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Examining component-based city health by implementing a fuzzy evaluation approach

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ABSTRACT

Cities have become the most important habitats for mankind in most regions of the world. Many researchers and organizations have attempted to evaluate the states of cities from the perspective of their functionalities. However, the comprising components of a city, which provide these functions, have not been evaluated explicitly and systematically. These components include people, infrastructure and environment, all of which are the foundations of city health and sustainability. In this study, we used the analogy of a healthy human and defined a healthy city as a state of complete demographic, infrastructural and environmental well-being, which means that all components are present with integrity and sufficiency and also function effectively, harmoniously and sustainably. Based on this concept, a component-based city health examination framework was constructed and tested in three major cities in China (Beijing, Shanghai and Shenzhen) in both 2010 and 2015. A total of 27 indicators (seven for People, ten for Infrastructure and ten for Environment), each with a health reference value, were chosen and calculated. The fuzzy logic method was selected to perform the evaluation task due to its effectiveness in assessing uncertain and relatively subjective objects. Results showed that all three case study cities failed to meet the healthy condition in both years. Shenzhen was, relatively, the healthiest city among the three in 2015 and had the highest health score in Infrastructure and Environment. Shanghai possessed the highest score in People in both years. Additionally, five indicators with the largest potential for improvement were also identified for each city. This component-based city health evaluation model can be applied to better inform urban planning policies and potentially improve the quality of life in cities in the future.

1. Introduction

Cities are playing a more and more important role in human economic and cultural development, while also greatly impacting on the environment. The United Nations defined cities as the remedy to global crises due to their ability to provide flexible and creative platforms that can forge new partnerships, trusts and respect among stakeholders (UN-Habitat, 2012). By 2016, over 54% of the world population lived in cities (UNPD, 2017). These aggregations produced more than 80% of the GDP in the world (The World Bank, 2017).

However, cities have also become the center stage of ecological and environmental problems, such as air, soil, water and noise pollution, urban heat island and loss of biodiversity and habitats (Bechle et al., 2011; Beninde et al., 2015; Zardo et al., 2017). For instance, cities consume approximately 60% of the world's energy and contribute to more than 70% of global greenhouse gas emissions (The World Bank, 2017). Li and Qiao (2015) reported that over 90% of the urban polluted water in China did not meet drinking standards. In addition to these environmental problems, many studies also found that people living in cities might suffer from greater health pressure, such as obesity, depression and cardiovascular diseases (Post et al., 1998; Sunyer, 2001; Gupta et al., 2015). Furthermore, rapidly growing cities are usually also accompanied by uncontrolled city development problems, such as traffic congestion, subsidence and flooding (Rao and Rao, 2012; Melo dos Santos et al., 2012; Yin et al., 2015). Being able to effectively and accurately assess these urban problems and monitor the condition of a city will become more and more important for future urban planning and management.

Many researchers and organizations have attempted to quantify the quality of urban development from various perspectives through indicators across the world. For example, WHO (2010) proposed a 12-indicator based evaluation framework to assess the resident-health-related development level of cities. UN-Habitat (2012) also ranked the state of the 69 world's cities based on productivity, quality of life, infrastructure, environment and equity. Wang et al. (2015) evaluated the status of eco-city development in 13 cities of China from economic

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Table 1
Examples of common city evaluation focuses and indicator frameworks.

Evaluation emphases	Indicator frameworks	References
Urban dweller health	Health outcomes (4 indicators), physical environment and infrastructure (2 indicators), social and human development (4 indicators), economics (1 indicator) and governance (1 indicator)	WHO (2010)
Sustainable development	Economy (4 headline indicators and 8 supplementary indicators), society (4 headline indicators and 7 supplementary indicators) and environment (4 headline indicators and 10 supplementary indicators)	Department for Environment, Food and Rural Affairs (2012)
City prosperity	Productivity (7 indicators), quality of life (3 indicators), infrastructure development (2 indicators), environment sustainability (3 indicators), equity and social inclusion (3 indicators)	UN-Habitat (2012)
Eco-city development	Economic development (8 indicators), Social progress (5 indicators), Environmental protection (6 indicators)	Wang et al. (2015)
Carbon sustainability	Energy climate (4 indicators), water quality, availability and treatment (6 indicators), air quality (4 indicators), waste (3 indicators), mobility (4 indicators), economic health (4 indicators), land use (3 indicators) and social health (5 indicators)	Zhou et al. (2015)
World status	Advanced producer services by interlocking network model	GaWC (2016)
Economic, cultural and political performances	Business activities (6 indicators), human capital (5 indicators), information exchange (5 indicators), cultural experience (6 indicators) and political engagement (5 indicators) Personal well-being (3 indicators), economics (4 indicators), innovation (3 indicators) and governance (3 indicators)	ATKearney (2017)
Overall urban competitiveness	Economy (13 indicators), R&D (8 indicators), cultural interaction (15 indicators), livability (14 indicators), environment (9 indicators) and accessibility (10 indicators)	The Mori Memorial Foundation (2017)

