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EVOLVEMENT OF URBAN SPATIAL STRUCTURE AND MAIN DRIVES IN WUXI, CHINA

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ABSTRACT: With the quick development of urbanization, urban expansion has been paid more and more attention to by researchers from western countries and China. Here Wuxi City of China is selected as a case study. Located in the core-area of Changjiang (Yangtze) River Delta, as the sources of Chinese township enterprise, Wu culture, and national industry, Wuxi has experienced great change in the urban spatial structure, especially in the land use structure, and urban shape and scale. The ratio of industrial land was about one-third of the construction land in 2003. Residential and public infrastructure land had decreased a little from 1956 to 2003, but it remains to be the main construction land at present. Green land has increased at the highest speed due to the demand of sustainable development. After the reform and opening to the outside world, this kind of evolvement of urban spatial expansion is helpful for sustainable development. Economic development, transportation, and administrative planning are the main reasons for these changes. During different periods, the main drives are different. Economic development is the basic factor that influences urban expansion. Transportation influences urban evolvement in different times, but now the importance is not as great as 30 years ago, because administrative force plays an important function in urban planning of China and influences urban evolvement.

KEY WORDS: Wuxi; urban evolvement; urban spatial structure

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1 INTRODUCTION

China, as a developing country, is experiencing rapid population growth and land expansion, which has generated considerable governmental concerns and scholarly attention (FAZAL, 2000). Researchers have revealed a massive increase in construction land and loss of rural agricultural land in China (YEH, 1999; YAO, 1997), which can hardly be matched by any other developing country.

Present researches on urban expansion in China can be mainly divided into two fields: most of them are traditionally based on assessment of the growth of population using statistical materials. The others focus on land use change and cover, so-called LUCC, in which high technology, such as GIS and remote sensing, is used. The Chinese government, especially bureaus associated with resources and environmental protection, has made considerable efforts to monitor and manage urban expansion and land use with some new technology. However, the use of GIS technology in urban and land management remains limited.

At present, big cities in the world are experiencing urban restructuring (WEI and FANG, 2003; YE and WEI, 2004), the incentive for which is that some developed countries have run into post-industrialization age and the world is running after economic globalization. Chinese urban space and its structure are faced with spatial restructuring as a result of rapid economic growth and great social change after reforming and opening to the outside world. Urban expansion and restructuring in China reveal four aspects. First, land structure changed greatly in urban regions. The quickly developed service industry has given rise to the blossom of commerce and tourism, and more and more CBDs have appeared in the city center. Second, urban expansion speeded up the development of urbanization in the suburbs. More and more opening zones and new construction zones appeared in the suburbs. From this view, the characteristics of urban expansion in China are quite different

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from western countries. Third, as urban spatial structure changes, more and more people are buying houses with good location but not close to working places as before. Fourth, with the idea of sustainable development, more and more green lands are built in urban regions, which is a great change after the 1990s.

Selecting Wuxi as a case study, this paper analyzes the characteristics of urban expansion from the viewpoint of urban scale, urban shape and urban structure.

Wuxi is located in the core-area of Changjiang (Yangtze) River Delta, a developed region in China, in the north of the Changjiang River, the south of the Taihu Basin. The area of Wuxi is 1631.8km^2, and the population is 2.12×10^6. The distance from Wuxi to Shanghai, the mega city in China, is about 120km, to Nanjing, the capital city of Jiangsu Province, is 177km (Fig. 1). Hu–Ning (Shanghai–Nanjing) Railway, Hu–Ning Highway, Jing–Hang (Beijing–Hangzhou) Grand Canal pass through Wuxi, which grants this city a very good location, with National Road 312, Provincial Road 101, and they have formed one of the busiest transportation corridors in China.

2 EVOLUTION OF URBAN SPATIAL STRUCTURE IN WUXI

2.1 Increase of Built-up Area in Wuxi

According to the rough estimation, the area of old city was 300ha in 1916, but the construction area was 1058ha in 1949, increasing by 3.5 times, with the increasing rate of 3.9% each year.

After the foundation of P. R. China in 1949, urban space has had quick increase in several periods. The first one was between 1956–1963, with the annual increase rate of construction land of 6.98%; the second one was between 1985–1990, with the annual increase rate of construction land of 4.94%; the third time was between 1995–2000, with the annual increase rate of construction land of 5.61%; and the fourth one was between 2000–2003, with the annual increase rate of construction land of 32.20%. From 1949 to 2003, the yearly increase rate of construction land is about 5.34%.

