Applied Geography 94 (2018) 163–177

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Identifying the relationship between urban land expansion and human activities in the Yangtze River Economic Belt, China

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ARTICLE INFO

Keywords:
Urban land expansion
Human activities
Interaction
Nighttime light data
Yangtze River Economic Belt

ABSTRACT

Urban land expansion is closely related to and interacts with human activities. Although extensive studies have investigated the characteristics and patterns of urban land expansion, the coupling between urban land expansion and human activities has been neglected. Therefore, this paper explores the relationship between urban land expansion and the scope of human activities in the Yangtze River Economic Belt (the YREB) of China during the period of 1995–2015 based on Landsat and nighttime light remote sensing data. Overall, a coupling exists between urban land and the scope of human activities at the scales of the metropolitan area and the urban agglomeration. On the one hand, the degree of match between urban land and the scope of human activities has an upward tendency with time. According to the results of our regression model and landscape indexes, the scope of human activities outside urban land is associated with the magnitude of urban land, and the land within the scope of human activities outside urban land changed more intensely in developed areas. On the other hand, a coupling between newly increased urban land and the scope of human activities was proven by calculating the degree of match and identifying three urban land expansion types based on the location relationship. This paper argues that although the degree of match increased and the dominant type of urban land expansion transformed from outlying to backfilling, the problems of disorderly expansion of urban land and imbalanced development of the spatial distribution and scale structure still exist. The results can be used to formulate reasonable policies and planning and to promote the regional integration and coordinated development of urban land and human activities.

1. Introduction

Since the second industrial revolution in the nineteenth century, cities have gradually become the central location for labour, capital and information (Fang & Yu, 2017). From 1950 to 2015, the urban population of the world grew from an estimated 0.75 billion to an estimated 3.95 billion. Currently, China has the largest urban population, accounting for 20 percent of the global total (United Nation, 2015). With rapid economic growth and unprecedented urbanization since 1978, when China entered the period of reform and opening up, Chinese cities have experienced dramatic migration and urban land expansion (C. Wu, Wei, Huang, & Chen, 2017; K.-y. Wu, Ye, Qi, & Zhang, 2013). From 1978 to 2015, China's urban resident population increased from 172.45 million to 771.16 million, and the urbanization ratio rose from 17.92% to 56.10%. The most rapid urban land expansion occurred in coastal cities and developed regions. China is emerging with novel features and properties that cannot be easily described by existing urban theories mainly derived from Western developed countries (F. Wu, 2016). China has become an important object of urban studies due to its special regional status, the political background and the development process. In 2014, China's National Development and Reform Commission released the National New-type Urbanization Plan (2014–2020), the first official urbanization plan. Urbanization has become the core content of social and economic development in China's post-reform period.

The development of urbanization in all cities is accompanied by population agglomeration, socioeconomic development and urban land expansion (Scott & Storper, 2015). The process of new-type urbanization involved many aspects, including non-agricultural population concentration, economic development, urban land expansion, the spread of urban culture and lifestyle, as well as others. Cities have emerged historically only where a food surplus (Jacobs, 2016) and the agglomeration of human activities, which include political administration, craft production and market trading, exist in geographic space (Childe, 1950; Wheatley, 1971). The agglomeration of human activities can be divided into two stages based on different factors promoting further agglomeration of output. The first stage is the agglomeration of labour and production capital, and the second stage is the agglomeration of technology and research and development (R&D) capital

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https://doi.org/10.1016/j.apgeog.2018.03.016
Received 12 November 2017; Received in revised form 18 March 2018; Accepted 22 March 2018

(Crescenzi, Rodriguez-Pose, & Storper, 2012). Urban agglomeration affects the patterns, determinants and driving forces of urban development and human activities. Four sources can be distinguished from an economic perspective: Internal increasing returns to scale, Marshallian externalities (localization economies), urbanization economies and Jacobs externalities (Frenken, van Oort, & Verburg, 2007). Generally, Marshallian externalities appear in smaller specialized cities, and Jacobs externalities appear in larger diversified cities. From a micro perspective, agglomeration can be understood as a mechanism of sharing (local interlinkages within production system and the supply of public goods), matching (the connection between local pools of firms and labours) and learning (the flow of formal and informal information) (Duranton & Puga, 2003; Scott & Storper, 2015), which determine the agglomeration capacity and urbanization level of a city. To some extent, changes in human activities can be reflected in changes in urban vitality and agglomeration abilities. The scope of human activities is defined as the city-centered area where the non-agricultural population is more concentrated and there are intensive living and production activities. The existing literature has consistently indicated that nighttime light data can efficiently reveal the vitality of urban development, and a significant correlation exists between these data and human activities, such as growth in the economy and infrastructure (Keola, Andersson, & Hall, 2015; Nordhaus & Chen, 2015), the population distribution (Anderson, Tuttle, Powell, & Sutton, 2010), energy consumption (Elvidge et al., 2009), the processes of urbanization (B. Gao, Huang, He, & Ma, 2015; Y. Liu et al., 2015; Qingling Zhang & Seto, 2011) and other elements on the national, urban agglomeration and metropolitan area levels. Although many scholars have extracted urban boundary and related information using nighttime light data and studied urban expansion and land-use changes in periods, the urban area can be exaggerated due to light spills caused by human activities.

