

## Urban sprawl: A case study of Shenzhen, China

### 1. Introduction

Urban sprawl has become a common phenomenon since World War II (Belser, 1960; Harvey and Clark, 1965; Gans, 1967; Jackson, 1985; Mills and Hamilton, 1994) in Western countries, especially in the United States. With the development of urbanization, on the edge of cities, the conversion of land to urban use became more and more severe and was out of control, mainly due to population growth, rising house-hold incomes and transportation improvements (Mieszkowski and Mills, 1993; Brueckner and Fansler, 1983; McGrath, 2005). The common definition of urban sprawl was given by Ewing (1994), who defined it as a form of low density spatial development, always characterized by scattered and discontinuous leapfrog expansion, single and segregation land uses.

Since the 1987 World commission on the Environment and Development and the 1992 Rio de Janeiro Congress on the sustainable Development, the awareness of environment has become more and more widespread in every walk of life. And in fact, from then on, urban sprawl has become a subject of particular interest among urban planners and policymakers all over the World (Frenkel and Ashkenazi, 2008). There is plentiful literature on the subject of urban sprawl or excessive urban expansion, and nowadays there is common agreement on the negative impact of urban sprawl on the environment, the economy, and the society. Brueckner (2000), for example, concludes that:

*Cities, it is claimed, take up too much space, encroaching excessively on agricultural land. Aesthetic benefits from the presence of open space are lost, and an allegedly scarce resource, namely farmland, is depleted. Excessive urban expansion also means overly long commutes, which generate traffic congestion while contributing to air pollution. Unfettered suburban growth is also thought to reduce the incentive for redevelopment of land closer to city centers, contributing to the decay of downtown areas. Finally, by spreading people out, low-density suburban development may reduce social interaction, weakening the bonds that underpin a healthy society (P.160).*

However, there are still lots of debates on urban sprawl. Due to its complexity, there is even no accurate and generally accepted definition and measures (Sutton, 2003; Galster et al, 2001; Wolman et al, 2005). And there is always disagreement on the confluence of urban sprawl, whether negative or positive to the society (Ewing, 1997). Above all, the principle dispute is whether the public policies should be changed to restrict the spatial expansion of cities (Brueckner, 2000). Those who support to regulate sprawl have suggested several strategies like the Compact City, New Urbanism, and Growth Management (Jenks, 1996; Johnson, 2001; Fulton, 1996). In contrast, others believe that urban sprawl is mainly due to consumers preference (Mills and Hamilton, 1994) and market failures, and can be adjusted by the market itself with the invisible hand. However, no matter support or oppose, police have

been made to intervene land uses in western countries, and from 1960s, the intervention has become more and more intensive.

Unlike western countries, urban sprawl began in China only a few years ago, and compared the systematic studies on the urban expansion in the United States and Europe, there is much less studies on the subject in China. The goal of this paper is to address three questions:

1. What is the nature of urban sprawl in China?
2. What are the causes of urban sprawl in China?
3. How to control urban sprawl?

These questions above are very important because they can help us to understand the essence of urban sprawl in China. In doing so, the following of this article will first analyze the nature of urban expansion phenomenon in China; second provides an integrated analysis of urban sprawl based on GIS, especially on the variation of land use pattern and the dynamics of urban sprawl, and presents Shenzhen as a case study. Finally, it will give the advice to the cities of China on how to effectively control urban sprawl.

## **2. What is the nature of sprawl in China?**

### *2.1 Sprawl in Western countries*

In the United States, suburbanization and sprawl started after World War II in many developed industrial cities. With the development of urbanization at an unprecedented rate for many decades, many cities came up with lots of problems. The well-documented problems include environment deterioration, traffic congestion, air pollution, crime, poverty, racial tension, poor schools, poor public services, and so on. So the rich people escaped from the inner cities in order to escape from the problems above and look forward to high quality of life. The suburban, with ready access to open space, provide city dwellers with a chance to enjoy nature and an easy escape from the city problems. So more and more people move to live in the suburban, and the phenomenon, which called population suburbanization, has lasted for decades. And job suburbanization and commerce suburbanization have also occurred as the cities have grown spatially. In addition, the population growth, rising incomes, and falling commuting costs have contributed to the suburbanization process in the U.S. cities. In this sense, urban sprawl in the U.S. cities is the consequence of suburbanization, and it is a spontaneous phenomenon that city dwellers look forward to high quality of living environment.

