

TOWARDS SUSTAINABLE URBAN TRANSPORTATION SYSTEM IN CHINA: ISSUES AND CHALLENGES

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Abstract:

Urban transport issues are of growing concern in many places around the world, with enormous environmental and social impacts increasingly threatening the urban quality of life. Sustainable transport issues are nowhere as critical as in those Asian cities with very high rates of economic growth. Since China adopted economic reform policy in the early 1980s, cities in China have gained mammoth development momentum i.e. economic and social growth and as a result the Chinese people have desired more mobility and space for living. Rapid urbanization has become a trend along with socio-economic development. Cities are becoming larger, and the concentration of urban population is becoming higher. This results in spatially separated land uses and lower accessibility of goods and services, especially as road demand overruns supply and the transportation network becomes congested. Additionally, urban air pollution will continue to rise as transportation mode shifts from transit and non-motorized modes to the personal automobiles. Rapid economic growth and urbanization have brought a greater than ever challenge for the Chinese urban road transport sector. The question is then, how China will be able to address and combat the issues and challenges of urban transportation system to keep pace with socio-economic development and increasing auto-ownership. This paper is an effort to investigate the issues and challenges towards sustainable urban transportation system in China based on existing literature and it also identified some Chinese cities that have taken approaches that could alleviate some of the transportation problems in other cities of China. The paper also provides some references of successful experience of cities in Asia, Europe and North America where the city authority adopted innovative measures to address urban transportation problems which can be replicated in some form or other in case of Chinese cities.

Key Words: Sustainable Transportation, Motorization, Auto Ownership, Public Transport, China.

1. INTRODUCTION

Chinese cities are acknowledged worldwide as being the leaders in non-motorized 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 motorization and a number of policies and factors that are pushing their transport systems towards greater reliance on cars and motor cycles (Kenworthy and Hu, 2002). Since China adopted its economic reform policy in the early 1980s, cities in China have gained great development momentum while China's economy has kept an average annual growth rate of 8–9%. The number of cities in China has reached 663 by 2000. Rapid urbanization has become a trend along with economic development. Cities are becoming larger, and the concentration of urban population is becoming higher. The number of residents in Beijing for example, has climbed from 5.8 million in 1985 to 11 million in 2000. Data in 2000 revealed population density in Beijing averages 654 people per square kilometer, reaching 27,300 people per square kilometer in the central area (Zhang, 2001). Fast economic growth and urbanization have brought a greater-than-ever challenge for the Chinese urban road transport sector. The question is then, how China will be able to meet the increased demand for urban road transportation. Sustainable urban road transport appears to be the only approach, given the resource and environmental carrying capacity constraints. Based on existing literature, this paper is an effort to investigate the issues and challenges towards sustainable urban transportation system in China and it also identified some Chinese cities that have taken approaches that could trim down some of the transportation problems in other cities of China. The paper also provides some references of successful experience of cities in Asia, Europe and North America where the city authority adopted innovative measures to address urban transportation problems which can be replicated in some form or other in case of Chinese cities.

2. SUSTAINABLE URBAN TRANSPORTATION DISCOURSE

There is no universally accepted definition of 'sustainability', 'sustainable development' or 'sustainable transport' (Beatley, 1995). According to Transportation Research Board of Washington DC "sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation" (TRB, 1997). The most widely quoted definition of sustainable development is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainable development is the achievement of continued economic development without detriment to the environmental and natural resources (Elliot, 1993). If future equity and environmental quality are concerns, it makes little sense to ignore equity and environmental impacts that occur during this generation in distant places (Litman and Burwell, 2001). So far, there has not been an authoritative interpretation on sustainable development. Efficiency and equity (for both intra and inter-generation), however, are often regarded as the major indicators of sustainable development (Zhang and Hu, 2003).

If we look at the literature about sustainable transportation, there are different notions and perspectives in this very issue. Sustainable Transport Coalition defines 'sustainable transport' which

interestingly complies with the definition that is developed by the Canadian Centre for Sustainable Transportation: A sustainable transportation system is one that: i. allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations; ii. is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; and iii. limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise (<http://www.stcwa.org.au>).

The goal of sustainable transportation is to ensure that environmental, social, and economic considerations are factored into decisions affecting transportation activity (MOST, 1999). A sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environmentally friendly mode of transport (Mohan and Tiwari, 2000). Liu et al. (1999) tend to believe that the goals of sustainable urban transport development are: i. to meet necessary demand for transport service; ii. to reduce the reliance on petroleum; iii. to avoid negative environmental consequences; iv. to reduce the reliance on non-renewable energy sources; and v) to reduce the cost of infrastructure construction. On the other hand, Pang (2001) lists the main elements of sustainable urban transport development as: i. balanced supply of infrastructure, equipment, and management and demand of the society for transportation services; ii. rational use of limited resources; iii. reduced consumption of non-renewable resources by changing consumption mode; iv. avoided environmental and ecological degradation; and v. equitable allocation of transportation facilities among the society.

