

Urbanization, environmental consequences and management in China^{*}

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Abstract—With the rapid development of urban economy in China, urbanization process has been sped up and urban environmental problems increased. In order to deal with the problems, more effective environmental management strategies and measures should be taken. In this paper, dynamic changes and spatial dispersion of urbanization, environmental problems with the increasing urbanization in China are thoroughly analyzed, and some feasible strategies and measures, urban ecological planning in particular, are suggested for dealing with urbanization and corresponding environmental problems.

Keywords: urbanization; environmental management; urban ecological planning

1 Introduction

In recent years, great changes have taken place in the world. China has played a most important part in the change process. Its institutional and economic reform has brought about not only a big economic change but also a rapid nation-wide urban restructuring. With the development of urbanization, more environmental problems have also appeared. For dealing with the problems, many environmental policies and strategies have been taken, urban planning is one of the most important tools.

2 Urbanization in China

Urbanization is a dynamic and spatial change process. The essence of urbanization is recombination of such production factors as land, labor force and capital. Recombination is realized by the shift of labor forces from one industry to another and from one place to another place. Therefore, urbanization, in appearance, is a process in which workers and their dependents migrate from one place to another.

Because of big difference between countryside and cities in standard of living and working conditions, for a long period of time, Chinese farmers have longed to migrate into cities. But due to the strict restrictions on migration, the urbanization process was very slow before 1978. Since then, more Chinese farmers have become richer, some of them, in fact, live or work in cities de-

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spite restrictions set by the Chinese government. And even with the development of rural enterprises, more and more small cities and towns have been established. Consequently, the rate of urbanization is much faster than ever before.

Urbanization level can be expressed by the ratio of the non - agricultural population in the urban district to total population. In terms of the expression, Table 1 shows the dynamic change of urbanization levels from 1949, when the People's Republic was founded, to 1988.

Table 1 Urbanization level of China

Unit: 10000 person

Year	National total of population	Urban district population		% of total population	
		Sub - total	Non - agriculture	Sub - total	Non - agriculture
1949	54176	3949.05	2740.57	7.3	5.1
1978	96257	11657.06	7986.66	12.1	8.3
1985	105044	21231.49	11821.70	20.2	11.3
1988	109614	29821.78	14034.07	27.2	12.8

Source: Adapted from China - The forty years of urban development, 1990

In 1949, urban population took only 7.3 percent of the national total, non - agricultural population only 5.1 percent. In 1978, the urban population was 12.1 percent, 1.66 times that of 1949. Non - agricultural population was 8.3 percent, 1.66 times that of 1949. Both only changed slightly in a nearly thirty year interval. But they shot up from 1978 to 1988. In only a ten year interval, the percentage of urban population increased to 27.2, 2.25 times that of 1978 and 3.73 times that of 1949. The percentage of non - agricultural population increased to 12.8, 1.54 times that of 1978 and 2.51 times that of 1949. Most importantly, the urban population increased much faster than the non - agricultural population. This means that more farmers have moved into or worked in non - agricultural sectors in cities, but not registered as non - agricultural people.

Table 2 Urbanization in China by city size (population)

Year	National total,		Mega - cities (more than 1,000,000),		Large - cities (500,000 - 1,000,000),		Medium - sized (200,000 - 500,000),		Small - cities less than (200,000),	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
1949	132	100	5	3.8	7	5.3	18	13.6	102	77.3
1957	176	100	10	5.7	14	8.0	37	21.0	115	65.3
1978	193	100	13	6.7	27	14.0	60	31.1	93	48.2
1985	324	100	21	6.5	31	9.6	93	28.7	179	55.2
1988	434	100	28	6.5	30	6.9	110	25.3	226	61.3

Source: China - The forty years of urban development, 1990

2.1 Dynamic change of city size

As shown in Table 2, over the past forty years, the number of Chinese cities increased rapidly, almost 3.3 times that of 1949. Of this, the number of mega-cities, large cities and medium-sized cities grew much faster, 5.6, 4.29 and 6.1 times that of 1949 respectively. During the same period the number of small cities showed small increase, only 2.61 times that of 1949, below the average increase. And it is worthwhile noticing that the percentage of small cities has decreased markedly, while the others shown slight or noticeable increases.

