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Dynamics of urban sprawl and sustainable development in China☆

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ABSTRACT

Compared with the rich literature on urban sprawl in Western cities, relatively little is known of the driving factors, processes, and future trends of urban sprawl in China. This research analyzes the socioeconomic forces behind two parts of urban sprawl in China: urban decentralization and urban renewal, and reveals two basic characteristics of Chinese urban sprawl: de-densification and expansion of urbanized areas. It uses the term "urban sprawl" to consider the reasons behind urban transformation on a regional level in China. This research begins with definitions of sprawl in Western and Eastern countries, and follows with a dynamic analysis of the social, political, and cultural aspects of sprawl. Three case studies focus on three urban regions in China: Beijing, Shanghai, and Guangzhou. This research provides a comprehensive definition of "urban sprawl" in China, identifies the patterns of urban sprawl and growth, and indicates possible alternative strategies for urban expansion. Finally, it offers suggestions on how to effectively control urban sprawl in China, and provides a pathway to achieving sustainable development.

1. Background

Over the past three decades, China has experienced rapid urban growth and massive rural-urban migration. Just over 680 million now live in cities – 51.27% of China's entire population of nearly 1.35 billion. With 75% of Chinese expected to be living in cities within 20 years, the demand for more transport, energy, water and other vital infrastructure is set to test resources and city planners [1]. The natural environment characteristics formed by topography and human environment affect the direction of urban sprawl [2], the concept of urban sprawl has been widely used in the planning literature to indicate disordered urban expansion. Urban growth with low density is sometimes called sprawl. There has been no clear consensus regarding what exactly "urban sprawl" is or how it is caused, because sprawl is a disputed issue from different scholars at many institutions, such as indicating urban sprawl changes on nation and local levels by Professor. Tingwei Zhang, pointing out urban sprawl creates a new era of decentralized forms by Professor. Fulong Wu, and stating Chinese urban sprawl originates in low-density urbanization by Professor. Qi Lei. First, the objective of this research is to give a better understanding of the concept "sprawl" in China. By focusing on the sustainability effects associated with urban sprawl and growth, this study provides a better understanding of the development direction in the future and problems caused by urban sprawl, moving towards sustainability in rapidly growing urban areas in China. It will contribute to an increased understanding of the causal relationship between urban sprawl and sustainable development by dealing with the sustainability impacts associated with urban growth and change.

Compared with the rich literature on urban sprawl in Western countries, relatively little is known of the driving factors, processes, and future trends of urban sprawl in China [3]. Distinct from Western countries, Chinese urban clusters have been the main urbanization mode. In the past 10 years, there has been an increase in the literature on Chinese urban sprawl, but most of it is focused on urban decentralization: suburbanization, dual-center or sub-center structure, and development zones. Urban sprawl refers to rapid, low-efficient, and disorderly growth of non-agricultural land towards peripheral areas in China [4].

There are two parts for China's urban sprawl: urban decentralization (the creation of development zones and new towns) and urban renewal (infrastructural changes to existing urban fabrics). One is urban expansion and growth towards to periphery areas [5], and the other is internal reorganization for transformation of urban operation and structural functions with land use pattern. These two parts are interrelated.

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1.1. Urban decentralization

New towns on the edges of existing cities can be a key contributor to de-densification. These "start again" cities are often motivated by preferences for modernity and the fact that it is less expensive to build new towns than to redevelop the existing run-down urban fabric [6]. In China, the outcomes of urban de-centralization are suburbanization, dual-center or sub-center structure, and development zones for updating house conditions and redirecting spatial development. This process attracts more and more people moving to suburban areas and has de-densification effects, and at the same time has transferred large rural areas to urban built-up areas and achieved expansion of urbanized areas.

1.2. Urban renewal (infrastructural changes to existing urban fabrics)

Urban renewal in the West is a program of land renewal in old inner cities. It may involve relocation of businesses, the demolition of historic structures, the relocation of people, and the use of eminent domain (government purchase of property for public use) as a legal instrument to take private property for city-initiated development projects. In China, urban renewal has two types: one is the transformation of "urbanized villages" in inner cities and around urban fringes, then updating urban infrastructure and service facilities in this district, including parks, roads, urban forests, public spaces, or transferring this district to CBD (central business district); the other is constructing luxury middle- or high-rise gated communities in this district, replacing original "urbanized villages." Although "urbanized villages" or "migrant enclaves" are located in inner cities or around urban fringes, they still belong to non-urban built-up areas, according to the Chinese urban land pattern system. Therefore, urban renewal involves an important consequence: reducing gaps in the city and raising the height of buildings. This process has demolished a large mass of urbanized villages and transferred non-urban built-up areas to urban built-up areas. However, the second type of urban renewal will enhance population density in the original district (it is a process from low-density to high-density for urban residents) and does not fit the first characteristics for Chinese urban sprawl (de-densification). For the first type of urban renewal, on the one hand, most of the original residents are forced to relocate to suburban areas or move to other undeveloped slums, and then the government builds a lot of infrastructure in this district or transfers this district to CBD (central business district); as a result, population density becomes much lower after the completion of the urban renewal program and it is a low-density development. On the other hand, due to the gradual disappearing of urbanized villages, urban built-up areas are expanding. Therefore, only the first type of urban renewal belongs to urban sprawl in China and achieves infrastructural changes to existing urban fabrics.

China is in a transitional period with a decentralized economy operated within a highly centralized governmental structure. Under this administrative system, the national government has made a series of decrees to guide land-use tenure, land-use rights allocation, and planning activities. The focus is on a separation between landownership and land use rights. Local governments carry out general land-use transfer activities under the national government's supervision [7]. Under this land use system, land use rights can be sold, transferred, mortgaged, leased and sub-leased, and donated. Under this circumstance, land users have to bear all the costs of use year by year [8].

Urban renewal is the main method of achieving "spatialized capital accumulation". The real estate sector in Chinese cities has been one of the major growth pillars. Since the 1990s, municipality governments have made large investments in real estate areas to prepare for reshaping the urban spatial structure [9]. Therefore, inner-city redevelopment in China can be considered as commercial development and infrastructure improvement with the relocation of original residents, protecting residents' legal rights and reasonable distribution of compensation [10]. Unlike western countries, urban sprawl began in China only 19 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: What are the causes of urban sprawl in China? What distinguishes urban sprawl in China from that of the U.S.? What are the driving factors behind Chinese urban renewal? These questions above are very important because they can help us to understand the essence of urban sprawl in China.

2. Theory and framing the debate on sprawl

2.1. Urban sprawl in western countries

Urban sprawl is usually considered as having diverse negative effects for urban growth, such as urban obesity, heavy loads of traffic, deteriorated inner city neighborhoods, and disappearance of public spaces [11,12]. Through urban sprawl, property developers can gain great profits from residential housing construction in new urban built-up areas due to high housing prices and commercial re-developing projects in inner-city areas by urban renewal, and local governments can make large profits from the conveyance of land-use rights and related taxes. Now revenues from land exchange include land tax, charges on land leasing, and various land use fees. Central and provincial governments have a share in revenue from leasing land use rights, and charges on land leasing are the main revenue source for local governments [13]. Therefore, it is not difficult to understand why developers and government officials continue engaging in and promoting sprawling development. Urban sprawl in the U.S. results from rapid urbanization due to industrial development and immigrants and results in urban space change [14]. Urban sprawl is emerging from urban centers to peripheral areas, and the increase of urban built-up areas is usually considered as effects of sprawl [15]. There are still many debates on urban sprawl. It is difficult to have a comprehensive and exact definition of it because of the lack of specific and complicated measures. Scholars who insist on controlling sprawl in general prefer compact city strategies [16,17]. In contrast, others think that urban sprawl is the result of residential preference [18], and governments should not intervene because government interventions are inefficient and lead to suboptimal distributions of land resources that ignore markets [19].