So far, there has not been a well-established definition of sustainable urban transportation. Zhang and Hu (2003) noted that, like sustainable development, sustainable urban transportation should also, in essence, embrace the major concerns about economic efficiency and intra-generational and inter-generational equity. Specifically, sustainable urban transportation should include at least following elements: i. an ability to meet the necessary demands of urban residents for transportation services; ii. economic efficiency and environmental soundness; iii. adequate attention paid to the socially disadvantaged; and iv. integration with urban planning.

3. PROBLEMS AND CHALLENGES OF URBAN TRANSPORTATION IN CHINA

Since the 1990s, the Chinese economy has been growing very fast, accompanied by a corresponding increase in travel demand. As a result of the economic boom, urban development has taken place at an unprecedented speed, including the expansion of built-up areas into suburbs and redevelopment within historical central areas. Urban economic development has attracted huge number of surplus manpower from rural areas, giving rise to a dramatic population increase in most cities. Apart from population increase and economic growth, the increase in travel demand is also a result of several other factors. Urban expansion and land use reconfiguration have broken the traditional balance between jobs and housing, i.e. the Dan Wei system, where people live near their work places (Shen, 1997). Encouragement of the auto industry by central and local government has provided further impetus to the travel increase, and the number of automobiles has been mounting dramatically in urban areas. In this part of the paper, some of the burning issues towards sustainable urban transportation are discussed based on existing data and information.

3.1 Poor Institutional Arrangement

China's early transportation development was focused on connecting all parts of a much divided nation. Policy makers were focused on opening communication lines between all provinces and major cities. As a result, the highway planning department was placed under the Ministry of Communication. Likewise, the Ministry of Railways is responsible for inter-city passenger and freight rail travel. These Ministries are the most founded and strongest institutionally because of their longer history and importance during China's early development (Cherry, 2005).

China established a planning policy of social and spatial integration at an urban level, which resulted in very mixed income communities with short distances between work and home. However, little infrastructure was developed and it was mostly built for non-motorized modes. With rapid motorization and spatial separation, China's institutional structure is unable to manage regional interaction. Transportation planning is a completely different institution under the planning commission, construction bureau, public security and finance. There have been several criticisms of Chinese transportation institutions and strategies.

Gaukenheimer (1996) identified some of the major issues confronting Chinese transport related institutions, which are as follows:

- Traffic and vehicle registration management: parking policy, registration limits;
- Pricing policy: transit, auto purchase, registration, parking, vehicle operating cost;
- Financial regime: determine finances transport-users, land owners, developers, and/or public agencies;
- Linked land use policy to transportation; and
- Institutional development: develop larger inter-institutional planning agencies.

China's transportation institutions are based on systems that are becoming obsolete as the country urbanizes, cities become spatially separated, and the desire for personal mobility drives the modal options of the Chinese people. Regional planning is essential to the development of efficient and sustainable cities. Additionally, linkages between land use and transportation must be considered when making transportation planning decisions and these agencies must be coordinated (Cherry, 2005).

3.2 Unhinged Growth of Motor Vehicle and Infrastructure Construction

The growth in urban transport in China has been significant, which is due to increased economic activities and sustained high urban population growth. The total civil motor vehicle population reached 16.08 million in 2000 with an annual growth rate of 11.3% during the 1990s. The total civil motor vehicle population in Beijing increased from 0.34 million in 1992 to 1.04 million in 2000 with the annual growth rate of 14.9%. In Shanghai, the biggest city in China, the civil motor vehicle population growth rate was 11.8% during the same period. In some cities, the vehicle population growth rate exceeded 30% (Zhang and Hu, 2003).

In the same note, urban transport infrastructure construction also showed rapid development over the past decade. For example, in Shanghai, 13–29% of the city's investment in infrastructure was put into the transport sector over the past decades. As a result, urban road transport infrastructure

in Shanghai gained a sustained development momentum. A similar trend is seen in Beijing and Shenzhen. However, the growth of urban motor vehicles has been much faster than that of urban road construction. This unhinged growth of motor vehicle population and transportation infrastructure is a major contributor to severe traffic congestions in Chinese cities.