Meanwhile, in the late 20<sup>th</sup> century, strong sentiment against urban sprawl has developed in the U.S. ( Brueckner, 2000). The sentiment includes a lot of critics. It is alleged that excessive urban expansion have encroached so much farmland and open space. Urban sprawl is also thought to contribute to the decay of the downtown area and a number of social problems. And urban sprawl always means overly long commute, contributing traffic congestion and air pollution. At the root of the perception that urban sprawl is against the idea of sustainable development, many policies have been made to restrict urban sprawl in the United States. And several strategies such as New Urbanism and Growth Management are suggested. However, urban sprawl in the U.S. and other western cities is still existence and even will continue in the future. After all, urban sprawl is a complicated phenomenon, and to restrict urban sprawl is not an easy task.

## 2.2 *Sprawl in China*

What are the differences of urban sprawl between western countries and China? What are the causes of urban sprawl in China? What the confluence of urban sprawl in China? To answer these questions, the definition of urban sprawl is essential. Although there are many definitions of urban sprawl, here, the term urban sprawl will refer to low-density, excessive spatial growth of cities. The key words of this definition are low-density and excessive. Of course, urban land should expand to accommodate the population and economy growth, but the problem is that low-density and too much spatial expansion occurs.

In western countries, urban sprawl is the consequence of suburbanization, and urban sprawl always means excessive suburbanization (Mills, 2003). In fact, the percentage of people who live in cities already reached 51.2 percent in 1920 in United States. And after that time, population, job and commerce suburbanization started, and when people take urban sprawl seriously in 1960s, the urban population proportion had already reached about 70 percent. Unlike western countries, urban sprawl began in some developed cities in China only a few years ago after about two decades' urbanization at an unprecedented rate. By 2006, the urban population proportion had only reached 43.9 percent (National Bureau of Statistics of China, 2007) in China. So now China is experiencing a high rate of urbanization, and the process of suburbanization like the U.S. does not occur until now. In this sense, urban sprawl in China is mainly due to low-density urbanization, not excessive suburbanization like western countries. Thus, many phenomena of urban sprawl in China could be easily understood. Unlike in the United States where excessive urban expansion always contributes to the decay of central cities by reducing the incentive to redevelop the land near the center, in China, the inner cities still keep prosperous with the development of urban sprawl. In addition, rich people prefer to live in the central cities where the environment always better and public services usually much more perfect. And meanwhile people who can not support the high price of housing have to move to suburban to sacrifice better environment and public services for larger dwellings.

The causes of urban sprawl in China are different from western countries. Institutional factors and policies always play an important part in urban sprawl and this will be discussed in the fifth section. However, there are many similar characters and confluences of urban sprawl both in China and western countries. Just like urban sprawl in cities of U.S., the impervious area of cities grows much faster than the population, and the population density becomes lower and lower in the past few years (Tab.1). Excessive urban expansion have encroached so much farmland and open space. Unlike the United States and other countries, farmland

Tab.1

Changes of built-up area, population and population density of ten cities in China form 2001 to 2005

Items	BJ	SH	GZ	SZ	TJ	NJ	CQ	CD	HZ	SY
Changes of built-up area (%)	0.11	0.11	0.09	0.11	0.06	0.25	0.16	0.15	0.08	0.07
Changes of population (%)	0.03	0.03	0.04	0.03	0.01	0.10	0.05	0.13	0.06	0.01
Changes of population density (%)	-0.08	-0.06	-0.05	-0.06	-0.04	-0.12	-0.10	-0.01	-0.02	-0.06

**Notes:** BJ: Beijing; SH: Shanghai; GZ: Guangzhou; SZ: Shenzhen; TJ: Tianjin; NJ: Nanjing; CQ: Chongqing; CD: Chongdu; HZ: Hangzhou; SY: Shenyang.

**Source:** China City Statistical Yearbook 2007

and other resources are much scarcer (Tab.2) in China. Thus, urban sprawl is a much more dangerous signal for China. And urban sprawl always generates overly long commute, contributing traffic congestion and air pollution. In fact, the consumption of petrol per capita

Tab.2

Comparison of main resources between China and other countries

Items	Russia	Canada	China	U.S.	Brazil
population density (persons per km <sup>2</sup> )	8.6	3.2	131.0	27.5	19.1
area of farmland per capita (km <sup>2</sup> )	1.39	2.50	0.21	1.64	1.47
water resource per capita (m <sup>3</sup> )	30599	98462	2292	9413	42975
total area of forest (1000km <sup>2</sup> )	754.9	247.2	133.8	209.6	566.0

Source: Chou Baoxing /City Planning Review, 2007,31(6): 9-15.

rises quickly and the auto-related pollution becomes much more serious than ever before. Urban sprawl also means magnitude of infrastructure investment, and it is not consistent with the idea of sustainable development, especially for the developing countries. Finally, urban sprawl also brings many social and economic problems. If the allegations noted above are correct, policies should be altered to restrict urban sprawl of cities.

