Urban population densities and their policy implications in China

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Abstract

In China, some people believe that urban land has a large potential for absorbing more of the urban population, while others think that urban population density is very high, and has already caused many urban problems. The population density of 135 major cities is studied by using the city population data (\textit{Shiren kou}) from the Fifth Census of China in 2000. The data included the floating population who lived in cities for more than 6 months/year, so it could more closely reflect the real size of the urban population. Land-use data were obtained from a digital map interpreted from remotely sensed data collected in 2000. The results show that urban population density was fairly high in China and the average urban land per capita of these cities was only about 76 m\textsuperscript{2} in 2000, but that the corresponding value was 106 m\textsuperscript{2} if it was calculated with the non-agricultural population. Moreover, urban population density varied greatly between cities: from 4 \times 10\textsuperscript{3} to 22 \times 10\textsuperscript{3}/km\textsuperscript{2}. Regression results show the differences in urban population density were strongly related to six independent variables, including wage per capita, city size and shape index of urban land, etc. The policies derived from the results deserve more attention in the new land-use planning with the target year of 2020 in China.

Keywords: China; Urban population density; Natural and socio-economic parameters; Policy implication

Introduction

It is not so easy to define urban population density, because of the definition of urban population is vague and the urban area boundary is unclear. However, urban population density continues to inspire researchers working in the fields of urban planning, geography and urban/regional economics (Kasanko et al., 2005), because it is closely related to land use, urban traffic, environment and living quality, etc. (Camagni, Gibelli, & Rigamonti, 2002; Li, Sato, & Zhu, 2003).

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In different countries/regions, there are large variations in urban population density. Generally speaking, urban densities in American and European countries are lower compared with densely populated cities in Asia, such as Hong Kong, Singapore, Tokyo, Seoul and Shanghai. In the Western context, high-density development is often considered to be over-crowded and cause excessive congestion, with potentially detrimental effects on society (Chan, Tang, & Wong, 2002; Oh et al., 2005; Williams, 1999), although more and more researchers are noticing the negative impacts of low-density development and believe that there are better modes of urban growth in the future, such as compact growth, growth management, etc. (Alig, Kline, & Lichtenstein, 2004; Frenkel, 2004; Nelson, 1999). On the contrary, in Asian countries, more people believe that dense and intense land use could be a solution used to satisfy rapidly increasing land demand for urban activities (Chen & Jia, 2005; Lau, Giridharan, & Ganesan, 2005).

Urban population density has become one of the important concerns of policy makers and researchers (Fu, 2001), because China is a country with a huge population size of 1.3 billion and limited land resources (National Bureau of Statistics of China (NBSC), 2005). Furthermore, as one of the most dynamic countries, China’s sustained economic development and massive rural–urban migration have increased urban land demand. In the 1990s, built-up areas increased by 1.76 million ha, 80% of which was from arable land (Liu, Zhang, & Zhuang, 2003). At the same time, the arable land area per capita in China is only 0.094 ha, less than half of the world’s average (Land and Resources Minister of China, 2005; Lin & Ho, 2003). Hence, the Chinese government strictly controls the conversion of arable land to built-up land. In 1997 and 2004, the central government even stopped approving any application for non-agricultural occupation of arable land across the country. The discrepancy between urban land demand and arable land protection is becoming acute.

In China, more intensive urban land use is often suggested as a solution to the discrepancy. One of the reasons is that most researchers prefer to use data on the urban non-agricultural population to calculate urban land per capita since the data are more continuous and steady compared with other urban population data. In the country, the urban non-agricultural population only includes the permanent residents in urban areas, who engage in the secondary and tertiary industries and people they feed (National Bureau of Statistics of China (NBSC), 1991–2001). These data neglect the floating population who actually work and live in urban areas. This leads to considerable distortions of urban population in some cities with a large inflow of migrant workers (Zhou & Yu, 2004). In most cases, urban population is under-estimated. Thus, it is easy to draw the conclusion that urban land has a big potential for carrying an increased urban population in the country.

On the contrary, others believe that the urban population density is very high in China, which has caused many problems. Firstly, over-development and over-concentration of urban areas results in various environmental problems, such as air and water pollution, and water shortage (Chen & Lotspeich, 1998). Secondly, a high urban population density leads to serious traffic congestion, especially in large cities, such as Beijing and Shanghai. Thirdly, in part due to the high urban population density, housing prices in cities are continuously increasing. For instance, the average housing price in China rose by 14.4% in 2004 (Liang & Ma, 2004; XinhuaEnglish, 2005).

