Economic and Environmental Sustainability in Shanghai

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We want to make Shanghai one of the international economic, financial and trade centres (of the world) as soon as possible, and bring about a new leaf in the economic development of the Yangtze River Delta and the whole Yangzte River Valley. (Chinese Government, 1992, 14th Session of the National Congress of the Communist Party of China).

Introduction

Over much of the past 150 years, Shanghai has been an economically dynamic and politically turbulent city. In 1842, Shanghai was one of the first Chinese cities to be formally opened to trade with Western countries. By the 1930s, it was China's leading industrial and trading city. Shanghai was also, in 1921, the birthplace of the Communist Party. In the 1960s, the city was in the vanguard of the Cultural Revolution and the local economy stagnated. However, following the political and economic reforms of the 1980s, by the late 1990s, Shanghai was both politically stable and China's most productive city.

As shown in Figure 1, Shanghai is located midway along China's highly populated and generally prosperous Eastern seaboard. The city itself sits on mainly flat land at the confluence of the Yangtze and Huangpu Rivers, on the south-east edge of the Yangtze delta.

Shanghai is one of four special municipalities in China with a status equivalent to a province. This means that the Shanghai Municipal Government (SMG) reports direct to the central government in Beijing. SMG administers a total area of 6340 square km of land. This area includes the central city, with its 10 urban districts, which covers only 280 square km; five suburban districts, namely Baoshan, Minhang, Jiadang and Pudong New Area - the latter is actually a new central business district; and five suburban counties namely Nanhui, Fengzian, Sonjian, Qingpu and the island of Chongming.

Figure 1 Shanghai Location and its Environs

Source: Yusuf and Wu, 1997.

By most counts, Shanghai is China's largest city, although some estimates put Chongqing in first place. Currently, the total population of Shanghai Municipality is about 16 million. This comprises some 11 million residents in the urban areas and 5 million in the suburban counties. These numbers include about 3 million unregistered mobile city dwellers. However, there are no accurate data on these unregistered city inhabitants.

Shanghai is also China's largest economic centre, with a gross domestic product of $30 billion. By Chinese standards, the average household income of $5,500 is high and many households are affluent.

Shanghai is evidently not a typical city in China. Nor, indeed, is it typical of cities in other developing countries. Shanghai is an economic powerhouse that is already one of the world's major business cities. In the words of Yusuf and Wu (1997, p.49), 'None of the other crowded cities in the developing world, such as Calcutta, Dhaka or Sao Paolo, conveys the extraordinary sense of teeming humanity as does downtown Shanghai during peak hours. Industry has been and remains the lifeblood of the municipality'. In terms of economic power, Shanghai will almost certainly become one of the world's leading cities.

But Shanghai is not, and cannot be, isolated from the rest of China. Its future is integrally related to the conditions of life elsewhere in China. If these remain poor, or even modest, people will flock in increasing numbers to Shanghai. There will be increasing overcrowding, slums, traffic congestion, air pollution, waste disposal and other environmental problems that especially afflict most large cities. In a free and mobile society, the welfare of the marginal resident in Shanghai can be little different from the welfare of the marginal resident in any other Chinese town or village.

Shanghai's economic success is almost assured. But herein lies the seeds of its ongoing environmental problems. Like Bangkok and Bombay, it is a honeypot for the rural poor. Shanghai's problem is how to manage economic growth with environmental sustainability in the face of ever increasing population – and this is the main theme of this chapter.

The chapter contains two main parts. The first part focuses on economic development. It describes the history of economic development in Shanghai, recent market reforms, and Shanghai's economic strengths as well as some weaknesses. The second and longer part discusses the main environmental problems confronting Shanghai and how it is responding to them. There is a short concluding section.

The Economic Development of Shanghai

Descriptions of Shanghai in the mid-nineteenth century vary. Yeung (1996) describes it as a 'third-class local town'. Yusuf and Wu (1997) describe it as a significant commercial centre for regional commerce and a 'gateway for exports from the lower Yangtze valley to other parts of the country and overseas'. Whatever the truth is, there is no doubt that the growth of Shanghai took off rapidly after its designation as a Treaty Port and the opening up of the country with the 'unequal' Treaty of Nanking in 1842. Within 10 years, it had overtaken Canton (now Guangzhou) as China's premier trading city.

By the turn of the century, Shanghai was, along with Canton, Tianjin and Wuhan, one of China's main centres of population and industry. In 1928, Shanghai benefited further, materially at least, from the move of the capital from Peking to Nanking. By 1936, Shanghai had a population of 3.8 million. It was the seventh largest city in the world and easily the largest in China. These were vintage years when Shanghai was 'as crowded as Calcutta, as decadent as Berlin, as snooty as Paris, as jazzy as New York' (Yeung, 1996).