### 3. Data

#### 3.1 Study area

Shenzhen is located in south China between 113°46'E to 114°37'E, 22°27'N to 22°52'N, with an area of appropriate 1952.84 km<sup>2</sup> (Fig. 1), bounded Pearl River to the west, Dongguan city and Huizhou city to the north, and Hong Kong Special Administrative Region to the south.



Fig. 1 The study area in China

one of the largest cities in China, Shenzhen has a development history of only 29 years and has undergone rapid economic development and urbanization over the past two decades. It was set up as the city in 1979 with a population of 0.314 million and the built-up area of only

about 3 km<sup>2</sup>. But now Shenzhen has become one of the most important cities in China with a population of 8.46 million (Shenzhen Statistics Bureau, 2007), the impervious area over 700 km<sup>2</sup> (Fan, 2006), the value of gross domestic production of 6765.41 billion yuan (Shenzhen Statistics Bureau, 2008). From 2001 to 2005, Shenzhen had experienced urbanization at an unprecedented rate, and at the same time the excessive spatial expansion had brought so many problems, such as environment deterioration, farmland depletion, auto-related air pollution, and so on.

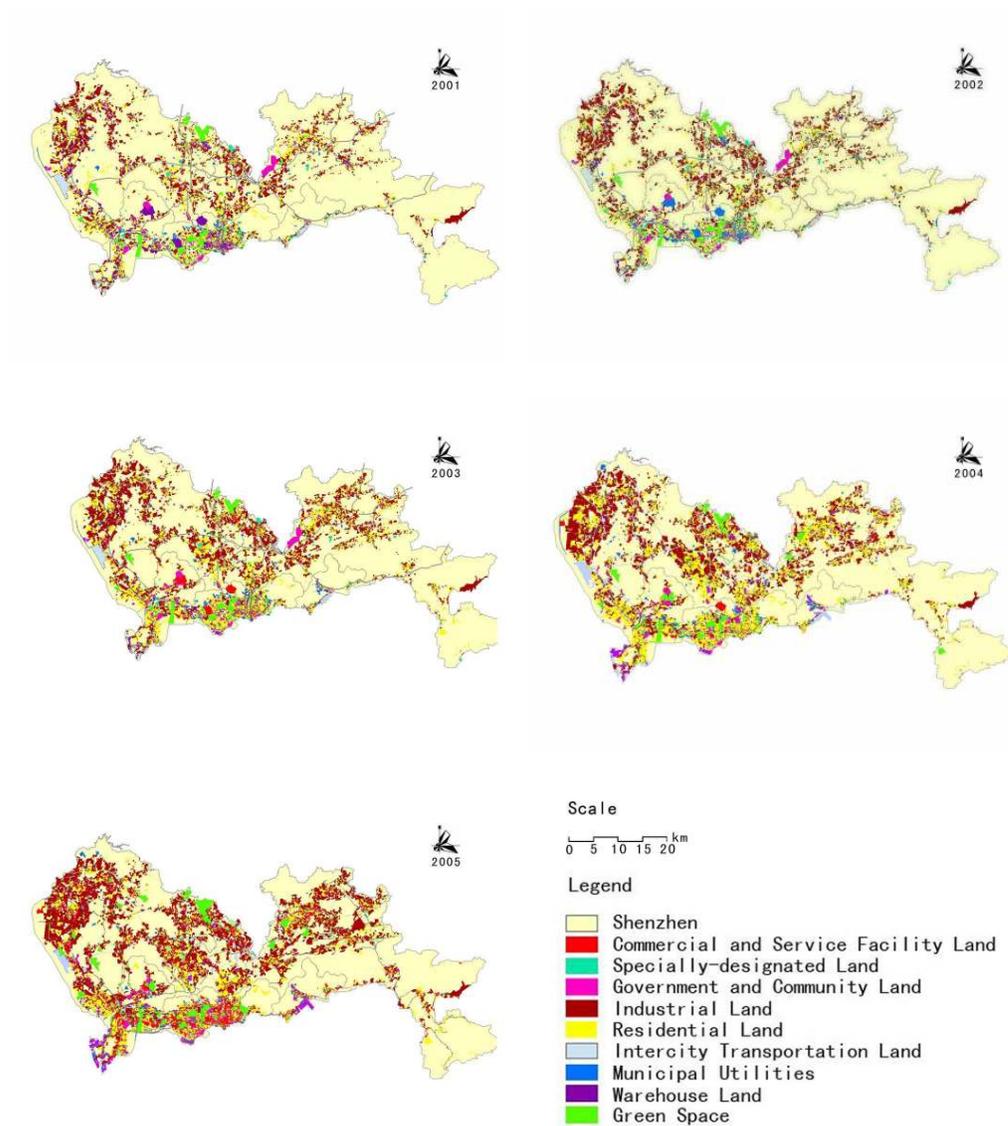
### 3.2 Data processing

SPOT5 image (2005.10, resolution 2.5m, panchromatic film; Fig.2), aerial photograph (2004.11), 1:1000 scale topographic maps, land use survey, and CAD data format land use situation from 2001 to 2004, and so on, was used in this study. The SPOT5 image was processed using ERDAS IMAGINE software, which involves geometric correction, supervised classification and GIS reclassification. Because the commercial remote sensing data have



