

Transport and Urban Form in Chinese Cities

An International Comparative and Policy Perspective with Implications for Sustainable Urban Transport in China

Chinese cities are acknowledged worldwide as being the leaders in non-motorised transport. Many other aspects of their transport and urban form are also conducive to low levels of automobile dependence. However, urban China is changing rapidly with very high rates of motorisation and a number of policies and factors that are pushing their transport systems towards greater reliance on cars and motor cycles. Development of quality public transport systems appears not to be keeping pace with the emphasis on private transport. This paper briefly explores how Chinese cities compared on key transport and urban form factors to a large sample of other cities from around the world in 1995. It further examines a range of important policies and factors that are shaping Chinese urban transport systems and explores the potential of Chinese cities to embrace the ideal of "sustainable urban transport", as opposed to increasing automobile dependence.

1. Background

With China's economy booming, a question has arisen about whether human life and global sustainability will suffer severe decline if China, the largest country on the earth, were to increase its urban automobile ownership and usage to the current US level (Hook and Ernst, 1999). A planner at one large auto company believes that "there could be 70 million motorcycles, 30 million lorries and 100 million cars in China by 2015" (Hook and Replogle, 1996). "The potential effects of this car explosion – on the quality of human life and the sustainability of all life – are staggering" (Tunali, 1996). Today, transportation accounts for 15 to 20% of the annual 6 billion tons of carbon emissions from human activities that are leading to climate change. By 2030,

China is expected to have 828 million city dwellers. If they were to drive as much as the average American, "the carbon emissions from transportation in urban China alone would exceed 1 billion tons, roughly as much as released from all transportation worldwide today" (Worldwatch Institute, 1999). "If China attains its dream of a car for every family, the resulting emissions could increase carbon concentrations to an extent that would affect the entire world and offset emissions reductions achieved in other countries" (Tunali, 1996), and "the implications for global warming and energy consumption are truly harrowing" (Hook and Replogle, 1996). Hook and Ernst (1999) state that: "Because of China's immense population, small changes in assumptions about China's motorisation could throw future global oil demand projections and greenhouse gas emissions estimates off by 100%" (p. 7).

It would be a disaster, not only for China itself, but also for the entire world, if China devastates its physical and social environments in the way that much of the developed world has been doing through its extreme dependence on the automobile. The global and local concerns that lie behind trends in motorisation in China are the motivation for this paper. The research presented here therefore attempts to develop a deeper insight into the scenarios for Chinese urban transport by asking the following key questions:

- What is the current situation in Chinese cities compared internationally to a large sample of other cities, in terms of land-use, transport infrastructure, transport patterns, motor vehicle ownership and usage, transport energy consumption and transport externalities?
- What are the key factors in shaping Chinese urban transport and land-use, and would Chinese cities develop along a path of automobile dependence in a period of rapid economic growth and modernisation?
- How would China integrate its urban development and transport policies in shaping sustainable urban transport and land-use?

2. A Comparative Overview of Land-Use and Transport Patterns in Chinese Cities

2.1 Urban Form and Land-Use Patterns

Before presenting some basic comparative land-use data on Chinese cities, it is necessary to qualify a few issues concerning how to compare Chinese cities with their international counterparts.

2.2 Some Methodological Issues

A useful way of presenting this discussion is to consider the fundamental issue of a city's urban density. Urban density is one of the most important factors in determining a city's level of car use, energy use and the viability of public transport, walking and cycling (Newman and Kenworthy, 1989, 1999). Urban density takes for its denominator the total built-up land (residential, commercial, and industrial land, etc., plus roads and streets). It excludes rural land, forests, large areas of contiguous undeveloped or vacant land, regional scale open spaces, but not local open spaces. Higher urban densities, and the mixed land-uses which are associated with them, shorten the length of trips by all modes, make walking and cycling possible for more trips and create sufficient concentrations of activities for an effective, frequent public transport service (Newman and Kenworthy, 1999; Kenworthy and Laube et al., 1999).

There are some problems in directly comparing Chinese cities with other international cities because of the urban form and some unique definitions in the Chinese statistical system, though in the final analysis these problems do not prevent worthwhile comparisons with other cities. In some ways the problems faced are similar to the urban data collection problems in many western and other Asian cities.

In China, statistical data are collected by administrative units on different levels. By means of administrative division, a typical Chinese city consists of an urban area and several counties which consist of a small or mid-sized city (or central towns), tens of towns and extensive rural areas. The county-level city that is actually an economically devel-

oped county is an exception. The normal statistical representations are therefore "Quian Shi" and "Shi Qu" which refer to "City-Wide Area" and "City Area" respectively. And the "City Area" actually also includes areas of land that are more or less rural in character. This results in some difficulties for research and international comparisons.

Unlike in western cities, suburbs in Chinese cities are mainly rural in the character of their land-uses, with some highly focussed nodes of urban development scattered throughout the rural lands. They don't bear very much relationship to the urban area, either in their residential patterns or the way they are extended. Therefore they cannot generally be regarded as parts of the urban agglomeration. So both "City-Wide Area" and "City Area" are not ideal statistical units, and unfortunately, built-up area is not a recognised administrative unit on which basic data are gathered, even though it is unquestionably much better for research. Under these circumstances, sometimes the only way to do meaningful comparative urban research, is through detailed analysis of existing information which permits some reorganisation of data and educated estimates where necessary. [1]

In summary, although there are particular data specification problems in Chinese cities, these are akin to similar problems in other cities and do not prevent a valid attempt at international comparisons. A full discussion of these methodological issues can be found in Kenworthy and Laube et al. (1999).