2.2 Land Structure Shift in Wuxi

Before 1949, the main industries were traditional textile

Fig. 1 Sketch map of location of Wuxi City

industry, handicraft industry and commence. The ratio of industrial land was lower than that of residential land and public construction. Since 1949, the land structure in Wuxi has changed greatly (ZHANG *et al*., 2003). From Table 1, we can find that, from 1956 to 2003, the ratio of residential land and public construction decreased from 63.47% to 43.12%, but that of industrial industry increased from 12.45% to 32.9%, that of storage land decreased 1.44%, that of road and square land increased from 5.57% to 9.59%, that of green land increased from 3.52% to 7.33%, and that of transportation land increased from 2.7% to 3.6%.

The change of land structure in Wuxi manifests three main characteristics:

(1) Industrial land increased before reforming and opening to the outside world, then it developed stably. As one of the industrialization basements, the ratio of industrial land has increased from 12.45% in 1956 to

Table 1 Structure change of construction land of different periods in Wuxi

Land use type	1956	1963	1974	1985	1990	1995	2000	2003
Residential land and public construction	63.47	50.15	45.86	44.18	45.53	43.15	42.08	43.12
Manufacturing land	12.45	29.78	34.63	32.28	28.07	28.42	31.27	32.90
Storage land	4.01	4.65	5.66	4.76	3.74	3.47	2.90	2.57
Transportation land	2.70	2.15	2.01	3.17	5.20	3.47	3.30	3.60
Road and square land	5.57	4.49	4.51	15.61	17.46	8.84	8.97	9.59
Public green land	3.52	2.20	1.76	3.70	6.88	10.19	10.45	7.33

Source: Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences

34.63% in 1974, and this ratio was about one-third of construction land. This means that industry has become a dominant department. From 1985 to 2003, the ratio of industrial land almost had no change, and it is now about one-third of the construction land (Fig. 2).

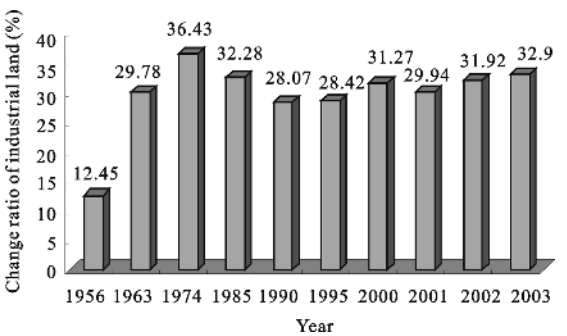

Fig. 2 Change ratio of industrial land to total construction land for 50 years in Wuxi

(2) Residential and public construction land decreased a little, but it was still the main construction land. Residential and public construction land took main place in the construction land for very long time. In 1956, the ratio was 63.47%, but it decreased to 45.86% in 1974. Since the 1980s, this decrease tendency has been still slowly going on, in 2003, the ratio was 43.12% (Fig. 3). For about 30 years, the ratio of residential and construction land is higher than that of industrial land. With the improving of people's living standard, the real estate develops very quickly and it has given rise to the quick development of residence.

(3) Green land is the land from that has the highest increase rate after reforming. For a very long time, paid not much attention to, from 1956 to 1974, green land did not increase, and relative proportion even decreased a little. From 1974 to 1982, the green land area increased only 17ha. Since 1978, with the increase of living standard, people pay more and more attention to living quality and begin to chase better environment. In 1985, the area of green land increased by 130ha, compared with the area in 1982, it increased by 2 more

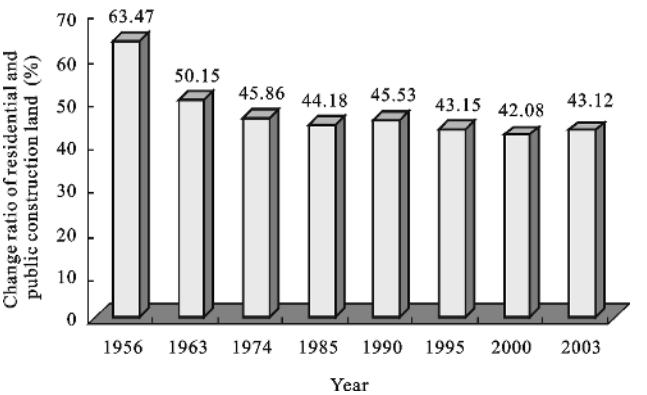

Fig. 3 Change ratio of residential and public construction land to total construction land for 50 years in Wuxi

times. After 1990, green land increased at a high speed, in 2003, the area of green land was about 1283ha, and the annual increase rate was over 10%.