**Fig. 2 The SPOT5 image of Shenzhen in 2005**

systematic geometric errors, so the geometric rectification is necessary to reduce the error before land classification, In this study, Gauss-Krüger projection was used to rectify the image, Using the remote sensing interpretation technology and data such as 1:1000 scale topographic maps, land use survey and aerial photograph, in the end, the image was accurately interpreted into different land use types, including residential land, commercial and service facility land, government and community land, industrial land, warehouse land, intercity transportation land, roads and squares, municipal utilities, green space and specially-designated land. And there is also some unused vacant land and the land which is under construction. Since it is difficult to classify this type of land to any land use types above, so, in this study, this kind of land was interpreted to a special land use, namely, Bu Ming land use. The CAD data format land use situations were processed using ARCGIS9.0 software, and converted into GIS data format. Finally, the land use database of Shenzhen from 2001 to 2005 was founded (Fig.3) and the data will be used in the next session in which the changes of Shenzhen's urban land use will be tested.



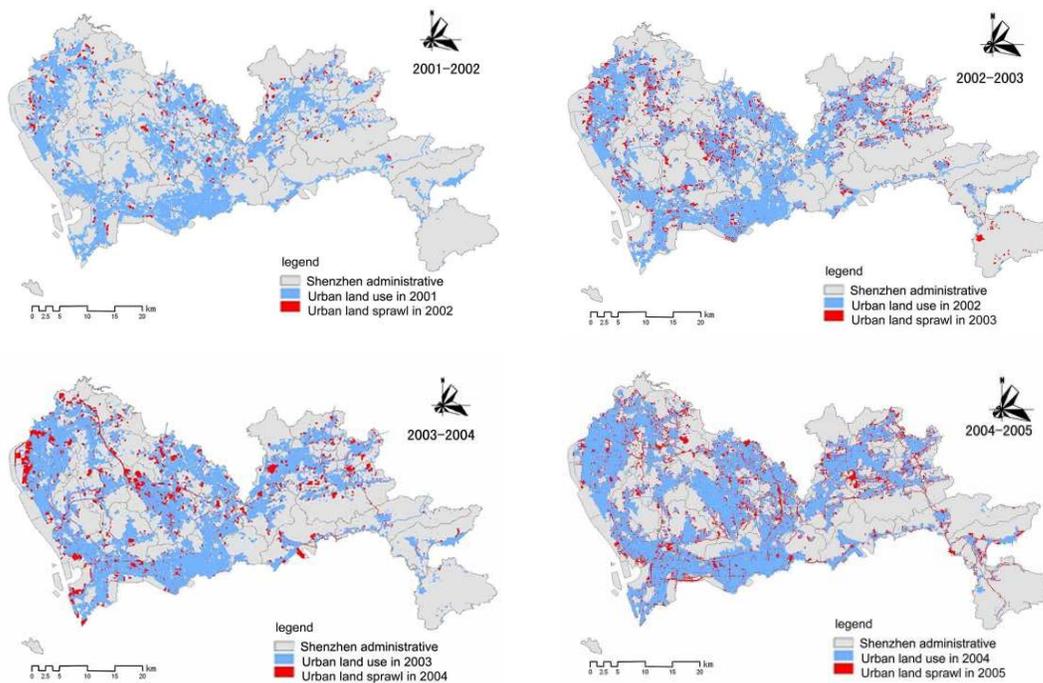
**Fig. 3 The situation of urban land use of Shenzhen from 2001 to 2005**