Table 3 gives a clearer illustration of the distribution of urban population in different size cities. In the long run, urban population in mega-cities has kept the highest percentage; large cities have also shown a steady growth, urban population occupied almost twenty percent; medium-sized cities also increased steadily; while the percentage of urban population in small cities decreased continually, in spite of the slight growth in recent years.

Table 3 Structure change of different size cities

Size	Unit: %			
	1952	1965	1982	1985
Over 1,000,000	40.1	43	43.3	39.4
500,000 - 1,000,000	19	20.5	20.5	19.3
200,000 - 500,000	17.4	20.7	22.4	24.5
Less than 200,000	22.5	15.8	13.8	16.8

Source: Sun Panshou, Change of population size of Chinese cities, Journal of Geography, Vol. 39, No. 4

The continuous growth of mega and large cities is related to a high birth rate of child-bearing women on one hand, particularly at the birth peak recently, on the other hand more emigration into these cities because of better working conditions and a comparatively comfortable living environment. Research results show that economic benefit of mega and large cities is the highest, higher than the average level of all cities; that of medium-sized cities ranks second; close to the average level; that of small cities is last, lower than the average (Zong, 1988). But the expansion of metropolises has increased existing urban problems such as housing and freshwater shortage, inconvenient traffic and telecommunications, and environmental problems. The slow development of medium-sized and small cities has impeded social economic development. This is due to the fact that the spatial distribution of supporting cities (small cities around medium-sized one and medium-sized cities around large ones) has not developed in a proper or ecologically healthy way. Where there is an appropriate city network, e.g., close to a mega or large city there are some medium-sized cities, surrounding a medium-sized city are a number of small cities, these types of regions are economically and technically advanced. There are four large areas of this kind: Shenyang - Liaoyang - Anshan - Yingkou; Beijing - Tianjin - Tangshan; Shanghai - Wuxi - Changzhou - Zhenjiang - Nanjing and Guangzhou - Pearl River Delta cities.

2.2 Spatial dispersion of urbanization

2.2.1 Spatial dispersion in three large regions

For the sake of the needs of formulating policy and planning, the economic and administrative departments of China are divided into the 30 provinces, autonomous regions and municipalities (not including Taiwan province now) into three regions, designated as the eastern region, the central region and the western region, according to the economic level and geographical distribution.

The Eastern Region covers Beijing, Tianjin, Liaoning, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan, and has 162 cities and 603 counties. The total area is 1.30 million m^2 .

The central Region covers Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan, and has 181 cities and 621 counties. The total area is about 2.8 million m^2 .

The Western Region covers Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang, and has 91 cities and 712 counties, and the total area is more than 5.4 million m^2 .

As indicated in Table 4, in 1949, in the eastern region, both the number of cities and percentage took first, that of the central region second, and that of the western region last. Even at that time, the eastern region was most prosperous, the western region was least developed. After forty years development, many medium-sized and small cities were founded in the central region, the number of cities has become first, that has facilitated the development of that region. Although the number of cities in the eastern region becomes second, it is still most highly urbanized region because most mega-cities such as Beijing, Tianjin, Shanghai, Shenyang, Guangzhou, Nanjing and so on, are located in the region. The number of cities increases very fast in the western region, but because it is historically backward, it still lags behind. Nevertheless, urbanization has sped up the development of that region since the favorable development policies for the western region were taken in the early 1980s.