Although many Western companies fled Shanghai during the war with Japan, Shanghai's overall economic configuration and its role in the regional economy in the late 1940s remained broadly as before the war (Howe, 1981). Shanghai was still China's largest port. It had a large industrial sector, especially strong in light manufacturing such as textiles and food processing as well as in small-scale

engineering and metalworking sub-sectors. But service sectors provided most employment, with many employed in banking, trading and retailing.

This economic structure was to change radically after the Communist takeover in 1949. The new government had three main policies that would particularly affect Shanghai. Firstly, the central government in Beijing, not market forces, would determine the allocation of capital and industrial structure. Secondly, the government viewed manufacturing as more productive than services and considered heavy manufacturing industry (such as petrochemicals, metallurgy and machinery) to be the most important ingredient to economic development. Thirdly, the government strongly favoured national and provincial autonomy. This meant that Shanghai developed an even more diversified economy than before, but it lost both international and domestic trade.

Government controls over labour flows complemented its controls over capital. Moreover, the new government viewed urbanisation as neither necessary nor desirable, especially in cities tainted by foreign influences. Household registration (the *hukou*), which was introduced formally in 1958, controlled access to food, housing and other urban services and checked the flow of people to cities (Ma and Fan, 1994). Moreover, between 1950 and 1964, over 800,000 young educated residents of Shanghai were sent to work in the rural areas of China. These labour controls contained the overall urbanisation of China to about 19 per cent from 1950 to 1980 (Zhou, 1991), but they did not stop the population growth of Shanghai. Shanghai's population rose from an estimated 6.2 million in 1953 to 10.0 million in 1970 to 11.8 million in 1985, and throughout this period it remained China's largest city (Yusuf and Wu, 1997).

The economic reform process, which began in 1978, unleashed another set of dynamic forces. These reforms had three main features. Firstly, over the next 20 years, market forces would increasingly determine capital and labour flows and prices within China. Secondly, the reforms transferred significant responsibilities from the centre to the provinces and major cities. Thirdly, they encouraged international trade and investment flows. In due course, all of these factors would favour Shanghai's development.

Initially, in the 1980s, reform and development were slower in Shanghai than in many other cities, especially those in the south of China. Between 1978 and 1991, Shanghai's GDP rose by an average rate of 7.4 per cent per annum, compared with 12.6 per cent in Guangzhou, and 8.7 per cent for the whole of China. This slower growth reflected political and economic factors. The Government in Beijing still viewed Shanghai with suspicion as a foreign-tainted city. But, economically, Beijing depended on Shanghai's strategic industries and finances. Cheung (1996) estimates that between 1949 and 1983, a full 87 per cent of Shanghai's total public revenues of RMB350 billion were remitted to Beijing, leaving only 13 per cent for its own uses. According to Yeung (1996), in the reform period, as much as one-sixth of the revenue of the central government was derived from Shanghai. Also, the heavily state-owned businesses in Shanghai were slow to reform.

The 1990s have been dramatically different. Change in Shanghai has been extraordinary, based on an average rate of growth of GDP of 14 per cent per annum. A local environmental consultant told the writer in 1996 that one-fifth of all the cranes in the world were currently employed in Shanghai. Whatever the basis for this statistic, it certainly seemed credible as one walked around the streets of the city, watching buildings being ceaselessly demolished and replaced at remarkable speed with vast new structures.

According to Cheung (1996), it was the Tiananmen incident and its international impacts that led to the Central Government's choice of Shanghai as a launching pad for economic reform and openness in the 1990s. In 1992, at the 14th session of the National Congress of the Communist Party of China, the Government declared that Shanghai should be developed into a world economic, financial and trade centre. To-day, with both China's president (Jiang Zemin) and vice-premier (Zhu Ronji) former mayors of Shanghai, the city's political rehabilitation is complete.

In 1990, China's first stock exchange was opened in Shanghai and Pudong (a major new business district) was established on the eastern side of the Huangpu River as an open area for international investment. In 1992, foreign direct investments into Shanghai amounted to US$3.4 billion. This exceeded the total of the whole previous 12 years. In 1994, the figure rose to US$10 billion. In 1997, there were some 2000 approved projects supported by nearly 50 countries. Areas of investment included all forms of real estate (including hotels), transportation (cars and aircraft), and large industrial projects (including computers, electronics, telecommunications, building materials and so on).

During the 1990s, under the national policy of the 'socialist market economy', central and provincial governments placed increasing emphasis on markets. Prices were freed gradually from political controls and prices of most commodities, including energy, increasingly reflected market forces. This encouraged investment and the efficient allocation of capital.

In 1994, China adopted a 'tax sharing system' whereby a uniform formula across the nation replaced the previous system of bilateral bargaining between provinces (and major cities) and the Central Government. Between 1990 and 1995, investment in urban infrastructure in Shanghai amounted to US$7.1 billion, which was three times the amount in the 10 years from 1980 to 1989. The change in the national tax system frees even more resources for Shanghai.