2.2. Limitation of the previous works on Chinese urban development

Today the exact meaning of urban sprawl is still in debate and is being explored in China, but the term "sprawl" has frequently emerged in diverse research papers and reports [20]. In the literature on urban studies and urban economics, there are different views on how to define urban sprawl and how to evaluate its types and impacts [11,21]; for example, Chiedozie [22] points out that urban sprawl is the uncontrolled expansion of cities and their suburbs to rural areas. It is an occurrence that has several drastic consequences; Kathy [23] believes that urban sprawl, sometimes called suburban expansion, is outward growth of metropolitan areas and a process of high density to low density development. In general, the definition of urban sprawl is described in two aspects: an inefficient or excessive urban expansion and the spatial pattern characterized by leapfrog development and low-density forms. However, some different opinions exist in academic fields on urban sprawl. Today, there is no generally accepted definition of this term [24].

Many scholars, such as Fulong Wu, Qi Lei, and Tingwei Zhang, do not consider "urban sprawl" simply equivalent to "suburbanization." For example, Wu [25] has pointed out that when a rapid urbanization process and urban growth provide broad sprawl spaces, and new urban built-up areas are concentrated in suburbs with large residential communities, development zones, new towns, and "leapfrogging

development areas," then this process has a great impact on urban patterns in China: overriding the period of compact cities and creating a new era of decentralized and multi-centered forms. Lei [26] argued that Chinese urban sprawl originated in low-density urbanization, unlike the U.S. and European countries, based on excessive suburbanization and intervention from local governments, and political influences have become the main driving forces for urban sprawl in China. Unfortunately, so far there have been very few studies on urban renewal as another part of urban sprawl in China.

Although Wu [25] adapted the concepts of urban redevelopment to analyze spatial changes on the inner and central area under new urban redevelopment, he does not point out the two types of urban renewal, and does not consider one type of urban renewal: infrastructural changes to existing urban fabrics as a part of urban sprawl. Most scholars have a misconception of urban sprawl in China. The second omission is the few studies investigating the comparison among different typical urban regions in China within characteristics of urban sprawl. More comprehensive analysis is provided by Zhang. Zhang indicated that urban sprawl changes on nation and local levels, investigated the driving forces of these changes, and reviewed interrelated interests and conflicts between these two level changes; however, far less in his analysis is known about the comparison and analysis for population density change on the district and county level for different urban regions within the concept of urban sprawl.

2.3. Social problems of urban sprawl

First, rapid urbanization results in the loss of cultivated land. Next, urban land growth has become unordered. Urban sprawl leads to fragmentation for urban structure and function [27,28]. Moreover, urban sprawl ruined a lot of farmland and destroyed the ecological balance [29]. Pollution and hazards caused by urban construction projects during the expansion process have become a serious problem in China [30]. Urban sprawl in China mainly creates a large number of development zones or new towns and transformation of urbanized villages. Local government has made large investments in development zones, transferring rural lands around cities into new urban lands, but much of the land in development zones has not been used for the anticipated purposes or will remain vacant for several years [3]. Urban renewal is based on property development and leads to changes to existing urban fabrics. Large urban redevelopment projects are driven by reconstruction of residential housing and transformation of land-use rights. The relocation of original residents has unavoidably brought about social conflicts between them and developers or local governments due to large commercial profits [31].

2.4. Sustainability concepts of urban sprawl and growth

Sustainable development has been raised by WCED (the World Commission on Environment and Development) in its report in 1987. The construction of ecological corridors connecting natural and cultural elements in surrounding areas can improve the level of sustainable development [32]. There are three important parts of the concept of sustainable development: economic development, environmental protection, and social equity [33]. To achieve sustainable development, all three dimensions need to exist in harmony. The interaction of man-made and natural capital will indicate the degree of sustainability. If the former replaces the latter, it receives a low grade. However, if the latter is not substituted by the former, it receives a high grade [34–39]. Nearly 50% of the world's population is living in urban areas, 3% of all habitable area. Byeong [40] has diagrammed human settlements based on a material paradigm and an ecological paradigm. Sustainable development can be considered as an applied idea, to balance economic growth and environmental protection not only at the current stage, but for future generations [41]. Urban sprawl is a complex process toward urbanization. If properly managed, it could contribute to ecological balance and sustainable development [42]. Urban sustainability is multifaceted [43], and the city is considered a growth machine. The whole urban region, including the center urban areas, inner ring suburbs, outer suburbs, satellite towns, and peripheral areas, should be taken as an integrated complex for planning and redevelopment [44]. In urban planning, inner ring suburbs should be considered as an independent part. Each district should have its different own developing strategy, besides comprehensive planning on the metropolitan region [45]. In the process of new construction projects and urban renewal activities, decision makers should consider socioeconomic and environmental aspects within the concept of sustainable development [46].

3. Methodology

Analysis of how to measure of urban sprawl, explanation on difference on urban sprawl between China and U.S.

3.1. Measuring urban sprawl

Urban sprawl is actually a phenomenon that can be expressed and quantified using a series of special parameters. The simplest parameter of urban sprawl is the average density of urban built-up areas [47]. Some scholars have taken three parameters for measuring and analyzing urban sprawl: residential density; neighborhood mix of homes, jobs, and services; and accessibility of the street network [48]. Sprawl measures indicate an objective approach for evaluating rate of spatial expansion [49]. In most of the literature, five major factors have a great influence on measuring sprawl: growth rates, density, spatial geometry, accessibility, and aesthetic measures [50]. In China, how to measure urban sprawl is still controversial [51]. Siedentop and Fina [52] indicate that measuring urban sprawl could be based on three types of indicators. These three factors are considered as surface indicators: total area, total built-up area, and the area change of built-up area; pattern indicators include the shape change of built-up area, fragmentation, and open space efficiency; and finally, suburban density, the change of suburban density, and the change of population density are regarded as density indicators [51].

3.2. Overview of how China is different from the U.S.

The U.S. and China are two of the most powerful countries in the world today, and, consequently, many similarities and differences can be seen between these two countries' urbanization processes. From a historical viewpoint, American and Chinese megacities have had different stages of urbanization processes. Empowered by the steel and textile industries in the second Industrial Revolution of the 18th and early 19th centuries, American megacities expanded rapidly outward, enabled by the development of rail-roads, streetcars, and trolleys in the 19th century. In particular, the popularization of personal cars and improvement of transportation facilities made suburbanization more intensive, followed by formation of metropolitan areas. China has experienced rapid urbanization since the early 1980s and continues due to population migration from rural to urban regions and construction of infrastructures [53]. Thus, significant differences exist with respect to levels of urbanization and developmental patterns between China and the USA, which are considered developing and developed countries, respectively [54]. The comprehensive comparison of the urban dynamic pattern is needed to enhance our understanding of urbanization processes and mechanisms. Comparison analysis is composed by two part: urban Decentralization and urban renewal.

3.3. Urban decentralization

In the United States, with rapid urbanization, central urban areas have deteriorated and are facing a series of social problems, such as

traffic congestion, urban poverty, poor public facilities, and residential differentiation. Pursuing a high-quality life, rich people have tended to escape the inner cities and traditional urban centers to suburban areas. 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 to for a high-quality living environment. Meanwhile, in the late 20th century, strong sentiment against urban sprawl developed in the U.S. Urban sprawl has brought about blight for traditional urban centers and downtown areas and a series of unprecedented social problems, so some scholars have pointed out “urban sprawl is against the concept of sustainable development” and “government should control the process of urban sprawl in the United States” [11]; p. 167).

What about China? What is the greatest distinction between China and the U.S.? What has happened in China with urban sprawl? First, we look at the differences in the definition and impetus. In Western countries, much urban sprawl has occurred and resulted in suburbanization since the1920s [18]. However, China has experienced rapid urbanization development since the 1980s. By 2006, the urban population proportion had only reached 43.9% [55], and it is at a low level compared with Western countries, so suburbanization in China cannot occur as it is in the U.S. In the U.S., the attraction for urban central areas is strong, high-income residents and foreign investment driving the construction of luxury high-rise buildings [56]. The situation is totally different in China. With the large scale of urban sprawl, downtown areas are still attractive and prosperous. Sprawl leads only to low-density urban expansion and the process of urbanization. Moreover, there are two contrary circumstances in China: young and low-income people are moving to suburban areas or satellite towns, whereas senior and high-income residents are still living in traditional urban centers for a better living environment and public facilities.

