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REPORT

Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems

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Abstract Urbanization is a global multidimensional process paired with increasing uncertainty due to climate change, migration of people, and changes in the capacity to sustain ecosystem services. This article lays a foundation for discussing transitions in urban governance, which enable cities to navigate change, build capacity to withstand shocks, and use experimentation and innovation in face of uncertainty. Using the three concrete case cities—New Orleans, Cape Town, and Phoenix—the article analyzes thresholds and cross-scale interactions, and expands the scale at which urban resilience has been discussed by integrating the idea from geography that cities form part of "system of cities" (i.e., they cannot be seen as single entities). Based on this, the article argues that urban governance need to harness social networks of urban innovation to sustain ecosystem services, while nurturing discourses that situate the city as part of regional ecosystems. The article broadens the discussion on urban resilience while challenging resilience theory when addressing human-dominated ecosystems. Practical examples of harnessing urban innovation are presented, paired with an agenda for research and policy.

Keywords Urban resilience · Ecosystem services · Social–ecological processes · Cross-scale interactions · Urban innovation · New Orleans · Cape Town · Phoenix

INTRODUCTION

Contemporary urbanization is a global multidimensional process, which manifests itself through changes in human population densities and land cover that are so rapid that we lag behind in understanding the process and its consequences. At the same time, we are facing an increasing uncertainty due to climate change, migration of people, and changes in the capacity of ecosystems to generate goods and services. In an urban context, this means that the traditional paradigm of planning for a predictable future is not only insufficient, but it may, in some ways, also be destructive. This article strives to lay a foundation for transitions in urban planning and governance, which enable cities to navigate change, build capacity to withstand shocks, and locate sources of experimentation and innovation in face of uncertainty.

The city can be thought of as an agglomeration of contested spaces that generate a range of urban services, from transport, housing, and medical aid, to jobs and financial markets (Harvey 1996). A presumption in this article is that such services are inextricably linked to ecological processes and the focus lies on such "ecosystem services," i.e., the benefits urban inhabitants and cities derive from ecosystem processes including, e.g., improved water and air quality, storm protection, flood mitigation, sewage treatment, micro climate regulation, and recreation and health values (Daily 1997; Bolund and Hunhammar 1999; Elmqvist et al. 2008). As ecological processes are in turn modified and entangled in social, and therefore political processes (most obviously through competing land-uses), the city comes into view as constituted out of political social–ecological processes (Swyngedouw 2006; Pickett et al. 2008; Grimm et al. 2008). Based on this, a normative strategy for urban governance would be to maintain or even enhance essential ecosystem services and to accomplish this in ways that recognize the spatial distribution of ecosystem services and their relation to social equity. The two-fold proposition of this article is that resilience theory from ecological research can contribute to our thinking on this normative goal, and that cities can help challenge traditional propositions used by resilience theorists when addressing human-dominated ecosystems. Our belief is that a resilience theory for human-dominated ecosystems is critically needed because such ecosystems are spreading across Earth.

In order to facilitate our discussion, we employ three important case studies—New Orleans, Cape Town, and Phoenix—these cities being suitable since they bring forth some of the most challenging issues of contemporary urbanization: climate change and rising sea levels, growing inequity in the access to resources, conflicts over water use between urban growth and agriculture, and the challenges of energy use and urban sprawl. Through pairing insights from our ongoing research in these cities, with ideas from geography and sociology, we will make four arguments that together aims to broaden the theoretical discussion regarding urban resilience:

- First argument will exemplify how urban social–ecological processes often work at different scales and how *cross-scale interactions* can be a key in driving changes in slow variables to push urban systems across thresholds;
- Second argument will utilize findings from geography, which position cities as part of "*systems of cities*" and reconceptualize cross-scale interactions as interdependencies between technical and social networks that tie cities together and sustain flows of energy, matter, and information;
- Third argument will draw upon findings that demonstrate that *cities are extreme innovation hubs*, with important impacts on technology, economy, and social organization;
- Fourth argument will discuss how to *harness urban innovation*, in the context of the politicized environment of the city, so as to make urban governance more sensitive to ecosystem dynamics and proactive in facing interlinked social–ecological uncertainties.