Table 4 Urban development in three regions

Year	Total		Eastern region		Central region		Western region	
	No.	%	No.	%	No.	%	No.	%
1949	132	100	69	52.3	50	37.9	13	9.8
1959	176	100	73	41.5	73	41.5	30	17.0
1978	193	100	69	35.8	84	43.5	40	20.7
1982	245	100	89	36.3	108	44.1	48	19.6
1988	434	100	162	37.3	181	41.7	91	21.0

Source: China—The forty years of urban development, 1990

2.2.2 Urbanization along the coast

In the northeast, north, west and southwest, the borders between China and adjacent countries are mainly plateaus and high mountains. These natural conditions are not suitable for the development of traffic and communication. But in the east and southwest, topography is primarily

plain and terrace with a small amount of hilly land, very favorable for traffic and telecommunication, and it can directly contact with other countries and regions along the coast by sea. Because of the geographic advantages, that area has become the exchange center of China with other countries and regions. Also for the same reason, some cities along the coast were allowed to take the first step towards city reform and to open the door to the outside world wider.

Among the coastal cities, which are approved to open to the outside, the percentage of urban population in mega - cities ranks first, that of medium - sized cities second. The mega - cities are Shanghai, Tianjin, Guangzhou, Dalian and Qingdao. The large cities are Fuzhou, Ningbo, and Shantou. The medium - sized cities are Yantai, Yingkou, Wenzhou, Zhanjiang, Xiamen, Qinhuangdao, Lianyungang, Nantong, Shenzhen and Haikou. And the small cities are Quanzhou, Beihai, Zhuhai and Sanya.

Table 5 Typical coastal cities in China

	Total		Mega city		Large city		Medium city		Small city	
	No.	%	No.	%	No.	%	No.	%	No.	%
City	22	100	5	22.73	3	13.64	10	45.45	4	18.18
Popu.	2339.22	100	1749.35	74.78	190.60	8.15	346.95	14.83	53.32	2.24

Source: Computed from Chinese urban statistical almanac, 1990

All the coastal cities are situated in 11 provinces and municipalities. But they are unevenly distributed, the more dense they are, the more advanced the location is. The most densely distributed areas are at the entry to Pearl River and entry to Yangtze River. Three coastal cities are located in each area, one is Shenzhen, Guangzhou and Zhuhai, the other is Nantong, Shanghai and Ningbo. Another five cities - Dalian, Yingkou, Qinhuangdao, Tianjin and Yantai are densely situated along the Bohai Bay. The agglomeration of the coastal cities has not only facilitated the development of the coastal cities themselves, but also stretched their affected areas and brought along the surrounding areas. Every coastal city has become an economic center at different level. Shanghai is the highest level with multi - functions, best basic conditions and favorable policies. Tianjin and Guangzhou are the second with multi - functions and better conditions. Dalian and Qingdao take the third position, they are regional economic centers. Ningbo and Fuzhou have become the provincial economic centers. Shenzhen, Zhuhai, Shantou, Xiamen, Haikou and Sanya are special economic zones, they enjoy the most favorable policies for importing advanced technology, human capital and natural capital, and they have developed very rapidly in recent years. And the others are economic centers with different functions in the local regions.

3 Environmental problems with urbanization

Urbanization has not only produced benefits to the Chinese people, but has also led to environmental degradation to some degree. It has brought about pressure on the arable land, water shortage, sewage discharge, air pollution, solid wastes, noise and so on.

3.1 Pressure on the arable land

In China, the ratio of population to arable land is far below the world average and will possibly become worse at a faster rate than the world average (0.15 hectares per person as estimated) up to 2000 A. D. (Table 6).

Deterioration is not only due to the growth of total population but also to a reduction in the amount of arable land. Much of the best quality land is being lost through the paving over of natural and agricultural ecosystem by housing, industrial land use and city expansion. Crowding in the cities has reached the level of 5 square meters of housing space per person in Shanghai, 6 sq. meters in Tianjin and 7.38 sq. meters in Nanjing. Equivalent levels of crowding can be found in most Chinese cities of over one million in population, where almost 40 percent of urban population lives. New urban expansion will inevitably make use of surrounding arable land.