An example of the Chinese characteristics of urban sprawl and the difference from the U.S. is Kangbashi New Town development of Eerduosi, Inner Mongolia. GDP in Eerduosi is on the top of urban regional level in China. A new town—Kangbashi district has been built as a typical model with a huge investment on urban infrastructure and residential housing in China's western region. There are a lot of architectural marvels and sculpture gardens in Kangbashi New Town, but there is one missing factor in this beautiful city: residents [57], so it is called a modern ghost town. There is a 34-km highway between Kangbashi New Town and a traditional center (Dongsheng); this distance is not a big problem for modern urban residents. The main reason why Kangbashi is empty seems to be a planning issue: The new town being only 34 km (beeline distance) from the old town has discouraged people from moving. Though a government official may work in the new town, his family may have little reason to move there. It is difficult for a lot of services to be operated normally for so few residents, which is the first reason not to move there [58]. The second reason is public transportation. If the weather is good and car ownership rate is very high like in the European Union cities, the distance of a 34-km highway is not a big deal. However, the weather of Eerduosi is sandstormy and most Chinese urban residents depend on public transportation. It is impossible for every resident or every family to have a car in Chinese cities. The presence of public transportation in Eerduosi is not sufficient for residents' job-housing balance: no trail traffic and only one bus every half hour between Kangbashi New Town and the traditional center (Dongsheng). The third reason is education. There are no good middle schools in Kangbashi New Town. Traditional Chinese parents mostly pay attention to children's education, so most middle-aged parents do not want to move to New Town and prefer to stay in the traditional center (Dongsheng). This is the Chinese characteristic of urban sprawl: traditional urban centers are still attractive and prosperous with the large-scale urban sprawl.

However, there are some similar characteristics and confluences of urban sprawl in China and the U.S. Just like urban sprawl in U.S cities, the growth of urban built-up areas is much faster than urban residents, so population density has become lower in the past several decades (see Table 1). But China has a very special circumstance: Cultivated lands and related resources are very scarce. Uncontrolled urban sprawl will damage a lot of farmland and is dangerous for China's national safety. For China and the U.S., urban sprawl always generates long commutes and accompanying traffic congestion, a magnitude of infrastructure investment, and other social problems.

In the Chinese geographic extension, one urban region includes a metropolitan area, several counties, and a large rural area, but all public facilities are provided by municipality governments, and development of urban, suburban, and rural areas will be unbalanced. So the development of urban regions should use all social resources and reorganize related policies achieving integration of urban and rural areas studied in the U.S. context [56].

Obviously, the result of suburbanization is urban sprawl both in China and the U.S. In the U.S., suburban areas are defined by political autonomy, including an independent school system, their own tax base, and power for controlling local development [56]. Compared with American-style suburbanization, the obvious characteristics of Chinese urban sprawl are that the inner-city area remains prosperous and the power of local governments is still crucial. The reasons are attributed to the uneven land reform that arbitrarily separates urban land and rural land.

3.4. Urban renewal

According to Zhu Xigang's description and explanation, there have been three waves of urban renewal in America. The first wave (1968–1973) was a sporadic development stage, the second wave (1980–1989) was a period of rapid development in many medium cities, and the third wave has been a climax of urban renewal since 1995 due to economic resuscitation and commercial prosperity. For China, because of the different developing mechanism and institutional backgrounds, there are some different characters and paradigms in the process, representation, and trend of urban renewal: (a) urban renewal on large scale provides good chances for updating urban infrastructure facilities, (b) urban renewal expands gradually from downtown to suburbs, (c) new-layer urban spatial structure gradually shows up, and (d) urban renewal accelerates.

As for downtown area renewal, replacement of residents’ composition, and the negative effects of urban renewal, China has the same experience as the U.S. However, there are obvious distinctions between the two countries: the alteration of urban downtowns, the dominant power for urban renewal, and redevelopment models (see Table 2).

3.5. Explanation of selection of case studies

Beijing, Shanghai, and Guangzhou are considered typical cities because of their distinctive features, and they reflect urban change trends in China. These three cities have crucial implications for change in Chinese cities through the changes of their urban patterns and forms [59]. Therefore, in order to realistically examine the consequences for urban sprawl, these three urban regions are chosen as cases to analyze urban sprawl and sustainable development in China (See Table 3).

These megacities also have significantly different characteristics in urban spatial patterns and urbanization trends due to their different population densities and impacts of economic conditions and politics [53]. Beijing has the most obvious trend toward large-scale suburbanization community development as the capital and the second largest urban region in China. Shanghai, the largest industrial and economic urban region, has experienced a dual-center or sub-center structure. Guangzhou, the social-economic center in the Pearl River Delta for South China, is the most typical case of development zones. From 2000 to 2010, the increasing rate of urban population in Beijing is more than 59%, in Shanghai it is nearly 28% [53]. People call them two most crowded cities in China. Having a comparison on fluctuation of population density between them will be meaningful. During the

Table 1
Changes in Built-up Area, Population, and Population Density of 10 Cities in China from 2001 to 2005.

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

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

1990–2000 period, Beijing reported the highest urban expansion rate and intensity at 11.0029 km^2/a and 0.5618%, respectively; 8 years later, from 2000 to 2008, Guangzhou experienced the highest expansion rate and intensity (12.3257 km^2/a and 0.6993%, respectively) [60]. New construction of Development Zones and transformation of urbanized villages are the key contributors to rapid urban sprawl. So comparative analysis will be focused on Development Zones and Urbanized Villages between Beijing and Guangzhou. The dominant discourse in Beijing regarding the hutong as living habitat is that this urban form is outdated and inefficient. Official Beijing municipal policy favors the conservation of 17% of the existing urban area occupied by hutong, and for the rest, following existing practices, demolition, land adjustment and leasehold sale to developers [61]. In Shanghai, as in many rapidly developing cities worldwide, the immense threat to the social fabric of the historic districts is evident. Although there is also a growing recognition of the need to conserve and rehabilitate the old inner districts, the challenge in implementing the sustainable concept has yet to be resolved [62]. Therefore, it is necessary to compare Beijing in the hutong with Shanghai in the old inner districts on urban renewal. Urban green space has been regarded as an integrated strategy of ecological infrastructure construction to sustain ecosystem services in urban areas. The urban green area per capita increased considerably from 1.5 m^2 in 1981 to 11.18 m^2 in 2010. In 2010, urban green area is $6.27*10^8$ m^2 in Beijing and $1.20*10^8$ m^2 in Shanghai, respectively 6.67 times and 1.28 times more than the average level in 24 key Chinese cities ($0.94 *10^8$ m^2). Beijing and Shanghai are on the top for urban greening in Chinese cities. So investigating green cities strategies in these two cities is useful to realize the development process of Chinese cities [63].

3.6. Comparison and analysis among case studies

3.6.1. Chinese research cases

3.6.1.1. Ecology & climate. Urban pattern in Beijing is belonging to "a typical concentric expansion". The average elevation of inner-city area is less than 50 m and basically lies on a plain. The annual average temperature in Beijing is 11–12 °C. The coldest period is focused on January (an average temperature is ranking from −7 °C to 4 °C) and the hottest dates are usually in July and August (an average temperature is around 25 °C). The annual average precipitation is around 500 mm and the period of the most rainfall is from June to September. For inner-city area, there are no big differences on the geophysical conditions and urban plant species assemblage [64]. From 1986 to 2007, the relation between rainfall and evaporation in Beijing is shown in Fig. 1. Obviously, the changes of rainfall and evaporation are on the converse in this period: the former has a decline trend, while the latter has a rise trend. This result has brought about loss of groundwater storage and dry climate. In the same period, the relation between urbanization rate and wastewater discharge is reflected in Fig. 2. From 1986 to 2007, the urbanization rate has been improved more than 12% and the rate of increase of the amount of wastewater discharge is more

Table 3
Circumstances of urban area sprawl in Beijing, Shanghai, and Guangdong province (km^2).

	1985	1995	2005	1985–1995	1995–2005	1985–2005
Beijing	373	477	1182	104	705	809
Shanghai	184	390	820	206	430	636
Guangdong Province[a]	483	1010	2564	527	1554	2081

[a] Guangzhou is the capital of Guangdong Province and Guangdong Province as the study case.

