International Journal of Sustainable Built Environment (2016) xxx, xxx–xxx

HOSTED BY

ELSEVIER

Gulf Organisation for Research and Development

International Journal of Sustainable Built Environment

ScienceDirect
www.sciencedirect.com

Original Article/Research

# The livability of spaces: Performance and/or resilience? Reflections on the effects of spatial heterogeneity in transport and energy systems and the implications on urban environmental quality

Laura Estévez-Mauriz [a,*], Jimeno A. Fonseca [b,c], Claudiu Forgaci [d], Nils Björling [e]

[a] Division of Applied Acoustics, Department of Civil and Environmental Engineering, Chalmers University of Technology, SE-41296 Gothenburg, Sweden
[b] Chair of Architecture and Building Systems, Institute for Technology in Architecture, ETH Zürich, 8093 Zürich, Switzerland
[c] Future Cities Laboratory, Singapore-ETH Centre, Singapore
[d] Chair of Environmental Technology and Design, Department of Urbanism, Delft University of Technology, 2628 BL Delft, Netherlands
[e] Department of Architecture, Chalmers University of Technology, SE-41296 Gothenburg, Sweden

Received 19 January 2016; accepted 6 October 2016

**Abstract**

Cities can be seen as systems of organized complexity formed by interrelated and highly dynamic sub-systems. This paper reflects on the interactions and tensions between socio-ecological and/or socio-technical sub-systems in cities and their capacity to either improve or block urban processes. In this context, spatial heterogeneity could enhance or hinder the performance and resilience of critical urban sub-systems such as transport and energy. The consequence of this interaction might be detrimental to environmental quality (air and acoustic) and the livability of urban areas. This rationale may improve political and expert decision-making processes toward sustainable, resilient and livable cities.


*Keywords:* Spatial heterogeneity; Environmental quality; Urban systems performance; Urban resilience

## 1. Introduction

A new and complementary way of thinking for a sustainable built environment involves the study of urban areas in terms of both socio-ecological and socio-technical systems. In such an approach, cities are complex adaptive systems capable of facing risks and unforeseen adversities. The system is composed of a series of interacting and interdependent sub-systems, which comply with the components' arrangement and processes that organize and guarantee life in urban areas. One key characteristic of such sub-systems is performance, understood as the system's effectiveness to maintain a certain quality level. Another important characteristic is resilience, expressed as the capacity of a system to absorb, adapt, and restore its performance after a disruption.

In the past decades, the study of urban form has become more complex, shifting from the physical characteristics of a built-up area to a multifaceted approach (Larkham,

* Corresponding author.
*E-mail address:* laura.estevez@chalmers.se (L. Estévez-Mauriz).
Peer review under responsibility of The Gulf Organisation for Research and Development.

http://dx.doi.org/10.1016/j.ijsbe.2016.10.001
2212-6090/

2004). As part of this new approach, the socio-spatial processes that generate urban form need to be considered. By understanding the complexities of urban systems and their sub-systems, planners could identify, learn and retain the qualities of urban form that are essential to guarantee sustainable development. With this vision in mind, cities should guarantee certain intrinsic abilities to face change, like the possibility to relocate urban objects (Roggema, 2014). Historically, the focus of urban form has been on the normative aspect, neglecting its analytical approach that embraces the relation between urban form and urban life (Marcus, 2007). In this direction, the urban environment can become obsolete, with no capacity to absorb, for example, the speculation on a future development, or the pressure and the environmental consequences of demographic changes. From a socio-ecological perspective, the main challenge is how to improve the livability of spaces and avoid damaging the quality of life on a global and individual level. To achieve this desired level of urbanity, certain trade-offs between urban sub-systems are necessary.

Cities hold several environmental challenges: they occupy 3% of the land surface, host 50% of global population, consume 75% of natural resources, produce 50% of the global waste and emit 60–80% of greenhouse gases (UNEP-DTIE, 2013). Without environmental quality, cities become hostile places, neglecting the chance of space optimization coupled with an improved environmental performance (van den Dobbelsteen and de Wilde, 2004).

A key challenge is to look at cities as systems of organized complexity formed by interrelated and highly dynamic sub-systems, including individuals engaged in different interactions (Atun, 2014; Dantzig and Saaty, 1973). Within the framework of achievement of current and future citizens' needs, we claim the importance of the underlying socio-technical systems in the built environment.

In such complexity, spatial heterogeneity is seen as a key strategy to increase the livability of cities. Heterogeneity is seen as an opportunity to allow the development of a suitable physical environment, not only as a reaction to modernism postulates of segregation (Fainstein, 2005). On one hand, spatial heterogeneity allows the diffusion of risks as it increases redundancy. However, it compromises optimization and tends to reduce performance of interrelated sub-systems (e.g., transport, energy, water etc.). In this case, spatial heterogeneity constrains underlying systems in cities, disrupting the capacity to reach certain equilibrium. Without this dynamic equilibrium, environmental quality as a leading vision of resilience and sustainability is not guaranteed (Wilbanks and Fernández, 2014).

This paper sets up a niche of discussion about the tensions between the capacities of urban socio-ecological and/or socio-technical sub-systems to either improve or block urban development. The focus lies on juxtaposing the effects of spatial heterogeneity in two major urban sub-systems, energy and transport. The reflection addresses the tension between urban performance and urban resilience and the consequent value of the entropy concept as an interaction capable of enhancing or hindering the quality of life. The emphasis is on the implications that this tension may have on urban environmental quality and livability. These implications are analyzed through the effects that spatial heterogeneity, transport and energy sub-systems have on the human habitat and livability, attending to main environmental stressors as air and noise pollution. The intention is not to analyze whether all kinds of spatial heterogeneity fit to the idea behind the current study, since some limitations in terms of scale and time may constrain the benefits of spatial heterogeneity to resilient behavior. Resilience of one scale is not automatically linked to another, allowing space for trade-offs in resilience between scales (Chelleri and Olazabal, 2012). This approach has been defended in previous studies (Boyd et al., 2015) and also supported in the present paper.

A further exploration is done on the relations, interdependencies and tensions between the socio-ecological perspective and the social-technical one of urban systems. The two perspectives are often subordinated to each other, thus reducing either performance or resilience. Does spatial heterogeneity have an impact on urban environmental quality due to the enhancement or hindering of the energy and transport systems? Is it plausible to reach equilibrium between the performance and resilience of these systems without giving up to urban environmental quality and the demanded spatial heterogeneity?

## 2. Urban form coevolution and spatial heterogeneity

Preoccupied about the physical representation and perception of the city in the book *The Image of the City*, Lynch (1960) stresses the importance of urban form in the everyday life of people. According to Lynch (1984, p.47), the urban form or the "physical environment" refers to the "permanent objects" in cities, such as buildings and streets. In his "normative theory", Lynch emphasizes the link between permanent objects that compose urban form and human values (Lynch, 1984).

Over the last few years, human and ecological systems have been increasingly regarded and studied as interconnected ones. Such interaction derived land use decisions from urban form and vice versa. The urban landscape needs to be seen as productive fields (Waldheim, 2016) where an outdated view on space as *form* need to be challenged and seen as interlinked processes that interact in both time *and* space (Corner, 2006). The spatial patterns and the need of underlying infrastructures arise in a certain spatial heterogeneity in the built environment (Alberti, 2005).

Extending Norberg and Cummings' (2008) study, spatial heterogeneity depends on combinations of material, relative and relational aspects of urban form. This results in non-random spatial and temporal differentiation, forming some sort of a pattern. These asymmetrical conditions of urban form are mainly sustained by plural access to