Writing in early 1999, one must ask whether the 'Asian Crisis' which developed in the second half of 1997, has affected, or will affect, Shanghai? From 1979 to 1993, one half of all foreign investment came officially from Hong Kong and one fifth from Japan and the United States combined (Yusuf and Wu, 1997). But the Hong Kong capital includes Taiwanese and doubtless other foreign-sourced capital. Also, there has been an increase in American and European investment in the last five years. Informal information gleaned from media reports and discussions with Shanghaiese suggest, at this stage, that vacancies are high in commercial buildings but not a serious problem in residential buildings. Investment is being postponed rather than cancelled permanently. On this reading, the Shanghai economy is undergoing a downturn in a business cycle rather than a structural change in the economy. As discussed below, the city's underlying strengths far outweigh its weaknesses.

Finally, it should be observed that economic growth has not only improved material conditions, but also greatly improved health. As a result of family planning, childhood immunisation, accessible primary health care, improved nutrition, and improvements in housing and sanitation, China's achievements in health and life expectancy over the last four decades have been remarkable. In Shanghai, life expectancy has almost doubled from 42 years in 1950 to 76 years in 1996. Infant mortality has fallen from an appalling 120 per 1000 to 9.5 per 1000 over the same period. The mortality of mothers has dropped from 320 out of 100,000 births to 22. The city has basically eradicated the diseases of diptheria, smallpox, snail fever, filariasis and leprosy.

Shanghai's economic strengths and weaknesses

Many of Shanghai's economic strengths are evident from its history. These strengths include its outstanding domestic and international location, its huge store of human capital and skills, and the breadth and depth of its industrial base. Shanghai is a major producer of steel and steel products, industrial plant and equipment, transport equipment, textiles, chemicals, electronics, food, synthetic fibre and clothing. 'In sheer scale of manufacturing capability, Shanghai has no rival in the developing world' (Yusuf and Wu, 1997, p.77). Shanghai is China's largest port and services centre. The handling capacity of the port is some 200 million tons, about one-quarter of China's total handling capacity.

Shanghai is located at the centre of an arc of large and prosperous Asian cities, which include Guanzhou, Hong Kong, Manila, Taipei, Tokyo, Seoul, Tianjin and Beijing. All of these are less than two hours flight time from Shanghai. Such a location is highly attractive to international capital. Nearly half of the world's top 100 multinational corporations are represented in Shanghai. In addition, Shanghai is integrated with the most prosperous hinterland in China. Eighty million people inhabit the rich Yangtze River delta. Another 300 million live in the upstream Yangtze River basin.

Moreover, the workforce in Shanghai is well educated and resourceful. Over 80 per cent of the workforce have graduated at least from junior high school. There are nearly 50 universities and colleges, and at least 266 independent research institutes, in Shanghai (Yusuf and Wu, 1997). Industries are undergoing drastic change as they face competition in newly opened markets at a time when they are losing state support. In the last few years, 400,000 jobs (half of the total) have been lost from Shanghai's once dominant textile industry. But unemployment is low as the workforce adapts to new jobs.

There are other economic advantages. A temperate climate is attractive to workers and conducive to work around the year. There is a reasonable supply of flat and usable land on the urban fringe. And there is a strong, stable and capable municipal government.

What, then, are Shanghai's economic weaknesses? Five main weaknesses, or potential weaknesses, are noted below. The first three of these are all related in some way to its successful economic development.

Firstly, Shanghai's very economic success attracts large numbers of workers into the city. Sample data suggest that immigrant workers in Shanghai rose dramatically from 1.06 million in 1988 to 2.51 million in 1993 (Daben, 1998). These workers provide cheap labour, especially to the construction and sanitation industries, often doing work that local residents are unwilling to do. At the margin, their real wage (inclusive of living conditions) is only a little better than that in the area from where they have some. Many of these immigrants to Shanghai live in extremely poor, insanitary and crowded housing (with less than four square metres per person), often in illegal squatter settlements, and have little access to the city's health, education and social services.

Secondly, the increasing city population places ongoing stress on the environment – on housing, transportation systems, air and water quality, solid waste disposal, land uses and so on. For example, there is only 1.17 square metres of green (recreational) area per person in Shanghai, compared with over 20 square metres per person in London and New York and most other major developed cities (Anxin et al., 1998). These various environmental stresses are discussed further below. Suffice to note here that the responses often require large expenditures of public funds. Such defensive expenditures to manage the environment may actually increase GDP but, when the expenditures are in response to new problems, they do not reflect an increase in living standards.

Thirdly, Shanghai's economic performance is sensitive to international conditions and to foreign investment. Foreign investment, averaging over US$8 billion per annum in the 1990s, is double the annual revenue of the Shanghai Government. There is also a high reliance on Hong Kong capital, although the exact amount from Hong Kong itself is difficult to estimate.

