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Measuring changes in urban functional capacity for climate resilience: Perspectives from Korea

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ABSTRACT

The purpose of this study is to measure urban resilience through indicators related to urban function and to classify 232 cities in Korea with regard to climate variability. Urban functions were classified into basic, developmental, sustainable, and maintenance functions, and were measured using 25 indicators. Confirmatory factor analysis was used to integrate each function into a single value. Cluster analysis was applied to 232 cities in Korea and analyzed for the years 2000, 2005, and 2010. The analysis revealed that clusters appeared between variables centered on metropolitan cities and variables of climate variability. In 2000 and 2005, Korean cities had similar clusters, but in 2010, they manifested a different pattern. This study suggests that the construction and accumulation of time-series data is necessary for understanding the lack of each function of the city in constructing adaptation policies for communities.

1. Introduction

The German sociologist Ulrich Beck (1992) suggested that the concept of resilience in at-risk societies was being discussed as a new approach to exogenous change in a situation of increased complexity, connectivity of society, and an unpredictable future (Leach, 2008; Berkes, Colding, & Folke, 2003; Wilkinson, Porter, & Colding, 2010). The current discourse on resilience is diverse, appearing in realms such as physics, biology, network engineering, civil engineering, psychology, economics, and urban planning (Brand & Jax, 2007; White & O'Hare, 2014). Although the conceptual scope of resilience varies by field, engineering limits it to a particular target and clearly defined exogenous impacts (Kim & Lim, 2016; Davoudi, 2012). Moreover, in psychology and economics, the discourse on resilience focuses on the systematic changes and targets that it encompasses, and limits types of shock to phenomena such as trauma and economic crises (Bonanno, 2004; Simmie & Martin, 2010; Vale & Campanella, 2005).

Among the many exogenous changes in risk society, climate change is particularly unpredictable, uncertain, and significant (Seeliger & Turok, 2013; Zhao, Chapman, Randal, & Howden-Chapman, 2013), and it is considered a major exogenous shift for cities (Osbahr, 2007; Satterthwaite & Dodman, 2013). Climate change relates to exogenous transformations in urban resilience and shock; urban resilience is employed as a concept of sustainable metropolitan growth (Carmin, Nadkarni, & Rhie, 2012; Leichenko, 2011). Thus, the notions of urban resilience and urban climate resilience do not derive from different categories but in fact overlap. They both relate to the obstacles facing cities and their functional capacity to respond to change.

Urban resilience deals with how climate change and cities relate to one another. Knowing the climatic conditions of a city is considered a prerequisite for building urban functions such as infrastructure, social networks, and an economy (Wilkinson et al., 2010). Climate change can impact conditions that are not otherwise easily changed and are considered external changes with patterns similar to past conditions (Kim & Lim, 2016). Understanding urban climate resilience requires some questions to be answered. Does it

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mean to return to the original state before risk, to accept exogenous change, or to move toward a better state? What is the scope of the object that one aims to return to? Does it incorporate social elements that are important in urban planning? (Friend & Moench, 2013; Pizzo, 2015). Such discourse has provoked a demand to find new ways of measuring urban resilience (Kim & Lim, 2016).

This study aims to measure urban resilience through indicators related to urban functions and to understand changes by linking those indicators to climate variability. Urban functions connected to urban resilience were operationally defined and relevant indicators were created. Indicators and measurement variables for these urban functions were constructed by nine experts for each urban function considering Korea's circumstances via the Delphi method. The measurement variables were integrated into the indicators through confirmatory factor analysis (CFA). The drawn indicators were applied to the years 2000, 2005, and 2010, using statistical data from 232 Korean cities. Climate variability was classified using factor analysis. The data on climate variability was collected from the Korea Meteorological Administration, 2012, which assessed climate change variability using the Representative Concentration Pathway (RCP) scenarios provided by the Intergovernmental Panel on Climate Change (IPCC). The 232 Korean cities were clustered based on the drawn indicators of urban resilience and climate variability. Finally, this study suggests implications for the climate change adaptation policies of local governments. This analysis provides a framework for local policymakers to understand how the functional factors that make up cities change over time from a methodological viewpoint. Analysis of the clusters is distilled into suggestions for ways in which local governments may develop climate change adaptation policies. Local policymakers can use the methods and results of this study to the state of their city and improve the resilience of their urban systems to exogenous change (climate change).