Now, the new land-use planning (Tudiliyong Zongtiquihua Xiubian) is under way in China with the target year of 2020. The planning will continue to place special emphasis on arable land protection through controlling urban land expansion and intensively using existing urban land.

In this context, it is necessary to study urban population density with more reliable data, which will be discussed in the Data section. The rest of the paper is organized as follows. In the Method section, a set of simple indicators to interpret urban population density is introduced. Results section examines the differences of population density for 135 selected cities across the country and the factors causing the differences. Discussion section presents several policy implications arising from the results in the Results section. Finally, short conclusions are offered in the Conclusions section. We hope that this study will help planners to strike a better balance between arable land protection and urban land growth, and allow more reasonable planning for future land use in China.

Data

Urban population data

In China, there are three levels of cities, namely municipalities, prefecture-level and county-level cities. The selected 135 cities in this paper are all above (and not including) the county level (Fig. 1). In the country, these
cities often administer a large area, comprising city proper, extensive exurban districts and rural counties (Fig. 2). Population in the administration area of a city was divided into three parts in the Fifth National Census of China in 2000: urban population, town population and rural population (National Bureau of Statistics of China (NBSC), 2002). Fig. 2 shows the population composition of municipalities or prefecture-level cities in China. In the Census, the city population is defined as the urban population in the city proper and exurban districts, and does not include the town population or rural population (Shi Renkou). In addition, in the Census, floating people were recorded at their current abode rather than at their place of registration if they lived at the abode for more than 6 months/year. So, the city population, including some of the floating population, reflects more closely the real size of the urban population, when compared with other population data in China (Zhou & Yu, 2002). The city population data are used to study urban population density in this paper.

Urban land-use data

The basic urban land-use data were extracted from the 1:100,000 digital land-use map of 2000 which was obtained from the Landsat Thematic Mapper images. These data are provided by the Resources and Environment Data Center, CAS. The field survey and random sample check (covering a survey line of 70,000 km and 13,300 patches) testified that the average interpretation accuracy for land-use/land-cover was better than 92% (Liu, Liu, & Zhuang, 2003). The data have been successfully employed to study land-use changes in China (Liu, Liu et al., 2003). The original map consists of six classes of land-use types, i.e., arable land, forest, grassland, residential areas and land for stand-alone industrial and mining sites, water, and unused land. Here, urban land, one of the subclasses of residential areas and land for stand-alone industrial and mining sites, is selected to study urban population density.

Urban land includes urban built-up areas in urban districts (city proper, and exurban districts) in this study. For example, in Beijing in 2000, urban land included urban built-up areas (not including built-up areas for rural residents) in the city proper and exurban districts of Shunyi, Changping, Fangshan and Tongzhou (Fig. 3).

In the city proper, all population who live here for more than 6 months/year, belongs to the city population, so it is easy to extract the urban built-up area. In an exurban district, only the members of the population, who live in the central area where the district government is located, belong to the city population. A city often has several exurban districts. As a result, it is possible to miss urban built-up areas in some exurban districts. In order to ensure that no exurban districts are missed, we have examined each exurban district for all the cities selected in this paper according to administrative maps at different levels. Thus, the spatial scope of the city population is consistent with that of urban land.
In addition, socio-economic data are sourced from Urban Statistical Yearbook of China (National Bureau of Statistics of China (NBSC), 1991–2001). Their meanings are shown in Table 1.

Method

Urban population density is influenced by various factors: natural resources endowments, economies of scale in production and consumption, usage of cars, etc. (Alig et al., 2004; Fujita, 1989; Kasanko et al., 2005; Oh et al., 2005). Through studying 15 European urban areas, Kasanko et al. (2005) present a more comprehensive understanding for the differences of population density and think that geographical surroundings, historical onset of the urbanization process, policy factors etc., lead to the differences of urban population density among different parts of Europe, namely, compact cities in southern Europe, cities with looser structures in eastern Europe, and central and western cities midway between the extremes.
However, it is unfortunate that, to date, only a few researchers have established a set of indicators to interpret differences of urban population density.