Fourthly, notwithstanding its preeminence in China, much of Shanghai's industry in not internationally competitive. As reported by Bei and Haojie (1998), Shanghai has not developed a stable international market for many of its products. The city is not competitive in high technology areas. Many of its enterprises are inward looking and relatively small scale.

Fifthly, the Shanghai economy is still highly reliant on the public sector. In the mid-1990s, the public sector employed 3.5 million people. In 1995, it reduced employment by 200,000 people, mainly in textiles, and it planned to reduce employment of state-sector workers by another 400,000, mainly in light industry, chemicals and building materials. This presents considerable adjustment pressures. Although there are some internationally competitive state-owned enterprises (SOEs), many are inefficient and starved of capital funds for improvements. In the mid-1990s, one-third of SOEs were losing money. These inefficiencies and losses reflect systemic disabilities: soft budget constraints, poor incentive structures, overstaffing and a confusion of economic and social welfare roles (as most SOEs provide an array of social welfare supports).

Given these weaknesses, is economic growth sustainable in Shanghai? The answer appears to be that growth is sustainable in the sense that total and average real incomes will continue to rise in Shanghai. Given inherited and present natural advantages, private and public industry are likely to be increasingly efficient under the pressure of market and international competition. And, as discussed below, there are adequate solutions to Shanghai's environmental problems. International investor interest in Shanghai is global, not just East Asian. This diversity of support will generally, although not always, reduce the volatility of capital inflows.

However, increased reliance on markets tends to increase inequality of income. This is particularly the case when, as in Shanghai, the welfare role of SOEs is being eroded. Moreover, Shanghai will always attract a high proportion of poor immigrants. The greater the growth of most incomes in Shanghai, the higher the number of poor immigrants is likely to be.

Environmental Issues and Reponses

In this review of environmental issues, we start with a brief discussion of housing conditions, which are critical to individual welfare. We then discuss the specific issues of water and air quality and solid waste management. Lastly, we discuss the more general issues of transportation and land use planning.

Housing

Housing has been, and is still, a major problem in Shanghai. In 1985, the average population density in downtown Shanghai was 40,000 persons per square km. In some densely populated areas, the density rose to 160,000 persons per square km. Average per capita living space in the city was only 5.4 square metres. An official survey found that 1.8 million households were living in overcrowded conditions, including over 200,000 households in dwelling units with less than two square metres per person (Xiangming, 1996).

Moreover, much of the housing was delapidated and lacked basic sanitary services. In the early 1990s, 16 million square metres of stone-framed-gate housing lacked toilet amenities. Four million square metres, housing three-quarters of a million people, were considered dangerous substandard housing.

During the 1990s, an average of 50,000 households has been rehoused each year. This means creating housing space at an average rate of 1.2 million square metres a year. In 10 years, 1.5 million people have been rehoused. By 1995, average per capita living space had increased to 8 square metres. Over half the dwelling units now have private kitchens and toilets. The government's aim is to increase average living space to 10 square metres per person by year 2000.

Two reforms have underpinned the housing program. One has been the gradual upward adjustment of rents from 3-5 per cent of household income to 15 per cent. This has increased the resources available to government. It has also facilitated the second reform – the privatisation of the housing sector. Since 1994, older state-owned residential units with independent kitchens and toilets have been sold to individuals. Also, new housing has been supplied increasingly by the private sector, with considerable foreign capital input. Yeung (1996) states that there are over 4000 foreign companies supplying housing in Shanghai. There is now an active market in second-hand housing.

Water quality

The Huangpu is Shanghai's mother river, as the Thames is to London and the Seine to Paris. The Huangpu River is the source of most of the city's water supplies, feeding 14 waterworks in the municipal supply system. It is also a huge port, a water transportation system and a sink for many of the city's industrial discharges. Eighty per cent of the delta landform on which the Municipality is located is drained by the Huangpu River catchment. This catchment is a complex interlocking network of canals, drains, minor watercourses and rivers. Groundwater is generally only about a metre below the surface.

There are seven urban tributaries of the Huangpu, including Suzhou Creek which is another major watercourse running through Shanghai.

With the exception of the Changiang (Yantzse) estuary, where water quality is quite high, most waterbodies in Shanghai are moderately to very severely polluted (Guoyuan and Chun, 1998). In the Water Source Protection Zones of the Huangpu River, only parts meet the Chinese Class 3 standard, which is required for potable water. Many parts of the Protection Zones are Class 4 and 5. The main pollutant in these water bodies is ammonia-nitrogen. Kinhill et al (1994) monitored 622 km of Shanghai waterways for ammonia-nitrogen, dissolved oxygen, COD, BOD5, volatile phenols and mineral oil and found that all the waterways were significantly polluted. Most fell into the lowest categories, Chinese Classes 4 and 5 (the latter is not suitable even for industrial use). Sixty per cent of the whole Huangpu basin was found to be seriously contaminated by toxic substances (phenol, cyanide, mercury, arsenic and chromium). In 1996, Kin-che and Shu described the Huangpu River as 'a chemical cocktail composed of raw sewage, toxic urban wastes, and huge amounts of industrial discharges'. Pollution in the Huangpu's tributaries and in the urban canals is generally worse, falling in places to Class 6 – the lowest of all classes.