Table 6 Ratio of population to arable land in China

Year	Population, in millions	Total arable in million hectares	Average amount of arable per person, in ha.	No. of people per ha. arable
1952	570	108	0.18	5.3
1981	990	99	0.10	9.8
2000	1200	96	0.08	12

Source: Qu Geping, Environmental problems and strategy of China, China Environmental Science Press, 1984

3.2 An impending water crisis

An over-explosion of urban population in mega-cities has got those cities in the danger of a water shortage, particularly in north China. China's per capita annual water resources are equivalent to 2700 cubic meters which is only approximately 1/4 of the world's average (approx. 10900 cubic meters). In the Haihe and Luanhe River catchments where Beijing and Tianjin are located, the per capita figure is only 298 cubic meters, only 1/9 of the national average. Hence Beijing and Tianjin face potential water crises in the near future.

The tremendous need for water has led to over-exploitation. This over-exploitation of surface water has caused a few rivers and lakes to dry up while over-pumping of groundwater has caused aquifers to dry up. Cities in north China depend largely on groundwater. As these cities expand, both domestic and industrial water needs increase. The stress on underground water is now greater than the replenishment rate. Prior to 1970 the ground water supply in the western suburbs of Beijing was plentiful. Since 1970 the water table has been dropping at a rate of 0.5 - 1.5 meters per annum.

Huhehaote and Baotou in Inner Mongolia also have shrinking water tables. The tables have dropped over 20 meters in the last 30 years. Wulumuqi has had its water table drop by 13.4 meters (Chen, 1989).

Moreover, discharge of sewage into rivers and lakes has made the water problem much more serious. It is estimated that some 25.4 billion tons of sewage is annually discharged from cities di-

rectly into rivers without treatment. That has polluted the waters surrounding the cities and made it difficult for urban residents to get clean water.

3.3 More sources of air pollution

High density of urban population, high concentration of traffic and transportation, and agglomeration of industries have caused the urban atmosphere more worsen than ever before. Air pollution in Chinese cities is generally caused by dust particles, SO_2 , NO_x and acid rain.

Dust particles come from burning coal, windy sand and industrial dust. There are more dust pollutants in the air in winter than in summer, and more in north China than in south China, because much more coal is burned in winter, and there are more sands blown by wind in northern cities than in the south. Every year almost 17 million tons of natural dust and 5 million tons industrial dust are given off in the air.

The most serious air pollution is caused by sulphur dioxide and is found in such cities as Chongqing and Guiyang where coal with high content of sulphur is used as the main fuel and they are incapable of diffusing the waste gas. In winter, when coal is used for heating in many northern Chinese cities and the climate is unsuitable for diffusion of the waste gas, this kind of air pollution is also serious, but is still lighter than the cities mentioned above. It is estimated that 132 - 175 million tons of sulphur dioxide is emitted annually, 90 percent of which results from coal burning. At present, the content of SO_2 is higher in the urban districts than in the suburbs, even in the north China in winter.

Comparatively air pollution caused by NO_x is not serious. Every year some 520 million tons of NO_x are dispersed, 78.34 percent, 21.11 percent and 0.55 percent result from the burning of coal, crude oil and fossil fuel respectively. But in large cities, especially at intersections of main highways, NO_x given off by vehicles becomes more and more.

Acid rain pollution mostly takes place in the south of the Yangtze River, particularly in the cities in the south - west such as Chongqing and Guiyang where the annual average pH value of acid rain is below 4.5. Some other cities, such as Qingdao, Suzhou, Hangzhou, Nanchang and Fuzhou, often get acid rain, but the pH value is not as low.

Table 7 Percentage of urban population and area at a given decibel value (%)

Decibel	55	60	65	70
Area	61.0	42.7	26.4	14.6
Population	65.5	46.5	29.4	16.5

Source: Improving ecological environment, Science Press, 1989

3.4 More solid wastes

Urban solid wastes primarily consist of industrial wastes, such as various kinds of cinders or slag and domestic rubbish. Every year about 400 million tons of industrial wastes are produced, only 18 percent of which are disposed and reused. Annual production of domestic trash is about 73 million tons. Most domestic wastes are transported to the suburban areas for storage, and some 20 thousand mu land (1ha=15mu) is occupied for this purpose annually.