### 3.3 Other data sources

Several socioeconomic data sets were also used in this study, including natural, society and economic statistic data sources. The data sets include information that will be used to create measures of the variables for testing the determinants of urban sprawl. The data come from two data sources. The first type of data come from land use information database that include natural statistic data like the farmland, the open space and the environment, and so on, which housed in the Bureau of Land Resources of Shenzhen. The second source of data is that which provides information on socioeconomic phenomenon, including gross domestic product, population, income, gross industrial production, and so on. This type of data come from Shenzhen statistical yearbooks, compiled by Shenzhen Statistics Bureau.

#### 4. Changes in Shenzhen's urban land

From 2001 to 2005, Shenzhen was experiencing urbanization at an unprecedented rate, leading to too much conversion of land to urban use (Fig.4). In fact, the built-up area increased from 470.68 km<sup>2</sup> in 2001 to 703.47 km<sup>2</sup> in 2005, increasing more than 58 km<sup>2</sup> each year. And the annual rate of built-up area increase come up to 10.56 percent. Meanwhile, the population grew from 7.25 million to 8.28 million, and its annual growth rate is 3.38 percent, which is much lower than the urban land's. In this sense, urban land grows much faster than the population, leading to decrease of the population density. Based on statistics, the population density dropped drastically during this period. In 2001, the population density of Shenzhen is approximate 154 persons per hectare, but in 2005, it decreases to only about 118 persons per hectare. As noted above, excessive urban expansion occurs from 2001 to



**Fig.4 Maps showing urban sprawl in Shenzhen from 2001 to 2005**

2005 in Shenzhen and it generates lots of negative impacts. In effect, because urban expansion has been too rapid, there is much less land to use in the future. In accordance with the speed of urban growth, before 2010 there will be no more land to use (Fan, 2006). Land scarcity now is the chief factor that restrict the sustainable development of Shenzhen in the future. And due to urban sprawl, lot of scarce open space is also encroached by urban land, and the ecological environment has deteriorated. Finally, low density spatial expansion generates long commutes, which generate traffic congestion. In Shenzhen, the consumption of petrol arises from 138 kilogram per person in 2001 to 278 kilogram per person in 2005, contributing to auto-related air pollution.

Based on the Shenzhen Urban Planning Standards (Shenzhen Municipality, 2004), urban land use is classified to 11 types. However, water bodies and other non-urban land use are not concluded in this study, and at the same time, a type of urban land use named Bu Ming land is added. Using ARCGIS9.0 software, the area of every kind of urban land use is

accurately calculated from 2001 to 2005, and the changes and contribution are also calculated (Tab.3). It is easy to find that, among all types of urban land use, industrial land and residential land grows most rapidly, contributing to urban sprawl in Shenzhen. And industrial land expands much faster, and its contribution of urban expansion even come up to 84.06 percent in 2004. Changes of area of other types of urban land use, like commercial and service facility land, specially-designated land, green space, government and community Land, roads and squares, intercity transportation land, municipal utilities, warehouse land and Bu Ming land, are unobvious. Thus, the low density, excessive urban expansion is most due to the rapid growth of industrial land and residential land, especially the industrially land. This is an interesting phenomenon. Unlike the western countries, where urban sprawl is generated