In this study, a simply explanatory framework is established with a set of indicators in order to explain the differences of urban population density among the selected cities (Fig. 4 and Table 1). Selection of independent variables mainly depends on the following principles in this study. Firstly, data should be available. Secondly, effects of an independent variable on urban population density should be easily measured. For example, some social factors, such as historical tradition and cultural background, may affect urban population density, but the effects are difficult to estimate. Thirdly, serious multicollinearity problems should be avoided among independent variables. Selection of independent variables will be discussed in depth as follows.

**Geographical surroundings**

Geographical surroundings can largely express the characteristics of the natural conditions and socio-economic development. This paper will consider the effects of geographical surroundings on urban population density from two aspects: regional location and landforms around a city.

Firstly, in China, regional features vary greatly due to an area of 9.6 million km². To express the regional differences, mainland China is traditionally either divided into three large regions: the East, the Middle and the West, or divided into two: the North and the South, by the geographic boundary of the Huai River and Qinling Mountains. Since Fig. 1 clearly shows the difference in urban population density between the

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### Table 1

<table>
<thead>
<tr>
<th>Variable group</th>
<th>Variable</th>
<th>Code of variable</th>
<th>Unit</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical surroundings</td>
<td>Regional dummy variables</td>
<td>N_{city,i}</td>
<td></td>
<td>Cities in North China</td>
</tr>
<tr>
<td></td>
<td>Dummy variables of city types</td>
<td>PL_{city,i}</td>
<td></td>
<td>Cities on the plains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MF_{city,i}</td>
<td></td>
<td>Cities at the foot of mountains</td>
</tr>
<tr>
<td>Urban shape</td>
<td>Shape index of urban land</td>
<td>Shape_{i}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>City size</td>
<td>Size_{i}</td>
<td>1000 persons</td>
<td>City size of city (i) in terms of city population</td>
</tr>
<tr>
<td></td>
<td>Salary level</td>
<td>Wage_{ij}</td>
<td>Yuan/person</td>
<td>Average wage of fully employed staff and workers of city (i) in year (j)</td>
</tr>
<tr>
<td>Economic factors</td>
<td>Economic structure</td>
<td>Sgdp2_{i}</td>
<td>Percent (%)</td>
<td>Share of secondary industry in GDP of city (i)</td>
</tr>
<tr>
<td></td>
<td>Investment in fixed assets</td>
<td>Fix_{ij}</td>
<td>Yuan/km²</td>
<td>Investment in fixed assets per km² of city (i) in year (j)</td>
</tr>
<tr>
<td>Social factors</td>
<td>Arable land per capita</td>
<td>Arable_{i}</td>
<td>ha/person</td>
<td>Arable land per capita in the scope of urban districts of city (i)</td>
</tr>
</tbody>
</table>

*Note: GDP means gross domestic product.*

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![Urban population density diagram](image)

Fig. 4. Factors affecting urban population density.
North and the South, the regional dummy variable of the northern cities ($N_{\text{city}_i}$) is set here. $N_{\text{city}_i}$ is a binary variable. If a city is in North China, its value equals one, and zero otherwise.

Secondly, landforms around a city may affect its population density. According to the landform characteristics around cities, they are divided into three groups: cities on the plains (PL$_{\text{city}_i}$), cities at the foot of mountains (MF$_{\text{city}_i}$) and cities in mountain areas. This division is realized by overlaying China’s landform map and urban map (Fig. 5). Thus, two dummy variables of PL$_{\text{city}_i}$ and MF$_{\text{city}_i}$ are set and they are also binary variables.

**Urban shape**

The shape index of the landscape has been used in many studies (Chust, Ducrot, & Pretus, 2004). Given that the urban land of a city is often composed of many land patches, the shape index of city $i$ ($\text{Index}_i$) is defined by the following formula:

$$\text{Index}_i = \frac{\sum_{j=1}^{n} P_{ij}}{2\sqrt{\pi \sum_{j=1}^{n} A_{ij}}}$$

where $P_{ij}$ and $A_{ij}$ are the perimeter and area of land patch $j$ of city $i$, respectively. $\text{Index}_i = 1$ when the urban land of a city is composed of a single circular patch. With the number of patches increasing or as the patch shape becomes more irregular, the value of $\text{Index}_i$ will be higher. A higher value means a longer perimeter per unit area of urban land. A longer perimeter means a longer rural–urban interface, often characterized by low buildings, less building form and more natural surroundings. So, a city with a higher value of $\text{Index}_i$ may be less compact.

