Rotterdam: Inaugural address.
Loorbach, D., and J. Rotmans. 2010. The practice of transition management: Examples and lessons from four distinct cases. *Futures* 42: 237–246. doi:10.1016/j.futures.2009.11.009.
Lu, P., and D. Stead. 2013. Understanding the notion of resilience in spatial planning: A case study of Rotterdam, The Netherlands. *Cities* 35: 200–212. doi:10.1016/j.cities.2013.06.001.
Maassen, A. 2012. Heterogeneity of lock-in and the role of strategic technological interventions in urban infrastructural transformations. *European Planning Studies* 20: 441–460. doi:10.1080/09654313.2012.651807.
Mader, C. 2013. Sustainability process assessment on transformative potentials: The Graz model for Integrative development. *Journal of Cleaner Production* 49: 54–63. doi:10.1016/j.jclepro.2012.08.028.
Markard, J., R. Raven, and B. Truffer. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy* 41: 955–967. doi:10.1016/j.respol.2012.02.013.
Marsden, T. 2012. Sustainable place-making for sustainability science: The contested case of agri-food and urban–rural relations. *Sustainability Science* 8: 213–226. doi:10.1007/s11625-012-0186-0.
Mason, K., and M. Whitehead. 2012. Transition urbanism and the contested politics of ethical place making. *Antipode* 44: 493–516. doi:10.1111/j.1467-8330.2010.00868.x.
McCauley, S.M., and J.C. Stephens. 2012. Green energy clusters and socio-technical transitions: Analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. *Sustainability Science* 7: 213–225. doi:10.1007/s11625-012-0164-6.
McCormick, K., S. Anderberg, L. Coenen, and L. Neij. 2013. Advancing sustainable urban transformation. *Journal of Cleaner Production* 50: 1–11. doi:10.1016/j.jclepro.2013.01.003.
McGinnis, M.D., and E. Ostrom. 2014. Social-ecological system framework: Initial changes and continuing challenges. *Ecology and Society* 19(2): 30. doi:10.5751/ES-06387-190230.
Mieg, H.A. 2013. Introduction. In *Institutional and social innovation for sustainable urban development*, ed. H.A. Mieg and K. Töpfer, 1–21. Abingdon/New York: Routledge.
Mieg, H.A., and K. Töpfer (eds.). 2013. *Institutional and social innovation for sustainable urban development*. Abingdon/New York: Routledge.
Monstadt, J. 2009. Conceptualizing the political ecology of urban infrastructures: Insights from technology and urban studies. *Environment and Planning A* 41: 1924–1942. doi:10.1068/a4145.
Mulugetta, Y., T. Jackson, and D. van der Horst. 2010. Carbon reduction at community scale. *Energy Policy* 38: 7541–7545. doi:10.1016/j.enpol.2010.05.050.
Murdoch, J. 2006. *Post-structuralist geography: A guide to relational space*. London/Thousand Oaks: SAGE.
Næss, P., and N. Vogel. 2012. Sustainable urban development and the multi-level transition perspective. *Environmental Innovation and Societal Transitions* 4: 36–50. doi:10.1016/j.eist.2012.07.001.
Neal, S. 2013. Transition culture: Politics, localities and ruralities. *Journal of Rural Studies* 32: 60–69. doi:10.1016/j.jrurstud.2013.04.001.
Nevens, F., N. Frantzeskaki, L. Gorissen, and D. Loorbach. 2012. Urban transition labs: Co-creating transformative action for sustainable cities. *Journal of Cleaner Production* 50: 111–122. doi:10.1016/j.jclepro.2012.12.001.
Newton, P.W. (ed.). 2008. *Transitions: Pathways towards sustainable urban development in Australia*. Collingwood: CSIRO Pub.
North, P. 2013. Knowledge exchange, "impact" and engagement: Exploring low-carbon urban transitions. *The Geographical Journal* 179: 211–220. doi:10.1111/j.1475-4959.2012.00488.x.
North, P., and N. Longhurst. 2013. Grassroots localisation? The scalar potential of and limits of the "transition" approach to climate change and resource constraint. *Urban Studies* 50: 1423–1438. doi:10.1177/0042098013480966.

