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A multi-scale and multi-dimensional framework for enhancing the resilience of urban form to climate change

Tapan K. Dhar *, Luna Khirfan

University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada

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ABSTRACT

Currently, both the planning and climate change literature highlight the concept of resilience to facilitate long-term adaptation strategies. Yet, decades before the onset of climate change science, uncertainty was dealt with in the urban planning and design literature since the latter half of the 20th century through various notions analogous to resilience. Through a review of these notions that presently remain isolated from the contemporary mainstream resilience and climate change discourses, this paper proposes an urban morphological theoretical framework that establishes theoretical and empirical links between urban form on the one hand, and climate change adaptation and resilience on the other. With urban morphology as its underpinning, the proposed theoretical framework identifies a set of variables that could potentially influence the resilience of urban form, hence, are proposed to measure its resilience to climate change. These variables underscore urban form's physical, spatial, and functional characteristics and their changes over time.

1. Introduction

Resilience, a socio-ecological concept, determines "the persistence of relationships within a system and is a measure of the ability of the system to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973, p. 17). Accordingly, a resilient system underscores non-linear dynamics, thresholds, uncertainty, and surprise. Most importantly, it holds the potential "to create opportunities for doing new things, for innovation, and for development" while responding to shocks, such as those caused by climate change (Folke, 2006, p. 253). Hence, in the field of climate change, operationalizing resilience is

* Corresponding author.
E-mail addresses: tkdhar@uwaterloo.ca (T.K. Dhar), lkhirfan@uwaterloo.ca (L. Khirfan)

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a possible way to capitalize on the beneficial opportunities of climate change adaptation actions-hitherto an unexplored area of adaptation research. Nevertheless, thus far, scholarship that underscores the relationship between adaptation/adaptive capacity and resilience remains limited (McEvoy et al., 2013; Smit and Wandel, 2006). In other words, the resilience knowledge domain is weakly linked to the adaptation and to the vulnerability domains (Janssen et al., 2006). In the planning literature, the emergence of resilience in relation to climate change adaptation is recent, and many consider resilience as a bridging concept between urban planning and adaptation (Davoudi et al., 2012). Particularly, in the realm of urban design, resilience potentially allows the built environment to accommodate new or retrofitted forms (and/or functions) through incremental transformation so as to adapt to climate change and its ensuing uncertainty (Lennon et al., 2014; León and March, 2014). This paper proposes a framework for transmuting the design of urban form to innately harmonize resilience.

The concept now known as resilience is analogous to several key ideas, such as alternative stable states, transformability, adaptability, and flexibility, and is opposed to rigidity, stability, and permanency, in many disciplines (Beatley, 2009; Davoudi et al., 2012; Gunderson and Holling, 2002; Smit and Wandel, 2006). This paper argues that resilience, along with these analogous notions, evolved in the planning and design literature decades ago independently of climate change scholarship in order to deal with uncertainty - albeit uncertainty that is not necessarily posed by climate change, but by socio-economic and cultural changes, technological up-grading, and personal preference. This evidence existed even in the early 20th century, for example, Le Corbusier's Maisons Domino in 1914 (Priemus, 1993), but has emerged mostly since the post-modern period. Depending on the scale of the shocks, a complex urban system may proceed toward an unknown trajectory (Grinberger and Felsenstein, 2014).While exploring the potential opportunity of such an urban system, these notions promote the innate ability of built environments in terms of their design for transforming incrementally as they respond to shocks, disturbances, and unknown future circumstances - whether or not posed by climate change. However, the ideas and their potential have to date been isolated from the mainstream resilience and climate change discourses. Thus, this paper highlights the design concepts, along with their underlying theories, that shape urban form and that simultaneously enhance its resilience to climate change and decrease its resulting uncertainty.

In order to address the increasing impacts of climatic change and uncertainty, the planning and design of new urban developments currently rely on climatic scenarios that have been projected by various climate models. In doing so, two key problems manifest: first, the disjunction between what these models render and what decision-makers require, including precise projections of the magnitude and the frequency of extreme events; second, the uncertainty associated with climate change models because of approximations, inadequacies, or errors (Collins et al., 2012; Hallegatte, 2009). While ongoing improvements in climate modelling and associated downscaling techniques hold the potential to address the former, the second remains more challenging. A real risk of confusion between past evidence and predictive model outputs is amplified by climatic uncertainty. Thus, the ambiguity of existing information along with its multiplicity of meanings to clarify a situation falls in the realm of uncertainty (Grote, 2009). The degree of this uncertainty is further intensified when combined with the impacts of climate change and with the complex interactions within an urban area between its bio-physical agents (e.g. local geomorphology, climate, and natural disturbance) and human agents (e.g. individual choices and actions) (Alberti et al., 2003). Additionally, the Intergovernmental Panel on Climate Change's (IPCC) 5th assessment report on urban areas revealed that inadequate knowledge about the vulnerability, uncertainty, and adaptive capacity of urban built environments to climate change hinders developing the appropriate adaptation responses needed, whether in terms of new or retrofitted systems (Revi et al., 2014). In the age of climatic uncertainty, resilience also highlights flexibility and transformability of city infrastructure to cope with an unknown future. In principle, the IPCC's expert recommendations calling for incremental and transformative preparedness would provide opportunities for urban adaptation and may also reveal trajectories toward sustainable and resilient development (Revi et al., 2014). The implementation of such a new concept through urban design however, faces key challenges pertaining to the limited knowledge whether regarding how to achieve incremental preparedness that would adapt existing urban landscapes, or regarding how to develop new urban forms that achieve such preparedness while simultaneously allowing for incremental positive change (Costa et al., 2014). Thus, questions arise with regards to how well our city forms are prepared or are resilient to withstand the impacts of climate change and to be changed incrementally toward an unknown trajectory? More specifically, how does the design of urban form influence this resilience and, accordingly, what design variables enable us to