Tab.3

Area, Changes and Contribution of urban land use of Shenzhen from 2001 to 2005

Items	C	D	G	GIC	M	R	S	T	U	W	BM	SUM
Land use area in 2001 (km <sup>2</sup> )	22.04	5.08	31.18	26.03	137.14	136.41	57.72	36.84	8.68	7.32	2.24	470.68
Land use area in 2002 (km <sup>2</sup> )	22.35	5.26	33.06	26.76	153.45	143.72	64.26	38.26	8.90	7.44	2.32	505.78
Changes(km <sup>2</sup> )	0.31	0.18	1.88	0.73	16.31	7.31	6.54	1.42	0.22	0.12	0.08	35.10
Contribution(%)	0.88	0.51	5.36	2.08	46.47	20.83	18.63	4.05	0.63	0.34	0.23	100.00
Land use area in 2003 (km <sup>2</sup> )	25.23	5.96	38.96	31.33	204.94	174.18	71.38	38.37	10.86	8.72	2.64	612.57
Changes(km <sup>2</sup> )	2.88	0.70	5.90	4.57	51.49	30.46	7.12	0.11	1.96	1.28	0.32	106.79
Contribution(%)	2.70	0.66	5.52	4.28	48.22	28.52	6.67	0.10	1.84	1.20	0.30	100.00
Land use area in 2004(km <sup>2</sup> )	25.13	5.33	46.79	29.17	240.74	169.26	72.08	37.79	14.07	10.36	4.44	655.16
Changes(km <sup>2</sup> )	-0.10	-0.63	7.83	-2.16	35.80	-4.92	0.70	-0.58	3.21	1.64	1.80	42.59
Contribution(%)	-0.23	-1.48	18.38	-5.07	84.06	-11.55	1.64	-1.36	7.54	3.85	4.23	100.00
Land use area in 2005(km <sup>2</sup> )	32.27	4.48	50.55	36.08	254.75	184.37	83.87	31.22	13.43	10.73	1.72	703.47
Changes(km <sup>2</sup> )	7.14	-0.85	3.76	6.91	14.01	15.11	11.79	-6.57	-0.64	0.37	-2.72	48.31
Contribution(%)	14.78	-1.76	7.78	14.30	29.00	31.28	24.40	-13.60	-1.32	0.77	-5.63	100.00

**Notes:** C: commercial and service facility land; D: specially-designated land; G: green space; GIC: government and community Land; M: industrial land; R: residential land; S: roads and squares; T: intercity transportation land; U: municipal utilities; W: warehouse land; BM: Bu Ming land; SUM: all types of urban land use.

by population suburbanization: people go to live in suburban in order to escape from problems in inner cities and look forward to high quality of life, urban sprawl in Shenzhen is most likely generated by industrialization. The key implication of this phenomenon is that the main causes of urban sprawl may be different between China and the western countries. But what are the main deterrents that explain urban land expansion in China? Which factors have been the most important in terms of their impact on the urban sprawl? How to effectively control urban sprawl? The rest of this paper will answer these questions.

## 5. What are the causes of sprawl in Shenzhen?

### 5.1 Empirical urban sprawl model

The fundamental theory in urban economics related to urban expansion is the monocentric urban model (Alonso, 1996.; Mills, 1967.; Muth, 1969). In this model,  $x$  denotes the distance from the central business district,  $y$  denotes the income,  $t$  denotes the commuting cost,  $u$  denotes the common utility level enjoyed by the residents,  $n$  denotes the population,  $q$  denotes the land consumption per capita and  $r$  denotes the land rental. The main idea of the monocentric model is as the following equations:

$$\int_0^x \frac{2\pi x}{q(x, y, t, u)} dx = n \quad (1)$$

$$r(x, y, t, u) = r_a \quad (2)$$

Equation (1) means that at the equilibrium the total population fits inside the urban area. Equation (2) means that at the edge of cities urban land rental equals the agricultural land rental. The key implication of the model is that urban expansion occurs when population and income grow and restricts when transportation cost and agricultural land rental raise (Deng et al, 2008). Some empirical studies have tested the hypotheses of the monocentric model. In their studies, they found that income, population, transportation cost and agricultural rental were significant determinants of urban sprawl (Brueckner and Fansler, 1983; McGrath, 2005 ).

However, unlike western countries, some other factors should be considered in adapting this model to study urban sprawl in China. First, the main cause of urban expansion is different between western countries and China. In western countries, excessive urban expansion is mainly caused by population suburbanization, and then job and commerce suburbanization. But now in China, in fact, urban sprawl is almost a phenomenon of low density of urbanization, caused mainly by industrialization and growth of population. Thus, consistent with this fact, inner cities in China become more and more prosperous with the development of urban sprawl, compared the decay of inner cities caused by urban sprawl in western countries. Second, the ownership of urban land and rural land is another factor to be considered. In China, compared the privatization of land in western countries, socialist national and collective ownership is adopted. So institutional and policy factors always play an important role in urban sprawl. For example, land use system, industrial policy orientation, reforms of land markets, capitalization of housing distribution, reforms of household system,

and so on, all contributed to the spatial expansion of cities (Li and Yang, 2007). Finally, other factors also should be taken into account, such as gross domestic product (GDP), investment in real estate development, density of main road and compensation for conversion of agricultural land to urban land, and so on. These factors could partly affect the spatial expansion of cities, especially in China.

