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Spatial differentiation of ecological security and differentiated management of ecological conservation in the Pearl River Delta, China

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ABSTRACT

The ecological security (ES) pattern in China is gaining considerable attention worldwide due to intensifying urban development and human activities that threaten ecosystem structures and ecological processes. The Pearl River Delta (PRD) has experienced intense economic development for nearly 40 years; however, the ES pattern in the PRD is poorly understood. In this paper, we used a multisource data approach to assess ES, performed downscaling to a $1 \times 1\,km^2$ grid size, and applied spatial statistics to analyze the ES pattern in the PRD. We found three natural "ecological buffers," namely, nature reserves and forest patches covering several municipalities in the delta, thus guaranteeing the socio-economic development of this highly urbanized area. The spatial autocorrelation results indicated that the ES pattern is significantly spatially correlative ($p = 0.001$), with a Moran's I of 0.7766. We identified several hot and cold spots for the ES spatial distribution that occupied 58.49% of the PRD's total area. Moreover, a semivariance analysis showed that structural factors are dominant in the ES spatial distribution. Based on the ES area proportions, the 9 municipalities of the PRD can be grouped into three categories: optimized development zones, comprehensive development zones, and ecological conservation development areas. Zhaoqing, Huizhou and Jiangmen are key areas for improving ES conservation in the PRD. In this study, we explore an ES assessment model coupled with a spatial heterogeneity analysis to provide insights into ecological conservation efforts in urban agglomerations.

1. Introduction

With the process of rapid industrialization and urbanization, a series of ecological environmental problems have appeared. Human activities are damaging the ecosystem by destroying the structure of the ecosystem and impacting ecological processes (Salvati and Carlucci, 2014). Generally, balancing biodiversity conservation with infrastructure development in urban areas has always been a key, but difficult, issue in this field. In many cases, infrastructure cannot be developed without destroying natural environments. To alleviate ecological pressure and resolve environmental problems, China's government has established a system for implementing environmental protection and ecological civilization policies. It integrates ecological security (ES) into the overall national security and takes numerous measures to build ES conservation development areas.

What is ES? Numerous scholars have offered definitions of ES (Table 1). In this study, which considers only ecosystem conservation, ES can be regarded as a status in which the structure, function and ecological processes of the ecosystem are not threatened, and the ecosystem is able to offer sufficient ecosystem services to support the development of the socio-economic system. The theoretical system of ES is continuously being developed and improved, and this change is mainly reflected in the following three aspects: first, the research content is rich and varied in terms of ecological risk, ecological health, ecological service value, ecological vulnerability, and ecological sensitivity (Chu et al., 2017; Peng et al., 2018). Second, the objects of evaluation are not the same; forests, grasslands, rivers, cities, lands, and coastal zones are the research objects (Giwa and Dindi, 2017; Lu et al., 2018; Zhou et al., 2014). Third, the research methods and indicators on ES have become more diverse.

ES assessment has gradually become a hot issue in regional environmental management and ecosystem studies, in which methods can be divided into qualitative and quantitative assessments (Liu and Chang, 2015). In the qualitative method, subjective macro-level judgments of a region are made. The purpose of the quantitative method is to understand the spatial and temporal dynamics. Mathematical modelling and landscape ecology methods, such as information entropy, analytic hierarchy process (AHP), Delphi and factor analysis methods

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