There are three main sources of wastewater discharges and polluted effluents: industrial discharges, domestic sewage and non-point sources. In the mid-1990s, industries discharged about 50 per cent of their wastewater into the Huangpu River and Suzhou Creek, 10 per cent into the Yangtze Estuary, Hangzhou Bay and the East China Sea, and 40 per cent into sewerage pipelines. The pipelines in turn discharged two-thirds of their wastewater into the rivers. Thus, only a small amount of wastewater went, directly or via pipelines, into the capacious Yangtze River or the sea, where it could be assimilated more readily. Moreover, although about two-thirds of industrial wastewater is treated, a high proportion does not meet discharge standards. Kinhill et al (1994) reported that in some industries, such as leathers, pulp and paper, pharmaceuticals, less than one quarter of discharges complied with standards. In others, including foodstuffs, beverages and tobacco, textiles, gas and coking, building materials, and metal products, a half or less of discharges complied with standards.

The amount of domestic sewage discharged in Shanghai is about 100 million tons annually. In 1993, only a quarter of this was treated, due to insufficient treatment capacity. The rest was discharged untreated into the waterways.

Non-point sources of pollution for the Huangpu River are distributed throughout a 5000 square kilometre catchment (80 per cent of the municipality) which drains into the river. Twelve thousand rural industrial sites discharge 10 tons of biological oxygen demand (BOD) per day into the Huangpu catchment, which far exceeds its natural assimilative capacity. Agricultural runoff in the Huangpu basin is around 1.5 billion cubic metres per year. This carries with it 4600 tons of nitrogen and 900 tons of phosphorus into surface waters. In 1992, livestock wastes from pigs, poultry and cattle were 72 million tons. The 84 million livestock in the municipality generated 630 tons of BOD per day, two-thirds of the total BOD for the Huangpu basin (Kinhill et al, 1994).

What policies have been, or are being, used to deal with water pollution? The Shanghai Environmental Protection Bureau has adopted a zoning system, which sets objectives for each part of the waterway system. The most important zoning is the Class 3 that applies to the upper part of the Huangpu River, which is designed to provide a potable water source.

The principal potable water intake for Shanghai is at Linjiang on the Huangpu. There, ammonia-nitrogen, total nitrogen, total phosphorus, phenols and oil far exceed their respective Class 3 standards. Toxic materials, such as mercury, reach almost the Class 4 maximum (i.e. 0.001 mg/l). To obtain Class 3 water, SMG is spending several hundred millions of dollars to relocate the major urban intake upstream close to DiQiao, 65 kilometres upstream of the outlet of the Huangpu River. This diversion will have a capacity of 5.4 million cubic metres per day. In order to manage water demand and to fund water quality investments, SMG has recently increased tap water prices by 25-40 per cent.

SMG is also carrying out some very large sewerage projects. In the mid-1990s, it completed a major (US$145 million) sewerage project to collect industrial and domestic wastewater along the Suzhou Creek, serving 2.6 million people, and to discharge the sewage after treatment into the Yangtze estuary. Currently, the second and much more expensive phase of the project will establish a large-scale centralised sewerage system for Shanghai, which will collect a large proportion of the industrial and domestic wastes from industry and households discharging into the Huangpu River. This will discharge wastes after primary treatment into the East China Sea.

Thirdly, the SEPB has adopted a large number of discharge regulations. The regulations prevent any new production activities in areas that might pollute the Water Source Protection Zones. The authorities have also reduced the permitted total discharges into the Huangpu River in these zones. Thirdly, all enterprises in Shanghai must have discharge permits and excess discharges are subject to an effluent charge. Fourthly, under the national Environmental Protection Law, all major new activities depend on approved Environmental Impact Assessments.

However, these regulations have not proved very effective. The regulations are not always enforced, especially for established SOEs. The law is 'softened' in order to spare the companies, and the state banks that support them, from bankruptcy and to shield their workers from unemployment. Nor are the regulations effective for the numerous rural and non-point sources of pollution in the catchment. Much pollution continues to occur via the spread of contaminants through food chains, soil and groundwater, or a complex of minor watercourse. Moreover, the effluent charges are very low and do not provide an incentive to introduce or upgrade treatment of wastewater.

