



# Nature-based solutions for urban landscapes under post-industrialization and globalization: Barcelona versus Shanghai



Peilei Fan<sup>a,\*</sup>, Zutao Ouyang<sup>b</sup>, Corina Basnou<sup>c</sup>, Joan Pino<sup>d</sup>, Hogeun Park<sup>e</sup>, Jiquan Chen<sup>f</sup>

<sup>a</sup> School of Planning, Design, and Construction and Center for Global Change and Earth Observations, Michigan State University, East Lansing, MI 48824, USA

<sup>b</sup> Center for Global Change and Earth Observations, Michigan State University, East Lansing, MI 48824, USA

<sup>c</sup> CREAM, Cerdanyola del Vallès, Spain

<sup>d</sup> CREAM and Univ Autònoma Barcelona, Cerdanyola del Vallès, Spain

<sup>e</sup> School of Planning, Design, and Construction and Center for Global Change and Earth Observations, Michigan State University, East Lansing, MI 48824, USA

<sup>f</sup> Department of Geography, Environment, and Spatial Sciences and Center for Global Change and Earth Observations, Michigan State University, East Lansing, MI 48824, USA

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## ABSTRACT

Using Barcelona and Shanghai as case studies, we examined the nature-based solutions (NBS) in urban settings—specifically within cities experiencing post-industrialization and globalization. Our specific research questions are: (1) What are the spatiotemporal changes in urban built-up land and green space in Barcelona and Shanghai? (2) What are the relationships between economic development, exemplified by post-industrialization, globalization, and urban green space? Urban land use and green space change were evaluated using data derived from a variety of sources, including satellite images, landscape matrix indicators, and a land conversion matrix. The relationships between economic development, globalization, and environmental quality were analyzed through partial least squares structural equation modeling based on secondary statistical data. Both Barcelona and Shanghai have undergone rapid urbanization, with urban expansion in Barcelona beginning in the 1960s–1970s and in Shanghai in the last decade. While Barcelona's urban green space and green space per capita began declining between the 1950s and 1990s, they increased slightly over the past two decades. Shanghai, however, has consistently and significantly improved urban green space and green space per capita over the past six decades, especially since the economic reform in 1978. Economic development has a direct and significant influence on urban green space for both cities and post-industrialization had served as the main driving force for urban landscape change in Barcelona and Shanghai. Based on secondary statistical and qualitative data from on-site observations and interviews with local experts, we highlighted the institution's role in NBS planning. Furthermore, aspiration to become a global or globalizing city motivated both cities to use NBS planning as a place-making tool to attract global investment, which is reflected in various governing policies and regulations. The cities' effort to achieve a higher status in the global city hierarchy may have contributed to the increase in total green space and urban green per capita. In addition, various institutional shifts, such as land property rights in a market economy vs. a transitional economy, may also have contributed to the differences in efficiency when expanding urban green space in Barcelona and Shanghai.

## 1. Introduction

Nature-based solutions (NBS) is defined by European Commission as “living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits” (European Commission, 2015). Including actions in green space planning, waterfront redevelop-

ment, neighborhood redevelopment and more, NBS has become a plausible concept to address the urban environmental challenges that arise as a city rapidly urbanizes. The concept is popular among planning professionals and decision makers in Europe (European Commission, 2015; Maes and Jacobs, 2015) and resonates in a number of theories relating to urban development, such as the environmental Kuznets curve (Stern et al., 1996), categories of environmental action taken by cities across different economic development levels

\* Corresponding author.

E-mail addresses: [fanpeilei@msu.edu](mailto:fanpeilei@msu.edu) (P. Fan), [yangzuta@msu.edu](mailto:yangzuta@msu.edu) (Z. Ouyang), [c.basnou@creaf.uab.cat](mailto:c.basnou@creaf.uab.cat) (C. Basnou), [joan.pino@uab.cat](mailto:joan.pino@uab.cat) (J. Pino), [parkhoge@msu.edu](mailto:parkhoge@msu.edu) (H. Park), [jqchen@msu.edu](mailto:jqchen@msu.edu) (J. Chen).

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(Satterthwaite, 1997), and the urban environmental transition theory (McGranahan et al., 2001). These theories distinguish one implication: NBS can only be pursued when a city reaches a certain economic development level.

Enthusiastic social reformers and planners within Western European and North American cities adopted the NBS framework during the industrial revolution (LeGates and Stout, 2015). Exemplar redevelopment followed, including Regent Park in London by John Nash, Paris by Baron Haussmann, and the USA's Urban Park Movement led by Frederick Law Olmsted in the 19th century. Contemporary urban planning and design also emphasizes the importance of trees and large, aesthetic open spaces to city streets and walkways (Jacobs, 1993; Gehl, 2010), as well as its contributions to ecosystem functions and services, such as preserving biological diversity (Ahern, 2013) and improving air and water quality (Chen et al., 2016). In Europe, urban planners have continuously advocated that nature and climate factors, green views, and proximity and accessibility to green spaces should be integrated into sustainable urban planning (e.g., Gehl, 2010; Iojă et al., 2014). In Spain, for example, the Green Infrastructure and NBS concepts emerged as a new way to not only defend the value of ecosystems, but also mitigate climate and landscape change. With an objective to build "the green city of the future", Vitoria-Gasteiz promoted urban and peri-urban green spaces in northern Spain, which became the European Green Capital in 2012. The initiatives aimed not only to promote and develop green spaces in and around the city, but to also to enhance citizen participation during the development and implementation. In Barcelona, landscape design and gardening are developed with an understanding that "everybody should need 5 min walking till the nearest green area within the city" (Garcia Espuche et al., 2008). Similar NBS examples have been increasingly reported both in Europe and other regions (e.g., Artmann, 2014; Boone et al., 2009; Breuste et al., 2015; Chiesura, 2004; De Ridder et al., 2004; Kabisch et al., 2016; La Rosa, 2014; Niemelä, 2014; Rabinovitch and Reitman, 2004; Wolch et al., 2014). Not only are large cities in industrialized nations participating (e.g., New York, London, Tokyo, Paris, Barcelona), but also those in rapidly industrializing nations (e.g., Shanghai, Sao Paulo, Mumbai).