As noted above, following the monocentric model and taking account of especially factors which could affect urban expansion, this paper seeks to establish a model to explain urban sprawl in China. Conceptually, the empirical model is

$$\text{urban land area} = f(\text{gross output value of industry, population, institutional and policy factors, other economic and social variables}). \quad (3)$$

To empirically implement the urban sprawl model in Eq. (3), it takes account of the situation of Shenzhen city, so the empirical model is specified that

$$\text{urban land area} = f(\text{gross output value of industry, population, incomes growth, GDP, investment in real estate development, density of main road}). \quad (4)$$

In order to test the hypotheses of the effects of the factors in the empirical model, the variables includes gross output value of industry. In fact, gross output value of industry measures the process of industrialization, and as noted above, industrialization is the one of the main cause of urban sprawl in China. Population is also included, and in this paper, the population data include population with residence cards and population with temporary cards. Institutional and policy factors are not included because they are difficult to measure, and meanwhile from 2001 to 2005 institution and policies of Shenzhen kept continuous successively, thus their influence on urban expansion can be ignored. The variable of income is include, which is an important determinant of urban sprawl in the monocentric model. Unfortunately, transportation cost is not included due to data limitations, and agricultural rental is not considered because there is no agricultural land in Shenzhen after the conversion of rural land to urban land in 2004. The idea of including the variable of GDP is that the development of economy is the determinant of urbanization, and now urban sprawl in China is a phenomenon of urbanization. Investment in real estate development reflects the policy of capitalization of housing distribution. And in fact, in China, with the growth of income, urban redevelopment and population growth, the demand of housing in cities plays an important role in urban expansion. In addition, the variable of main road density is chosen because with high main road density in suburban people could travel more faster and convenient, which reduces the cost of commuting and hence is likely to lead to urban expansion. In the next section, the result will reported from this empirical model.

## 5.2 *Multivariate analysis*

To estimate the role which the factors included in Eq. (4) plays on the urban expansion in Shenzhen, multivariate analysis is used in this paper (Tab.4). The magnitude of the pearson correlation coefficients are 0.992 and 0.991, Which mean population and gross output value of industry play the most important roles in urban sprawl of Shenzhen. The result shows that

the hypothesis that urban sprawl in China is a phenomenon of low density of urbanization and mainly caused by industrialization and population growth is correct. This view is consistent with the situation of Shenzhen. Population is the most important factor of urban spatial expansion of Shenzhen. In fact, population grew rapidly during this period. In 2001, the number of population was 7.25 million, however, in 2005 the number increased to 8.28 million, added 1.03 million (Shenzhen Statistics Bureau, 2007). Obviously, with the increase of population, the demand of housing also rises. But in the inner city of Shenzhen, there is not enough land to support the large amount of added population, and people always can not afford the high price of housing in inner city. Thus, people have to live in the suburban,

Tab.4

Multivariate analysis of determinants of urban sprawl of Shenzhen

Items	Pearson correlation	Significant
Gross output value of industry	0.991	0.001
Population	0.992	0.000
Income	0.047	0.470
Gross domestic product	0.982	0.001
Investment in real estate development	0.866	0.029
Density of main road	-0.982	0.001

Note:  $R^2 = 0.984$ , Significant at 0.001

Dependent variable: built-up area, in square kilometers

sacrificing the high quality of environment for low price of housing. This is different from the case in western countries, where people go to live in suburban in order to escape from problems in inner cities and enjoy the open space. In China, rich people always enjoy to live in inner cities, so the inner cities also keep prosperous with the excessive urban expansion. And most people who live in suburban can not afford the car, they usually go to work by public transportation, which is always relatively cheap. So the transportation cost and density of highway or main road seldom affect urban sprawl in China, thus, it is easy to understand the correlation coefficient of density of main road is -0.982.

Industrialization is another important factor of urban spatial expansion. Now Shenzhen is experiencing a high rate of urbanization, which is always propelled by industrialization. Actually, the gross output value of industry of Shenzhen increased from 374.77 billion yuan in 2001 to 1017.45 billion yuan in 2005 (Shenzhen Statistics Bureau, 2007). In working with the development of industrialization, land is needed to support industrialization, thus, urban expansion occurs. And as noted above, institutional and policy factors always play an important role in urban sprawl. With the practice of the policy of regulation and optimization of Industrial Structures in Shenzhen, the inner city now is developing the third industry with great exertion, and labor intensive industry is moved to the suburban. As a result, low density and excessive urban expansion occurs in the suburban, mostly due to the industrial land expansion (Tab.3).