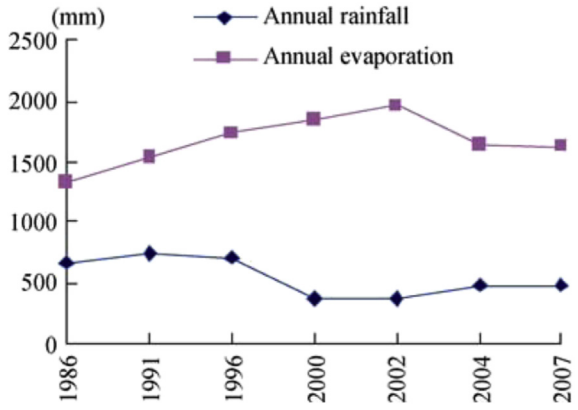

Fig. 1. Change of rainfall and evaporation in Beijing from 1986 to 2007 [65].

Table 2
Comparison with China and U.S. of Urban Renewal in Inner Cities.

	Urban renewal in inner cities	
	Differences	Similarity
China	Urban downtowns didn't experience a large-scale reduction, but instead have had favorable improvements of service facilities and residential environments. The market is obviously dominated by the state and characterized by a non-market economy. Urban renewal has been mostly realized through transformation of "urbanized villages" and updating urban infrastructure facilities.	Dilapidated downtown areas have been renewed and are becoming the place of high land price and rent. There is a replacement of resident composition, and the original group mainly with low income is replaced by the middle class and urban infrastructure facilities.
U·S.	Urban renewal occurred in urban downtown areas that were derelict after large-scale suburbanization. The power of the market played a leading role in the process of gentrification. Urban renewal is generally realized through the course of renovating dilapidated houses and districts, gradually creating a rent gap and then promoting the replacement of residents in urban downtowns.	Urban renewal has negative effects on the low-income group.

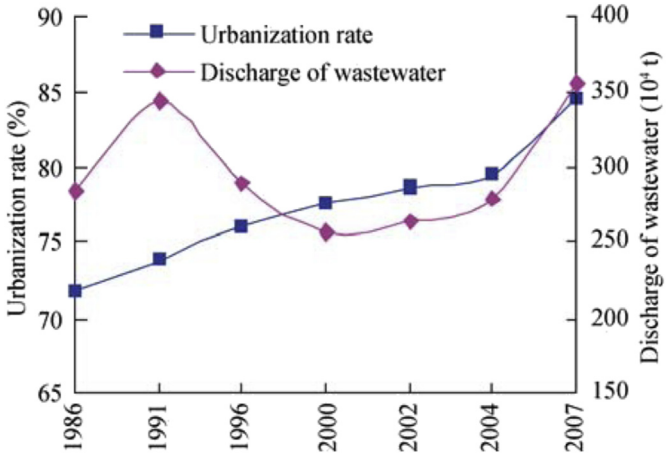

Fig. 2. Change of urbanization rate and wastewater in beijing from 1986 to 2007 [65].

than 33%. Rapid urbanization process and a large of wastewater discharge have resulted in living environmental degradation [65].

Urban climate of Shanghai has features of "a heat island of air temperature and maximum and minimum air temperature" and "a cold island of surface soil temperature" [66]. Until 2005, urban population is more than 14 million, which is increased by 24% in the past three decades. Disorderly and low-efficient urban sprawl has brought about serious ecological problems. First example is water environment in downtown areas, which has been gradually deteriorated; next is soil quality, which is experiencing pollution with metal materials, particularly in the Baoshan District [67]; and the third is the river status. There are three rivers crossing through Shanghai: "The Yangtze River", "Huangpu River", and "Suzhou Creek", which compose a dense natural water system. Urban expansion has taken up a lot of the area covered by water and destroyed original channel network and ecological balance: the percentage of surface waters in Shanghai is decreased to less than 8% in 2001 [68].

Guangzhou is a typical city with "a humid subtropical climate" [69]. In the north of Guangzhou, there are urban forests, creeks, wetland, and grassland, which are important natural habitats for this city. In middle and south areas, a lot of rural lands and low density buildings are considered as buffer zone for future development. Downtown areas of this city are located on the south and southwest regions with high density development and heavy loads on living environment [70], such as serious water pollution, eroding soil, deteriorated air quality, and so on [71]. Moreover, disordered and high-density development has negative impact on urban green spaces. Policies of intensifying land use have made a large of loss of "tree-growth spaces". Guangzhou's urban forest is being degraded [72]. Main threatening sources for air quality in Guangzhou are SO_2 caused by "mass use of fuels high in sulfur content", NOx derived from rapid automobile development after 1995, and total suspended particulates originated from a large scale of infrastructure construction and real estate development [73]. Main sources contributed to air pollution in Guangzhou include industrial production, residential uses, public facilities, and urban transportation. Although some new energy-saving technologies are applied in industrial plants, industrial facilities are still driving forces for deteriorated air environement. At the same time, with population growth, "residential emissions" has been experienced increasing [74]. Moreover, water bodies of this city have no obvious improvement and are equally bad to its air environment. Nowadays, the main wastewater pollution is transferred from "industrial sewage" to "domestic sewage".

In a word, air pollution is the most important ecological problem in Beijing; For Shanghai, rapid urbanization process has great impacts on

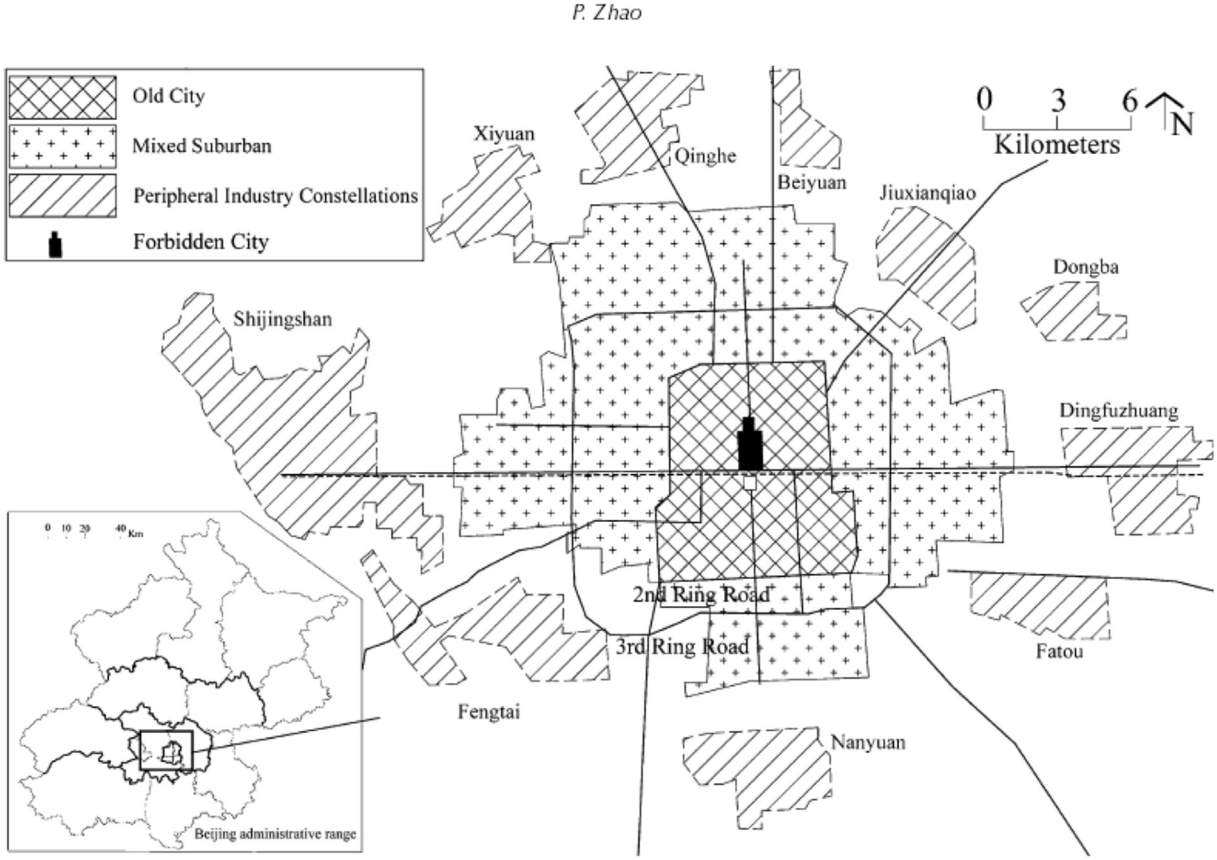

Fig. 3. Urban spatial structure of beijing urban area in 1983 [75].

its urban climate by improving “the urban surface air temperature”; the main wastewater pollution in Guangzhou is transferred from “industrial sewage” to “domestic sewage”.

