



Measuring urban sprawl and its drivers in large Chinese cities: The case of Hangzhou

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ABSTRACT

This paper examines features and driving forces of urban sprawl in Hangzhou from 1995 to 2005 by using urban expansion classification, density analysis, spatial metrics, and geospatial analysis. We classified Hangzhou's urban development into three types: infilling, edge, and leapfrog growth, and used a leapfrog development index to indicate the extent of this type of urban expansion. We defined a sprawl index that takes both urban land expansion and population density into account to measure the magnitude of sprawl at the street-town level. Further, we employed landscape metrics to describe the change of spatial pattern of Hangzhou's urban expansion. To assess the inconsistency between actual urban expansion and planning, we compared the current urban land use with the latest urban land planning. Based on our findings, we identified features of urban sprawl of Chinese cities that are distinct from those identified in cities of western countries and discussed the role of critical policies that have affected urban sprawl in Hangzhou.

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Introduction

Developing countries have become the main driving force of global urbanization as 15 of the world's 20 largest cities are in these countries (Brinkoff, 2009). Urban sprawl, the encroachment of urban land uses on non-urban land, has become a common phenomenon throughout the developing world (Liu et al., 2011). Although the negative consequences of urban sprawl are commonly acknowledged, especially its dire implications for environmental quality and food security, analysis of urban sprawl in developing countries, especially in China with its particular institutional characteristics, remain scant (Bhatta et al., 2010; Ji et al., 2006). China has experienced unprecedented urbanization since the economic reform; the urbanization ratio increased from 18% in 1978 to 50% in 2011 (United Nations, 2011). Further, by 2030 China will have 80% of its population living in urban areas, as Chinese cities are expected to receive 450 million rural migrants (Xu and Zhou, 2009). In this paper, we will use Hangzhou, a large Chinese city, as a case to measure and model urban sprawl and analyze its driving forces and consequences.

Over the past three decades, urban sprawl and its impacts have attracted increasing attention from planners and policy makers (Frenkel and Ashkenazi, 2008; Frenkel and Orenstein, 2012), resulting in heated discussions on its definition, measurement, causes and negative consequences.

It should be noted that not any form of suburban growth should be counted as urban sprawl (Downs, 1994). For instance, Fulton et al. (2001) proposed that an area experiences increasing urban sprawl if land is consumed at a faster rate than the growth of the population. Further, Ewing et al. (2002) defined urban sprawl as a type of low-density development with residential, shopping and office areas that are rigidly segregated, a lack of thriving activity centers, and limited choices in travel routes. Similarly, Burchell et al. (2005) pointed out that urban sprawl has its particular spatial patterns: unlimited outward and "leapfrog" expansion of low-density new development. Though there is no commonly accepted definition of urban sprawl, some studies agree that urban sprawl is a type of urban expansion that is low in density, unordered, and unorganized (Deng and Huang, 2004; Frenkel and Ashkenazi, 2008). In this paper, taking the Chinese context into account, we define urban sprawl as a low-density type of urban expansion occurred beyond the urban built-up area, including low density edge-growth or leapfrog growth such as industrial development zones or college towns.

To quantify the degree of urban sprawl, it is necessary to use measures that capture the relative intensity of sprawl at different

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times or various areas (Wilson et al., 2003). The measures can be compared between cities, or for a single city between different regions or different time periods. Many statistics and spatial metrics can be employed, such as growth rate of urban land, population density, employment density, spatial geometry, accessibility, and aesthetic measures (Ji et al., 2006; Jiang et al., 2007; Song and Knaap, 2004; Zhao, 2010). In addition to these single dimensional measures, measures with multiple dimensions are often used. For instance, in a study that measures urban sprawl in 13 cities, Galster et al. (2001) developed an urban sprawl measure with eight conceptual dimensions of land use patterns: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses, and proximity. Using principal component analysis (PCA), Ewing et al. (2002) summarized 22 highly related variables into four conceptual dimensions of urban sprawl: (1) residential density, (2) neighborhood mix of homes, jobs, and services, (3) strength of activity centers and downtowns, and (4) accessibility of the street network. Frenkel and Ashkenazi (2008) measured urban sprawl from the dimensions of density, scatterness, and mixture of land uses in cities of Israel. However, most studies did not assess urban sprawl at different parts of a city, despite the distinct dynamics of the core and different portions of the urban periphery.

Market forces, pursuing diverse housing styles, land privatization and the widespread use of private vehicles are considered the main driving forces leading to urban sprawl in Western countries, especially in the USA (Galster et al., 2001). Because of its very different institutional context, China's urban sprawl is driven by different factors such as state and rural collective ownership of all land, limited land resources, vast numbers of rural-urban migrants, and the dual-track land transaction system through both market and State mechanisms (Zhao, 2010).