The correlation coefficient of GDP, 0.982, means GDP also affect urban expansion to a great extent. Investment in real estate development also plays an important role in urban expansion. Interestingly, the correlation coefficient of income is only 0.047, which is much lower compared to other factors' coefficients. Unlike the western countries, in China,

compared the suburban, inner cities have more perfect infrastructure, more convenient public facilities, higher quality of environment, and so on. Thus, with the growth of income, people will not choose to live in suburban, but live in the inner cities. In consistent with this situation, income plays an important part in urban sprawl. In short, the most important lesson from this part of analysis is that main cause of urban sprawl of Shenzhen is urbanization, not suburbanization which is determinant of excessive urban expansion in western countries. Finally, most factors' coefficients change significantly, especially the population, and the R square is 0.984, which means the empirical model works well.

### 5.3. *How to control urban sprawl?*

If the allegation that urban sprawl in Shenzhen is a phenomenon of low density of urbanization and mainly caused by industrialization and population growth is correct, then how to control urban sprawl, how to encourage sustainable development of urbanization in China? Taking into account of the situation of Shenzhen, two main policies should be adopted to deal with this problem. The first policy, namely, zoning control is a useful tool to control excessive urban expansion. For example, urban land use in Shenzhen should be classified to forbidden area, limited area and suitable area for construction in order to restrict urban sprawl and protect the ecological environment. Concerns about the scarce of open space, some valuable natural resources like water source, natural reserve, places of historical interest and scenic spots, farmland, forest, wetland and other scarce resources which are valuable to the ecological environment should be protected based on zoning control policy. The key implication of this policy is that with the development of industrialization and population growth, urban spatial expansion in China could not be restricted, and should not, but sustainable development of urban expansion should be encouraged. In fact, the policy of Administrative Regulation of Shenzhen Municipality on the Essential Area of Protecting Ecology has been taken effect since 2005 coping with urban sprawl.

If the tendency of urban expansion could not easily restrained in cities of China, where is experiencing a high rate of urbanization, then to adopt a sustainable urban form may be more feasible. Taking account of the main contradiction of urbanization that there is a large number of population but limited land to accommodate it, the compact city (CEC, 1990) policy should be adopted, which claims that high density, mixed land use and public transportation are important for the sustainable urban form (Jenks et al, 1996). Now the compact city theory is considered as a useful tool to control urban sprawl in western countries, and it claims that the compact city can effectively restrict urban sprawl, protect the open space, decrease the consumption of energy resources and create various livelihoods. If the allegation is correct, the compact city is also a sustainable urban form for cities of China. Other policy measures like to perfect the ownership system of land, to simplify the urban planning system and to strengthen the participant of community (Li and Yang, 2007) are also useful to control urban sprawl. However, policy measure designed to attack urban expansion will ultimately affect the urbanization process in China. Therefore, the stakes in these policy measures should be well considered before putting into practice.

## 6. Conclusion

This paper studied the phenomenon of urban sprawl in Shenzhen, which now is experiencing a high rate of urbanization. The study shown that unlike the western countries, where urban sprawl is the consequence of suburbanization, and it is a spontaneous phenomenon that city dwellers look forward to high quality of living environment and escape from problems in inner cities, the nature of urban sprawl in Shenzhen is a phenomenon of low-density urbanization. The study shows that from 2001 to 2005, the built-up area of Shenzhen increased rapidly, and the low density, excessive urban expansion is most due to the rapid growth of industrial land and residential land, especially the industrially land. In order to find the causes of urban sprawl, the monocentric urban model is shown in this paper. Taking account of the nature of urban sprawl in Shenzhen, factors like gross output value of industry, population, institutional and policy factors, incomes growth, GDP, investment in real estate development, density of main road are included to establish the empirical model. However, urban sprawl is so complicated that it is difficult to include all measures factors which may affect urban expansion. Although it doesn't account institutional and policy factors (mainly due to the difficulty in measuring), the multivariate analysis suggests that population and gross output value of industry play the most important roles in urban sprawl of Shenzhen. The result shows that the hypothesis that urban sprawl in China is a phenomenon of low density of urbanization and mainly caused by industrialization and population growth is correct. Moreover, this paper suggests that the tendency of urban expansion could not easily restrained in cities of China, where is experiencing a high rate of urbanization. Maybe the policy measures of zoning control and the compact city which are useful tools to encourage sustainable development should be adopted.

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