3.7. Planning policies

After the Founding of People's Republic of China in 1949, developing policies for cities is transferring “consumptive cities” to socialist “productive cities”. Beijing has become a typical sample pursuing for “socialist industrial reconstruction”, including “heavy industry” (iron, steel, and manufacturing sectors) in inner-suburban areas and “light street industry” (textiles and printing) in the inner-city area. In 1980s, a lot of heavy industry factories are still distributed in suburban areas (see Fig. 3). They are connected to downtown areas by the main radial roads and expected for establishing new industrial development zones. After 1990s, Beijing was targeted to become a modern and open international metropolis under influences of economic market and globalization. Since 2000, urban policies have great adjustment: driving growth of high-tech industry and controlling development of traditional industry for reducing production of wastes and having better living environments [75]. In the end of 2004, the new Beijing Master Plan (2004–2020) was advanced and its main developing strategy is transferred the city into “two urban axes, two development corridors, and polycentric urban structure”. This plan aims to transfer the developing focus from traditional downtown areas to urban fringe areas. According to Beijing Master Plan (2004–2020), the main theme of the spatial structure is “Two axes, two belts, and multi-centers”. This master plan is targeted. Two axes through the downtown area (from north to south and east to west) is created to retain Beijing's traditional cultural characteristics and social status and two belts (“the west conservation belt” and “the east development belt”) are established for ecological balance and environment protection of Beijing [76]. Multi-centers are designed to develop high-tech enterprises or service sectors and moving factories with heavy pollution out of the core; to reduce population density in inner-city areas; and to improve urban green coverage rate and update living environments [77]. The newly developed urban space in Beijing spreads over to all directions, but new developments are less in the south, an area traditionally concentrates the poor. New urban space takes the form of expansion of the central district. Along the east axis, the new CBD has been designated. North to the CBD is Shunyi Manufacturing center for advanced. At the initial stage of suburbanization in Beijing, the government played a major role in suburban industrial relocation and suburban development because it controlled industrial, land and housing development.

Before 1949, the international status of Shanghai in Asia is equal to Tokyo on urban images. Modern urban infrastructure, including power supply, drainage system, and “tramways”, has been built in “International Settlement” and Foreign Concession in Shanghai and operated by foreign companies, similar to many European cities. After 1949, Shanghai has been the most important industrial city and has submitted a large of tax revenues to the national government. Traditional socialist “fiscal well-being” in China has negative impacts on economic development and urban renewal in Shanghai in the end of 1970s. Started in the beginning of 1990s, Pudong New District was founded and Shanghai has been experienced a new construction boom. This city has been “a world tourist destination and has been described as the ‘showpiece’ of the world's fastest-growing major economy” [78]. In the subsequent four years, the amount of completed urban projects is more than the sum over past 40 years [51]. Then, Shanghai started rapid urban development process. Nowadays, along with the steady growth and development of economy, the job opportunities in Shanghai have driven large labor forces into urban areas. The population congregating of the past decades results in complex changes in land zoning and brings a compound impact on the ecosystems' structure in urban areas. A central feature of Shanghai's development plans is to reduce its high population density. For decentralization, substantial industrial relocation has been occurred to nine satellite towns trying to achieve decentralization on the local planning authorities [79]. Guided by Shanghai master plan, most new urban space is developed in the nine New Towns in addition to the Pudong New District. Around Shanghai, there are some New Towns. The cores of the New Towns have several hundred thousands to over million inhabitants each. At the same time, many villages in this area are designated to compact high-rise building blocks [80]. In Shanghai, after decentralization, some important authorities, such as management of local land revenue and land use, have been transferred from municipality government to district governments. For urban renewal, some district governments have become a type of business partnership for real estate companies in despite of bans from the central government. Two district governments (Luwan and Xuhui) are good at attracting investment for infrastructural changes to existing urban fabrics [81].

From Qing Dynasty, Guangzhou has been a key trade center and transportation node facing overseas. However, from 1949 to 1979, the traditional key role of this city has been gradually decayed in this period due to two reasons: rapid rise of other cities (such as: Shanghai and Hong Kong) and gradually decreasing investment from national government. Since 1979, Guangzhou has gained great profits from “reform and open door policies” and has a new era on urban development. After 1990s, with deep reform of housing and land use, Guangzhou's traditional core role of economic, transportation, trade, and administrative fields has been re-established [5]. In 2000, five institutes are invited by Guangzhou City Planning Bureau for “Guangzhou Urban Strategic Development Plan” respectively. After all reports are submitted, the municipality government of Guangzhou has a comprehensive evaluation on them with some experts and related administrative bureaus for establishing “Guangzhou Overall Urban Strategic Plan” [25]. The focus for new urban spatial strategy is “expanding the south, optimizing the north, advancing the east and coupling the west”. Municipality of Guangzhou has done its best to attract investment from HongKong and foreign countries for large scale infrastructure and public facilities construction to form a “polycentric and networking” urban structure. The plan is to build a series of new functional urban sub-centers around the traditional downtown areas and convenient transportation network, including “expressway-oriented” and “subway-oriented” system [82]. The restructuring process in Guangzhou was mainly supervised by the municipal government. As a result, the city image of Guangzhou has been renovated: urban expressways, high-rise apartments, and commercial offices have been built in replace of slums, deteriorated neighborhoods, and narrow lines. On one side, this process will update urban infrastructure and improve our cityscape, but on another side, it will destroy original social status, neighborhood communities, and life styles for this city. A lot of heritage buildings have been tearing down with a large of urban renewal in traditional urban center. Tianhe District with a large of urban expansion has been formed in 1995: a new town characterized by high-rise and high dense buildings. New projects are very magnificent, including apartments, commercial buildings, hotels, and cultural facilities. Based on principles for urban growth in USA, urban sprawl in Guangzhou can be considered as a type of urban expansion driving by economic factors [83].

In brief, at the initial stage of suburbanization in Beijing, the government played a major role in suburban industrial relocation and suburban development because it controlled industrial, land and housing development. In Shanghai, after decentralization, some important authorities, such as management of local land revenue and land use, have been transferred from municipality government to district governments. Urban sprawl in Guangzhou can be considered as a type of urban expansion driving by economic factors.

3.8. Urbanization and sprawl

Apart from traditional development model of urbanization before the end of 1970s, Beijing has been experienced “a more divergent path

Table 4
Beijing urbanized area: 1990–2001.

	1990	2001	Change
Population	6244000	8614300	38.0%
Land Area (Square Miles)	153.4	288.7	88.2%
Density	40694	29836	−26.7%
Land Area (km^2)	397.4	747.8	88.2%
Density	15712	11520	−26.7%

of urban change". Large-scale sub-urbanization community development is the most obvious characteristic for Beijing urban sprawl. The change of the urban function from a traditional manufacturing base to a center of service is a major force of social polarization in Beijing. The whole city is expanding outward along the main radial roads to the inner suburbs and the urban fringes. Simultaneously, density-based sprawl is clearly evidenced by decreases in density that have occurred during the current urban expansion process. In ten year period (from 1990 to 2000), population density in urban areas has decreased by more than 25% due to large scale of urban sprawl [75]; See Table 4). One of the most famous examples of such extensive residential district is Fangzhuang's development. This district is established on the southeastern edge of Beijing, which was a nearly 150 ha agricultural land before real estate development. Fangzhuang was planned for more than 75,000 residents in a mixture of structures from "2-storey town houses" to 30-storey buildings. The new town is composed by social mix of residents and some companies and organizations bought large number of apartments as employee benefits in it. At the same time, there are also around 1000 peasants who occupied the small farming village until 1984, and some foreigners who purchased houses in Fangzhuang. This district has grown into a mature community, providing schools, parks, shopping area, and other facilities for the residents. However, there were no industry facilities in the district and most of residents commute by public transportation or "company-provided vehicles to work" [59].

