Regional Differences of China’s Urban Expansion from Late 20th to Early 21st Century Based on Remote Sensing Information

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Abstract: This study investigated the regional differences of China’s urban land expansion from the late 1980s to the year of 2008, based on the spatio-temporal analysis of CLCD (China’s land cover/land use data base) datasets which were mainly produced from remote sensing imagery data. A newly defined urbanization level index (UI), based on urban land area, is proposed to describe Chinese urban expansion process at 1 kilometer, provincial, regional, and national scales, together with the absolute urban expansion index (UEa) and the relative urbanization expansion index (UEr). The results indicate that the percentages of total land area occupied by urban in the late 1980s, 1995, 2000, 2005, and 2008 were approximately 0.25%, 0.32%, 0.33%, 0.43% and 0.52% of China’s total land area, respectively. Between the late 1980s and 2008, the total urban expansion in the mainland of China was 2.645 × 10⁴ km², resulting in an annual urban expansion area of about 1322.7 km²/yr, with the UEr of 111.9%. This study also finds that there has been an obvious spatial gradient of urbanization ratio running from the east coast to the west inland, and the urbanization gaps among different regions have persisted over the past two decades. The study also reveals obvious temporal variations of the urbanization rates. There was very little urban growth during the period of 1995–2000 due to the governmental policy factors.

Keywords: regional difference; spatial pattern; temporal variation; urbanization; China

1 Introduction

In many parts of the world, there was a tremendous migration of people from rural regions to urban areas in the past 60 years. This trend has placed about half of the world’s population, and most human wealth, into urban regions (United Nations, 2008). In China, the unprecedented combination process of economy development and population increase has led the country into a quick transition from a largely rural society to a predominantly urban one. In 1947, China had only 69 cities; by 1980 the number of the cities had risen to 223. There are now 670 cities that host 44% of Chinese population (as of 2008), of which 15 are among the world’s 100 fastest-growing cities with populations of a million or more (Normile, 2008).

It has been shown that urban land expansion has significant impacts on atmosphere (Keller et al., 1991; Molders, 1999), regional climate (Carlson and Arthur, 2000; Xie et al., 2007; Jones et al., 2008), soil quality (Islam and Weil, 2000; Cao et al., 2007), hydrology (Weber et al., 2001; Li et al., 2008; Zhang et al., 2008), and ecosystem (Diem et al., 2006; Xu et al., 2007). Therefore, analyzing the characteristics and spatio-temporal differences of urban land expansion has great significances for sustainable urban development. Monitoring urban land dynamics at regional or national scales can provide a linkage to econometrics models to identify the driving forces of urban expansion, and to regional climate models to assess the environmental
effects of urbanization.

For economic, demographical and geographical researchers, the study on the relationship between urbanization process and urbanized land is one of important topics. Traditionally, urbanization studies are much relied on statistical data, including population and economic statistics. Usually, the national scale census is held every ten years or longer, and it is very difficult to obtain yearly data or up-to-date data using such census method in a country with a large population. Furthermore, in China, researchers have generally agreed that the process of urbanization has lagged behind its economic development due to the strict migration policy, household registry (Hukou in Chinese), macro land-use management, and cropland preservation institutions (Lin, 2001; Chen, 2002; Ma, 2002; Zhang and Song, 2003; Shen et al., 2006; Normile, 2008). Assessing the level of urbanization using census data, i.e., population data, therefore, has presented obvious problems including overestimating or underestimating the factual urbanization ratio.

Remote sensing (RS) technology, compared to traditional census and investigation, has provided a reliable and relatively inexpensive method to monitor and evaluate the changes of urban land. Many researchers have investigated the magnitude, patterns, and types of changes in urban regions with remote sensing information (Haack et al., 1987; Masek et al., 2000; Ji et al., 2001; Seto et al., 2002; Liu et al., 2003b; 2005b; Durieux et al., 2008). However, the interpretation and analysis of urban land change using RS imagery still present many theoretical challenges and practical difficulties (Tatem and Hay, 2004). Although some global scale land cover datasets are now available through the internet, there are few reliable and precision-enough documentations relating to the national urbanization process. The lack of database supports meant that most previous studies had to be restricted to local or regional scales, such as a single city, a metropolitan region, or a river delta at most. And the topics of previous studies were normally confined to the patterns of urban land distribution, the types of urban land expansion, driving forces of urban changes, and so on (Herold et al., 2003; Liu et al., 2003c; Seto and Kaufmann, 2003; Weber and Puissant, 2003; Liu et al., 2005d; Tian et al., 2005; Bao and Wang, 2009). Little attention has been paid to the research in a large spatial scale and a long temporal scale.

In this study, we used urban land information which was derived from remote sensing information by using GIS technique, rather than urban population by using census method, as an alternative indicator to assess Chinese urbanization process. The objective is to evaluate the characteristics and spatio-temporal differences of urban distribution and urban expansion in China from the late 1980s to the year of 2008. Two issues were mainly focused on the urban distribution patterns and its changes during different eras, and the urban expansion patterns and its temporal dynamics. The main research questions posed include: 1) How much urban land was there in each period? 2) How much has urban land expanded since the late 1980s? 3) What is the spatial pattern of urban land distribution in each era? And 4) what are the spatial and temporal characteristics of urban expansion process?

2 Data Sources and Processing

2.1 Remote sensing imagery and China’s land cover/land use database

The primary data source of this study is remote sensing imagery, i.e., Landsat MSS/TM/ETM+ and China-Brazil Earth Resource Satellite 1 (CBERS-1) images which were mainly taken in 1989/1990, 1995/1996, 1999/2000, 2004/2005 and 2007/2008. The spatial resolution of the above imagery is about 30 m. The images were enhanced using the linear contrast stretching and histogram equalization to help identify ground control points, and rectified to a common Albers coordinate system. Senior and experienced researchers were then organized to work on these RS imagery through a series of unified technical standards for image processing, computer-aided visual interpretation, error checking, and field validation. Land maps at scale of 1:100,000 were classified into 25 categories, which were then grouped into six aggregated classes, i.e., cropland, woodland, grassland, water body, built-up area, and bare land. A detailed technical description can be found in previous papers (Zhuang et al., 1999; Liu et al., 2003a; 2003b; 2005a).

Based on the above work, China’s land cover/land use database (CLCD) was then built. Supported by the time-series CLCD, a series of national scale, multi-disciplinary and comprehensive projects are able to be conducted successfully at home and abroad (Liu et al.,