

## Research Paper

# The rapid and massive urban and industrial land expansions in China between 1990 and 2010: A CLUD-based analysis of their trajectories, patterns, and drivers



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## HIGHLIGHTS

- China's urban and industrial lands increased by  $4.23 \times 10^4$  km<sup>2</sup> between 1990 and 2010.
- The urban lands' expansion rate in the 2000s was 2.15 times that in the 1990s.
- The industrial lands' expansion rate in the 2000s was 5.79 times that in the 1990s.
- National policies played a more important role than economic factors.
- The use of China Land Use/Cover Dataset (CLUD) in national level analysis is effective.

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## ABSTRACT

The past two decades saw rapid and massive urbanization and industrialization in China. Despite much research has been reportedly done at local and regional scales, little has been reported on the trajectories, patterns, and drivers of these two intertwining processes at the national level. This is mainly due to the fact that until recently, high resolution spatial data of land use and land cover change were not available at national level. The research reported in this paper aimed to fill this knowledge gap. Employing the China Land Use/Cover Dataset (CLUD), a national land use/cover change database our research team developed over the past decade, we analyzed the two intertwining processes at a 5 year interval from 1990 to 2010 to identify their trajectories, spatiotemporal patterns, and driving forces. Among out key findings are that (1) the nation's urban and industrial land areas increased from  $4.85 \times 10^4$  km<sup>2</sup> in 1990 to  $9.08 \times 10^4$  km<sup>2</sup> in 2010; (2) compared to those in the 1990s, the expansion rates of urban land and industrial land in the 2000s were respectively 2.15 and 5.79 times higher; (3) the expansion rates varied significantly across regions, revealing a distinctive spatial pattern with coastal regions being the fastest and the northeastern the slowest; (4) national development strategies and regional land-use policies had prominent impacts on land expansions; while (5) socioeconomic factors along with local and regional land-use policies explained the regional variations.

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## 1. Introduction

More than half of the global population now lives in cities and the global urban population is predicted to reach 6.29 billion by 2050 (United Nations, 2012). Population growth and emerging

trends of immigration to urban areas created serious environmental problems, especially in developing countries in Asia, such as China and India (Montgomery, 2008; Xiang, Stuber, & Meng, 2011). Industrialization is another process emerging in developing countries along with rapid urbanization (Deng, Huang, Rozelle, & Uchida, 2008). Urbanization and industrialization have become major factors affecting ecosystem services and environmental quality (Grimm et al., 2008; Kaza, 2013; Pickett et al., 2011; Seto, Guneralp, & Hutyra, 2012; Wu, 2014). Conversions from natural lands to urban and industrial lands have substantially affected the carbon cycle (Normile, 2008; Zhang et al., 2008), hydrological

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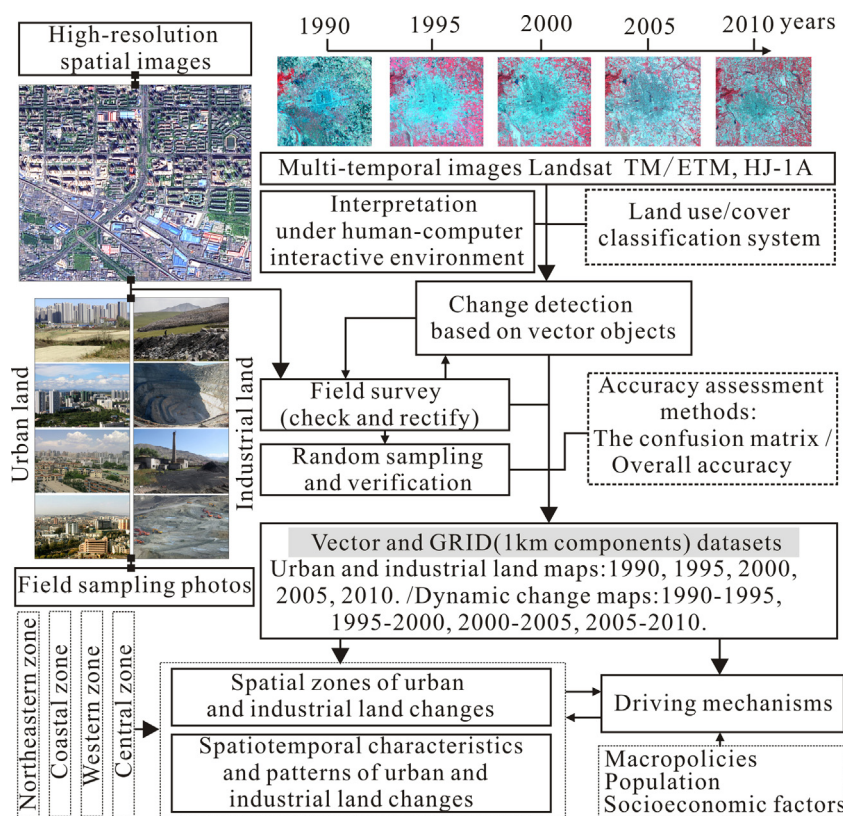


