

An eco-city evaluation method based on spatial analysis technology: A case study of Jiangsu Province, China



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ABSTRACT

An eco-city is an eco-sustainable, balanced and intensive human settlement, and the method selected to evaluate an eco-city is an important determinant of the accuracy of the evaluation. We present a new eco-city evaluation method comprising an ecological vulnerability evaluation index system and an economic, social and environmental evaluation index system based on land use, economic development, social progress and environmental protection using spatial analysis technology (remote sensing (RS) and geographic information system (GIS)). We constructed an ecological vulnerability evaluation index system using a pressure-state-response (PSR) model and the analytic hierarchy process (AHP) based on an ecological suitability index, landscape pattern index and land resource utilization degree index and comprehensively evaluated the ecological vulnerability condition using principal component analysis (PCA) and an expert scoring method. We established an economic, social and environmental evaluation index system using factor analysis. These index systems are associated with the GIS and the AHP, and Jiangsu Province was used as an example to verify the applicability and efficiency of the evaluation method. The results show the following. (1) The ecological vulnerability of Jiangsu is relatively low but unevenly distributed. The regions with slight, light and medium vulnerabilities comprised 79.49% of the total area. (2) Thirteen cities were divided into economic advantages type (Suzhou), environmental advantages type (Nanjing, Wuxi, Yangzhou, Zhenjiang and Taizhou), social security advantages type (Changzhou, Xuzhou and Nantong) and general type (Lianyungang, Huaian, Yancheng and Suqian). (3) The overall condition of the eco-cities was classified as middle or upper and was unevenly distributed. The eco-cities were divided into four categories and there was a gradually decreasing trend from southeast to northwest, resulting in a gradient from southern Jiangsu to middle Jiangsu and northern Jiangsu. Every city should be constructed on the basis of its weak points to achieve healthy and optimum development. The results indicated that the method is an efficient and practical process, which differs from existing methods, and makes extensive use of spatial information technology and can be widely applied to evaluate eco-cities.

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1. Introduction

The concept of the eco-city was first proposed in the “Man and Biosphere (MAB)” program launched by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1971 (Wu et al.), and its prototypes are the garden city concept devised by utopian socialist R. Owen in 1820 and the garden city theory proposed by British architect Howard (1898). Since then, domestic and foreign scholars have conducted extensive research on the significance of the eco-city. Summarizing their views (Yanitsky, 1987;

Register, 1987; Huang and Yang, 2001; Mou, 2009; Krasny and Tidball, 2012), eco-cities are eco-sustainable, balanced, intensive human settlements; the development of the economy, society and nature are coordinated in an eco-city; material, energy, and information are used efficiently; technology, culture, and the landscape are fully integrated; residents are healthy and the full potential of humans and nature is achieved.

The eco-city is an essential model to achieve sustainable development, and the assessment of an eco-city forms the quantitative basis of eco-city planning, construction, and management effectiveness. Different evaluation methods produce different significance of evaluation results, after studying the evaluation methods used by scholars worldwide, we found that eco-city evaluation mainly adopts two types of index system framework:

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One is the structure–function–coordinated degree index system, which considers that the eco-city should be the ecosystem with reasonable structure, efficient function, coordinated ecological relationship, and the structure, function and coordinated degree are generally taken as the primary indicators. Song et al. (1999) established the structure-function-coordinated degree index system, evaluating the ecological level of five coastal cities with the weighted index method, and the evaluation results were basically consistent with the actual situation, but the fine detail was greatly reduced by using the administrative divisions as the evaluation unit. Li (2003) established such an index system and evaluated the eco-city level of Zhangjiagang, Suzhou Jiangsu using PCA, and although the evaluation effect was good, there was only qualitative and not quantitative analysis in the evaluation process. Liu and Yang (2011) analyzed the structure and function of urban systems and established an ecological network based mainly on industry, agriculture, tertiary industry, and transportation subsystems and effectively assessed the eco-city level of Beijing with the analysis tools based on a life-cycle network, but it did not consider the spatial association of different regions. The other system is the economy–society–environment index system, which uses the development of a compound ecosystem as the core and considers economic, social and environmental systems to have the relationship of coordinated development and mutual restriction, usually using economic development, social progress and environmental protection as its primary indicators, and this index system framework has been widely used at home and abroad. Hu and Huang (2006) established an eco-city multi-level fuzzy comprehensive evaluation model and evaluation support system based on the social, economic and environmental index system, which was a type of effective method to evaluate the eco-city, but lacked the support of spatial analysis technology, the analysis of the evaluation results were not intuitive or in-depth enough. Li and Yu (2011) combined index systems developed by domestic and international authoritative organizations and domestic ministries and commissions and constructed a set of evaluation index systems based on five perspectives, i.e., resource-saving, environmentally friendly, economic-sustainability, social harmony and innovation-leading, using comprehensive selection methods, expert discussion, the Delphi method and case studies, and although the indicators were relatively comprehensive, it ignored the ecological factors. The findings of Wang et al. (2015) also showed that the existing