According to the goal of a "1-9-6-6" urban-rural planning system, many new cities and new towns are being built around Shanghai. They will make Shanghai to be an international metropolis step by step in the future. In addition, they can help to disperse population out of the city of Shanghai, attract farmers to move into towns, and merge natural villages (See Fig. 4). The development of new cores is a revival of pre-revolutionary pattern, and it is also an expansion of the theory of decentralization. For example, Jiading district is located in the northwest area of Shanghai. It is one of the fastest developing places in the urban fringe areas. The urban land sprawled rapidly around the center of this district, especially to the south from 1990 to 2006. Through urban decentralization, annual urban land growth rates are both more than 10% from 1990 to 2000 and from 2000 to 2006. The traditional housing form in Shanghai from the mid 19th century is called lilongs. They are connected two-storey buildings on a city block. The shops are fronted outwards to public streets. The residents are living above and are accessed from the interior alleyways. This model can partly represent the history of Chinese architecture – the lack of formalized public space. The residents live, cook, eat, and communicate in these alleyways and form a strong social network of extended family and neighbors. Therefore, the urbanized villages in Shanghai are more important in inner city compared with Beijing and Guangzhou.

Guangzhou is the capital of Guangdong Province and southern China's key transportation hub and trading port, located on the Pearl River which is navigable to the South China Sea. Urban sprawl mainly depends on various development zones: Guangzhou Economic and Technological Development Zone, Tianhe High-Tech Industrial Zone, Huangpu Development Zone, Xintang Manufacturing Zone, Lianhua Industrial Zone, East Guangzhou ETDZ, and Nansha Economic Development Zone. Decentralization for central power is very obvious in Guangzhou, which these powers of management and planning transferred from center government to Guangdong provincial government, then to municipal government of Guangzhou due to the economic and political reforms. Regarding the driving force of urban sprawl, unlike the massive suburbanization in North American cities, urban sprawl is a result of impetus from local government for the economic growth in Guangzhou. Urban sprawl, here referring to a rapid expansion of the built-up area into suburbs in a discontinuous, low-density form, has produced the landscapes of leapfrogging development areas, large peripheral residential communities, and development zones and sub-centers. As far as in Guangzhou, urban sprawl has been greatly accelerated during the l990s, with its built-up area reaching 308 km^2 in 2001, while only l82.26 km^2 in 1990. The average annual sprawl rate is 4.89%. Both of the economy and the size of Guangzhou have grown very rapidly since the reforms. Rapid urban sprawl generates numerous opportunities and challenges. Urban sprawl has brought about two contrary results: the rapid growth of GDP and a series of social problems [84]. With urban expansion, more and more farmlands are transferred to urban use land in suburban areas, and then many natural villages are surrounded by these urbanized areas and become urban villages. In 2000, the total area of urbanized villages is up to 80.6 km^2, more than 26% of urban built-up area. In generally, these urbanized

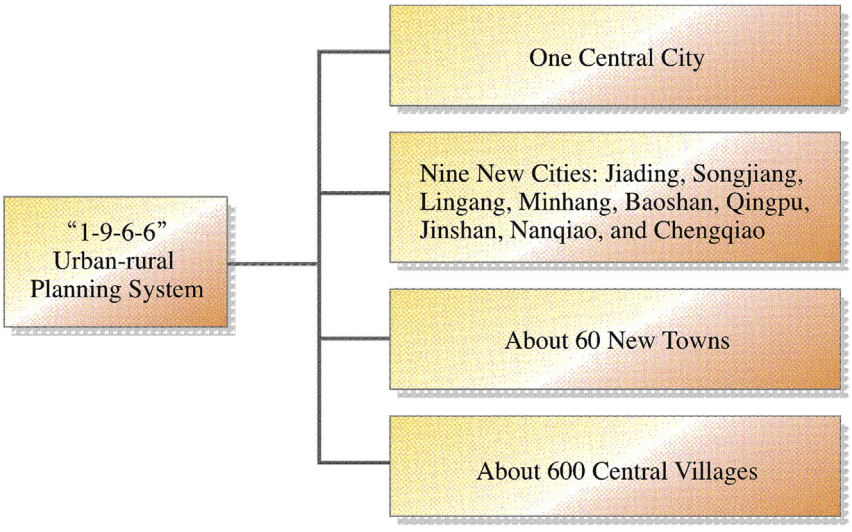

Fig. 4. Frame of the "1-9-6-6" urban-rural planning system.

villages are distributed around urban periphery areas and along main traffic lines. In the process of urbanization, urbanized villages have their own special functions in the economic development due to their geographic location and needs from temporary migrants. At the same time, local residents in urbanized villages have tried to construct a large of cheap, low-quality, and high density housing to rent for large rural immigrants who are looking for jobs in cities and this event will brought out a series of serious social problems [85].

In sum, the whole city is expanding outward along the main radial roads to the inner suburbs and the urban fringes in Beijing; many new cities and new towns built around center areas is the main feature in Shanghai; Urban sprawl is a result of impetus from local government for the economic growth and mainly depends on various development zones in Guangzhou.

3.9. Evaluation

Now urban function for Beijing has been transferred “socialist product city” to “capitalization consumption city”. Although the flourish of real estate development has been main driving factor for rapid increase for GDP and prosperous market, rapid urban growth and urban renewal (infrastructural changes to existing urban fabrics) has brought about socio-spatial differentiation. Moreover, a large of rural migration (low income, intense labor, and temporary, or unstable jobs) has brought about serious social problems in Beijing. For urban sprawl in Beijing in recent 20 years, there are three main driving factors: moving factories from central district to suburban areas; the flow of rural population; and large requirements for residential housings. The urban road system is unreasonable: “single center + ring road” circle growth pattern (new housing and shopping areas are built around the third, the fourth, the fifth roads keeping outward step by step) has led serious traffic congestion. Now different districts have different functions for Beijing: office spaces are concentrated in downtown areas; more and more dwelling houses are built in sub-urban areas. Disordered sprawl for suburbanization community development directly leads to traffic congestion. Due to the large-scale residential development in sub-urban areas, these communities are called “sleeping city” for Beijing [86].

In Shanghai, there are four circumstances for massive construction for new towns: new homes for moderate-level residents due to urban renewal in central areas; new manufacturing bases (Jiading, the “Automobile Town”); new university campus concentration areas (Songjiang, the “University Town”); “logistics bases and harbors (Luchao New Harbor Town)” and luxury “villa” and “gated community” districts (“Qingpu New Town”). Urban sprawl leads to loss for a large of cultivated lands and activities for farm products. In one side, “surrounding the older parts of towns are new residential sites interlaced with antiquated peasant housing, modern factories, and buildings belonging to government institutes”. In anther side, environmental protection and ecological balance are paying more and more attention by the central government. It is possible for having a conflict between original peasants and the new urban-oriented immigrants due to distribution for limited resources and quality of life [87]. For urban renewal, local authorities have great fever to pursue luxury villa and high-level commercial housing for more taxes and improving urban images. There will be a series of serious conflict between developers or local governments and original residents that need to be relocated to suburban areas for a large of scale for urban renewal [81]. Another negative impact brought by large scale renewal projects is threat to Shanghai's historic architecture. Shanghai is relatively a “young” city in China, but it is famous for historical architecture styles, especially the “lilong” house (a local townhouse style). Similar to the urban renewal in American cities, some historical buildings has been torn down in the urban renew process.