The last argument implies a call to combine systemic and functional understanding of cities (through resilience theory), with cultural critique and political perspectives. We limit our discussion to the quite well-resourced cities in high- and middle income countries.

Resilience theory—in its current form closely linked to complex adaptive systems theory (Levin 1998)—models reality as consisting of identifiable parts that through localized interaction (process) produce stable patterns (structure) across temporal and spatial scales (e.g. Holling 1973; Gunderson and Holling 2002; Berkes et al. 2003; Folke 2006). These patterns could be plants and pollinators that interact to produce landscape patterns, or the extension of a city through car transport generating sprawl. A key thought is that "positive feedbacks," i.e., processes and structures that mutually reinforce one another sustain dynamic and path-dependent stability regimes that shape and govern system dynamics (and thus influences localized interaction). Indeed, these processes of self-organization create systems far from equilibrium, characterized by external input and multiple possible outcomes of system dynamics (Levin 1998). Through often unnoticed slow changes in these structuring processes (indicated through changes in "slow variables"), the system can pass thresholds and reorganize—often triggered by a period of rapid change or disturbance—into a new regime in which system dynamics are qualitatively different. This is depicted in Fig. 1 where changes in two slow variables (along the *x* and *y* axes) are seen as "moving" the system on an "equilibrium surface" that is folded upon itself generating inherent thresholds (Zeeman 1977). As the system moves, its current stability regime changes shape (Fig. 1b), demonstrating that as resilience declines, systems are exposed

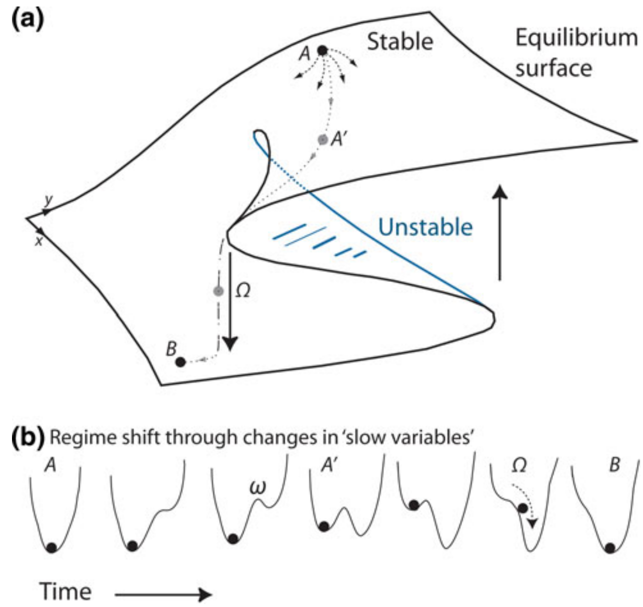

Fig. 1 Regime shifts, slow variables, and thresholds. The figure (**a**) shows a simplified image of how changes in slow variables can produce a regime shift. An example trajectory of a regime shift is followed from *A* to *B*. Even in *A*', there is no great noticeable change in system dynamics, but as the system moves through a threshold at *Ω*, a rapid reorganization into a new stable regime with qualitatively different system dynamics occurs (see Holling 1973; Zeeman 1977; Levin 1998; Gunderson and Holling 2002). It is consequently not necessary for a system to experience a disturbance to "fall into" regime *B*. However, and as illustrated in bottom figure (**b**), as the system looses resilience (lower and lower depth of valley *A*), it takes smaller and smaller disturbances for the system to be "pushed" across the threshold *Ω* (i.e., to be pushed over the middle peak *ω*) so as to fall into state *B*. The combination of changes in slow variables (e.g., sea level rise, duration of dry spells) can thus move the system closer to thresholds, where disturbances (e.g., tsunamis, droughts) can trigger disasters. For coupled social–ecological systems, the set of ecosystem services in *A* can be markedly different from those in *B*

to greater risks, uncertainties, and surprises; it often takes progressively smaller shocks for that system to lose its capacity to sustain a certain regime. Often disturbances and changes in slow variables are influenced by cross-scale interactions and likewise should ecosystem services be seen as emergent from interlinked processes at different scales. Ecosystem services are thus not controllable in themselves, but different regimes uphold distinct sets of ecosystem services, and some ecosystem services could be lost (and others emerge) when a new regime is established (Folke et al. 2004).