What are the implications of this extensive water pollution for Shanghai people? The principal implications are economic and aesthetic rather than threats to life and sustainability. Adequate treatment and disposal of wastewater will require expensive solutions for both the public and private sectors. Recreational activities, such as fishing and swimming, will continue to be impossible in Shanghai waterways. Many of the waterways will continue to be odorous and unsightly. However, the health impacts appear to be minor and under control. Nearly all urban residents receive treated tap water supply. There is little evidence that this tap water is a source of disease, partly because most households boil the water before use. The relocation of the main water supply upstream in the Huangpu River will improve the quality of the water source, although some supply may still be below the desirable standard. Moreover, a third of Shanghai residents in the rural areas depend on deteriorating catchment resources. Tighter controls on activities in the catchment will be needed to prevent this deterioration.

Air quality

At the start of this discussion of air quality, we should note that ambient measures are not very reliable, due to limited monitoring. In 1996, there were only five urban sampling sites and eight rural sites for monitoring sulphur dioxides (SO2), nitrogen oxides (Nox) and total suspended particulates (TSP) (Mott MacDonald et al, 1996). Industrial emissions of heavy metals and toxics are not routinely measured.

Nevertheless it is clear that air quality is generally very poor in Shanghai. Concentrations of sulphur dioxides (SO_2), total suspended particulates (TSP), and lead are far above healthy levels in the urban districts. Ambient levels are not so bad in suburban counties. The major cause or air pollution is coal consumption, which rose from 9.1 million tons in 1970 to 30.3 million tons in 1993 (Jingchun, 1998). Much of this coal is poor quality, high in sulphur and ash content.

The estimated annual mean concentration of SO_2 in the urban districts of Shanghai was 68 micrograms per cubic metre ($\mu g/m^3$) in 1998 (Shanghai Environmental Protection Bureau, SEPB, 1998). This is substantially higher than the World Health Organisation (WHO) standard of 40-60 $\mu g/m^3$ for health safety. It is also higher than the Chinese Class 2 level of 60 $\mu g/m^3$ that is designed to protect public health, animals and plant life. Given that there are considerable variations around this mean, sulphur dioxide emissions are clearly a very serious risk to health in Shanghai.

The annual mean concentration of large particulates (up to 100μ diameter) in urban districts was 233 μg/m3 in 1998 (SEPB, 1998). These levels of particulate air pollution from energy and industrial processes in Shanghai are among the highest in the world (WRI et al. 1998). This concentration is far in excess of the WHO standard for healthy living of 70 μg/m3 and well above the Chinese Class 2 standards of 150 μg/m3. Although health risks depend more on levels of finer particles of less than 10μ, aeroallergens and toxic materials, which have not been measured, it is clear that TSP in the atmosphere are greatly excessive and that health damages are likely to be very high.

Both SO2 and TSP are products of coal combustion. There are over 10,000 point sources of air emissions in Shanghai, including 7000 coal-burning boilers. Ten major industrial sources (power plants, large iron and steel works, and chemical works) consume large amounts of coal and contribute a third of all SO2 emissions, smoke and dust in Shanghai. However, because of their greater stack heights, they contribute about 10 per cent to ambient concentrations in the city. Industrial emissions of heavy metals and toxics are also significant contributors to air pollution in Shanghai.

Overall, the high combinations of SO2 and TSP create significant levels of respiratory disease and bronchitis (Kinhill et al, 1994). The World Bank (1997) estimates that the health damages from air pollution (in terms of premature deaths, morbidity, restricted activity days, chronic bronchitis, and other health effects) are several times higher than the damages from water pollution in China. This is almost certainly the case in Shanghai.

The transport sector is also now a major contributor to air pollution. The problems stem not just from the growing size of the motor fleet but also from low emission standards and poor road infrastructure. Vehicle emission standards are equivalent to the standards of the developed world in the 1970s. Chinese vehicles emit 2.5 to 7.5 times more hydrocarbons, 2 to 7 times more nitrous oxides (NOx) and 6 to 12 times more carbon monoxide (CO) than foreign vehicles (Kebin et al, 1996). In central Shanghai, motor vehicles are responsible for 70 per cent of CO and NOx emissions (Kinhill et al. 1994).

In recent years, the mean NOx ambient concentration level in the urban districts has almost doubled from around 60 μg/m3 to 105 μg/m3. Although this is below the WHO standard of 150 μg/m3, it is over the Chinese Class 2 objective of 100 μg/m3 and is another serious threat to public health (Shanghai Environmental Protection Bureau, 1998). The risk from CO is unknown because of lack of measurements.