Two parts of urban sprawl (urban decentralization and urban renewal) are both based on “ill defined property rights over land” in Guangzhou. Compared to market prices, the cost requirement land and compensation fees are very low for farmlands and orginal residents from local governments due to “the dual system of land ownership” (“Dual Ownership” refers to land ownership formed by the combination of subject ownership and additional land ownership. Subject ownership indicates that the land itself, and its value, belong to the land owner, while additional ownership refers to a land contractor's ownership of the appreciated part of the land contract after the land contracting behavior occurs.) This unfair land policy has brought about arbitrary and unsupervised behaviors for local government to deal with a lot of cultivated lands and inner-city areas for pursuing rapid economic growth by creating new industrial zones and urban redevelopment projects [84]. Therefore, “regarding the driving force of urban sprawl, unlike the massive suburbanization in North American cities, urban sprawl in Guangzhou is not driven by residential preference, but by plans formulated by the municipality with the intention of stimulating local growth”. For urban decentralization (the creation of development zones and new towns), a large of “self-serving gated compounds and industries” has been a main impetus for suburbanization. These gated compounds are connected with urban center by new urban railway. Under this developing model, several peripheral counties and districts are incorporated into the whole planning of “The Great Guangzhou”, such as Panyu district in the South and Huadu district in the North. After intervention of use rights of state-owned land from municipality government of Guangzhou, new town development has unavoidably been the most obvious result for urban expansion. However, the biggest problem is that economic level and urban construction is following behind new town development, then a series of social problems will be appeared, including financial crisis and loss of a large of farmlands [88]. At the same time, with the expansion of urban built-up areas, fragmented green spaces around city fringe areas will be gradually integrated into the whole urban green space system. Disordered planning and inefficient control on farmlands with “collective ownership” will be main barriers for urban sustainable development [89]. For urban renewal (infrastructural changes to existing urban fabrics), with the rapid urban expansion in Guangzhou, a lot of urbanized villages are disappeared and original villagers are moving to suburban areas according to related compensated regulation. All social fabric, economic structure, and life-styles are destroyed in one night, and then it is difficult for these original villagers to adapt new life transition and living environments. Thus, with the process of rapid urbanization, there are two dilemmas: a). Location of construction lands is flexible and floating, not totally decided by original planning; b). strict regulation for agrarian protection is not far satisfied for requirements of planning and construction projects [82].

3.10. American research cases

3.10.1. Development overview

Over the last few centuries, the United States of America has transformed from a series of rural communities to a highly urbanized country. This historical process can be divided into three stages, the first of which lasted from 1690 to 1830. While urbanization was not obvious in this stage, there was a high proportion of rural population growth. In addition, even though agriculture was a leading industry, people in cities engaged primarily in commerce and manufacturing. Towards the end of this stage, the marine trade industry in the coastal areas of New York and Boston was developed, laying the foundation for the subsequent urbanization process and urban expansion. The second stage lasted from 1830 to 1920. Before the American Civil War began, in 1861, the manufacturing industry in the northeast thrived on the back of the industrial revolution. The rapid development of capitalism enabled the gradual distribution of cities across various crucial industrial areas. After the Civil War in 1865, the level of urbanization peaked in the context of the rapid spread of industrialization. The large-scale expansion of cities, the increasing population, and the improvement of transportation technology promoted the industrialization and

urbanization of the central and western cities. Around 1890, the development of the western regions in the US was largely completed, and the urbanization of the south was initiated. As a result, regional manufacturing belts formed, urban space developed in terms of the multi-center structure, and suburbanization began to form. The third stage began in 1920 and continues into the present. The development of suburbanization has gradually shifted populations to the outskirts of cities. Due to this, numerous enterprises, government agencies, residential buildings, and the like, move to suburban areas, and so the government promotes housing subsidy policies. City cores expand outward, gradually forming metropolitan areas. After World War II, in 1945, land prices in the central US increased, but there were generally poor living environments, insufficient means of transportation, and a declining urban population density. As the transportation system improved and automobiles were popularized, the scope of population activities widened. Given the increase of per capita income and industrial structure upgrading, the US government consistently promoted state-level highway plans, housing loan policies, and dispersed urban plans. As such, this period saw a large percentage of the population moving to the suburbs and an increase in the number of urban areas.

China has a far longer history, which includes attempts of division by foreign invaders. Furthermore, China has a distinct urban-rural dual structure as well as a socialist market economy. Each of these factors differentiates the development of China and the US. Due to their high level of urbanization and perfect measurement evaluation system, developed western countries, of which the US is representative, have transitioned from single-center, centralized development, from the late seventeenth century to 1920, to the current multi-center, decentralized development. As the top three cities in the US, New York, Los Angeles, and Chicago are representative in terms of development. Therefore, these cities were selected as research cases to analyze the characteristics of urban space development in the US and for comparison with China's three major cities. While the two countries have different political systems, populations, and economies, the development modes of major cities around the world remain fairly similar. Undertaking a comparative study is far more conducive to furthering an understanding China's urban expansion.

3.11. Urbanization and expansion

Chicago is located in the southern part of Lake Michigan in the Midwest, at the boundary of the Great Lakes water system. The city serves as a significant railway terminal, connecting the Northeast and Midwest, and is a prominent economic hub. In the process of transformation from a traditional city to a new type of city, Chicago has achieved metropolitanization; the Chicago metropolitan area comprises Chicago, Cook County, DuPage County, Kane County, Lake County, McHenry County, and Will County. Chicago has experienced four stages in its development. In the early 19th century, in the context of industrialization dominated by machinery and the manufacturing industry, the city expanded concentrically. Urban construction was mainly concentrated in the urban areas, and the core areas dominated marginal zones. Local areas expanded outward along the traffic trunks and the suburbs developed slowly. From 1900 to 1945, satellite industrial cities continued to emerge. Chicago began a large-scale suburban merger and the city continued to expand. As the industrial structure changed, the central city declined. At this stage, the development of the urban fringe area was at its peak, and many factories moved to suburbs. From 1945 to 2000, Chicago's transition to a multi-center mode began. With large-scale population migration, the suburban population increased by nearly one million in two decades, and rapid urban expansion brought about several urban problems. The fourth stage in Chicago's development can be estimated from 2000 until the present. Traditional industries have successfully transformed, and the service industry has taken the lead, forming a multi-center, decentralized pattern.

New York is located on the Atlantic coast of southeastern US. The city originally sprang up due to the shipping convenience of the Hudson River, and this traffic influence laid the foundation for urban development. The development of New York matches the trajectory of the independence of the US. In the early days, the city featured a typical single-center, centralized development. With the opening of the canal and railway lines, however, New York gradually became the largest industrial base in the period of US industrialization because of its convenient location as a transportation hub. During the industrial revolution, a vast number of intra-national migrants, foreign immigrants, and enterprises streamed into New York, and the city's radiation range expanded, indirectly promoting its urban expansion. After the end of the industrial revolution, transportation improved, and automobiles were popularized. Many multinational companies set up their headquarters in New York, and its image as an international city was gradually established. After the Second World War ended in 1945, New York became the world's largest city. As a powerful, central city, New York radiated and clustered its surroundings; together with Boston, Philadelphia, Washington, and Baltimore, the New York metropolitan area was formed. In the development of New York, the superior geographical location and strong water and land transportation network were the promoters of urban development. In the early stage of development, the advantages of shipping to and from New York secured its position as a trade center. The wealth accumulated from the import and export trade prompted the start of the financial industry and industrial investment increased. This attracted vast numbers of merchants and immigrants, and so the city expanded on an even large scale. In 1898, threatened by the rapid development of Chicago, New York established the Brooklyn Bridge in order to strengthen its links with the eastern region of the US and began to expand westward. The overall region expanded nearly seven times, forming a spatial pattern of five jurisdictions. Later, in 1945, the city decided to excavate several tunnels and build multiple bridges, gradually unifying the pattern of the metropolitan area. However, rapid growth also brought about social problems. Single-centered circles, for instance, were unable to meet the needs of future development. After a failed attempt at “re-centralization”, the urban capacity in 1945 was highly saturated, the suburban population density increased sharply, and there was a successful transformation of industry. In 1968, New York proposed a “multi-centered” model and began to curb urban expansion. In recent years, New York's development has matured. The tertiary industry is located in the central area, and the primary and secondary industries are distributed in the suburbs. The sub-central city was formed independently, and it is connected to the central city organization by the transportation network. Jobs and residential areas have also spread along the network.

