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Indicators for quantitative evaluation of the social services function of urban greenbelt systems: A case study of shenzhen, China

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ABSTRACT

Existing ecological service assessments of urban green space have concentrated on natural environment, while research on the social services function remains underexplored. Taking Shenzhen as an example, this study starts with integrating the function of green space system with human needs. An indicator assessment technique that combines spatialization, rasterization and detailed of land ecological assessment was established with regard to the benefits of landscape aesthetics, function of disaster prevention and mitigation, and accessibility of park greenbelts. The results show that Shenzhen has very high recreational and cultural value, as the areas above medium level account for 66% of the city's land area, and the recreational and cultural services are worth approximately 40.8million Yuan. Forest parks and comprehensive parks are important places to carry out social service function, particularly the disaster prevention and mitigation function, and the green spaces for disaster prevention and mitigation can be found in most of the disaster-prone areas. The accessibility of service shows a certain level of centrality, since the highest grade is concentrated in the central Bao'an, central Longgang, and the central part of the city. Based on the GIS overlay analysis, this study recognizes the distribution of essential patches, and constructs the structure of essential patches in urban green greenbelt systems by a combination of point, line, and surface elements. It shows the services of the Shenzhen greenbelt system have high potential for social integration, and this study also discusses the policy implication for macro decision-making. The assessment results objectively reflect multiple social services of the green space system in this region and provide a reference for the management, planning and construction of urban ecology in similar cities.

1. Introduction

Urban greenbelts refer to urban land that mainly combines with natural vegetation and cultivated vegetation (Amati, 2008). The roles and benefits of green spaces for urban dwellers cannot be denied (Li et al., 2005). As the element of the urban landscape, urban greenbelts not only promote ecological functions, namely, the so-called "natural service" of maintaining natural ecological processes and the regional ecological environment, but they also have an important social function (Daily, 1997). The social services function of urban greenbelts involve the effects that they have on the society to improve people's life quality, including urban landscape pattern alteration, research and cultural education, leisure and entertainment, health promotion and urban sprawl impediment (Shafer et al., 2000; Sherer, 2006; Yao and Kang, 2007). As the evaluation of urban ecosystem services becomes increasingly concerned with social and cultural values (Gómez-Baggethun and Barton, 2013; Raudsepp-Hearne et al., 2010), further in-depth studies about the ecosystem's social services function will be conducted.

Since the end of the 20th century, with the development of spatial and landscape ecology, quantitative research on urban ecological functions has been increasing (Mao et al., 2012). Undoubtedly, it has been indispensable for research to establish a comprehensive scientific indicator system and evaluate the social services function of urban greenbelt systems. Scholars have focused on the recreational value, usage (De Ridder, 2004; Neuvonen et al., 2007), and, especially, the value-added effects of greenbelt systems on properties (Anderson and Cordell, 1988; Morales, 1980). Chinese scholars emphasize discussions about urban greenbelts' integrated services and typically only regard the social services function as one of the indicators. For example, Zhang et al. (2012a) uses accessibility, satisfaction, and public participation to indicate residents' perception and awareness of greenbelts, and then qualitatively

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proposes an assessment system for urban greenbelts' ecosystem functions. There are only a few studies that merely aim to quantitatively evaluate the social function of urban greenbelt systems. Song et al. (2010) examines and analyzes the usage of urban park greenbelts and their non-use value with questionnaires and field observations; Yu et al. (2013) adopts the service area coverage of park greenbelts, service duplication, and service population per unit of park greenbelt as indicators to conduct a quantitative analysis of the social services function that the major park greenbelts in downtown Shanghai brought to residential areas. Based on the literature, despite the many achievements that current studies have made, systematic research on the concepts, supporting theories and technological methods of the social services function of urban greenbelts is still lacking. In terms of how to define the social services function, how to quantify the functional effects, and how to explicitly demonstrate their expression in space, we are still stuck at the stage of simple analysis and conceptual elaboration.

The measurement of urban greenbelt functions should seek unity among ecology, the environment, and social effectiveness (Mononen et al., 2016). In consideration of Shenzhen's particularity as a huge population-intensive city, the function of urban greenbelts should be more concerned with human needs. Thus, this paper proposes an index system through investigating relationship between products and services to evaluate the social services function of urban greenbelt systems in Shenzhen. By using quantitative analysis, this paper constructs the structure and pattern of in ecological patches the urban green greenbelt system, and discusses the fairness of greenbelt services as well as the implications for city's ecological management, greenbelts system planning, and park construction. The mathematics models and management measures are proposed to enrich the methodological system of ecosystem assessment and provide a reference for other cities and related research.

