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Research article

Changing man-land interrelations in China's farming area under urbanization and its implications for food security

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ABSTRACT

The Huang-Huai-Hai Plain (HHH) is typical of China's farming area, and was predicted as one of the fastest growing areas of urbanization in the world. Since the turn of the new millennium, construction land and farmland transitions in this region driven by rapid urbanization have resulted in dramatic loss of farmland, which triggered a serious threat to regional even national food security. In this paper, the coupling relationships between per capita construction land transition (PCCT) and per capita farmland transition (PCFT) in the HHH and their implications for regional food security are analyzed. During 2000–2015, the farmland decreased by 8.59%, 72.25% of which were occupied by construction land. There are two major coupling types between PCCT and PCFT, one is the double increasing of per capita construction land area (PCCA) and per capita farmland area (PCFA); another is the increasing of PCCA and the decreasing of PCFA. The fluctuant increasing of PCCT and decreasing of PCFT coexisted and presented symmetrical coupling characteristics in space. Physical, location, transportation and socio-economic factors play significantly different roles in driving PCCT and PCFT. The implications for ensuring food security involve promoting the reclamation and redevelopment of inefficient and unused urban-rural construction land, reducing inefficient occupation of farmland resources, developing appropriate scale management of agriculture, and establishing a better social security system to smoothly settle down the floating rural population in the city.

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1. Introduction

China's total agricultural available resource is large, but the per capita possession is less. The per capita farmland area (PCFA) of China is 0.1 ha, only 12% that of the United States (Xiao et al., 2017). The farmland area per China's household is 0.38 ha, which is below the world average, even lower than that of India, Japan and South Korea (Song et al., 2013). The proportion of households with a total farmland land area of less than 0.6 ha is 83% (NBSC, 2008). Since the new millennium, the urban-rural transformation development in China has entered a critical period (Long et al., 2011). The extensive and accelerated urbanization has brought more challenges to scarce land resources (Jiang et al., 2012; Liu et al., 2007).

In the process of urbanization, urban construction land and rural housing land are increasing rapidly (Lambin et al., 2001), but the efficiency of land development and utilization of construction land both in the urban and the rural is limited (Huang et al., 2002; Long and Li, 2012). Under the stimulation of "land revenue" and the pursuit of GDP, local governments are accustomed to planning large development areas far beyond the actual needs, and the inefficient or idle land use phenomena is very common (Fan et al., 2017; Huang et al., 2017). In 2003, there were 6866 economic development zones in China, covering an area of 3.86 Mha, of which 1.3 Mha land resources was idle (Cartier, 2001; Wei and Ye, 2014).

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During 2003–2013, urban built-up area increased by 78.5%, while the urban population increased by only 46% (Bai et al., 2014). This phenomenon led to an enclave sprawl of urban, which brought about the serious waste of farmland resources and the disorderly sprawl of the urban (Chen et al., 2014a; Jiang et al., 2012).

During 2000–2015, China's urbanization rate increased from 36.22% to 56.1%, the number of rural resident population decreased from 808 million to 603 million, with a decrease of 205 million (NBSC, 2016). Simultaneously, China's rural housing land increased from 18.12 Mha in 2000 to 19.11 Mha in 2015, with an increase of 0.99 Mha (MLRC, 2016). The per capita rural housing land of China increased from 204.5 m^2 to 231 m^2 from 2000 to 2008 (MLRC, 2016), and the phenomenon of "decreasing population vs. increasing rural housing land" occurred in rural areas (Long et al., 2012). Along with the population outflow, the issue of rural hollowing became a hot research topic (Liu et al., 2014b; Tu and Long, 2017), the efficiency of rural housing land use is low, combined with farmland fragmentation (Deng et al., 2015) and abandoned (Wang et al., 2016).

Land use transitions research provides theoretical support and technical guidance for rational allocation and optimization of urban-rural land resources (Lambin and Meyfroidt, 2010; Long and Qu, 2017). At present, many scholars has launched an in-depth study on urban-rural land use transitions, such as forest transition (DeFries et al., 2010), rural housing land transition (Li et al., 2015; Long et al., 2007a), farmland transition (Long and Li, 2012; Song and Deng, 2015), urban construction land transition (Gao et al., 2016; He et al., 2013; Song and Deng, 2015), etc. The impacts of land use transitions on the agricultural production system (Seto and Ramankutty, 2016) and the safety of food production (van Vliet et al., 2017) under urbanization process have also contributed to more research. With the rural-to-urban migration, the plight of land use transitions in the process of urbanization of China is obvious. The urbanization progress affects the food production and consumption system (Godfray et al., 2010), which gives the farmland protection with more severe challenges (Davis et al., 2016). As the world's most populous country, revealing its coupling mechanism between per capita construction land area (PCCA) and PCFA has an important practical significance for ensuring the food security of China who bears the more people and less farmland (Peng, 2011; West et al., 2014). The change and evolution of PCCT and PCFT are the core elements of regional man-land interrelations, which can reveal the process of demographic transition (urban-rural population distribution and employment structure) and urban-rural transformation development under urbanization (Ge et al., 2018a).