Due to the late development of the western US, Los Angeles did not experience the rapid development that is common to the cities on the East Coast. Los Angeles became part of the US in 1850. In the beginning, the city was dominated by agriculture, and large areas of agricultural land developed in a decentralized manner. From 1910 to 1940, car ownership increased year-by-year, and cars became the main mode of transportation. Since cars were free of driving routes, the original undeveloped area was redeveloped and constructed into many new small towns. The city gradually developed in clusters. Due to the popularity of automobiles, Los Angeles became suburbanized and regional development featured characteristics of decentralization. In the 1880s, in order to develop the oil industry, Los Angeles built multiple ports to facilitate the transportation of oil goods. In this context, the urban population increased rapidly and, by the end of the 19th century and the beginning of the 20th century, the rail transit systems connected the towns of Los Angeles. Since tramlines usually extended into the suburbs, urban residential construction began to expand to the suburbs. By the middle of the 20th century, due to the promotion of real estate development and construction, the Los Angeles government had built highways extending in four directions, and this broke the radial development mode of the city. The solution was to bypass the city and

build interstate highways. Thereafter, many enterprises were established along these highways for convenient transport, drawing in personnel and attracting a large customer base. The city was, thus, further expanded. However, in over 40 years of urbanization, Los Angeles lacked a central city with robust growth that could help the common development of the central city and its suburbs, enabling spontaneous expansion to take the form of clusters with a uniform multi-center structure. Unlike Chicago and New York, the Los Angeles metropolitan area has a low population density because it is located within a seismic belt and, on the whole, extends in a low-density, flat, and horizontal direction. A high-density road network covers the entire area, and private cars have become the primary means of transportation. This highly car-dependent mode makes both urban air pollution and traffic jams severe.

3.12. Evaluation and comparison

China and the US have great differences in terms of their political systems, cultures, and driving force mechanisms. The process of urbanization in the US is much faster than that in China. At the same time, China's special socialist market economy system regulates its urban development through policies and markets. Each city's unique history and the common development of surrounding cities should be taken into consideration in the formulation of development strategies. However, both China and the US have experienced the same *S*-shaped curve in the process of urbanization. An in-depth understanding of the developmental history of these six cities will help promote a shared perspective and help us to understand obstacles in future development earlier. In this way, the obstacles can be avoided in advance, and sustainable development can be promoted.

1. Industrial structure. Urbanization is based on industrialization. Initially, industrialization provided jobs for the population and, in turn, these jobs attracted professionals from outside of the area. This agglomeration drove urbanization, but, in the later period of development, the drawbacks of industrialization continued to emerge. The high saturation of the central area, environmental pollution, underdeveloped transportation networks, and other disadvantages continuously weakened industrialization prompting urbanization to enter a new stage. In this new stage, the tertiary industry has taken the lead. The transformation of industrial structures not only slowed the pressure on the central area but also dispersed the sub-center to the suburbs. As a result, the urbanization rate rose. Currently, China's industrial structure has entered the modernization stage. In 2015, the value-added ratio of the service industry reached 50.2%. However, the variances across China's different regions are obvious. The increase in the ratio of the knowledge industry is far less than that of developed countries in Europe and the US. In some regions, the industrial structure remains unchanged, and the principal need is still rooted in industry. Under the dual economic structure, single-minded pursuit of industrial upgrading is not a good choice. Rather, the employment of rural surplus labor should be considered. China has a vast territory and is greatly affected by natural geography. Therefore, in the next stage of development, it is necessary to adjust each urban development pattern in relation to the particularities of the situation.
2. Traffic. From the development processes in Chicago, New York, and Los Angeles, it can be seen that the early development of cities counts on advantageous transportation. We can hardly imagine the powerful promoting effects of transportation networks, such as railways, highways, and shipping, for the flow of population and resources. Regional contacts in New York were strengthened by opening tunnels and building bridges for further expansion. Since the reform and opening up, over four decades, China has witnessed how transportation develops from breaking through institutional constraints to adapting to socio-economic development. Its growth has also promoted the acceleration of urban modernization. In the past 25 years, the railway network has increased by 20,000 km. By 2017, the high-speed railway had a mileage of 127,000 km—accounting for two-thirds of high-speed railway in the world. In addition, the development of transportation also drives the expansion of the express delivery industry. The implementation of Postal Law has integrated the express market access system, logistics, and other industries cross-border integration, which has had a great positive effect on the Chinese economy. However, the number of car ownerships has also increased year-by-year, and road construction is not as advanced as that of developed countries. Furthermore, the basic national condition of too many people for the amount of land has not changed. All this triggers traffic congestion as a major problem in China's urban development.
3. Metropolitan economy. The US government implemented policies that incentivize suburban development, which eases the pressure on the central areas. At the same time, the US government sets policies to drive the development of western cities by the eastern cities. The spatial pattern has changed from point-like to linear, to area, from disorderly dispersion to single-central agglomeration, to multi-core dispersion. To a certain degree, internal factors, such as transportation and industrial structure, affect the change of urban scale. Drawing on the experience of the cases in the US, the Chinese government has prioritized Beijing, Shanghai, and Guangzhou as three major cities to develop through economic integration in the Beijing-Tianjin-Hebei region, the Yangtze River Delta, and the Pearl River Delta region, respectively. Central cities and cities with robust growth are supposed to drive the development of their surroundings. With the transportation network taken as the development axis, the links between inter-regional skilled professionals and resources should be strengthened, prompting an economy industrial system. China's national conditions should be taken into account in the process of urbanization. The old industrial bases in Northeast China should be revitalized, and the transformation of the original single industrial structure will be driven by new and high-tech industries so as to stimulate the reinvigoration of cities.

4. Conclusion

Today Chinese cities are expanding at an unprecedented pace: (a) urban residents have begun to prefer larger houses and a better living environment in the suburbs; (b) governments have become the main driving force for urban expansion to pursue new development space and new revenues from land auctions; and (c) many rural migrants have flowed into urbanized villages in inner-city areas and urban peripheral areas [90]. With prosperous urban scenes and rapid GDP growth, a series of serious social problems have been gradually emerging, such as a loss of cultivated lands, segregation among different social classes, ecological deterioration, disappearance of local urban culture, unbalanced development between urban and rural areas, fragmentation of urban land uses, and so on. These social threats have been the “bottleneck” that inhibit sustained and rapid development in China for the future [91]. In both China and the West, suburbanization—and what we today term “sprawl”—is as old as urban settlement itself; suburbs have been “a persistent feature in cities,” writes Robert Bruegmann, “since the beginning of urban history” [92] p.4). And in this, China is no exception.

Now these three questions in the beginning of this paper could be answered. Causes of urban sprawl in China include the changing residential preferences of some residents willing to move out of the core, and overcrowded, deteriorated, and old-fashioned structures in central cities becoming targets for demolition in pursuing a new era of modernity, prosperity, and renaissance. In the U.S., urban sprawl leads to blight in the central area, and the people who move up are the high-income class. Compared to the U.S., urban sprawl in China has kept its own characteristics in loss of farmlands and leapfrog development for

urban expansion [13]. In China, with the large scale of urban sprawl, traditional urban centers are still attractive and prosperous; the rich and old people prefer staying in downtown areas because of a better living environment and public services facilities, and most young couples and people who cannot afford the high prices have no choice but to move to suburban areas. As for downtown areas renewal, replacement of resident's composition, and negative effects of urban renewal, China has a similar experience as the U.S., but there are obvious distinctions between the two countries: the alteration of urban downtowns, the dominant power behind urban renewal, and redevelopment models. With the large scale of urban renewal, dilapidated downtown areas have been renewed and are becoming the place of high land prices and rent. The original, mainly low-income group is replaced by the middle class and urban infrastructure facilities; this process has negative effects on the low-income group in both countries. In China, driving factors of urban renewal has been mostly regarded as through transformation of urbanized villages in inner cities and around urban fringes, and updating urban infrastructure facilities as a part of urban sprawl.

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