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A comparative analysis of urban and rural construction land use change and driving forces: Implications for urban–rural coordination development in Wuhan, Central China

Yaolin Liu [a, b], Ti Luo [a, *], Zhongqiu Liu [c], Xuesong Kong [a, b], Jiwei Li [a], Ronghui Tan [a]

[a] School of Resource and Environmental Science, Wuhan University, Wuhan 430079, China
[b] Key Laboratory of Geographic Information System, Ministry of Education, Wuhan University, Wuhan 430079, China
[c] Information Center of Jiangan District in Wuhan, Wuhan 430079, China

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ABSTRACT

This paper explores the spatial–temporal changes of urban–rural construction land use and its anthropogenic driving forces in Wuhan from 1996 to 2009. The vector maps and data from two National Land Investigations in China, socio-economic information from government departments are used, and land use dynamic models and landscape metrics with mathematical statistical method are applied. The outcomes show the expansion of urban–rural construction land, which is extremely rapid that the amount of cultivated land drastically dwindled, the aggregation of urban construction land strengthened, and the fragmentation of rural construction land aggravated. The urban–rural difference of construction land use changes exists in the regional disparity between the inner city and the outer city of Wuhan. During the study period in Wuhan, the quantity and structure changes of urban–rural construction land in the outer city play a decisive role for the change trends of the total city. Societal and economic factors, which include demographic change, economic growth, living standards, and policies, are closely related to the pattern of urban–rural construction land use. Significant regional and urban–rural differences exist on the driving mechanism between the inner city and the outer city of Wuhan. The smooth implementation of urban–rural coordination development can be achieved by allocating the rational scale of urban–rural construction land, optimizing city–town–village spatial system, improving the efficiency of urban–rural land utilization and restructuring urban–rural production, living and ecological spaces.

Introduction

Since the International Geosphere–Biosphere Program (IGBP) and the Global Environmental Change in the Humanities Program (IHDP) promoted the land use and land cover change (LUCC) research project in 1995, this area has rapidly become a research frontier that delved into topics of global change and sustainable development issues (Zhang, Kang, Wang, & Sun, 2010). The spatial–temporal dynamics and driving forces of land use change are the recent focus of scientific research of the LUCC research project worldwide (e.g., Bicik, Jelecek, & Stepanek, 2001; Ferreira & Condessa, 2012; García-Romero, 2007; Gaughan, Binford, & Southworth, 2009; Kroll & Haase, 2010; Shoshany & Goldshleger, 2002; Yoshida, Iizumi, Nishimori, & Yokozawa, 2012; Zachary, 2013; Zia, 2012). Anthropogenic factors, which are determined by demographic, economic, political, and societal developing processes, are the most common major forces that contribute to land use change on a global scale. However, regional discrepancies of LUCC continue to exists and have been increased by active economic growth and urbanization because of enormous physical and human diversity (Long, Heilig, Li, & Zhang, 2007; Long, Tang, Li, & Heilig, 2007; Verburga, Veldkampb, & Frescoa, 1999). Regional comparative studies, which include change process, spatial distribution and pattern, driving forces, and consequences of land use change, are considered effective methods for global and regional studies on the spatial–temporal evolution of land use (Liu et al., 2010).

* Corresponding author. School of Resource and Environment Science, Wuhan University, 129 Luoyu Road, Wuhan 430079, China. Tel.: +86 02787152415.
E-mail addresses: yaolin610@163.com (Y. Liu), ltmmadd@163.com (T. Luo), 394814654@qq.com (Z. Liu), kxsiu@tom.com (X. Kong), lijiwei19850620@163.com (J. Li), tanronghui1999@gmail.com (R. Tan).

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Significant changes in land use and land management have taken place in China in the last three decades (Lin & Ho, 2003). The accelerated industrialization and urbanization following economic reforms and population increases have greatly affected land use change through rapid residential and urban expansion (Deng, Huang, Rozelle, & Uchida, 2008; Wu, Sun, Zhou, Huang, & Zhao, 2004). An increasing number of policymakers and academic researchers have focused on land use change and driving forces in China, especially on the dynamics of cultivated land related to food security (Chen, 2007). To protect the cultivated land and achieve optimal land allocation in cities and in the countryside, the Chinese central government has introduced strict farmland protection objectives and implemented a series of land use management policies on the use of construction land. These policies include "economic and intensive land use", "land consolidation and rehabilitation" and "increasing versus decreasing balance of urban–rural construction land" (Liu, Fang, & Li, 2014; Liu, Yang, & Li, 2013; Long, 2014a).

However, an inevitable tension exists between the increase of urban–rural construction land with strikingly urbanizing development and the protection of cultivated land as a national strategy (Huang, Chen, & Zhang, 2011; Long, Li, Liu, Woods, & Zou, 2012). In addition, the urban construction land expanded continuously with the mass migration of rural population into urban land in China, but rural construction land has not decreased according to theoretical prospection (Li et al., 2008). The unreasonable inner structure, the low-density distribution of urban–rural construction land, and the ecological environment deterioration brought about by urbanization were considered important issues related to LUCC and land use optimization.