Farmland is the core resource ensuring food security (Chaplin-Kramer et al., 2015; Foley et al., 2011). Enlarging agricultural production, we can intensify and expand the farmland utilization (Johnson et al., 2014; Rudel et al., 2009). No matter what methods, adequate farmland resource is a prerequisite. The Huang-Huai-Hai Plain (HHH) accounts for 4.3% of China's land area, while the share of farmland, population and grain yield of total China is 20.6%, 22.5% and 30.8%, respectively, which is a main grain-producing area of China. Seto et al. (2012) and Bren d'Amour et al. (2017) predicted that the HHH is one of the fastest growing areas of urbanization in the world, which includes the Beijing-Tianjin-Hebei urban agglomeration, Shandong Peninsula urban agglomeration and the Central Plains urban agglomerations (Li et al., 2017). Therefore, taking the HHH as an example, the coupling relationship research between PCCT and PCFT is of great significance for revealing the law of farmland transition and protecting regional food security.

Accelerated urbanization and corresponding human activities are triggering tremendous land use transitions in China (Long, 2014). Farmland and construction land are tightly inter-related with human livelihood and production activities, and are treated as the two most important land-use types depicting urban-rural development in China (Long and Li, 2012). Land use transitions in China under rapid urbanization were mainly characterized by the shrinkage of farmland and the rapid expansion of urban-rural construction land (Liu et al., 2010; Long et al., 2007b; Su et al., 2016). So, farmland and construction land play an important role in facilitating land use transitions (Su et al., 2014). To some extent, probing the coupling relationship between PCCT and PCFT in the HHH may be helpful to find a solution for ensuring food security of China. Therefore, based on the major grain-producing areas with rapid urban-rural transformation development and most population density areas of the HHH, we deeply study the coupling relationships between per capita construction land transition (PCCT) and per capita farmland transition (PCFT) and the related influential factors. And then, we reveal the implications of land use transitions for regional food security.

2. Study area

The HHH, one of traditional major grain-producing areas of China, is undergoing rapid urbanization, and the contradiction between urban-rural transformation development and farmland protection and grain production is being intensified (Fig. 1). During 2000–2015, the total population of the HHH rose to 328 million from 276 million in 2000, of which the urban population increased from 63 million to 157 million, and the urbanization rate increased by 24.9 percentage points to 47.47% in 2015 (NBSC, 2016). Under the background of accelerated urbanization, farmland protection pressure and ecological environment bearing pressure continuously emerged (Chen, 2015; Seto et al., 2012). How to evaluate and forecast the transition of the man-land interrelations (Prokop and Ploskonka, 2014), it is not only related to the general pattern of

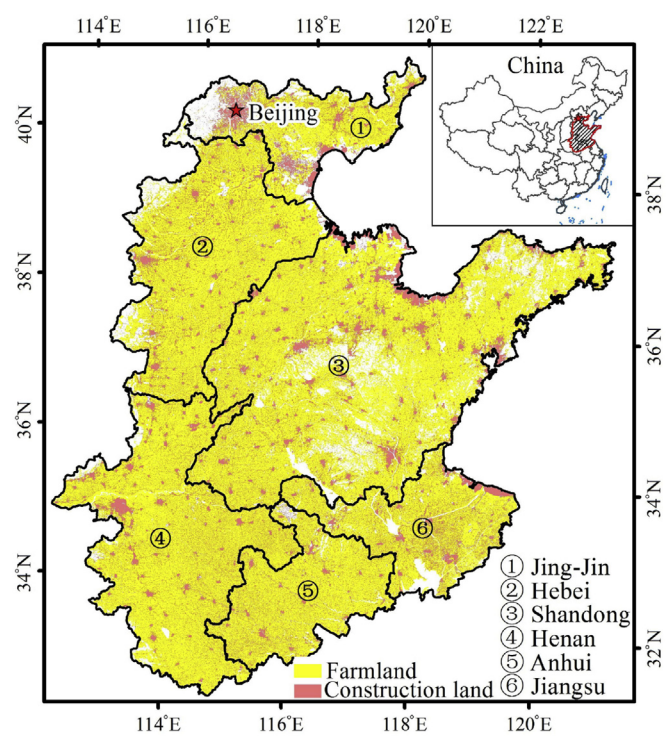

Fig. 1. Map of the HHH in China. The distribution pattern of construction land and farmland is in 2015. In accordance with the administrative boundary, the HHH is divided into six parts, Jing-jin, Hebei, Shandong, Henan, Anhui and Jiangsu.

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