3.5 Increasingly serious noise pollution

High density of urban population is the main factor of noise pollution. The higher the density, the higher the noise. On the average in Chinese cities, the noise level is about 60 decibels. Traffic noise in most cities is above 70 decibels, and the average level reaches 74 decibels as a result of rapid increase of vehicles, narrow roads, poor traffic management and the like. Cities which have high traffic noise with decibel value more than 78 are Suzhou, Wuhan, Nanning, Changchun, Shanghai, Xian, Xiamen, Fuzhou, Nanjing, Zhengzhou, Zhangzhou, Quanzhou and so on. Normally, if the decibel value is above 55, the environment is recognized to be a relatively noisy environment, a decibel value more than 65 is regarded to be unbearable. As indicated in Table 7, two thirds of the urban population in China lives in a noisy environment and some 30 percent lives in an unbearable environments.

4 Strategies for dealing with urbanization and corresponding environmental problems

4.1 General environmental policies concerning with urbanization

As discussed above, in the wake of rapid change all over the world, urbanization level and its spatial dispersion are still on the increase. It does stimulate the development of China as a whole. But its adverse effects, especially environmental problems, should not be overlooked. Facing these problems, China has been formulating policies to combat them.

It is compulsory that every city, whether old or newly established, should have its own feasible city plan to implement the comprehensive treatment of urban environment, from a system point of view, that is, the city is taken as an urban ecosystem as a whole. As stipulated in the Environmental Protection Law of the People's Republic of China, "in the course of old city rehabilitation and new city construction, environmental impact assessment on industry, residence, basic infrastructure, green area, and so on, should be done, all sectors should be rationally distributed, and a comprehensive city plan should be formulated, based on the climate, geography, hydrology, ecological conditions and so on, to prevent environmental pollution and other public hazard and to build the city into a modern and clean city".

In order to avoid environmental disasters such as housing shortage, traffic jams and water crises caused by the explosion of mega-cities, the continuing expansion of mega-cities should be carefully carried out. Emigration into those mega-cities should be strongly restricted. Development of the large cities should also be cautiously considered to make marginal benefits suitable. But medium-sized cities and small cities are positively encouraged to develop further to an optimal size, with which land and infrastructure are fully used and ecological benefit is high and environmental cost is low.

In terms of the water crisis in Chinese cities, new methods of preserving and saving water, and comprehensive treatment of water resource and sewage, are being introduced. In many cities, a unified plan for extraction, utilization and preservation of water resources has been set

up and any violation of that plan punished. Drinking water is especially conserved. Within the drinking water reserve, no tourism or project construction, which would lead to water pollution, is allowed. Some effort is being devoted to dredging the rivers and lakes in hopes to clean water and reduce drought, flood, alkalization and salinization. At the same time management of water use has been strengthened to increase the water recycling rate and to reduce discharge of waste water. Sewage treatment is emphasized to improve the quality of water for irrigation. For that purpose many chemical treatment plants or land treatment systems have been established.

Air pollution should be abated or gradually reduced by changing energy consumption structure. In some cities, which abound in various kinds of inflammable natural gases, gasification rate is needed to increase piecemeal, and coal should definitely be replaced by gas. Policy and techniques are also guaranteed for the cities, where inflammable natural gases are unavailable. One plan is to replace ordinary coal with moulding coal, the final product after the ordinary coal is processed and harmful chemicals removed. If funds are available, the traditional disperse heating stoves should be substituted by concentrated heating system to reduce pollution sources and to improve heating efficiency. For factories, where old boilers or heaters with low heating efficiency, high energy consumption and serious pollution are used, or there is a lack of pollution abatement equipment, administrative and economic leverages are being taken to force renovation.

