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Land eco-efficiency for new-type urbanization in the Beijing-Tianjin-Hebei Region

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ABSTRACT

The intensification of urbanization has had a significant impact on land-use change, ecosystem services, and the urban environment in China. In this paper, we measured land eco-efficiency from an economic and ecological perspective using a Super Efficiency DEA model and Malmquist Index. Our study included 13 prefecture-level cities in the Beijing-Tianjin-Hebei region and covered the period from 2005 to 2013. We then built an indicator system to evaluate new-type urbanization and quantify the impacts of new-type urbanization on land eco-efficiency based on an extended Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) Model. Our results reveal an average annual growth rate of 14.3% for land eco-efficiency. There were distinct differences among cities that are closely related in terms of their development stage of new-type urbanization. The relationship between land eco-efficiency and new-type urbanization produced an N-shaped curve. This suggests that, when the development of new-type urbanization is taken into consideration, the land eco-efficiency trend followed a pattern of up-down-up. Enhancing technology, as well as modifying policies for environment management, will also help improve intensive land use and land eco-efficiency. Our paper provides a significant contribution to strengthening land-use management and advancing sustainable urban development in China.

1. Introduction

China is undergoing a new round of rapid urbanization, and urban construction land expansion encroaches on cultivated land, forest land and others (Chen et al., 2017; Deng et al., 2017a, 2017b). The contradiction between regional urban development, agricultural land protection and ecological conservation has become increasingly prominent. Extensive urban land use patterns caused land use problems such as unreasonable construction land structure, scattered spatial layout and low land use efficiency (Lambin and Meyfroidt, 2010; Wang et al., 2014). With the conflict between rare land source and growing population, improving urban land use efficiency has become an inherent requirement for promoting regional sustainable development and national ecological civilization construction. In this context, the concept of new-type urbanization was proposed to guide the intensive land use in the process of urbanization (Bai et al., 2014; G. Wang et al., 2015; X.R. Wang et al., 2015).

Compared with traditional urbanization, new-type urbanization presents new characteristics in terms of methods of thinking, geographical layout, and models of development. The question remains whether the new-type urbanization can lead to intensive and efficient land use through urban economic structure adjustment, technological externality improvement and environment-biased technological progress (Peng et al., 2017; Song et al., 2018). Meanwhile, the effect of human activities on the environment and urban systems, where land utilization is central, has increased continually (Song et al., 2015). A complicated relationship exists between land-use change and environmental change, which indicates that changes in the land utilization model often impact the function of urban ecological services (Deng et al., 2015; Liu et al., 2015).

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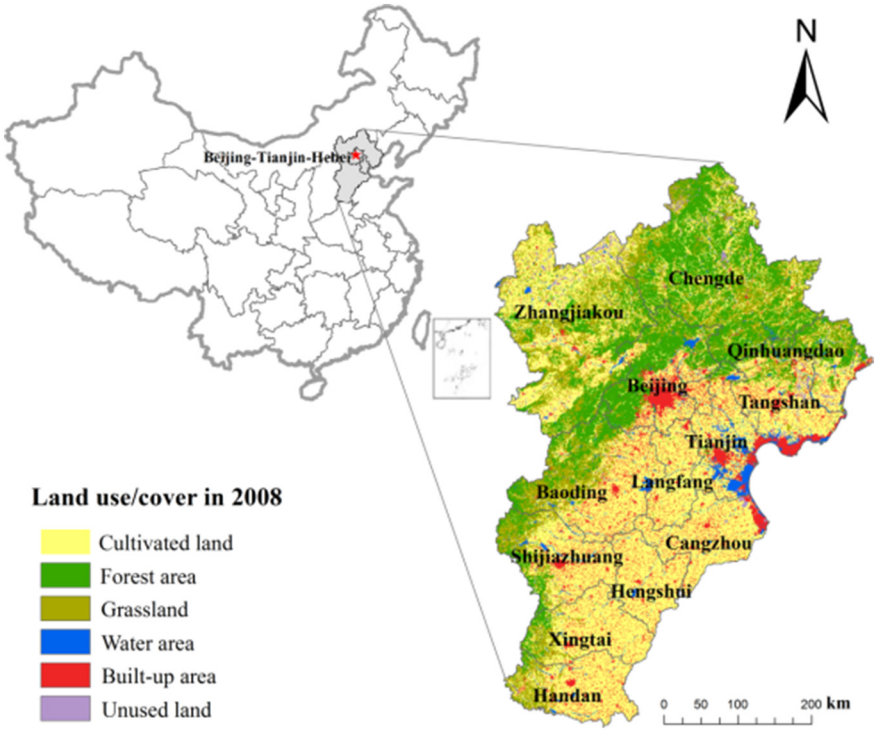

Fig. 1. Administrative boundary and land-use pattern of the BTH metropolitan region.