Urban and rural developments in contemporary China are undergoing a transition period, which is the transformation of a traditional agricultural society into a modern industrial and urban society (Long, Heilig, et al., 2007; Long, Tang, et al., 2007). The binary structure of urban and rural is more specific in China because of historical reasons. The most notable issue is a shift in the economic balance and the widening of the prosperity gap between urban and rural areas (Long, Zou, Pykett, & Li, 2011). The fundamental ways to break the imbalance are to integrate urban and rural resources, optimize resource allocation, and improve resource utilization efficiency (Yan & Wan, 2011). Thus, the Chinese central government proposed a project on "urban–rural coordination development" (*Chengxiang Xietiao Fazhan*) to promote the optimal allocation of regional resources between urban and rural systems (Long et al., 2011; Seto & Fragkias, 2005). As the spatial projection of urban–rural economic, societal and ecological harmonious development, the coordination of urban–rural construction land use becomes one of the key contents in smoothly implementing national urban–rural integration development strategy (Long, 2014b). Therefore, it is significant to analyze and compare the spatial–temporal evolution of urban and rural construction land for integrating regional urban–rural construction planning and socioeconomic development in China.

Most researchers pay more attention to the urban or rural land use change in the coastal regions of China, such as the Yangtze River Delta region (Xu, 2004; Zhong, Huang, Zhang, & Wang, 2011) and the Pearl River Delta region (Seto & Kaufmann, 2003; Zhang et al., 2010). The economic growth in these areas was stimulated by economic reforms and characterized by acute open door policy and tremendous urbanization and rural transformation. Studies about the less developed inland cities of China are relatively weak. Wuhan is the only megacity in Central China, and is also one of the 17 cities included in the global sustainable development city plan issued by the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). Research about the land use change of Wuhan is typical and significant for the sustainable utilization of land resource in inland China. This paper investigates the characteristics and differences between urban and rural construction land use changes of Wuhan City in Central China. The disparity between booming cities and laggard villages in this area is increasing, which is affected by the stubborn binary structure of urban and rural areas. The purposes of this paper are as follows: a) to describe and compare the spatial and temporal patterns of urban and rural construction land use changes; b) to analyze the relationships between the changes of construction land use and the variable of major socio-economic factors in urban and rural development; and c) to explore the possibilities and introduce the major implications for achieving a more coordinated and balanced urban–rural development in the future.

Study area and data

Area description

Wuhan, which is situated in the intersection of the middle reaches of the Yangtze (the longest river in Asia and the third longest in the world) and Hanshui (the biggest branch of Yangtze) rivers, and the most populous city in Central China, is the capital of Hubei Province, China. Wuhan covers an area of 8494.41 km^2, and extends between 29°58′ to 31°22′ N latitude and 113°41′ to 115°05′ E longitude. Topographically, Wuhan features mostly low hills and plains with a gently sloping terrain. Water makes up about one quarter of the entire city. The abundant water resources in the city proper of Wuhan distinguish it from other cities in China and even in the world. As the Wuhan is a major transportation hub with dozens of railways, roads, and expressways passing through the city. The city is now recognized as the political, economic, financial, cultural, educational, and transportation center in Central China. According to the administrative division and the urban master planning, Wuhan consists of thirteen administrative districts, which include seven central urban districts and six suburban districts (Fig. 1). The suburban district area is about four times the central urban district area in Wuhan. However, the population of central urban districts is about 57.2% of the total population in 2009.

With the continuous improvement of urban infrastructure and the high-speed propulsion of urbanized construction in recent years, the gross domestic product (GDP) of Wuhan ranks fifth among the sub-provincial cities of China. However, compared with other metropolises like Beijing, Shanghai, and Guangzhou, the rural population of Wuhan maintains a higher proportion and relatively lower urbanization level (Fig. 2). Similarly, urban and rural binary economic structure disadvantages are exposed more obviously. The most remarkable feature of that binary structure is the chronic coexistence in one city of the developed urban area where modern industry is agglomerated and the backward rural area where traditional agriculture continues to dominate. Fig. 3 shows the imbalance of population distribution and economic development between central urban and suburban in 2009, which represents the urban–rural gap. Without control, this gap poses a more serious danger to the coordination development of urban and rural and the sustainability of regional development in Wuhan.

Data sources and pre-processing

This paper analyzes systematic data on land use change in Wuhan based on two land use–land cover (LULC) vector format maps at a 1:10,000 scale, which were gathered in the two nationwide land surveys (ended in 1996 and 2009 separately) conducted in the history of the People's Republic of China. The results of the