Nevertheless, scholars seem to agree on the negative impacts of urban sprawl, including (1) a lack of economies of scale, which reduces the level of public services in the suburbs and weakens the economic base of central cities, (2) increased energy consumption through the encouragement of the use of private vehicles, causing traffic congestion and air pollution, and (3) irreversible damage to ecosystems, caused by scattered and fragmented urban development in open lands (Bhatta et al., 2010).

Despite the rich discussion on urban sprawl of developed countries in the literature, there are relatively few studies conducted in the developing world, including China. Further, studies of urban sprawl in China have concentrated on a few first-tier cities, such as Beijing and Shanghai, with some on second-tier cities such as Nanjing (i.e. Liu and Tan, 2009; Xu et al., 2007; Yeh and Li, 1999; Yu and Ng, 2007; Zhang, 2000; Zhao, 2010). Despite their extremely high growth rates and unique sub-national governmental structures, urban sprawl in second-tier Chinese cities has not gained enough attention from the academic researchers. We chose Hangzhou, the capital of Zhejiang Province, as our cases, due to its representativeness of similar large cities in China, especially provincial capitals. Hangzhou has experienced dramatic economic growth and urban expansion since the economic reforms in 1978. Unlike Beijing, Tianjin, Shanghai, and Chongqing, cities that are directly administered by the central government, Hangzhou and other provincial capitals are under the control of their respective provincial governments. With fiscal restructuring in China, Chinese cities started to take care of a large portion of their local fiscal revenue; local governments are under more pressure to increase local revenue to enabling infrastructure development to attract more investment (Wu and Radbone, 2005) and compete investment with each other. They are encouraged to use fees from land transfer as a means to boost local revenue. By considering these different characteristics of provincial capitals from first-tier cities, an empirical study of Hangzhou will enrich our understanding of urban sprawl in large Chinese

cities, bringing quantitative knowledge into the discussion and suggesting possible solutions to urban sprawl (Batty et al., 1999; Frenkel and Ashkenazi, 2008).

This paper aims to measure the degree of urban sprawl in Hangzhou and analyze how various factors have affected the spatial pattern of this urban sprawl. Section 2 introduces the study area and describes the data and methodology, including various measures of sprawl. Section 3 presents findings on the characteristics, intensity, and spatial-temporal pattern of Hangzhou's urban sprawl based on these measures, such as sprawl index. Section 4 considers the implications of our findings. Section 5 discusses policies that may have significantly affected urban sprawl in Hangzhou, such as farmland reservation, household registration, urban planning, and the dual-track land system. Section 6 concludes the paper and summarizes the observed characteristics of Hangzhou's urban expansion.

Methodology and data

Study area and the unit of investigation

Hangzhou is located 180 km southwest of Shanghai in the Yangtze River Delta (Figure 1). It has a total administrative area of 16,596 km², with 3,068 km² as the city proper area, and a total population of 6.89 million, with 73% as urban population in 2010.¹ Regarded as one of the most beautiful cities in China, Hangzhou has numerous tourist spots such as West Lake, the Qiantang River, and the recently preserved Xixi Wetland, among others. Benefiting from its proximity to Shanghai, Hangzhou's economic growth accelerated after the economic reform, especially in the 1990s. Currently, its GDP per capita is 68,398 yuan in 2010 (equivalent to \$10,103), ranking it 8th of China's 35 major cities.² Like many other large Chinese cities, accompanying its impressive economic growth is Hangzhou's rapid urban expansion and transformation from a medium-sized city to a mega-city. However, to distinguish itself from other large cities in the Yangtze River Delta area, especially Shanghai, Hangzhou has promoted itself as a city with a high quality of life through various planning efforts. Some of these efforts enable Hangzhou, as a pilot city selected by the central government, to test out various land policies such as land banking system and to use land trusts and land bonds to finance the land reserve system (Zhu, 2008).

To quantify Hangzhou's urban sprawl in the past 10 years, we selected the street-town (a sub-district or sub-county administrative unit illustrated in Fig. 1) as the spatial unit for our investigation. Chinese cities have three levels of administrative management units: (1) the municipal government, (2) the urban district or county,³ and (3) the street-town, i.e., street (*Jiedao*) or township (*Xiangzhen*). Similar to the differences between districts and counties, streets are located in urban areas, while townships are located in rural areas. Street-towns, also called sub-districts, are the smallest geographic unit at which census data are released to the public (Wang and Zhou, 1999). Further, as the smallest administrative unit, the street-town is also the spatial unit where many municipal policies are enacted and implemented. It is therefore appropriate to use street-towns as our spatial unit to characterize urban sprawl and planning efforts of Chinese cities.

¹ This data is obtained from the sixth national census conducted in 2010 provided by Hangzhou Statistics Bureau and available at <http://www.hzstats.gov.cn/web/>.

² Here the major cities refer to provincial capitals and cities specially designated in the state plan. The data is obtained from Data China Statistical Yearbook (2010).

³ A city has both districts and counties; districts are located in the urban area, while the counties are located in rural area.

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