2.3 How do Chinese Cities Compare in Land-Use Characteristics?

By any international standards, Chinese cities, like their other Asian neighbours, have high urban densities and are characterised by quite intensively mixed land-uses in their built-up areas. Table 1 provides the urban densities in 1990 and 1995 for six Chinese cities ranging in size from 1 million population up to 7 million population, while table 2 provides an international comparison of urban densities in 1995. The tables show that urban densities in the Chinese sample in 1995 ranged from 119 to 196

City	Estimated population in built-up area 1995 (1,000 persons)	Area of built-up area 1995 (ha)	Density in built-up area 1990 (persons/ha)	Density in built-up area 1995 (persons/ha)
Beijing	6,528	47,700	141	137
Shanghai	7,656	39,000	251	196
Tianjin	4,752	35,900	138	132
Guangzhou	3,083	25,900	157	119
Hangzhou	1,148	9,600	155	120
Ningbo	914	6,200	144	147
Average	4,014	27,400	164	146

Source: Statistics Bureau of China (1991, 1996), Beijing Statistical Yearbook (1991, 1996), 1991/96 Statistical Yearbooks of Shanghai

Table 1: Urban densities in Chinese cities, 1990 and 1995 (persons per ha).

	Urban densities (persons/ha)
Australia/New Zealand cities	15
American cities	15
Western European cities	55
Chinese cities	146
High income Asian cities	150
Low income Asian cities	204

The metro regions outside China are from Kenworthy and Laube (2001)

Source: Kenworthy and Laube (2001)

Table 2: Comparison of urban densities in global cities, 1995 (persons per ha).

per ha, with an average of 146 per ha. This represented an apparent average reduction for the six regions of 18 persons per ha (11%) from the 1990 average of 164 persons per ha. These data, however, need to be considered in light of the discussion under Urban Planning Law and Regulations later in the paper, which indicates that the real decline in density between 1990 and 1995 is smaller than that shown in table 1. The average urban density of Chinese cities in 1995 was approximately ten times the American and Australian-New Zealand (ANZ) cities, over 2.5 times the western European cities, and a little lower on average than the urban densities of some wealthy and low in-

come Asian cities. It is apparent that the current urban form and land-use pattern in Chinese cities is quite distinct from all western cities. Further discussion of the unique nature of urban form in Asian cities can be found in Kenworthy et al. (1995).

2.4 Provision for the Automobile

Another key factor in automobile dependence is how well the automobile is catered for in basic transport infrastructure.

- Roads: The length of road per capita in Chinese and other cities is summarised in table 3. It shows that the Chinese cities are extremely low in this indicator compared to western cities, with

only one-fortieth to one-thirtieth the road provision in Australian and American cities, one-sixth that of European cities, and much lower even than the average of other Asian cities. Furthermore, these data are for the "City Area", as described in the previous section because of the lack of data for the actual built-up area. Road length per capita is even more constrained in the built-up area. As the comparison illustrates, present road infrastructure in Chinese cities does not favour automobile dependence. It suggests that congestion will rise rapidly as motorisation proceeds.

- **Parking:** The number of parking spaces in the centre of Chinese cities (CBD in western terminology) is a very difficult item to obtain because of lack of statistics. However, the data we have collected demonstrates enough to make a useful comparison.

According to a report of the Transport Engineering Institute of Beijing's Traffic Management Bureau, the number of parking spaces in the Beijing metropolitan area in 1995 is 38,671. It is even lower in other Chinese cities. Shanghai had only 10,468 places in its CBD in 1996 and Guangzhou 25,061 places in its metropolitan area in 1995 (Wang, 1997; Auto Weekly, 1999; TSSPSB, 1997). The three Chinese cities of Shanghai, Guangzhou and Beijing in

	Metres per capita
Australia/New Zealand cities	8.1
American cities	6.5
Western European cities	3.0
High income Asian cities	2.2
Developing Asian cities	0.6
Chinese cities	0.4
Beijing	0.3
Shanghai	0.3
Guangzhou	0.5

Source: Statistics Bureau of China (1996)

Note: The reference area and population for Chinese cities are 'City Area' as described in the methodology section because of difficulty in data availability. Correct populations have been used in each case.

Table 3: Comparison of road length per capita in global cities, 1995 (metres per capita).

City	Walking/Cycling (%)	Transit (%)	Private Motor Vehicle (%)	Total (%)
Chinese cities	65.0	19.0	16.0	100.0
American cities	8.1	3.4	88.5	100.0
ANZ cities	15.8	5.1	79.1	100.0
W. European cities	31.3	19.0	49.7	100.0
High income Asian cities	28.5	29.9	41.6	100.0
Low income Asian cities	32.4	31.8	35.9	100.0

Source: Kenworthy and Laube (2001)

Table 4: Comparison of modal split for all trips in global cities, 1995.

1995 had 17 parking spaces per 1,000 jobs compared with 555 in the CBD of US cities, 505 in ANZ cities, 261 in W. European cities, 105 in wealthy Asian cities and 127 in low income Asian cities (Kenworthy and Laube, 2001). Chinese cities are indeed not yet built for the automobile, and as the data imply, it would take a total reconstruction programme to adapt them to the automobile on the scale of US and Australian cities.

2.5 Automobile ownership and usage

The rate of motorisation in Chinese cities is increasing quite rapidly and this fact lies at the heart of this paper. Data from the Traffic Management Bureau in Beijing and Hangzhou shows that vehicle ownership per 1,000 people has risen in Beijing from 23 in 1983 to 93 in 1994. In Hangzhou over the same period it rose from 15 to 37. In terms of absolute numbers, cars in Beijing in 1990 numbered 89,373 and in 1994 there were 259,921, or a threefold increase. Zhou (1995) discusses in detail some of the causes of this rapid rise.