New-type urbanization emphasized the idea that an ecologically-minded civilization should be integrated into urban development through green production, lifestyle and consumption patterns. Doing so requires minimizing trade-offs and maximizing synergies to achieve sustainable urban development during the eco-urbanization process (Chen et al., 2016; G. Wang et al., 2015; X.R. Wang et al., 2015). However, the rapid urbanization development, with "land finance" and industrialization as the core concepts, has brought great pressure to the environment. This is evidenced by decreasing land cultivation and an increase in environmental pollution (Deng et al., 2008), and promoting sustained and rapid development of the national economy (Li et al., 2015; Ozturk et al., 2016). New-type urbanization proposes to promote intensive, intelligent, green and low-carbon sustainable development as well as improve urban development quality and intensive land-use (Liu et al., 2017; Sun, 2017). In this context, research on the effect of land-use change on urban ecological services (Broadbent and Cara, 2018; Drescher et al., 2016) and on the relationship between urbanization and urban ecological services (Al-Mulali et al., 2015; Zhao et al., 2016) has important academic and practical significance.

Eco-efficiency is based on creating economic value with fewer environmental impacts and this is achieved by improving land-use efficiency. With a focus on minimizing the environmental impact, this model has become essential for the new-type urbanization. Previous research on land-use efficiency was primarily based on the evaluation of economic and social efficiencies. However, research based on the scarcity of land resources and the evaluation of land eco-efficiency was lacking (Hernandez et al., 2014; Bryan et al., 2015; Saikku and Mattila, 2017; Deng et al., 2017a). Although previous research has demonstrated an important relationship between land-use and land ecology, the premise and results of land use and land ecology are only part of this complex relationship (Yu et al., 2016; Masuda, 2016; Shi et al., 2017). Therefore, we concentrate on land eco-efficiency, which allows us to couple land use and ecological impact by analyzing methods for minimizing resource consumption and ecological loss, and maximizing urban land-use value from an input-output perspective. This process helps guarantee the efficiency and sustainability of land utilization during eco-urbanization process (Egilmez et al., 2016; Yang and Zhang, 2018).

At present, existing research on land eco-efficiency is limited. Reith and Guidry (2003) analyzed eco-efficiency in a sustainable agricultural consortium test area in Louisiana and proposed that diversified land-use was the basis for ecological efficiency analysis. Sorvari et al. (2005) studied the eco-efficiency of land restoration in a polluted land management area and summarized the differences between and characteristics of eco-efficiency of land restoration in four sample regions. In addition, researchers also addressed the relationship between urbanization and the urban ecosystem. Wang et al. (2014) proposed two integrated index systems to assess urbanization and the environment and estimate the relationship between them. Luo et al. (2013) measured China's provincial eco-efficiency and found that the relationship between urbanization and eco-efficiency is an asymmetrical U-shaped curve. However, little has been published on the relationship between new-type urbanization and land eco-efficiency. We believe that measuring land eco-efficiency and evaluating the impacts of new-type urbanization, both in theory and in practice, has significant value.

In this paper, we measured land eco-efficiency using a super efficiency DEA model and Malmquist total factor productivity index. Our study included 13 prefecture-level cities in the Beijing-Tianjin-Hebei region and covered the period from 2005 to 2013. We constructed an indicators system for new-type urbanization and applied an extended STIRPAT model to analyze the impacts of new-type urbanization on land eco-efficiency. All our results have implications for land eco-efficiency management, as well as sustainable urban development in Beijing-Tianjin-Hebei region and other similar urban agglomerations.

2. Study area

The Beijing-Tianjin-Hebei (BTH) region (36°01′N–42°37′N, 113°04′E–119°53′E) is governed by the two municipalities of Beijing and Tianjin and the 11 cities in Hebei Province, including Baoding, Langfang, Tangshan, Handan, Xingtai, Qinhuangdao, Cangzhou, Hengshui, Chengde, Zhangjiakou, and Shijiazhuang. The total area of the BTH region is 218,000 km^2. The region contains landforms of various types, including the Bashang plateau, Yanshan and Taihang

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