Unfortunately, there are limited empirical studies on how NBS are associated with post-industrialization and globalization, particularly from a comparative perspective (P. Fan et al., 2016; Gong et al., 2013; Tian et al., 2014; Zhou and Wang, 2011). There are a plethora of researches on various aspects related to NBS or on linkages between urbanization and economic development. For instance, the importance of green space planning for sustainable cities has been emphasized (Chen et al., 2015; Chiesura, 2004; Iojă, 2014; La Rosa, 2014; Maes and Jacobs, 2015). Green space planning has proven effective in improving urban environmental conditions, such as the urban heat island (Inostroza, 2014; Yue et al., 2012), air quality (Chen et al., 2015), and climate mitigation and adaption (Kabisch et al., 2016). As urbanization is driven by economic development, particularly post-industrialization and globalization, NBS policies and planning are needed as cities move up the ladder of economic development and citizens desire more urban amenities (Florida, 2005; McGranahan et al., 2001; Sassen, 1999; Satterthwaite, 1997). Nevertheless, there has been a lack of serious effort to link all these aspects together as an integrated analysis with drivers, patterns, and impacts centered around NBS and urban green planning. It is necessary to provide insightful views of inter-linkages between post-industrialization, globalization, and urban green space, and the impacts. This paper illustrates such an attempt and contributes to literature by both theoretical advancement and methodological contribution.

A critical question to start is: How did cities implement the NBS concept in their urban landscapes within the constraints of social and economic imperatives? To fill this knowledge gap, this paper presents a comparative case study on NBS for cities experiencing post-industrialization and globalization, using Barcelona and Shanghai as examples.

Barcelona and Shanghai are treated as the potential front-runner and follower cities, respectively, to mirror the protocols of the Horizon 2020 program (European Commission, 2015). Barcelona is one of the world's leading green cities, which motivated our selection. Shanghai, a sister city of Barcelona, is labeled as a "follower city" to demonstrate the implementations of NBS-like concepts in other regions. The two represent industrialized vs. industrializing countries and market-based vs. transitional economies. As a region with a strong market-based economy, major metropolises in Western Europe led industrialization for most of the 20th century and started post-industrialization in recent decades. London, Paris, Madrid, and Barcelona are the four largest metropolitan areas in Western Europe. However, Barcelona was selected because it is not a national capital. This allows the municipal government to have more control over urban land change, and thus, NBS analysis becomes more convenient. Shanghai is a good choice to compare with Barcelona because both cities have similar economic positions in their respective countries, including the economic structure resulting from a transitioned society (i.e., industrial to post-industrial), geographic and climate conditions, and impact from globalization. Both cities are located in relatively wealthy regions and have been the most important economic growth engines of their respective countries. They are also role models for other cities within their countries, demonstrating how to restructure from an industrial to a post-industrial economy and allowing the tertiary to become the dominant sector influencing economy. Geographically, they are both located in the coastal area of a sub-tropical climate. Both have integrated the global economy more successfully than the rest of their country, which is reflected by global trade volumes, global financial flows, as well as international tourists. More importantly, both municipal governments have committed to NBS in city planning and development, for which their invaluable lessons can be learned by other cities with similar endeavors. Although others have conducted research on urbanization and green development in the case study city of Shanghai (Yue et al., 2012; Zhang, 2013; and Fan et al., 2017) and for Barcelona (Catalan et al., 2008; Llausas and Roe, 2012; and Basnou et al., 2013), their analyses are at different spatial and temporal scales, and thus difficult to compare. For example, Yue et al. (2012) examined Shanghai's urban heat island in 2008 and how vegetation affected temperature and Fan et al. (2017) evaluated the accessibility of its urban parks for 2000 and 2010. Zhang (2013) also reviewed the urban green development of Shanghai in the second half of the 20th century, but spatial analysis was excluded. For the city of Barcelona, Catalan et al. (2008), Llausas and Roe (2012), and Basnou et al. (2013) studied urbanization, green infrastructure, and urbanization/forestation, respectively, but all had focused on certain time periods that did not extend to the most recent post-industrial decade. Catalan et al. (2008) compared urban built-up land from 1993 to that of 2000 and focused on the transformations from an extreme compact to a polycentric urban form in Barcelona, but did not provide an analysis on urban green space. Llausas and Roe (2012) theorized and discussed the potential green infrastructure planning of the Catalonia region, in comparison with that of northeast England. Basnou et al. (2013) generated land use land cover change maps for Barcelona from 1956 to 2000 and found that urbanization and forestation are the dominant pressures on biodiversity, followed by crop abandonment and deforestation. In this study, however, the temporal scale for NBS is extended as long as the data allowed, with spatial analysis spanning at least three decades. The spatial analysis for urbanization and green space was conducted at a reasonable spatial resolution (e.g., 30 m of Landsat Thematic Mapper (Landsat TM) images). More importantly, previous research did not link green space development with the driving factors of economic development, particularly post-industrialization and globalization. By making these connections at the municipal scale through quantitative modeling, our research can bring significant insights to policy makers in Barcelona and Shanghai.

We aim at the following specific questions: (1) What are the spatiotemporal changes in urban built-up land and green space in

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