economic–social–environmental index system cannot effectively evaluate the development level of the eco-city, and the ecological factors were urgently required.

Most of these methods selected specific evaluation indicators from the economy, society and nature and qualitatively or semi-quantitatively evaluate eco-city levels, but rarely consider urban ecological factors (land use, terrain, climate, etc.) or spatial correlations or in-depth analysis of the evaluation results.

We present a new evaluation method for eco-cities comprising an ecological vulnerability evaluation index system and an economic, social and environmental evaluation index system using land use, economic development, social progress and environmental protection based on RS and GIS technology. Jiangsu Province was used as an example to verify the applicability and efficiency of this new evaluation method. The results indicate that the method is an efficient, practical and widely applicable process.

2. Methods

2.1. Eco-city evaluation process

The eco-city evaluation index system includes an ecological vulnerability assessment index system and an economic, social and environmental evaluation index system; these index systems are associated with AHP and GIS technology. We built the ecological vulnerability assessment index system using RS and GIS technology combined with a PSR model, the AHP and PCA. We constructed the economic, social and environmental evaluation index system using factor analysis and an expert scoring method to determine the weight of each evaluation index to comprehensively evaluate an eco-city. The combination of the ecological vulnerability assessment and the economic, social and environmental evaluation provides a powerful exploration of eco-city evaluation. The eco-city evaluation technology roadmap is presented in Fig. 1.

2.2. Ecological vulnerability assessment index system

Currently, ecological vulnerability research mainly concentrated in the evaluation of ecosystem variety, sensitivity, potential impacts and adaptability. The method of building an ecological vulnerability assessment index system combining the AHP, factor

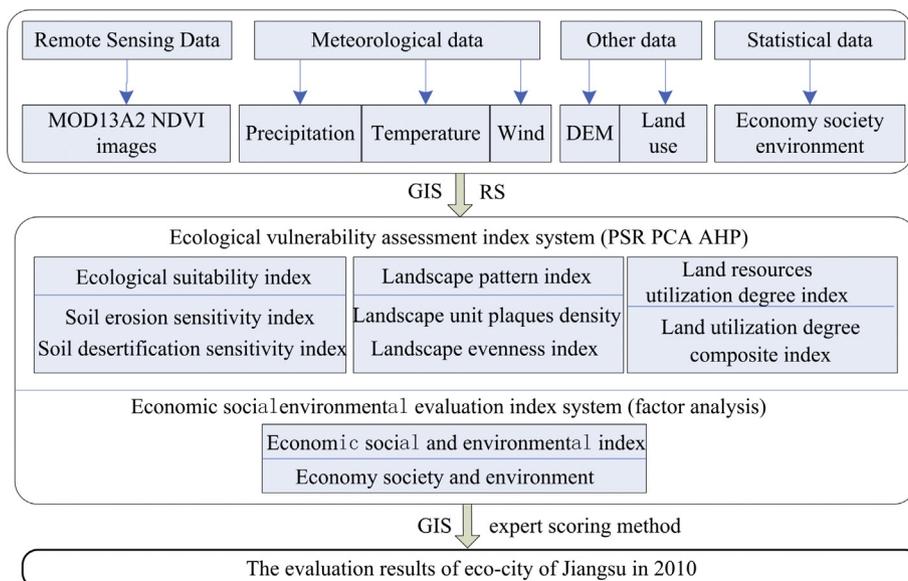


Fig. 1. The eco-city evaluation technology roadmap.

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