Although these figures show the rate of growth in automobile ownership in Chinese cities has been fairly high in recent times, ownership and usage are actually still very low in an international sense. Automobile ownership per 1,000 people in Beijing, Shanghai and Guangzhou averaged only 26 in 1995 (Kenworthy and Laube, 2001). This is compared to 587 in American cities, 575 in ANZ cities, 414 in W. European cities, 210 in high income Asian cities and 105 in low income Asian cities in 1995 (Kenworthy and Laube, 2001). Total private motor vehicle (car and motorcycle) kilometres per capita in Beijing, Shanghai, and Guangzhou averaged 434 in 1995. This is in contrast to 12,847 in American cities, 7,416 in Australian cities, 4,532 in W. European cities, 2,292 in high income Asian cities

and 1,110 in low income Asian cities in 1995 (Kenworthy and Laube, 2001).

2.6 Transport patterns

● Modal Split

Table 4 provides modal split in Chinese, American, ANZ, European, and Asian cities. The major urban transport modes in Chinese cities are obviously still bicycles, walking, and transit. Non-motorised modes account for 65% of total trips while cars and motorcycles account for 16%, which is significantly lower even than in other Asian cities. The other important point about these data is the comparatively poor use of transit in Chinese cities. This is pursued later in the paper.

● Walking and Cycling

Walking and cycling are still the most popular modes in Chinese cities. Despite the fact that in some cities the authorities wish to restrict the bicycle, the number of bicycles is still steadily rising with population, with little evidence of any significant slowing down, at least not up until 1995 (table 5). It is interesting to note that the level of bicycle ownership in most Chinese cities in the early 1990s was in excess of typical total motor vehicle ownership rates in US cities. US cities averaged 755 total vehicles per 1,000 persons in 1990 (Kenworthy and Laube et al., 1999). The rate of bicycle growth in Chinese cities significantly outstripped population growth between 1990 and 1994.

However, Hook and Ernst (1999) report that in south China, the use of bicycles is falling rapidly. For example, they state that in rapidly motorising Guangzhou, bike use dropped from 34% of total trips to 24% in one decade. Pendakur (1992) and Smith (1995) discuss this issue in more detail. Modal choice in favour of the bicycle is strongly related to the trip distance and the physical condition of users. Bicycles are the most popular mode between 5 and 30

	Population		Number of bicycles			Increase in bicycles	
	1990	1994	1983	1990	1994	1983-90	1990-94
Beijing	7,000,000	7,260,000	4,290,000	6,272,568	7,885,188	46%	26%
Hangzhou	1,340,000	1,440,000	628,833	834,020	1,272,665	33%	53%

Source: Traffic Management Bureau in Beijing and Hangzhou

Table 5: Number of bicycles in Beijing and Hangzhou, 1983 to 1994.

minutes travel distance, which is usual for most trips in Chinese cities.

● Public Transport

Although public transport vehicle numbers per capita are still low, public transport passenger kilometres per capita are fairly high in Chinese megacities. Public transport vehicle numbers per million population in Beijing, Shanghai, and Guangzhou in 1995 average 711. This is compared to 616 in US cities, 1,066 in ANZ cities, 1,247 in western European cities, 1,195 in high income Asian cities and 2,547 in low income Asian cities. In addition, most of these cities have a significant higher capacity rail component as part of their vehicle numbers, whereas the Chinese cities have almost all buses, apart from in Beijing (Kenworthy and Laube, 2001).

Nevertheless, the public transport passenger kilometres per capita in Chinese cities averaged 1,897 in 1995, which was higher than western European cities (1,524). However, it is well below the high income Asian cities (3,636) and about the same as the other low income Asian cities (1,944). Of course, public transport use in Chinese cities far exceeds that in US and ANZ cities (488 and 918 respectively).

The average occupancy per public transport vehicle in Chinese cities is also very high (53 persons per vehicle on average). This is compared to 14, 17, 20, 36 and 38 in the US, ANZ, European, high income and low income Asian cities respectively. Average public transport system speed is only 14 km/h, while the other cities range between 18 km/h and 33 km/h.

This is consistent with the crowded situation in buses in most Chinese cities. The major result of poor transit provision is that transit usage is depressed. It suggests that Chinese cities are not well prepared in terms of public transport development for the onslaught of the private car or motorcycle. Trips will tend to shift from non-motorised modes to cars and motorcycles if transit systems are not better developed. This will be discussed later in this paper.

2.7 Traffic Safety

The cost of road trauma in any society is a major issue, both economically and in terms of human pain and suffering. Table 6 shows the number of transport deaths per 100,000 persons in the Chinese cities compared to cities in other regions.

In an international context, deaths in transport accidents are relatively low in Chinese cities. The data seem to suggest that traffic deaths tend to follow both the degree of automobile dependence and the level of development of the traffic regulatory system. In American cities with their highly developed road systems and strictly regulated traffic, traffic deaths are very high, due it seems to the world's highest level of exposure of the population to auto traffic (Kenworthy and Laube, 1996).

The situation in Chinese cities can be expected to worsen and perhaps begin to mirror the picture in the other rapidly motorising Asian cities in this sample (15.2 deaths per 100,000 people) as more and more traffic begins to mix with the high numbers of pedestrians and cyclists. This is especially true if little or nothing is done to slow down this rate of motorisation or to plan for effective harmonisation of motorised and non-motorised transport (Hook and Ernst, 1999).