2. Research area and data

2.1. Overview of the research area

At a longitude of 113° 46′ to 114° 37′ and latitude of 22° 27′ to 22° 52′, Shenzhen is located in the south of Guangdong Province, east of the Pearl River Delta, and adjacent to Hong Kong. It is the first Special Economic Zone established since China's reform and opening up. Under the jurisdiction of Shenzhen, there are six administrative regions—Futian, Luohu, Nanshan, Yantian, Bao'an, and Longgang—and four new districts—Guangming, Longhua, Pingshan, and Dapeng. The city's total land area is 1996 km^2. Over the past 35 years, Shenzhen has demonstrated a remarkably fast rate of growth. On one hand, Shenzhen's GDP has increased from 0.277 billion Chinese Yuan in 1980–1.6 trillion Chinese Yuan in 2014, with per capita GDP exceeding $20,000, meaning that over the long term, Shenzhen ranks first in the list of major cities in China. On the other hand, Shenzhen's resident population has increased from 0.3 million in 1980–10.62 million in 2014, with a population density of approximately 10,000 per square kilometer, making Shenzhen, together with Macao and Hong Kong, a highly urbanized area.

As Shenzhen is realizing rapid social and economic development, land for urban construction continues to be rapidly expanded, resulting in a decrease in total ecological land and huge pressure on urban ecological resources. In 2005, Shenzhen demarcated China's first eco-control line and rapidly advanced urban greenbelt systems, particularly urban park construction. According to the Urban Greenbelt Classification Criteria, Standard for Basic Terminology of Landscape Architecture and Shenzhen Urban Planning Criteria and Guidelines, urban greenbelts are divided into five categories: public parks, production greenbelts, green buffers, subsidiary greenbelts, and others. In 2014, Shenzhen conducted a survey of afforestation resources; it demonstrated that the total area of various greenbelts in the city was 1052 km^2, accounting for approximately 53% of the total area of the city; the area of other greenbelts (mainly including geological parks, forest parks and natural protection zones) was 778 km^2 (approximately 74%); the area of subsidiary greenbelts was 179 km^2 (approximately 17%), and the area of public park greenbelts was 84 km^2 (approximately 8%) (as shown in Fig. 1).

2.2. Data source and processing

The data used in the study are presented as follows: the survey results of Shenzhen's geological condition (2014), and related economic and social statistical data such as the Engel coefficient and exchange rate coefficient are adopted as indicators of the recreational and cultural function; the survey results of Shenzhen's afforestation resources (2014) are adopted as indicators of the disaster prevention and mitigation function; Shenzhen's current park data, road data, building survey data, and data on geologically disaster-prone areas as well as urban orange-line are adopted as indicators of accessibility (data on geologically disaster-prone areas is taken from Shenzhen's geological disaster prevention planning); and data on land prices are from the dynamic monitoring results of Shenzhen's land prices in 2014.

Due to the differences that exist among data sources and for spatial accuracy, this paper processes all data on the ArcGIS 10.2 software platform. In a quantitative evaluation, the grid is used as the research unit; the grid size is defined as 10 m × 10 m.

3. Indicators

To more clearly define the social services value of urban greenbelt systems, this paper divides the relationship between products and services. As spatial places, greenbelt systems are regarded as a public product unto itself. According to general presumptions, products are only meaningful when they satisfy a certain need and want in the form of a service. For example, greenbelts provide recreational places that are available to the public; thus, they can be viewed as a product. However, the service relationship (such as cultural awareness, subjective impressions, and recreation) brought by greenbelts is more important. In addition, how difficult it is for the public to gain access to the park and how convenient it is for the public to be able to enjoy the space should also be indispensable factors for the evaluation of the eco-service function (in the paper, these are referred to as subsidiary services). Through research, Kaplan et al. (1998) argue that the design of urban green facilities, especially urban greenbelt systems, must focus on humanity and take full consideration of the convenience and accessibility of their use to better serve the urban population. In this sense, services are not useful for objects but for activities.

Therefore, from the perspective of realizing the quantitative and spatial evaluation of greenbelts system in highly urbanized areas, this paper determine the research scope in terms of recreational and cultural value, the disaster prevention and mitigation function, and accessibility. Other social functions such as scientific study, social employment, and price appreciation conduct methods mainly through conceptual analysis and experiences, as which are beyond the scope of this article (as shown in Fig. 2).

3.1. Recreational and cultural value

Recreational and cultural value involves the non-material benefits that people obtain from urban greenbelts, including cultural awareness, subjective impressions, recreation, and aesthetic experience (La Rosa et al., 2016). Considering the difficulty of quantifying recreational and cultural value, this study uses the market value