Peters, M.D., S. Fudge, and T. Jackson. 2012. *Low carbon communities: Imaginative approaches to combating climate change locally*. Cheltenham: Edward Elgar.

Pickett, S.T.A., C.G. Boone, B.P. McGrath, M.L. Cadenasso, D.L. Childers, L.A. Ogden, M. McHale, and J.M. Grove. 2013. Ecological science and transformation to the sustainable city. *Cities* 32: S10–S20. doi:10.1016/j.cities.2013.02.008.

Pincetl, S. 2012. Nature, urban development and sustainability – What new elements are needed for a more comprehensive understanding? *Cities* 29: S32–S37. doi:10.1016/j.cities.2012.06.009.

Portney, K.E. 2009. Sustainability in American cities: A comprehensive look at what cities are doing and why. In *Toward sustainable communities, Transition and transformations in environmental policy*. Cambridge, MA: MIT Press.

Quitzau, M.-B., B. Hoffmann, and M. Elle. 2012. Local niche planning and its strategic implications for implementation of energy-efficient technology. *Technological Forecasting and Social Change* 79: 1049–1058. doi:10.1016/j.techfore.2011.11.009.

Quitzau, M.-B., J.S. Jensen, M. Elle, and B. Hoffmann. 2013. Sustainable urban regime adjustments. *Journal of Cleaner Production* 50: 140–147. doi:10.1016/j.jclepro.2012.11.042.

Rauws, W.S., and G. de Roo. 2011. Exploring transitions in the peri-urban area. *Planning Theory and Practice* 12: 269–284. doi:10.1080/14649357.2011.581025.

Raven, R., J. Schot, and F. Berkhout. 2012. Space and scale in socio-technical transitions. *Environmental Innovation and Societal Transitions* 4: 63–78. doi:10.1016/j.eist.2012.08.001.

Reusswig, F. 2010. Sustainability transitions through the lens of lifestyle dynamics. In *Sustainable production consumption systems*, ed. L. Lebel, S. Lorek, and R. Daniel, 39–59. Dordrecht: Springer.

Roggema, R., T. Vermeend, and A. Dobbelsteen. 2012. Incremental change, transition or transformation? Optimising change pathways for climate adaptation in spatial planning. *Sustainability* 4: 2525–2549. doi:10.3390/su4102525.

Rotmans, J. 2006. A complex systems approach for sustainable cities. In *Smart growth and climate change: Regional development, infrastructure and Adaption*, ed. M. Ruth, 155–180. Cheltenham: Edward Elgar.

Rotmans, J., R. Kemp, and M. van Asselt. 2001. More evolution than revolution. Transition management in public policy. *Foresight – The Journal of Futures Studies, Strategic Thinking and Policy* 3: 15–31.

Rydin, Y., C. Turcu, S. Guy, and P. Austin. 2013. Mapping the coevolution of urban energy systems: Pathways of change. *Environment and Planning A* 45: 634–649. doi:10.1068/a45199.

Sassen, S. 1991. *The global city: New York, London, Tokyo*, 2nd ed. Princeton: Princeton University Press.

Scerri, A., and M. Holden. 2013. Ecological modernization or sustainable development? Vancouver's "greenest city action plan": The city as "manager" of ecological restructuring. *Journal of Environmental Policy & Planning* 16(2): 1–19. doi:10.1080/1523908X.2013.836962.

Scholz, R.W. 2011. *Environmental literacy in science and society: From knowledge to decisions*. Cambridge/New York: Cambridge University Press.

Schreuer, A., M. Ornetzeder, and H. Rohracher. 2010. Negotiating the local embedding of socio-technical experiments: A case study in fuel cell technology. *Technology Analysis & Strategic Management* 22: 729–743. doi:10.1080/09537325.2010.496286.