2.3 Land Distribution Change of Wuxi

2.3.1 Urban expansion before 1949

The development of Wuxi in the old times had close relationship with canal and river. Before 1949, the characteristics of spatial economic development and distribution were as follows. 1) The development of commercial industry originated in South Gate of Wuxi, later it moved to outside of North Gate of Wuxi. After the middle of the Qing Dynasty, with the movement of rice market from South Gate to the outside of North Gate and the Railway Station, the commercial center was naturally moved to the outside of North Gate. 2) Wuxi was one of cities that had modern industry, but the scale of factories was normally small and they distributed separately. Some of silk plants concentrated on the both sides of the Jing–Hang Grand Canal. 3) From the viewpoint of urban function, Wuxi was a rich industry city, with weaving, flour, milling and silk as its main industry parts. This function was helpful for the cooperation between city and county, and made it possible for the plants to be located in the outside of the city.

2.3.2 Urban expansion between 1949–1977

From 1949 to 1977, the speed of urban expansion in Wuxi was relatively slow, and the area of construction land increased from 1058ha to 2806ha, the scope of urban expansion was just surrounding Wuxi Town, but along the canal and railway. Compared with the shapes of 1977 and 1949, we can find that due to the influence of the canal and Hu–Ning Railway, urban shape of Wuxi had changed in this period (Fig. 4).

2.3.3 Urban expansion since 1978

From 1978 to the early 1990s, the city expanded toward east, northwest and southwest due to the following reasons: 1) influenced by administrative planning, in the east there was the boundary of Wuxi City and former Xishan City; 2) a former town, Dongting, became the governmental place of Xishan City; 3) the industrial factories in northwest have boomed; 4) the sceneries in the southwest of Wuxi were open to tourists at that time.

a: 1949 b:1965 c:1977

Fig. 4 Shape change of Wuxi City

Since 1992, Wuxi City expanded mainly toward east, southeast and south, especially to east and southeast, the city expanded along the main transportation roads, and spindle shape formed long times ago has changed into groups. The distance of different axes is about 15km to 18km. The following three reasons influenced urban expansion: 1) the requirement of urbanization and industrialization made it possible for the city to exploit the land among transportation roads with projects; 2) Hu–Ning Highway and National Road 312 made it convenient to distribute different projects near to national road and highway; 3) extension of transportation road and building of hi-tech developmental zone induced the urban expansion.

3 MAIN DRIVES FOR URBAN EXPANSION

3.1 Economic Development, Population Increase and Industrial Development

This paper takes economic increase (GDP), industrial increase (industrial output) and population increase (population) as independent variable X_1, X_2, X_3, built-up area as dependent variable Y, using statistical analysis with the data of 1985–2003. The result shows: urban spatial expansion has close relationship with urban economic increase, industrial development as well as urban population increase, which means economic and industrial development and population increase are the basic driving forces of urban spatial expansion (Table 2). Under the comprehensive influence of a series of factors such as urban economic increase, industrial development as well as urban population increase, urban space expands quickly.

Table 2 Related matrix of urban spatial expansion factors

	X_1	X_2	X_3	Y
X_1	1.0000			
X_2	0.9032	1.0000		
X_3	0.8408	0.9706	1.0000	
Y	0.9327	0.9758	0.9704	1.0000

3.1.1 Economic development

Economic development is the engine for urban structure evolvement. In 2003, GDP in Wuxi was 1066.12×10^9 yuan (RMB), GDP per capita was 48.548×10^3 yuan (WSB, 2004), compared with 1978, and they increased by 62.2 times and 47.1 times respectively. The annual increase rates were 18.04% and 16.76% respectively. With the rapid increase of economic development, more and more construction land is needed. The built-up area

increases at the same time. The built-up area of Wuxi increased from 3460ha in 1978 to 18 030ha in 2003, increasing 4.21 times, and annual growth rate was 6.83%. After the correlation analyses with GDP per capita and built-up area since 1985, we find the correlation index between those two indicators is 0.9224, which means that Wuxi City will surely expand with economic development.

3.1.2 Population increase

Population increase has stimulated the demand of construction land. The direct result of population increase is the quick increase of construction land, the demand of residential land, public transportation, and green land. From 1985 to 2003, residential land per capita, industrial land per capita, roads per capita, and green land per capita had increased by 15.82m^2, 12.38m^2, 4.13m^2, and 4.32m^2 respectively. According to urban planning of Wuxi, the demand of construction land per capita will reach at 100m^2 in Wuxi in 2020. In the future, the construction land increase in Wuxi will keep at a high speed.

3.1.3 Industrial development and structure shift

Industrial development and structure shift has pushed urban expansion. From 1949 to the middle of the 1960s, the industrial land in Wuxi expanded to the inner city from Jing–Hang Grand Canal and formed a 10.5km-long, 2km-wide extension axis. From the 1970s, more and more plants are moved to the suburbs. The movement of polluted enterprises forced related enterprises to move to the suburbs.

From 1957 to 1973, industrial land in Wuxi increased 693ha, accounting for 56.8% of the construction land. From 1982 to 2003, industrial land in Wuxi expended at 4598ha, accounting for 32.5% of the construction land. Though the proportion to the urban construction land dropping, industrial land is still the major urban construction land in Wuxi.