In regard to treatment of solid wastes, some cities have introduced incineration equipment with the incinerated cinders used as raw materials for manufacturing cement concrete. In some rural areas, manure residues are used to make marsh gas which is a substitute of energy resources.

With regard to noise control, environmental management is the most useful instrument. Because a large percentage of noise comes from traffic and transportation, regulation on strict control of traffic noise has been adopted in many cities, narrow roads are forced to be widened, and old vehicles with louder noise eliminated. Noisy factories are discouraged from further development in urban districts or forced to move to suburbs or even to stop.

The last but not least, China is trying to improve environmental education and to make Chinese people understand how they can personally reduce pollution and environmental degradation. There are some newspapers, magazines or TV programs devoted to the work. Some training schools are established by the governments at different levels for training specialists, cadres or youngsters. And some related laws or regulations are formulated to ensure success of environmental education and environmental management.

4.2 Urban ecological planning as an important instrument

With the continuous spread of urbanization and degradation of the urban environment, more importance is being attached to urban ecological planning in China. Many urban environmental problems, in reality, are caused by irrational city growth (spatially or temporally) due to a lack of a suitable comprehensive city plan. In China, urban planning provides a comprehensive plan or master plan and various specific plans as needed. The comprehensive plan indicates general directions for the urban development, while the specific plan provides very practical alternatives to the general direction in terms of specific aspect or urban district.

4. 2. 1 Main guidelines and principles for urban ecological planning

It is stipulated in the City Planning Act of the People's Republic of China that, "in the compilation of city planning, attention should be paid to the protection and improvement of the city's ecological environment, the prevention of pollution and other public hazards, the development of greening and afforestation".

Importance of the planned city or region should be deeply analyzed. Functional areas should be rationally divided, and different kinds of overall land uses which are suitable not only for production but also for living arranged.

Such natural conditions as rivers and lakes, hills, green areas and climate should be fully used to create a hygienic, comfortable and tranquil living environment for urban residents.

A satisfactory master plan should not only give the limit to urban growth, but also provide directions and leave space for further development of the city. Economic feasibility of urban construction and management should be put into full consideration.

4. 2. 2 Concerning factors considered

In China, urban planning is now at the turning point from traditionally pure physical planning to comprehensive ecological planning. Urbanization or urban development and its corresponding environmental problems are caused not only by physical factors but by economic, social, and ecological factors as well. Therefore, in order to comprehensively improve urban environment and to provide correct directions for sustainable development of the planned city, the following factors should be taken into account: economic - factors - different requirements of economic sectors, such as industry, water conservancy, traffic and transportation, marketing, banking and service; resources - ores, forests, water, energy, landscape, and their distribution; natural environment - landform, topography, geology, hydrology, soil and climate; social factors - political system, religious beliefs, life patterns and so on; current status - population size, different types of land use and their distribution, economic productivity and spatial dispersion, status of environmental pollution and its distribution and so on.

4. 2. 3 Dealing with urbanization and environmental consequences

Any urban activities, whether social or economic, in violation of the legally approved comprehensive plan and specific plans are prohibited. Violating organizations and personnel are punished according to the related laws and regulations.

The city plan has provided urban population size and its distribution at a given period. Natural increase and migration of urban population should be seriously controlled in the light of the city plan.

According to the planning schemes, new production, trading and other facilities should be established where suitable, and old production units, particularly pollution sources, if located in unsuitable places, should be moved to a suitable location or removed if necessary.

Economic sectors are forced to abide by the urban economic development plan, which incorporates and considers economic and environmental benefits, to avoid some environmental consequences by changing economic and technologic structures.

Green area is needed to increase where possible both for entertainment and for improving en-

vironmental quality in accordance with the planning schemes.

In order to direct urbanization towards suitable development and to comprehensively reduce environmental degradation, in many Chinese cities, the Urban and Rural Construction Commission was established for coordinating the related organizations to fully implement the urban planning schemes.

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