development, social progress and environmental protection perspectives. In Table 1, we summarized some typical city evaluation emphases and frameworks.

All of the abovementioned evaluation frameworks mainly focus on the functionality of cities. However, these functions that a city provides, such as innovation, industrial production, information exchange, economic activities, cultural experiences, etc., depend on the basic components of cities. The origins of these functionalities, which are the comprising components of a city, have not been examined from an explicit and well-rounded perspective yet. These components refer to all of the entities in a city such as people, building, roads, wildlife etc. They should draw particular management attentions since all kinds of urban planning and management that aims at functionality ends up designing and managing the components directly. Without an explicit and comprehensive evaluation on city components, it would be very hard to create a management plan that can improve city functionalities effectively.

In addition, having high quality city components are also essential for creating healthy cities. Many studies have treated complex systems like ecosystems and cities as living organisms (Ariza-Montobbio et al., 2014; Xie et al., 2014; Silva-Macher, 2016). For instance, back in the late 1980s, researchers like Rapport (1989) and Ryder (1990) have already made the metaphor from human medicine to discuss the definition of ecosystem health. In urban studies, Wolman (1965) also proposed the concept of urban metabolism as an analogy to the metabolism of organisms. Studies like Wang et al. (2017) applied this concept and compared the metabolic patterns of different cities in China. According to the WHO, the definition of human health is a “state of complete physical, mental and social well-being” (WHO, 1998). In our view, a healthy city should be similarly defined as a state of complete demographic, infrastructural and environmental well-being, which means that all essential components are present with integrity and sufficiency and also function effectively, harmoniously and sustainably. It should be noted that this definition of a “healthy city” is completely different from WHO’s (1998) concept, which focuses on the health of urban dwellers. Instead, we treat the healthy city we proposed as an entity by itself and examine its present status as a whole.

In this study, we tried to explicitly and systematically evaluate the health condition of a city based on the quantity and quality of its components in order to better inform urban planning and management. Accordingly, we constructed a fuzzy model that evaluates city health. We selected an array of component-based indicators to comprehensively measure the progress toward healthy cities. Since China has undergone one of the fastest urbanization processes in the past 40 years, it now possesses cities at various stages of development and was a suitable place for testing this model (Crawford and Cenzatti, 2017). We chose three major cities (Beijing, Shanghai and Shenzhen) with differences in development history and urban planning goals as the illustrative case study cities to test the applicability of this model.

2. Methods

2.1. Component-based city health indicators

From a reductionist point of view, a healthy human body is generally comprised of living cells, which form organs, blood, neurons, etc., cell derivatives, such as bones, hairs, hormones, excretes, etc. and external inputs, such as food protein, water, vitamins, symbiotic bacteria, etc. In an analogy to the human body, a healthy city can also be reduced to three basic components: People, Infrastructure and Environment.

- People, or urban dwellers, which are the essential elements of any city, are like cells in a human body (i.e. blood cells, skin cells, neurons, etc.). Every person living in the city falls into this category. They are the most important component since all cities are the creation of man.
- Infrastructure, which refer to anything that is manmade in a city, such as roads, buildings, vehicles, etc., are like cell derivatives (i.e. bones, hair, hormones, etc.). They represent the things that people build and manage in order to live and prosper in a city. Infrastructure can reflect much information of a city such as the stage of development level, urban planning philosophy, city history and culture, etc. (Chen and Nordhaus, 2011; Levin and Duke, 2012).
- Environment, which stands for anything that is not manmade in a city, such as plants, soil, water, animals, etc., is like all of the external inputs in a human body (i.e. water, vitamins, parasites, etc.). A city relies on the resources and services that provided by the environment in order to be able to function properly (Wackernagel et al., 2006; Song et al., 2011). Although people can build systems such as parks, gardens and lakes in cities, the organisms or elements that make up these environments establish themselves through