**Economic factors**

For a city, economic factors mainly include city size, economic development level and economic structure. Firstly, in urban areas, many firms are located close together in order to reduce transport costs and increase the opportunities for face-to-face communication with other firms and customers (Fujita, 1989). Hence, the urban population density may be higher because more human activities bid for scarce land resources in a
bigger city. For example, after examining 88 US cities in 1960, Hoch (1972) found that urban density increases with city size.

Secondly, urban economic development level can be mirrored by income per capita, GDP per capita, etc. Because, many studies prove that land consumption per capita grows with an increase of income (Alig et al., 2004; Camagni et al., 2002; Zhang, 2001), wage per capita is used to interpret urban population density in this study.

However, wage per capita cannot affect urban land demand immediately. For instance, an urban family needs some time to save up to buy a house. Hence, the sum of average wage per capita of fully employed staff and workers in the last 5 years (1996–2000) ($\sum Wage_{ij}$) is used as an independent variable (Table 1). $\sum Wage_{ij}$ is calculated at the constant price of 2000.

Economic structure may have some effects on urban population density. Secondary industry, in particular heavy industry, may need more urban land and less labor relative to tertiary industry, because manufacturing processes of the former are capital intensive, and its input and output requires significant amounts of land (Goldberg & Chinloy, 1984). Since there is an obvious collinearity relationship between shares of secondary and tertiary industries in GDP, only the former (the variable of Sgdpl) is employed as one of the independent variables (Table 1).

In addition, higher investment in fixed assets per km² ($Fix_{ij}$) can improve building conditions and even offset some of the disadvantages of the natural environment, for instance, construction of transport infrastructure and drainage. Moreover, by building some industrial and service establishments, higher investment can create more social and economic activities, which will present more job opportunities. Hence, $Fix_{ij}$ is selected as one of the independent variables. Because it is a stock variable, the sum of investment in fixed assets during the last 5 years (1996–2000) ($\sum Fix_{ij}$) is employed here. $\sum Fix_{ij}$ is calculated at the constant price of 2000.

Social factors

It is very difficult to estimate the effects of social factors on urban population density, because social group covers a wide range of factors, including cultural background, historic tradition, policy, land ownership and social fairness, etc. (Ding, 2007). Of all the social factors, the policy factor may play an important role. For example, adopting a growth-management policy could contribute to the prevention of urban sprawl and the preservation of open space, which can effectively control the urban de-concentration trend (Alig et al., 2004; Frenkel, 2004; Nelson, 1999).

In China, of all the policies related to urban population density, the policy of dynamic balance of arable land plays a central role. It emphasizes that the government at provincial level must ensure that arable land quantity is in a state of dynamic balance in the jurisdictions (Yang & Li, 2000). This means that governments in some regions with less arable land resources are forced to adopt a more compact urban land-use policy. Here, arable land per capita in 1995 is used as an independent variable (Rural Survey Organization of National Bureau of Statistics of China, 1996), for two reasons. First, for 135 cities, only the arable land data for 1995 and 1999 can be obtained. Here, the arable land of a city only refers to that in its urban districts (including the city proper and exurban districts) (Fig. 2). Second, impacts of arable land per capita on urban population density cannot be reflected immediately.

Finally, as linearity is necessary in the multiple regression analysis, this paper uses logarithms of the dependant and independent variables. Since Ncity, PLe, and MFcity are binary variables, which equal one or zero, they are not transformed into logarithms.

Results

The results show that urban land per capita of the 135 cities was about 76 m² in 2000. However, the corresponding value would approach 106 m² if it was calculated with the non-agricultural population data. The latter is about 47% higher than the former, especially in large cities with city populations more than 5 million (Fig. 6).
Urban population density varied from $4 \times 10^3$/km$^2$ in Kalamyi city in Xinjiang Autonomous Region to more than $20 \times 10^3$/km$^2$ in Fuzhou city in Fujian Province in 2000 (Fig. 1). Of all the 135 cities, 120 had urban population densities exceeding $10 \times 10^3$/km$^2$.

In North China, urban land per capita was 84 m$^2$, much higher than 69 m$^2$ in South China (Figs. 1 and 7). 7 of the total 8 cities with an urban population density higher than 20,000 persons/km$^2$ were situated in the Yangtze River Delta in South China, such as Hangzhou, and Ningbo (Fig. 1). However, it is notable that the urban population density in South China would be lower than that in North China if it was calculated with the non-agricultural population, and urban land areas per capita in South China and North China were 110 and 102 m$^2$ in 2000, respectively (Fig. 7).