Seyfang, G., and A. Haxeltine. 2012. Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy* 30: 381–400. doi:10.1068/c10222.

Shove, E., and G. Walker. 2010. Governing transitions in the sustainability of everyday life. *Research Policy* 39: 471–476. doi:10.1016/j.respol.2010.01.019.

Smith, A., and A. Stirling. 2010. The politics of social-ecological resilience and sustainable sociotechnical transitions. ed. The Resilience Alliance. *Ecology and Society* 15: 11.

Smith, A., and G. Seyfang. 2013. Constructing grassroots innovations for sustainability. *Global Environmental Change* 23: 827–829. doi:10.1016/j.gloenvcha.2013.07.003.

Smith, A., J.-P. Voß, and J. Grin. 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39: 435–448. doi:10.1016/j.respol.2010.01.023.

Späth, P. 2012. Understanding the social dynamics of energy regions—The importance of discourse analysis. *Sustainability* 4: 1256–1273. doi:10.3390/su4061256.

Späth, P., and H. Rohracher. 2010. "Energy regions": The transformative power of regional discourses on socio-technical futures. *Research Policy* 39: 449–458. doi:10.1016/j.respol.2010.01.017.

Späth, P., and H. Rohracher. 2012. Local demonstrations for global transitions—Dynamics across governance levels fostering socio-technical regime change towards sustainability. *European Planning Studies* 20: 461–479. doi:10.1080/09654313.2012.651800.

STRN. 2010. *A mission statement and research agenda for the sustainability transitions research network*. Sustainability Transitions Research Network.

Taylor, P.J. 2012. Transition towns and world cities: Towards green networks of cities. *Local Environment* 17: 495–508. doi:10.1080/13549839.2012.678310.

Truffer, B., and L. Coenen. 2012. Environmental innovation and sustainability transitions in regional studies. *Regional Studies* 46: 1–21. doi:10.1080/00343404.2012.646164.

Truffer, B., E. Störmer, M. Maurer, and A. Ruef. 2010. Local strategic planning processes and sustainability transitions in infrastructure sectors. *Environmental Policy and Governance* 20: 258–269. doi:10.1002/eet.550.

UN SDSN. 2013. *The urban opportunity: Enabling transformative and sustainable development*. Bangalore/New York: UN Sustainable Development Solutions Network.

Uyarra, E., and S. Gee. 2012. Transforming urban waste into sustainable material and energy usage: The case of greater Manchester (UK). *Journal of Cleaner Production* 50(2): 101–110. doi:10.1016/j.jclepro.2012.11.046.

Van der Voorn, T. 2012. Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study. *Futures* 44: 346–364.

Vojnovic, I. 2014. Urban sustainability: Research, politics, policy and practice. *Cities* 41: S30–S44. doi:10.1016/j.cities.2014.06.002.

Wiek, A., R. Scholz, D. Lang, M. Stauffacher, and A. Walter. 2003. *Grundlagen des Transition-Managements von Regionen. Systemanalyse, Variantenkonstruktion, Bewertung. Ein Handbuch*. Zürich: Natural and Social Science Interface. Swiss Federal Institute of Technology.

Wiek, A., C. Binder, and R.W. Scholz. 2006. Functions of scenarios in transition processes. *Futures* 38: 740–766.

Wilson, G.A. 2012. Community resilience, globalization, and transitional pathways of decision-making. *Geoforum* 43: 1218–1231. doi:10.1016/j.geoforum.2012.03.008.

Wolfram, M., and R. Vogel. 2012. Governance and design of urban infostructures: Analysing Key socio-technical systems for the vulnerability and resilience of cities. *Raumforschung und Raumordnung* 70: 323–336. doi:10.1007/s13147-012-0169-8.

Young, R. 2010. The greening of Chicago: Environmental leaders and organisational learning in the transition toward a sustainable metropolitan region. *Journal of Environmental Planning and Management* 53: 1051–1068. doi:10.1080/09640568.2010.508948.