2.8 Summary

The comparisons here have answered the first question put forward in the be-

City	Number of deaths in transport per 100,000 persons
Chinese cities	8.6
American cities	12.7
Australia/New Zealand cities	8.6
Western European cities	7.1
High income Asian cities	8.0
Low income Asian cities	15.2

Source: Kenworthy and Laube (2001)

Table 6: Comparison of transport deaths in global cities, 1995.

ginning of this paper about how Chinese cities compare with their international counterparts. It has shown that urban form and infrastructure provision are not in favour of heavy automobile use in Chinese cities, and automobile ownership and usage were still very low in 1995, even compared to other Asian cities. The next step is to look at how Chinese cities might develop in land-use and transport terms as they continue to modernise and attempt to accommodate the automobile.

3. Nature of the Chinese City: Accommodating Motorisation

As is well established, the automobile city is not efficient or effective in an environmental, economic, or social sense (Newman and Kenworthy, 1999). However, for China, the issues are particularly acute because of the resource availability problem, which must inevitably be confronted as automobile dependence rises.

3.1 Issue 1:

Acquiring the Immense Amount of Land and Capital Investment Required in Infrastructure to Accommodate a Large Automobile Fleet

China possesses a vast territory, however, it is not rich in arable and inhabitable land, especially compared with the huge population. Land is in fact a major limitation for China. Nevertheless, with the economy booming and rapid urbanisation, even at high urban densities and with very low automobile dependence, the total amount of agricultural land has decreased significantly in the last two decades. It is reported that over 200,000 ha, including 100,000 ha of arable land, were requisitioned for construction purposes every year (People's Daily, 1996). Agricultural land reduction is already a serious problem that has occurred even during the non-motorised transport era prior to the current motorisation leap.

If Chinese cities are to accommodate large numbers of automobiles, urban

density would inevitably have to decrease greatly, with a vast demand for land for transport infrastructure including roads, parking, lower density houses, auto-orientated retail, commercial and industrial developments. With motorisation, Chinese cities would begin to manifest many of the characteristics of western style suburbanisation. How could Chinese cities accommodate this trend? And is it worth doing in an economic sense?

The People's Daily reported on February 6, 1996 that the Beijing Traffic Management Bureau has announced the "Public Notice for Decreasing Traffic Flow". This notice regulates that jeeps, cars and other small passenger vehicles are permitted to run only on odd or even dates during weekdays according to the last digit of the number plates (Tian and Pan, 1996). The reason behind this is to control traffic congestion. Beijing spent 309 million US dollars on roads (excluding resumption fees for land and houses) between 1990 and 1994 (Kenworthy and Laube, 2001). Much of the road surface is now dedicated to motor vehicles, while pedestrian and cycling facilities are degraded. Hook and Ernst (1999) reported that the situation is getting worse with segregated bicycle lanes in Beijing torn out for automobiles, and other lanes blocked by parked cars. Bicycle parking space is being relocated and convenient space is being converted to car and motorcycle parking. This trend is especially evident in new commercial and retail developments. Meanwhile, traffic congestion has increased over 1,000 times a month in Beijing in 1995. The average speed of motor vehicles on the second and third ring roads, which are the widest ones in the metropolitan area, reduced from 45 km/h in 1994 to 33 km/h in 1995. And the overall average road network speed reduced to 12 km/h (Tian and Pan, 1996).

As far as land is concerned, parking is another problem in Chinese cities. It is reported that only 10 to 20% of private cars have their own garages in Chinese cities. More cars just park in public open space in residential areas (Zhu, 1996).

Some questions which must therefore logically be asked are: How many roads would have to be widened and constructed in Beijing and other cities to accommodate the massive automobile fleet if it follows the American model? How much land would be consumed by transport infrastructure and its by-product – urban sprawl? Is it economically efficient to develop automobile cities in China? Detailed answers to these questions are beyond the scope of the paper. However, the data and discussion that have been presented here suggest that the answers to these questions may be painful for those holding a vision of a future China with similar levels of automobile ownership and use as those found in the west.

3.2 Issue 2: The Environmental Impacts of Automobile Dependence

Some research suggests that urban air pollution has exceeded even the national standard, sometimes by a few times, in most major cities in China. With better control of coal burning in industry through investment in environmental technologies and by moving factories away from city centres, the proportion of vehicle exhaust emissions has rapidly increased. Hook and Ernst (1999) report that transport is the fastest growing source of urban air pollution and is now responsible for 80% of CO, a majority of particulates and 40% of NO_x in major cities. A study in Beijing shows that CO concentration exceeds the national standard by over 100% and NO_x is exceeded by over 50% on some main roads. A linear pollution belt can be observed along these roads, especially in the warm seasons. In Beijing 79% of HC, 80% of CO and 55% of NO_x are from vehicle exhaust emissions (Xiang, 1995).

Of course, air pollution is only one of the environmental impacts associated with burgeoning car ownership and use. Others include growing noise, major local traffic impacts in terms of severance of neighbourhoods, vibration effects on buildings and the sheer space consumption and intrusion of motor ve-

hicles into the public realm, which adversely affects interaction in public space and traditional community in Chinese cities. Such issues constitute major tensions within a society embarking upon a new era of motorisation.

3.3 Issue 3: Finding the Oil Needed to Feed Huge Numbers of Vehicles, and the Cost of This in the Next Century

If the number of private cars increases to 13.2 million by 2010 as some have predicted, oil consumption would greatly be increased. China would have to import a significant amount of oil from the international market. According to a study by Campbell and Laherrere (1995), the global peak in cheap oil production will occur in the first ten years of this century and production capacity will then begin declining. Thereafter world oil production will halve every 25 years. Some questions, which China will therefore need to consider, are: Where would China get the vast quantity of oil required? Is it wise for China to compete with other countries for oil on the international market at a time when prices are likely to rise significantly? How much would it cost? Is it worth doing?