To shed light on the differences in urban population density, the variables in Table 1 are entered as a block in a single step in the linear regression model of the SPSS software package. Table 2 lists the results. Overall, our results are consistent with the discussion in the Method section above. Of all the independent variables, six of them exhibited close relationships with the dependent variable at the 5% statistically significant level,
including Salary_{ij}, Size_i, Fix_i, Ncity_i, Shape_i, and PLcity_i. Among them, the variables of Size_i and \( \sum \text{Fix}_i \) had positive relationships with urban population density, while the remaining four variables all exhibited negative relationships with the dependent variable (Table 2).

The relationship between Sgdp2_i and urban population density was not as apparent as we expected. One of the important reasons is that most cities in China are in the process of industrialization, and their shares of secondary industry in the GDP were very high. The shares of 129 of 135 cities were higher than 40% in 2000, which weakened the explanatory power of the differences of urban population density between cities. Similarly, because of the implementation of the strict farmland protection policy across the country, the variable of Arable_i had a very weak relationship with urban population density.

MFcity_i had no obvious relationship with urban population density, which meant the urban population density of cities in mountain areas was approximately equal to that of cities at the foot of mountains (Table 2).

In the model, the adjusted \( R^2 \) is 0.560. Collinearity statistics results show that no obvious multicollinearity exists among independent variables since the values of variance inflation factor (VIF) are all lower than two (Table 2). In general, if the VIF value is more than five, there will be significant multicollinearity between independent variables (Zhu, 2004).

### Discussion

Compared with the western countries (Demographia, 2005; Kasanko et al., 2005; Kline, 2000; Nelson, 1999), the urban population density in China is very high. Population densities of some cities selected in this study are even higher than those of other densely populated countries, such as Japan, Israel and India (Demographia, 2005; Frenkel, 2004). Of the 20 urban areas with the highest population density in the world, eight are located in mainland China (Demographia, 2005). In addition, Hong Kong (China HKSAR) and Taipei (China-Taiwan) rank in first and fifth place, respectively. In the future, China’s government will continue to implement the policy of strict farmland protection and control urban land expansion. In order to mitigate the discrepancy between urban land growth and arable land protection, the following countermeasures are put forward based on the results of this study.

To more exactly assess urban land demand

It is strongly necessary to assess urban land demand, in order to strike a balance between urban land expansion and arable land protection. At present, two aspects deserve more attention.
Firstly, China is a developing country with a low urbanization rate (41.2% in 2004) (National Bureau of Statistics of China (NBSC), 2005), so many factors causing urban agglomeration still work. As a result, the urban population of nearly all cities is increasing, because of massive migration into cities from rural areas. With the step-by-step cancellation of the “urban household registration system”, more floating people will live in the urban areas and enjoy the same urban welfare and equal job opportunities as urban residents, which can cause urban land growth.

Secondly, urban land-use planning is often based on the assumption that urban land demand per capita is constant over time in the country. However, the regression model shows that wage per capita had a negative relationship with urban population density. In China, per capita annual income of urban households is increasing rapidly. From 1985 to 2004, it increased by 339% (Fig. 8). With income increasing, land consumption per capita may increase (Mak et al., 2007).

In China, economic growth and massive migration from the rural population are exacting an unprecedented demand on urban land, so it is important to assess urban land demand for both maintaining urban economy growth at a stable and relatively fast rate, and for avoiding excessive expansion of urban land and enclosure of land.

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{Fig_8}
\caption{Changes of per capita annual income of urban households, 1985–2004. Note: Data are from (National Bureau of Statistics of China (NBSC), 2005), and income per capita is computed at constant price for 2004. RMB (Yuan) is China’s money (now about 7.5 Yuan/US dollar).}
\end{figure}

To establish discrete criteria for quantifying urban land per capita for different types of cities

China has 660 cities, with diverse characteristics of urban development. So, it is necessary to establish discrete criteria for quantifying the urban land per capita for different types of cities. Based on the results of this study, several types of cities should be taken into account.

Firstly, South China has a higher urban population density than North China, due to better natural conditions in South China, such as warmer weather, and richer water resources. But, in many studies, urban population densities are often seriously underestimated in some cities of South China. So, in South China, we should appropriately increase land supply to meet urban land demand in order to maintain sustainable urban growth.