Fig. 1. Framework of data processing and analysis.

processes (McDonald et al., 2011; Mitchell, Mein, & McMahon, 2001), and surface energy balances (Bierwagen et al., 2010; Kuang, 2012; Kuang, Dou et al., 2015) of land ecosystems. Meanwhile, the accompanied environmental problems such as urban heat island effects and air pollution, severe smog and haze in particular, constitute a significant threat to human health (Kuang, Liu et al., 2015; Lu, 2007; Matus et al., 2012; Normile, 2008; Parrish & Zhu, 2009; Weng, Lu, & Schubring, 2004; Xiang et al., 2011; Zhang et al., 2013; Zhou et al., 2004).

The implementation of China's economic reform and open policy in 1978 stimulated rapid urbanization and industrialization in the country. In the early 1990s, the transition from a centrally planned economy to a socialist market economy greatly accelerated urbanization and industrialization in China (Gu & Shen, 2003). From 1990 to 2010, China's gross domestic product (GDP) underwent an unprecedented increase at an average rate of 10% per year; in the same time period, the number of prefecture-level cities increased from 188 to 287. The percentage of the population living in urban areas increased from 26.4% in 1990 to 49.9% in 2010 (National Bureau of Statistics of China, 2011) and exceeded 50% by the end of 2012. For the first time in its history, China became a predominantly urbanized country.

In this context, understanding the spatiotemporal patterns and driving forces of urban and industrial land expansions at the

national scale is important to informed land use planning and sustainable development. Many studies have indeed investigated the spatiotemporal patterns of urban expansion in megacities, such as Beijing, Shanghai, and Guangzhou (Kuang, Chi, Lu, & Dou, 2014; Li, Zhou, & Ouyang, 2013; Schneider & Mertes, 2014; Wu & Zhang, 2012; Zhang, Ban, Liu, & Hu, 2011). Moreover, the spatiotemporal trajectories, patterns and socioeconomic driving forces of urban land expansion have been investigated at the urban agglomeration scale, including the Pearl River Delta, the Yangtze River Delta (Li & Yeh, 2004; Seto & Fragkias, 2005; Tian, Jiang, Yang, & Zhang, 2011; Weng, 2002), and the Beijing–Tianjin–Hebei agglomeration region (Kuang, 2011; Tan, Li, Xie, & Lu, 2005). However, because of the lack of high resolution national data, national scale analysis has been limited in both quality and quantity, inevitably creating knowledge gaps and leaving many important issues unaddressed or even unattended. While a limited number of studies focused on the urbanization processes, driving forces, and the reductions in the area of cultivated land during the 20th century (Deng et al., 2008; Liu, Liu et al., 2005; Liu, Xu, Zhuang, & Gao, 2005; Liu, Zhan, & Deng, 2005; Tian et al., 2005), little if any attention was paid to the industrialization process (Kuang et al., 2014; Wang et al., 2012). The claim that the country's urban expansion has been undergoing a transformation from a mode of clustering expansion to a mode of dispersed sprawling (for example,

Table 1  
Urban and industrial land classification system.

1st level classes	Subclasses	Description
Urban and industrial land	–	Land used for urban and industrial land
	Urban land	Land used for residential, commercial, industrial, recreational, and transportation in cities and towns
	Industrial land	Land used for factories, quarries, mining, and oil-field wastes outside cities as well as land for special uses, such as roads and airports

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