Considering that the per capita use of private passenger transport energy in Guangzhou, Shanghai and Beijing, averaged only 2,498 MJ (megajoules) per person in 1995 compared to 60,034 MJ in US cities, auto dependence is a major energy issue for China to confront. Again, answers to these questions are likely to be painful.

3.4 Issue 4: Urban Liveability

It might be expected that the process of motorisation would begin to have a relatively large impact on the traditional, dense and compact Chinese city with its vibrant urban life and long cultural and architectural heritage. As in Europe in the 1960s, this process of declining public livability of cities may have some moderating effect on the rush towards motorisation (e.g. see Kenworthy, 1990).

4. Policy Implications

4.1 Land-Use Constraint by the Land Management Law

The Land Management Law of the People's Republic of China, which was enacted on December 29, 1988, is one of the four national fundamental laws defined by the Constitution in China, which take precedence over other laws and regulations.

In chapter 1, clause 1, it states: "According to the Constitution, this law is formulated in order to enhance land management, safeguard land's socialist public ownership, protect and exploit land resources, reasonably use the land, strictly protect the arable land, and promote social and economic sustainability."

In chapter 1, clause 3, it states: "Very esteemed and reasonable use of the land, and strict protection of the arable land is one of the fundamental strategies of the country. Every level of local government should adopt measurements, integrate planning, tighten management, protect and exploit land resources, and restrain illegal occupying behaviour on land."

The Land Management Law of the People's Republic of China is designed to prevent massive urban sprawl as has occurred in America and Australia, and also restrains excessive use of land for transport infrastructure. This is one of the major differences between Chinese cities and some other Asian cities.

4.2 Urban Planning Law and Regulations

The Urban Planning Law of the People's Republic of China, which was enacted on December 26, 1989, is another important law that enables urban planning to be consistent with the national fundamental laws, and also ensures the implementation of urban planning principles. There are a few special regulations under the urban planning law, which are important to understand.

As has been explained, Chinese cities are traditionally high density and mixed in their land-use. There is no evidence to show that Chinese cities (except in remote areas) would be allowed to reduce

their density to a medium or significantly low level to accommodate cars. Indicators in tables 7, 8, and 9 explain how urban planning is controlled in China in practical terms.

Table 7 sets out the standard for per capita "construction land" for different grades of urban development. "Construction land" includes residential land, commercial and public facilities land, industrial and manufacturing land, warehouse land, transport and public squares land, municipal utilities land, green land, and special purpose land. These are defined in the Urban Land-Use Classification and Code, and the Urban Land-Use Classification and Planning Land-Use Standard.

According to the regulation, the planned per capita land-use should be in context with both the present per capita land-use level and the defined grade of the city with a permitted range in which adjustments can occur. The grade definition is specified by the Urban Land-Use Classification and Planning Land-Use Standard (GBJ 137-90), which is published in the State Standards of the People's Republic of China. It defines that new urban development should normally be regarded as Grade 3, but in land constrained areas, it should refer to Grade 2. For the capital city and some special economic zones, such as Shenzhen and Haikao, Grade 4 is recommended. Grade 1 is usually used for old and dense central city areas where land is extremely limited.

Tables 8 and 9 provide more details in four major urban land-use categories: residential land, industrial land, roads and public squares land, and green land. Table 8 gives the permitted ranges of per capita land-use of the above four categories. Table 9 defines the permitted ranges of land-use in each category in percentage terms.

Following the above regulatory requirements, the density of urban development in China would generally not be allowed to be lower than 100 persons/ha. Newman and Kenworthy (1999) explain that 100 person per ha or more is typically associated with "walking cities", certainly not heavily auto-dependent cities. Although, the

data in table 1 show an 11% decline in urban densities from 1990 to 1995, based on official data, the following points should be noted.

First, the density in the central area of some large cities was too high. Some areas in Shanghai were over 500 persons per ha. Some cities such as Ningbo nearly rebuilt the whole central area to provide better facilities such as a large city square and central city gardens, making the city more liveable. These changes would have caused some downward tendency in density in the interests of enhanced liveability as incomes have risen, although they would also have reduced mixed land-uses and permitted greater space to be allocated to the car, to the likely detriment of walking and cycling.

In addition to this, most Chinese cities experienced significant development in the 1990-95 period, as a result of economic liberalisation by Deng Xiaoping in 1992. This resulted in rapid increases in the built-up area for many large cities. Counter to this, however, the "true" population of these cities is not recorded, because many new residents flooding in from rural areas as a result of policy liberalisation, were outside of the registration system. Most cities had 10 to 20% "floating population", especially the coastal and large cities, and the proportion in 1995 was larger than in 1990. It was estimated that Shanghai may have had 2 million people excluded from the statistical system in 1995, more so than in 1990. The true density of Shanghai (and other cities) in 1995 is therefore closer to the density in 1990 than it appears to be (table 1). Guangzhou and Shenzhen may have the highest percentage of "floating population" because of economic development and a more open population policy.

In terms of land-use for roads, the Ministry of Construction rules that main roads should be between 30 and 60 metres in width, which consists of motor vehicle lanes, non-motor vehicle lanes, and footpaths. The secondary trunk routes should be between 24 and 40 metres, including 2 to 4 motor vehicle lanes. The local roads should be between 15 and 20 metres including 2 to

Present per capita land use level (m ² /person)	Planning per capita land use		Permitted adjustment range (m ² /person)
	Grade	Per capita land use (m ² /person)	
≤ 60.0	1	60.1– 75.0	+0.1–25.0
60.1–75.0	1	60.1– 75.0	>0
	2	75.1– 90.0	+0.1–20.0
75.1–90.0	2	75.1– 90.0	no limitation
	3	90.1–105.0	+0.1–15.0
90.1–105.0	2	75.1– 90.0	–15.0–0
	3	90.1–105.0	no limitation
105.1–120.0	4	105.1–120.0	+0.1–15.0
	3	90.1–105.0	–20.0–0
>120.0	4	105.1–120.0	no limitation
	3	90.1–105.0	<0
	4	105.1–120.0	<0

Source: State Standard of People's Republic of China. Urban Land-Use Classification and Planning Land-Use Standard, Ministry of Construction, March 1, 1991

Table 7: Standard of per capita land-use in China.