3.2 Transportation

3.2.1 Railroad and land use change

When urban space is small, railroad will hinder the urban expansion, which will lead to abnormal expansion. When urban space is big enough, the advantage for urban expansion to a certain direction will disappear, and urban development will get across railroad, which was formerly regarded as a threshold.

3.2.2 Highroad and land use change

Highroad was the most important factor that influenced urban development in the beginning. It attracted infrastructure to be distributed in nearby areas and forced urban land to expand along the highroad. From 1956 to 1982, highroads of Su–Xi (Suzhou–Wuxi), Xi–Hu (Wuxi–Shanghai), Xi–Cheng (Wuxi–Jiangyin) were built, and city expanded at that time just along these three highroads. At the beginning of the 1990s, National Road 312 began to be used, the transportation capability of Hu–Ning Road increased greatly, and more and more projects were distributed along it.

3.2.3 Expressway and land use change

Expressways have great influence on urban land use, but it is quite different from highroad. Expressway hinders urban expansion but not accelerates urban expansion. The reasons are as follows. First, expressway is so completely closed that it is not allowed to build an exit at will. Second, in order to decrease the bad influence, green corridors are normally arranged to keep distance between city and expressway to decrease the noise pollution, air pollution and so on, which is beneficial for urban environment. Since the building of Hu–Ning Expressway, this road has not much attraction on the land use of Wuxi and surrounding towns, and from the images of remote sensing, city did show no tendency close to expressway.

3.2.4 Sea-route's influence on urban land

People used to transport mainly by water carriage, as a result, a large number of productive land were distributed along the canal, and gave rise to the spindle shape. From 1970 to the 1980s, after a new canal was dug, the city expanded along the new canal, which had good influence on the environment and shape of Wuxi. But with the rapid development of railway and expressway, the function of canal decreased gradually.

3.3 Urban Planning and Administrative Planning

Normally in China, administrative force is great. The changes of administrative planning, urban planning, and land use planning have an unpredictable influence on urban expansion. In other words, urban planning and administrative planning have influence on urban spatial structure.

3.3.1 Administrative planning and land use change

Whether administrative planning is rational or not has direct influence on urban development. First, it influences the space of hinterland, then influences greatly urban development. In this field, many scholars have done a lot of research. The administrative planning in Wuxi is changing all the time. Before 1949, Wuxi adopted "city ruled county" system, in 1949, city and county were separated, when Wuxi City and Wuxi County were founded. In 1992, in order to accelerate the development of Wuxi, hi-tech developing zone and economic development area (we call it New Region)

were founded in the south suburbs. In 1994, Shuofang, a small town that used to belong to Wuxi County, became a part of New Region. In 2001, Wuxi County belonged to Wuxi City. The adjustment of administrative planning, especially the building of New Region, will surely accelerate the urban expansion towards southeast and north.

3.3.2 Urban planning and land use change

From 1980, urban planning has been adjusted for several times. Till 2001, the problem of integration of city and county was solved completely, which is helpful for urban development in Wuxi. Now the area of Wuxi City has increased from 518km^2 to 1658km^2. Facing with this new situation, Wuxi needs more urban space and has to enlarge urban scale in order to support high-densely population in the city center, and adjust urban structure of old city and districts of Xishan, Huishan and Binhu. According to new urban planning, the population in Wuxi will be 2×10^6, the construction land will reach at 2402km^2, and the south will be the main direction for urban expansion in 2020. A new group will be formed in the near future.

4 CONCLUSIONS

Since 1949, the change of urban land use structure, urban shape, and urban structure in Wuxi has always accorded with the concept of modern city and the requirement of urban sustainable development. As a rapidly developing city located in the core-area of Changjiang River Delta, the built-up area expanded quickly, corresponding with great change of urban land use structure, urban shape and urban structure. After 1949, the area of urban construction land increased quickly, and the annually increased rate was 5.25%. On the process of urban construction land increasing, the proportion of industry land, residential land and public construction land decrease with the proportion of urban green land increasing. And urban land use of Wuxi expanded on the direction of east and southeast, which caused urban shape to change from originally spindle shape to group shape.

The development of urban spatial structure is caused by the comprehensive effects of many factors. Urban economic increase, industrial development, as well as urban population increase result in the expansion of urban space and the change of structure. In different stages, the factors that influence urban spatial structure development are different. The basic factor of urban spatial structure development is economic development. The importance of transportation varies in different times. For example, transportation was very important in the old times when urban expansion was always used to along the main transportation system, but now, it is not as important as 30 years ago. Administrative force is another factor to integrate urban expansion. Administrative force plays a more important function in urban planning.

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