Ambient lead levels have also been a major concern. Until recently, the motor vehicle fleet was fueled mainly by leaded gasoline. Few cars had catalytic converters. Although data on lead levels in the atmosphere are scanty, Kebin et al. (1996) noted that ambient lead levels in Chinese cities often exceeded 10 μg/m3 compared with the national standard of 1 μg/m3. Blood-lead levels are far above the threshold associated with impaired intelligence, neurobehavioural development, and physical growth. Over two-thirds of children in Shanghai have blood-lead levels greater than 10 μg per deciliter (the US standard). In industrial and congested areas, the levels averaged between 21 and 67 μg per deciliter. (WRI et al. 1998). Studies in Shanghai and elsewhere have shown that high blood-lead levels in children are significantly associated with lower mental development (World Bank, 1997).

The Central and Shanghai Governments are dealing with air pollution in several ways. These include a major industry relocation program (see below), the development of natural gas in the East China sea and the conversion of household coal burning to gas. As from 1 October 1997, the use of leaded petrol in motor vehicles in Shanghai has been banned. These are substantial programs, which should improve air quality. Factories are required to have waste gas treatment facilities. Excess discharge fees are based on the pollution load and type of pollutants. There are also current proposals to greatly increase emission charges. Improving coal quality, by reducing its sulphur and ash contents, could greatly

improve air quality. A slowing down of the frenetic construction activity in Shanghai will reduce TSP concentrations.

On the other hand, there are new challenges, especially with the growth of motor traffic and currently with the highly polluting growth of two-stroke motor cycles. Moreover, as with water pollution, the effectiveness of the regulations and discharge fees may be questioned. On balance, SMG's policies seem likely to produce a net improvement in Shanghai's air quality. But it may be many years before it achieves WHO standards for all parameters of ambient air quality.

Solid waste management

Like all mega cities, Shanghai produces a huge amount of solid waste daily. In 1994, the city generated 35,000 tons of solid waste per day, equal to 12.5 million tons over the year. Two-thirds of these wastes were generated by industry, one-third by households.

Although industry reuses 80 per cent of its wastes, disposal of the rest is a major problem. Three industries (smelting, power and chemical engineering) account for three-quarters of all industrial waste in urban Shanghai. The principal wastes are smelting residue, fine coal ash and slag. The city contains some 1400 industrial stockpile sites covering 4.1 square km. In 1992, industry also generated 600,000 tons of hazardous wastes. These were principally heavy metal waste, organic waste, waste acids and alkalis, calcium carbide residue, organic sludge and various organic chemical compounds.

Municipal solid waste amounts to about 12,000 tons per day in the Huangpu basin, including 10,000 tons of domestic garbage. Transport is by fully closed transport. However, there is a lack of facilities for proper disposal. In the early 1990s, 40 per cent of the waste was barged along canals and rivers to two poorly designed landfills. The rest was either disposed at 410 unofficial stockpile sites or dumped, often into waterways.

Outside the urban areas, and even in some residential areas around the outskirts of the city, municipal waste was not collected. Around the urban fringe, where no nightsoil collection of sewerage is available, residents dispose of plastic bags of nightsoil into canals, wastecourses and sundry locations where municipal waste is dumped. Most river and canal banks are littered with domestic and other wastes. Leachate from wastes, washed into the catchment, is a further source of polluted water.

Shanghai's capacity to deal with solid waste has improved in recent years. The amount of waste from heavy industry has actually decreased due to energy saving, technical innovation and integrated pollution controls. The second phase of the Laogang landfill plant increased the average disposal capacity from 3000 to 6000 tons per day. Much of the rest of the urban domestic waste was collected and dumped temporarily at two other sites (Jiangzheng and Sanlintang). At the end of 1998, the Jiangzheng landfill site was closed and a new temporary landfill site established at Bainoggang, close to the East China Sea in New Pudong Area. The Shanghai Government has also invested in additional collection and transfer stations, and garbage-transport trucks and barges. (Xiangming, 1996). The government plans to treat 80 per cent of domestic waste by year 2000, including incineration of 40 per cent.

In summary, Shanghai's waste disposal practices have lagged far behind its economic development. As with water and air pollution, the city has a long way to go to achieve developed country standards. Dealing with waste disposal is mainly a matter of political will, organisation and municipal finance. SMG is well aware of the problems and, providing the economy continues to grow and to provide the financial resources, there should be continued improvement in solid waste disposal practices.

Transport

Not surprisingly, in an old, densely populated city like Shanghai with a very rapid rate of economic development, traffic is a major problem as a source of congestion, noise and accidents, as well as air pollution. Road space in the city is only a little over two metres per person. Road widths in old

established areas are often only 9-10 metres, with vehicles restricted to 7 metres. On the other hand, the number of motor vehicles increased at a staggering rate from 212,000 in 1990 to 372,000 in 1994. It is expected to increase to 800,000 in year to 2000 and to 1.4 million in 2010. There has also been a rapid increase in motor cycles in recent years. In addition, there are over seven million bicycles in the city. Between 1985 and 1995, average traffic speeds fell from 19 to 15 kilometres per hour (Xiangming, 1996).