As a product or result of the agglomeration of human activities, urban land expansion can be described by six dimensions: density, continuity, concentration, clustering, centrality, and proximity (Galster et al., 2001). Related studies mainly contain the processes (Ji et al., 2001; Yin et al., 2011), determinants (Qianwen Zhang & Su, 2016), driving forces (He, Liu, Tian, & Ma, 2014), simulation and prediction (Al-sharif & Pradhan, 2016) of urban land expansion within a temporal interval between selected years. Scholars have employed various statistical or spatial indicators to investigate the magnitude and spatial change of urban land expansion, such as the increment, growth rate, and percentage of urban land (Ma et al., 2014; Y. D.; Wei, Li, & Yue, 2017; W.; Wu, Zhao, Zhu, & Jiang, 2015)and the size, density, shape, and arrangement of urban land patches (Deng, Ke, Hong, & Qi, 2009; Tian, Ge, & Li, 2017; W.; Wu et al., 2015). Types of urban land expansion include infilling, edge-expansion and outlying, which can be quantified by a common boundary (Sun, Wu, Lv, Yao, & Wei, 2013; C.; Xu et al., 2007) or landscape expansion index (X. Liu et al., 2010). Remote sensing has been widely used as the primary data source for directly studying urban land expansion. Scholars from geography, urban planning and other disciplines have employed Landsat (Y. Chen, Liu, & Li, 2017; Jiao, 2015; Z. Zhang et al., 2016), MODIS (Ma et al., 2014; Y. D.; Wei et al., 2017; M.; Xu, He, Liu, & Dou, 2016), Quickbird (You, 2016) and other remote sensing data sources with different resolutions and investigated urban land expansion on national (Jiang, Deng, & Seto, 2012; Ma et al., 2014; Qianwen; Zhang & Su, 2016), provincial (Zhong, Chen, & Huang, 2016), urban agglomeration (S. S. Chen, Yan, Gao, & Liu, 2015; J. Gao et al., 2015; X. Li & Yeh, 1998), metropolitan (J. Chen, Gao, & Chen, 2016; Jiao, 2015) and other levels. Many studies have investigated the spatiotemporal change in urban entities using impervious surfaces, but these urban entities are assumed to be homogenous inside the city or between cities, with the difference in vitality caused by human activities ignored.

The development of human activities promotes the expansion of urban entities. As a spatial carrier, urban entities also accumulate a certain amount of human activities. For urban land expansion and the scope of human activities (population concentration and socioeconomic development), the synchronous development contributes to eliminating various problems, such as environmental pollution, job-housing balance, the loss of arable land and habitat destruction, but these aspects are not always coordinate or match in every region and period under the influence of the spillover effect, land control, location selection and others. First, external trade and human activities are outside of the city, and the function and influence of cities not only are internal but also spill into the periphery of cities (Meijers & Burger, 2017). With the evolution of modes of commute and the construction of transportation and other infrastructures, the barriers that hinder human activities are consistently decreasing (Xie, Fang, & Liu, 2016), and the decisive reasons for urban change and its patterns are becoming diverse and complex. Second, state-led urbanization countries, such as China, which control land and other natural resources, create conditions for urban land expansion by exerting fiscal policies and political pressure, developing New Towns and New Areas (Y. H. D. Wei, 2012; Ye, 2014). Land-centered and planned urbanization usually leads to an oversupply or undersupply of land and may not be consistent with population concentration and socioeconomic development (Lin, 2016; Tian et al., 2017). Third, the location selection for human and firms is not confined to the inner of the city or its edge. Rural migrants tend to live in peri-urban location due to a shortage of private rental space inside cities (F. L. Wu et al., 2013). In addition, local government arrange industrial land onto outside city and evacuated original industrial firm or factory to peri-urban. Nighttime light has an impressive record in capturing the spatial distribution of population and socioeconomic activities, and urban expansion can be measured using Landsat data. Yimin Chen employed Landsat and nighttime light data to study the relationship between urban land expansion and changes in human activities in Guangzhou, China (Y. Chen et al., 2017). However, the study did not reveal the interaction between urban land expansion and changes in human activities. Meanwhile, related studies are subject to the limitation of scale. Discrepancies in the spatial distribution and change characteristics between urban land expansion and the scope of human activities were ignored.

This paper aims to illustrate the changing characteristics, relationship and interaction between urban land expansion and the scope of human activities in the YREB, which stretched from eastern to western China and has experienced rapid urbanization from 1995 to 2015. Landsat data and nighttime light data were adopted to detect the spatiotemporal change characteristics of urban entities and human activities, and the essential relationship between urban land and the scope of human activities was captured using regression analysis and landscape indexes. In addition, the interaction between urban land expansion and the scope of human activities was investigated by calculating the degree of match and identifying the urban land expansion type. The three primary questions we intend to address are as follows: (1) What are the main characteristics of spatiotemporal change in urban land expansion and the scope of human activities in the YREB from 1995 to 2015? (2) Is there a coupling between urban land expansion and the scope of human activities? (3) If there is a coupling, what are the main differences and reasons among different periods, levels and regions? The rest of this paper is organized as follows. The next section introduces the area and data selected in the study. The third section introduces the methods adopted in the study. The fourth section illustrates the results of the empirical analysis of the spatiotemporal changes in urban land expansion and the scope of human activities and their relationship and interaction. The fifth section discusses the core cause of regional differences, the relationship between urban land and human activities, and potential biases and future steps. The final section concludes the paper.