3 motor vehicle lanes (Ministry of Construction, 1994). The regulations also provide some options for road surface allocation for different users. It seems that footpath and non-motor vehicle lanes are usually recommended to account for half the width of main roads. Footpaths are also emphasised in lower level roads.

4.3 Environmental Law and the National Ambient Air Quality Standard

Although it is difficult to meet reasonable standards of air quality in some

	m ² /person
Residential Land	18.0–28.0
Industrial Land	10.0–25.0
Roads and Squares	7.0–15.0
Green Land	≥9.0

Source: State Standard of People's Republic of China. Urban Land-Use Classification and Planning Land-Use Standard, Ministry of Construction, March 1, 1991

Table 8: Permitted ranges of per capita urban land-use (m²/person).

	%
Residential Land	20–32
Industrial Land	15–25
Roads and Squares	8–15
Green Land	8–15

Source: State Standard of People's Republic of China. Urban Land-Use Classification and Planning Land-Use Standard, Ministry of Construction, March 1, 1991

Table 9: Permitted ranges in the percentage of urban land allocated for different uses (%).

Chinese cities, the Chinese government is currently making efforts to ensure air quality improvement and that existing air quality regulations are more respected. In practice, air pollution in many Chinese cities is quite serious and increases in motorisation make it more difficult to control. However, recently there have been some important advances in control of emissions from vehicles in Beijing, requiring more stringent emissions controls on cars manufactured in China (Hook and Ernst, 1999).

4.4 Public Transport Policy

Government reports and documents show that the Chinese government has been trying to promote public transport development, though financial difficulties have slowed down the process. A statement issued by the State Council in 1985 urges that: "For passenger transport in big cities, the principle of developing track-transport should be adopted. It is difficult to solve the transport problem by relying on current buses, trolley buses and limited roads. Rather we must 'go up towards the sky and down underground' and realise multiple-level, multiple-structure 'stereoscopic' transport systems."

The Ministry of Construction also issued a Current Industry Policy for Carrying Out Of Urban Transport (CIPCOUT) in 1990, following the above document. The CIPCOUT further emphasises the importance of urban public transport planning, and requires that transit be integrated into urban planning. The Ministry of Construction then formulated Design Regulations for Stops, Stations and

Factories of Public Transport in order to improve the effectiveness of public transport planning. Subsidies and some priorities, including supply of fuel and other raw materials at lower prices, are given in order to maintain effective transit operations. Ownership reforms are also gradually being introduced.

More importantly, new urban rail systems are about to be launched in the next decades. Although only Beijing, Tianjin, and Shanghai had built subways by 1995, local governments are enthusiastic about rail systems. As of 2000 over twenty cities have lodged applications for rail projects, though the planning department of the central government is still cautious in ratification because of the huge amount of capital investment required, as well as the general requirement of national macroeconomic control. It is said that the central government's attitude towards rail transport can be described as "both fondness and heavy-heartedness" (City Planning Review, 1995, No. 1, p.25).

4.5 Summary

The major evidence concerning the possibility of future growth in automobile dependence distinguishes Chinese cities from Bangkok and some other developing Asian cities, in that China has clear and strict national laws and regulations to secure the control of urban development. China's centrally planned economy, though relaxing to some extent, has its advantages in some circumstances, especially in its potential capacity to integrate planning of land-use and transport in cities.

5 Towards Sustainability of Transport in Chinese Cities

5.1 Private Cars

Although the major urban policies in China intend to maintain high density and mixed land-use, and to encourage walking, cycling, and public transport, as in many other places, a variety of policy conflicts always exist. Integrated transport planning and urban management are evolving in China, as they are in the west.

It is not hard to understand a government department's position, which is responsible, for example, for the national machinery industry, wanting to promote and protect a national automobile industry. A casual glance to the east reveals some of the economic successes which can flow from a healthy automobile industry.

However, the national Automobile Industry Policy, which was propounded by the former Ministry of Machinery Industry, encountered resistance from some local governments, urban planners, researchers, and other departments once it was released via the media. It was formally reviewed in a symposium organised by the Urban Sciences Association of China on March 17, 1995.

Liu Jun, the director of the Department of Motor Vehicle Industry in the Ministry of Machinery Industry, addressed the initial thinking of the document. She said that automobile industry development is an inevitable result of economic growth, which has been proven from the experiences of a number of other countries in the world. She also asserted that the national economy is under pressure to choose appropriate "pillar" industries. She quoted the case of Japan to explain that a "large population and lack of land" is not a limitation for "Private Car Entering Family". Meanwhile, it is viewed as time to foster a national industry to compete with foreign companies entering the potentially vast Chinese market. Liu's opinion expresses the perceived economic and political realities behind the document.

Following Liu's speech, some researchers questioned how Chinese cities could accommodate so many automobiles when present urban transport issues are already serious. Zhao Jianing, a deputy director of the Department of Urban Construction in the Ministry of Construction, addressed the limitations of automobile development in Chinese cities. His speech represented the views of most planners, as well as the Ministry of Construction.

It is obvious that opinions over the automobile are still not consistent, even among central government departments

in China. Nevertheless, the automobile industry policy has become rather less prominent since it was released, with pressure from national and international organisations. The Far Eastern Economic Review reported that China had: "ceased calling its car industry a 'pillar' of the economy. The move came during an annual four-day economic plenum attended by the top leadership [...]. Sources say plenum participants allowed the car industry's status to crumble after it became obvious that the goal of an affordable car for all families would mean national gridlock" (TFEER, 1996).