From a resilience perspective (Folke et al. 2005), governance can be thought of as purposeful collective action (among state, private, and civil society stakeholders) to either sustain and improve a certain regime, or to trigger a transition of the system to a more preferable regime; these are referred to as adaptive capacity and transformative capacity, respectively. While our shorthand definition of resilience is to sustain a certain dynamic regime, urban governance also needs to build transformative capacity to face uncertainty and change (cf. Berkes et al. 2003).

Several elements of resilience theory are highly relevant to cities (cf. Batty 2008). However, given its origins in ecology, it is not surprising that most resilience scholars have historically been interested in empirical analyses of non-urban areas (e.g., shallow lakes, production forests, and small-scale agriculture, see Berkes and Folke 1998; Gunderson and Holling 2002; Berkes et al. 2003), and have devoted less attention to the specifically human and social elements of human-dominated systems, such as cities. In order to address urban resilience, we propose a distinction between at least two scales that can aid in aligning analysis, governance and urban politics.[1] The first concerns “resilience *in* cities,” which operates at the city scale and deals with sustaining local-to-regional ecosystem services. The second is “resilience *of* cities,” which instead operates at the scale of a “system of cities,” which is a concept from geography meaning a set of cities tied to each other through relations of exchange, trade, migration, or others that sustain the flow of energy, matter and information among the cities (Pumain et al. 1989; Batty 2008). The resilience *in* cities, which has been the main preoccupation of most urban ecologists (Alberti and Marzluff 2004; Pickett et al. 2004; Andersson 2006; Colding 2007), is tightly linked to urban form and land-use patterns on the one hand, and local and spatial ecological processes on the other. This involves stakeholders like urban planners and housing companies, but also housing, squatter and urban social movements, along with those influencing and/or have knowledge about urban ecological processes. The latter group importantly includes, apart from conservation managers, also user groups engaged in local level social–ecological interactions such as urban community gardening, farming, and forestry that simultaneously meet social needs while improving ecosystem function (Stanvliet et al. 2004; Barthel et al. 2005; Borgström et al. 2006; Colding et al. 2006; Andersson et al. 2007; Tidball and Krasny 2007; Krasny and Tidball 2009; Barthel et al. 2010; Ernstson et al. 2010). The second scale, resilience *of* cities, involves a broader category of stakeholders, but particularly those associated not only with technical networks like water, electricity, sewage, waste disposal, and telecommunications, but also with agriculture, mining and other broader interests in society. Along with our four arguments, we will use these scales to broaden the discussion on urban resilience.

[1] First author acknowledges early discussions with Erik Andersson, SLU, Sweden, on the scales of urban resilience. See also his article, Andersson (2006).

FIRST ARGUMENT: SLOW VARIABLES AND THRESHOLDS

Although not in the strict sense specific to resilience theory, an important part in its development has been the idea that slow variables may push systems over a threshold, first developed by René Thom and then elaborated by Christopher Zeeman (Zeeman 1977) (Fig. 1). In this section, we will, therefore, take the city as an example of the ways in which slow variables and thresholds may combine to precipitate irreversible changes.

Urban populations worldwide continue to aggregate in areas that are vulnerable to combinations of slow variables (e.g., sea level rise, periodic flooding, etc.) that can move the system closer to thresholds (situations where “disasters are waiting to happen”), where disturbances (e.g., tsunamis, hurricanes, etc.) can trigger disasters (Fig. 1). As a deltaic city, New Orleans has always been situated in a dynamic landscape, and its recent history—with Hurricane Katrina in 2005 devastating the city leaving 1,500 dead and tens and thousands without homes—therefore provides an important case study to illustrate the interaction between thresholds and changes in slow variables (Fig. 2).

After achieving its peak urban population in the early 1960s, during the 40 years before Hurricane Katrina, New Orleans was experiencing trends in multiple slow variable indicators that, in combination, worked to make the city increasingly vulnerable; rising seas, a compacting deltaic landscape, population decline, suburban sprawl in areas below sea level, coastal wetland loss, economic decline, and low maintenance of levee systems (Campanella et al. 2004; Kates et al. 2006). In terms of most of these indicators—that were well known at the time (Westrum 2006)—New Orleans was heading toward crucial thresholds, but Hurricane Katrina provided a shock to the New