The Shanghai Government spent billions of dollars in major projects to increase transport infrastructure in the 1990s. Major road and bridge projects include two large-span bridges over the Huangpu River and a tunnel underneath, a six-lane north south highway along Chengdu Road, construction of elevated 48 km inner ring road and the start of the outer ring road. The Yangpu Bridge over the Huangpu River, which cost nearly US$200 million, is the longest suspension bridge in the world. The Government completed the first part of the subway system (17 km of track and 13 stations) in 1994 at a cost of US$680 million. A second segment of 32 km, connecting East Pudong with western Shanghai, is due to be operational in 2000. A second international airport is also being constructed in East Pudong. In all cases the rate of construction has been exceptional.

However, in Shanghai as in most mega cities, the demand for transport can never be fully satisfied. There has to be demand management. The city has started to do this via traffic management schemes that limit vehicle use of some roads, including Nanking Road in peak hours, one-way systems and segregation of motor vehicles, bicycles and pedestrians. There are also frequent bus services as well as metro services. However, vehicle ownership is not heavily taxed, vehicle registration costs are low and fuel is cheap. It is difficult to see how the growth in vehicle ownership and use can be managed without making vehicle ownership and use much more expensive.

Land use planning

Ever since the production of the first *Metropolitan Plan for Shanghai* in 1927, Shanghai's municipal government has been actively involved in land use planning (Yuemin, 1998) . In the 1950s, under Soviet expert guidance, Shanghai was planned as a metropolitan city with only one centre. Typically, industry and housing were closely located, often in inner city areas, as SOEs provided a complete package of jobs, housing and social services to their employees.

However, the monocentric city became impractical with population growth and SMG has sought increasingly to set up alternative commercial and industrial districts and residential towns and suburbs. In the 1980s, major new industrial / residential areas were developed in the Baoshan-Wusong area on the southern bank of the Yangtzse River and in the Jinshanwei-Caojing area on the northern bank of Hangzhou Bay. Satellite towns, such as Minhang, Jiadang, Sonjiang and Anting, with separate industrial districts, were established 30-40 kilometres away from the city centre. Today, the Shanghai urban system consists of 230 centres, including 7 satellite towns, 31 county seats (designated towns), 2 industrial districts, 175 market towns, and 15 farm market towns. Each of these centres is required to have a development plan.

A key feature of recent planning has been the break in the nexus between industry and housing. This has been essential for the provision of both environmental amenity and housing space. In the 1990s, large numbers of polluting factories in the inner areas have been closed down or relocated to urban fringe areas. Bei and Haojie (1998) claim that 455 enterprises have been relocated in the last five years, which has freed up 163 square kilometres for redevelopment in central Shanghai. As an example of the benefits, the closing down or relocation of 25 heavy polluting factories in the Xinghua Road area has contributed to Class 2 SO_2 and TSP levels in that area (Xiangming, 1996).

Two other features should be noted. Firstly, the opening up of a major new financial and industrial centre in Pudong on the eastern side of the Huangpu has removed some of the critical physical limitations of old Shanghai. In 1996, over one million square metres of office space came onto the

market, including 18 major office blocks in Pudong alone. The development of Pudong has been a major catalyst for the development of Shanghai.

But, secondly, the planners are also highly conscious of the need for more green space. The current Plan calls for public green space to be increased from 1.1 square metre per person in 1992 to 4 square metres in 2000 and to 8 square metres in 2010. The land will be acquired by demolition of sub-standard housing. This will require a significant expansion of the city, along with substantial expenditures on expanded urban services and transport systems.

Conclusions

For most of the past 20 years, Shanghai has experienced high and accelerating rates of economic growth. Material prosperity has greatly increased. Moreover, the city's economic strengths substantially outweigh its weaknesses and future economic growth seems assured.

The environmental report is more mixed. Shanghai has had, and still has, a poor environment. Water and air are heavily polluted and solid waste collection practices are inadequate in many parts of the city. On the other hand, housing conditions, air and water quality, and waste collection practices have all improved in the last 10 years. Current policies and projects should produce further environmental improvements.

Rather less is published about the social impacts of the economic reforms in Shanghai. Unless market reforms are complemented by adequate publicly-financed social services, the reforms may increase inequality and unemployment in the community. Casual information suggests that this may have happened in Shanghai.

More fundamentally, Shanghai is confronted with the issue of how to deal with potential and actual immigrants and the possibility of a population in excess of 20 million in the quite near future. Even low incomes in Shanghai are often double or triple those in many other parts of China. Increased government support for low income households and environmental improvements would make Shanghai even more attractive. There is little that SMG can do about this. In 20 years time, the real income of poor households in Shanghai, including the environmental standards they experience, will be more closely related to the real income of poor households elsewhere in China than to average real incomes in Shanghai.

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