It can be said that the car in itself is not a devil, it is a convenient means of private transport when used appropriately. The problem for China, and indeed all other nations, is how to deal with the issues raised by mass car ownership, and increasing dependence on the automobile to the detriment of other modes. A proper balance of modes must be found in all cities to ensure sustainability and to protect liveability. It is particularly important for the Chinese government to integrate the various economic and planning policies towards the automobile at an early stage. This has been the basis of Singapore's success at controlling car ownership and use to comparatively low levels while still advancing economically.

A potential major problem that China will face in this regard is the recent World Trade Organization agreement (November 1999). Under this agreement, China has been effectively forced by western nations to accept overseas non-bank lending institutions into the country with the express purpose of providing access to credit for motor vehicle purchases (The Chinese Herald, November 22, 1999, p. 5). In this sense it is somewhat ironical for western nations to express grave concerns about motorisation in China, and at the same time be facilitating changes that will make this more likely to happen.

5.2 Walking and Cycling

High density and mixed land-use, especially with a high degree of "work unit" provided houses, arising from the previ-

ous economic era, make non-motorised modes particularly convenient in Chinese cities. Home and work in these environments are often tightly linked.

As mentioned previously, modal choice in favour of the bicycle in Chinese cities is strongly related to trip distance and the physical condition of users. Bicycles are an ideal mode for travel between 5 and 30 minutes. Because of high density and compact urban forms, the sizes of most Chinese cities are within these travel time ranges.

Other reasons for the popularity of bicycles in Chinese cities are the poor provision of public transport and the low cost of bicycle operation. As discussed previously, public transport is overcrowded especially in rush hours. It is reported that 52% of bus ridership in Chinese cities is in peak hours (6:30 to 8:30 and 16:30 to 18:30). Passenger boardings on buses sometimes reach 13 people per square metre in peak hours (Wang, 1995). This inevitably makes cycling the favourite mode for commuting. The government subsidised bicycle commuters in the 1970s and 1980s when oil supply was constrained in the country. Even at present, bicycle costs are still lower than any other mechanical modes. The price of a typical new bicycle is around US\$50, half of an average month's salary, with up to ten years' life. It is also easy to maintain and to park. If door-to-door time is considered, the bicycle is usually faster than buses when making up to a 5 kilometre trip. Cycling, as a convenient and healthy mode of transport, is still likely to be extensively used in the future. On the other hand, the bicycle is inconvenient on rainy or windy days, and is apt to be stolen, so that there is a need for other options at certain times.

Integrating cycling and public transport is a feasible and effective strategy. Both these modes have their unique strengths and weaknesses. Together they can or could offer competitive performance over the private car for most trips. Better facilities such as bicycle-transit exchange hubs around transport stations in association with commercial services could attract more people to

transit, convert long-distance bicycle commuters, improve transport efficiency, and relieve road traffic pressure.

On the negative side recent main road development in major Chinese cities is focussed on building overpasses for pedestrians and cyclists. This results in more difficulties, especially for children and elderly people, and also creates visual intrusion. There seems to be little doubt that Chinese cities, which have been shaped by non-motorised transport, will need to enact policies that protect the important role of these modes if they are to avoid major future problems.

5.3 Public Transport

High densities create sufficient concentrations of activities for an effective, frequent public transport service (Newman and Kenworthy, 1996). Despite this positive land-use framework in Chinese cities, providing better public transport is actually a key issue in Chinese urban transport. An integrated transit system could decrease cases of very heavy bicycle traffic, reduce private transport, and therefore increase road efficiency. In order to realise the goal of better transit systems, some issues need to be reviewed.

Firstly, the bus fleet could be relatively easily increased in the early stages of public transport development when high capital investment for rail systems is still difficult. Limited bus capacity is one of the reasons for poor service provision. Secondly, bus priority should be given. This priority includes specified bus lanes and bus activated traffic lights. It is common in Chinese cities to see buses caught in congestion and many people waiting at stops. With priority, buses can run faster and more efficiently, which makes them more reliable and therefore more attractive.

Thirdly, it is important to integrate public transport with other transport modes, as described above. This will allow a greater variety of connections to be made and greater flexibility for the non-car user.

The fourth issue is to reduce the number of staff and to make transit systems more cost efficient. Table 10 shows the average number of staff for every bus is

	Number of			Income (million CHN\$)		Costs (CHN\$/1,000 km)	
	Buses/ Trolley Buses	Staff	Staff per Bus (average)	Ticket Income	Government Subsidy	Annual Cost	Fuel Cost (estimated)
Beijing	5,378	58,410	11	362.60	212.10	1661	550
Shanghai	6,562	86,325	13	611.30	187.00	1750	580
Hangzhou	779	7,648	10	47.85	13.06	1565	570
Tianjin	2,063	23,193	11	85.00	61.00	1326	550
Shengyang	1,261	9,485	8	38.50	17.90	1192	600
Wuhan	1,523	20,092	13	112.90	21.60	1205	600
Ningbo	207	1,983	10	14.84	2.48	1083	490
Average	2,539	29,591	12	-	-	1397	563

Source: Public Transport Association of China (1992)

Table 10: Staff numbers and operational costs in bus companies in Chinese cities (1991).

12, compared to 2 to 4 in developed cities (APTA, 1991). It is suggested that savings from the large amount of salary spending could help to finance the vehicle fleet update and expansion in Chinese cities.