This study targeted Korean cities. From the 1960s to 1980s, Korean development focused on physical infrastructure development with rapid economic growth. In the past, urban planning and policy in Korea had focused on supporting physical development to accommodate the population rather than exogenous risk. However, in recent years, exogenous changes and risks, such as depopulation, aging society, climate change, and disasters, have been emerging, and thus, it is important for urban planning to reflect the various components of the urban system. In particular, the impacts of climate change, such as heatwaves and heavy rainfall since the 2000s, are changing the direction of urban planning, but there is no index to diagnose the changed conditions and support plans and policies. Although this study focuses on Korea, it can provide implications for developing countries where rapid growth and development and the impacts of climate change are occurring simultaneously, and where resilience needs to be reflected in urban planning and policy.

For the purpose of this study, we review relevant literature and provide a theoretical discussion on climate change, urban resilience, and urban functions in the second section. In the third section, we describe the methods and materials used for the analysis, and then demonstrate the results of the analysis in the fourth section. Finally, we provide a conclusion and suggest implications for policy makers.

2. Theoretical discussion

2.1. Urban resilience and climate change

Meerow, Newell, & Stults, 2016 conducted a meta-analysis of 239 key papers on urban resilience. They explored the tensions between the conceptual constructs of urban resilience and provided an operational definition of the term. They identified six conceptual tensions of urban resilience: (1) the definition of the term "urban"; (2) the understanding of equilibrium; (3) resilience as a positive notion; (4) positive versus neutral (or negative) conceptualizations of resilience; (5) adaptation versus general adaptability; and (6) timescale of action. The sixth tension relates to how a city should be defined and how its characteristics should be classified.

The discourse on urban resilience contains a controversial debate over whether climate change should be considered a threat or impact on its own, or included in urban resilience (Meerow et al., 2016). This leads us to the question of whether urban resilience and urban climate resilience can be discussed as separate ideas. Climate change causes mid- and long-term disturbances in uncertain ways, and although it does not impact particular sectors from the angle of urban resilience, it is difficult to clearly distinguish between urban resilience and urban climate resilience (Kim & Lim, 2016). Studies on urban resilience have yet to clearly portray its nature and the extent to which it exists in cities; hence, the definitions of targets for measuring urban and urban climate resilience remain unclear (Meerow et al., 2016).

Although definitions of targets for measuring resilience remain vague, prior research has formulated "the city" in two ways: (1) As a complex, self-contained system; and (2) As a series of networks. In the first viewpoint, a city consists of social, technological, and ecological features that change over time and follow certain patterns. Some previous studies have examined the dynamic aspects of the changes in a city's characteristics (Smith & Stirling, 2010). The second viewpoint considers the connections among a city's various networks as fundamental to how it is shaped (Brugmann, 2012; Da Silva, Kernaghan, & Luque, 2012; Desouza & Flanery, 2013). All physical and social networks are included in the shifts in a city's dynamic links.

Kim and Lim (2016) presented a framework for understanding urban resilience from the angle of climate change considering various perspectives on resilience. Their framework portrayed the links between climate change and urban resilience as follows: (1) A disturbance system related to climate change; (2) The transition process of the urban system; and (3) A preemptive and reactive process. The first aspect describes a sudden change that can act as a stressor or shock to the urban system, causing irreversible and ongoing transformations. The second aspect refers to transforming the current urban system into new systems through the changes in each functional sector of a city (e.g., transport, water, and housing) and the interactions of their sectors. The likelihood of a transition depends on a city's capabilities; adaptation is the ability to make a transition via disturbances and change. The preemptive and responsive process relates to the discourse on engineering resilience, which is linked to reducing disaster risks. Moench, Tyler, &