Secondly, city size had a positive relationship with urban population density (Table 2). The standardized coefficient was 0.513. In fact, this relationship has already been mentioned in the planning criteria of urban land per capita promulgated by the Minister of Construction of China in 1991. However, the criteria emphasize calculation of urban population density with the non-agricultural population. This hides the real relationship between urban population density and city size, because the non-agricultural population seriously underestimates city size in China, especially in large cities with city populations over 5 million (Fig. 6).
Thirdly, in the regression model, cities in plain areas were negatively related to urban population density. This implies that urban population densities of these cities were lower than those of cities at the foot of mountains. The main reason may be that cities in plain areas can expand in every direction with fewer natural barriers. Owing to the importance of the plain in grain production in China, a more strict policy should be implemented to control urban land expansion of cities in plain areas.

**To efficiently use urban investment in fixed assets**

In the regression model, the variable $\sum \text{Fix}_i$ had a positive relationship with urban population density. In China, urban investment in fixed assets per km$^2$ varies greatly from region to region. From 1996 to 2000, cities with the sum of urban investment in fixed assets more than 30,000 Yuan/km$^2$ were mainly located in east China, especially in the provinces of Hebei, Jiangsu, Zhejiang and Guangdong. Cities with values less than 20,000 Yuan/km$^2$, were mostly in Northeast China and West China, including Liaoning, Shanxi, Inner Mongolia and Guangxi (Figs. 9 and 10). Most of these belong to mining cities, such as the cities of Liaoyang, Fushun, and Anshan in Liaoning province, Panzhihua city in Sichuan Province, and Hegang city in Heilongjiang province. Now most of the mining cities are facing resources exhaustion, and construction conditions are destroyed due to mining activities. Thus, these cities develop very slowly and cannot attract more migrants. So, the cities need more urban investment for urban development.

By contrast, in some cities in developed regions, urban investment in fixed assets still increases quickly although the amount is already very large. It is known that unscientific investment can cause serious economic loss and even has negative effects on urban development and urban environment. For instance, in Hangzhou in Zhejiang Province, a 22-story building on the bank of the famous West Lake was pulled down in 2007. The building served a mere 13 years, although it cost 20 million Yuan (about US$2.7 million) and was designed to last 100 years (Wu, 2007). Actually, in China, many high buildings and some basic infrastructures in developed regions suffer similar fates, due to random decision making.

So, how to efficiently use urban investment is very important for China’s urban development, since high urban investment in fixed assets cannot only improve the urban environment, but also help transform the economic structure and create job opportunities to attract the urban population, especially for mining cities.

**To properly increase population density in cities with high shape index**

The regression model shows that the shape index of urban land had a negative relationship with urban population density. In a city with a high shape index, its infrastructure cannot be efficiently used due to its looser urban land-use structure. For instance, in Zibo city in Shandong Province, the shape index of urban land was high and close to 6.61 in 2000. In this city, it is difficult for urban residents who live in Place A to use

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Fig. 9. Urban investment in fixed assets (Yuan/km$^2$) of 135 major cities in China from 1996 to 2000.
the public infrastructure in Place B (Fig. 11). Hence, in Zibo, the population density was only $7.37 \times 10^3$ people/km$^2$ (135 m$^2$ person) although it was a large city with a 1.76 million city population in 2000.

In some cities composed of several separate sub-centers, the urban population scale of each center is not very large, which can mitigate urban problems (e.g., traffic over-crowding) to some extent. So we should properly increase urban population density of these cities by improving the public infrastructures. In the world, there are many cities with high shape index, which have very high urban population densities, such as Singapore, and Hong Kong (Liang, 1973).

**Conclusions**

In China, the urban population density is often underestimated, because it is calculated with the non-agricultural population, which does not include the massive migration from rural areas. As a result, most
people believe that urban land has a big potential for burdening urban population and that it is necessary to strictly control urban land growth in order to protect arable land.

However, if taking into account the floating population, population density in most cities is very high. In 2000, the average urban land per capita was only 76 m². Moreover, urban land per capita varied greatly among these cities. Now, rapid economic growth and massive rural–urban migration are exacting unprecedented demands on urban land. It is very important to assess urban land demand for different types of cities with reliable data.

To analyze the differences in urban population density between cities, a simple explanatory framework is established. However, a city is a very complicated system, and its formation and growth are affected by many factors. Due to lack of data, some explanatory variables were not considered in the framework. This could be improved in further studies, by collecting more data to enhance our understanding of the characteristics of urban population density in China.

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