The fifth and final issue is to increase ticket prices. Chinese bus tickets are perhaps the cheapest in the world. The average rate is less than US 0.5 cents per passenger km, compared to US 1.7 cents in Manila and US 6 to 9 cents in Australia, America and Europe (Kenworthy et al., 1997). The main reason behind the low price is not the low quality of service provision but political unwillingness to do something that is likely to be unpopular.

Xiamen's success demonstrates that transit can be operated very well in Chinese cities. In this medium size city, the bus fleet was doubled, bus lines increased from 8 to 28, passenger boardings increased from 70 million to 170 million, revenue increased from CHN\$ 1.25 million to \$6.08 million, and all this happened in three years without any subsidies from the government (Zi and Gong, 1996).

In the context of the built form of Chinese cities, it seems imperative that there be continuing improvements to public transport, especially the eventual development of good urban rail systems.

6. Conclusion

The growing trend towards motorisation in Chinese cities presents a number of important opportunities and challenges, both for the cities themselves and potentially for the global environment. For

Chinese cities, automobiles mean a whole new way of life for the residents of the world's most populous country, offering levels of personal mobility previously unthinkable. For global car manufacturers, China offers one of the biggest markets in the world. The benefits will, however, exact a toll on the urban environment and the quality of public spaces and human interaction in Chinese cities, as the automobile has in countless other cities. Accommodating the automobile will also have big impacts on China's land supply for agriculture and on its economy through a whole range of new costs. For the global environment, China's potential demand for oil and its rising greenhouse contribution are major uncertainties.

Chinese cities need, however, to be understood in an international context before the sceptre of unbridled automobile dependence, as exhibited in the US, is accepted uncritically. When a detailed analysis of Chinese cities is carried out the data reveal urban environments of very high density and mixed-use urban forms. It also reveals levels of car ownership and use that were in 1995 very low by world standards, though with evidence that they are increasing rapidly, with very little physical or economic constraints being imposed on this process. Non-motorised transport was still very strong in 1995, though space for pedestrian and bicycle movement is under enormous pressure, especially from political leaders in cities who see the bicycle as a symbol of backwardness. Public transport usage in 1995, by international standards, was still high, although this predominantly consists of captive riders, not

choice riders. Such captive riders will all too readily switch to motor cycles and cars as their growing incomes allow them to escape the crowded conditions and slow and unreliable services of public transport systems based mainly on buses. Chinese public transport systems are significantly constrained in their fleet capacity and service levels and do not have a high proportion of services provided on reserved rights-of-way (i.e. dedicated busways and rail systems).

Analysis of the urban planning policy context in China does reveal a strong planning tradition, under a centrally planned economy. However, economic liberalisation is placing enormous pressure on the land-use controls previously exerted by the planning system and these controls are not very well-coordinated with transport. Much new development will require significant use of motor cycles, private cars and taxis, rather than public transport systems.

It is still an open question if the Chinese planning tradition will be strong enough to prevent or reverse severe negative impacts of motorisation, which are already beginning to be quite evident throughout many Chinese urban centres. Critical to the future will be the institutional capacity and willingness of China's planners and decision-makers to control the use of land in ways they have done in the past and to better link urban development with improved public transport systems. In this respect there will also be a need to balance investment in new high capacity road infrastructure with investment in improved bus systems and new rail systems, or even to prioritise public transport systems above road investment. According to 1995 data in Kenworthy and Laube (2001), Chinese cities are second only to North American and Australian cities in the ratio of road investment to public transport investment. An average of twice as much was spent on roads than on public transport over a 5-year period from 1991 to 1995, so the pendulum has some way to swing back. Furthermore, it will also be essential to have strong space sharing policies that allow non-motorised modes to dwell alongside cars in a way that they can continue to

flourish safely and contribute to access, mobility, energy savings, air pollution and noise reductions, and healthy urban community. This will mean resisting the removal of generous bicycle lanes and footpaths for parking and road widening.

Pressures to enact policies in favour of strict, coordinated land-use controls for new development, investment and planning priorities towards public transport and non-motorised transport properly integrated with urban development, and preservation of traditional high density, mixed land-use areas, are likely to encounter obstacles. They will have to be balanced or harmonised with China's apparent desire to have a strong automobile industry, WTO efforts to ensure that credit is freely available in China to purchase cars and the multiple influences of overseas car manufacturers eager to claim a stake in the Chinese automobile market.

Overall, it remains a significant challenge for Chinese planners and decision-makers to ensure that the many positive land-use and transport qualities of Chinese cities are protected against the excesses of automobile dependence, while still reaping the full benefits of rapid economic growth. The international data comparisons of urban transport also show, however, that Chinese cities are still amongst the least auto-dependent in the world. It is western cities, especially those in the United States, who have the biggest potential to reduce their already extraordinary levels of automobile dependence and global resource consumption. Unless this point is recognised, studies and concerns about motorisation in China, may remain somewhat distorted.

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[1] Though the Chinese system is somewhat unique, the problems faced here with regard to specifying data on an urbanised area ba-

sis are similar to those in other cities. For example, although the US Census has a reporting category called Urbanized Areas and publishes a lot of data on this, much essential transport data do not relate readily to this, and one has to accept data for the Counties within which the urbanised areas fall as being reasonably representative. In Australia, the cities are specified as "metropolitan statistical divisions" and include a lot of non-urban land. Urbanised land area is not readily available and there is virtually no data at all published on the basis of actual urbanised area. Urbanised land area must be gleaned from the planning authority's GIS operators in each city. In Europe it is easier to specify the urbanised land area within different metropolitan regions because there is nearly always a good land-use inventory available. However, most data refer to the whole metropolitan region and it is virtually impossible, for example, to get vehicle registrations or road length or any other transport item just for the urbanised component of the region.

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