3.3 Declining Public Bus Use vs. Increasing Use of Private Cars and Taxis

In the recent past, there has been an upsurge in the number of private vehicles, especially private cars, in some large cities in China. The rapid growth in the private vehicle population has been a major driving force in China's civil motor vehicle growth, and also an important contributor to urban transport congestion. In 2000, the number of private vehicles reached 6.25 million, of which 3.04 million were private cars. The average growth rate in the number of private cars was as high as 31.3% over the past decade in China. There was 0.12 million motor vehicles added in Beijing by the end of June, 2002. This was 50.6% higher compared to the same period previous year, and approximately 90% of them were private vehicles. In Shanghai, 20,000 private cars were registered by the end of June 2002, 5,000 more compared with the same period of previous year. The population of private motor vehicles was 65,867 in 1996 in Shenzhen, and the figure was doubled by 2000 (Li, 2001).

Conversely, there has been a relative decline in public bus usage and an increase in taxi usage in large cities. The share of conventional buses in the total passenger vehicle usage decreased from 97% in 1996 to 55% in Shanghai, while that of taxis increased from 2.33% in 1991 to 20% in 2000. In Beijing, the taxi population increased from 11,147 in 1990 to 65,127 in 2000 with an annual growth rate of 19% (Zhang and Hu, 2003). This kind of switch in modal split behavior has resulted in increased traffic congestion and pollution, as well as putting the socially disadvantaged in a more unfavorable position.

3.4 Insecurity in Energy Supply

With rapid increase in vehicle population energy consumption in transport sector is increasing as well. Energy consumption in China's road transport sector increased from 36.4 million tce in 1990 to 93.6 million tce in 2000. The average growth rate was about 10% each year during the past decade. Gasoline consumption increased by 8.28% on average, while diesel increased by 14.93%. Approximately 85% of gasoline output and 20% of diesel output was consumed by motor vehicles in 1999 in China (SETC, 2001). The oil consumption of motor vehicles in 2005, 2010, and 2015 is projected to be 51.75 million tons, 59.84 million tons and 73.14 million tons, respectively, even taking into account of significant improvement in road traffic condition, fuel quality and vehicle performance. Currently China's oil output is about 163 million tons each year, and there will be no significant increase in production in the future. This is to say that civil motor vehicles will have consumed nearly half of China's oil output in 2015 or the total oil import in 2000. Another projection shows that the oil consumption of motor vehicles would reach 150 million tons in 2020. In that case, the oil consumption of motor vehicles alone would be equal to China's oil output, making China's oil consumption much more dependent on the international oil market (Zhang and Hu, 2003). China is the second highest consumer of oil in the world (behind the United States). If China motorizes as rapidly as expected, the increase demand of fuel could cause the global price of fuel to skyrocket

(Cherry, 2005).

3.5 Environmental Pollution Issues

In China, capital city Beijing has the largest motor vehicle population. The growth of motor vehicles in Beijing has also been the fastest among Chinese cities. In Beijing, the major pollutants from motor vehicles are CO, HC, NO_x, and particle matter (PM). According to Beijing Environment Protect Bureau, of the 1.1 million light motor vehicles, only 0.43 million or 39% could meet the city's standard on motor vehicle emissions in 2001. For heavy motor vehicles, the percentage was only 8% (Li, 2001).

In 1998, a survey conducted in Shanghai demonstrates that each index of air pollutants from motor vehicles exceeded the standards at more than 20 major measured intersections. Among the measured locations, 30% were heavily polluted, 65% polluted to a great extent, and only 5% lightly polluted. In addition to local environmental pollution, transportation sector is also a major CO₂ emitter, as most fuels consumed in the sector are fossil fuels. In 1990, the transportation sector contributed 5.66% of China's total CO₂ emission (Zhang and Hu, 2003). From a global perspective, China's motorization could have adverse effects on the global climate. Currently, the transportation sector accounts for 17% of the greenhouse emissions globally, but this proportion could increase significantly if the motorization trends continue (Cherry, 2005).

4. TRANSPORTATION POLICY INITIATIVES IN DIFFERENT CHINESE CITIES

Some of the Chinese cities have taken different approaches to confront their transportation challenges (Figure 1). All cities seem to identify that uncontrolled growth of auto ownership and use will result in economically debilitating congestion and pollution. As a result, different cities have adopted different strategies to control congestion and auto use. Most research has investigated the transportation systems in Beijing and Shanghai, the economic engines of China. These two cities have high economic productivity and incomes (relative to other cities in China), and as a result have very high auto ownership rates compared with other cities in China. They also have two major events in their hand, that are spurring major infrastructure improvements, the 2008 Olympics in Beijing and the 2010 World Expo in Shanghai (Cherry, 2005).

4.1 Decline in Non-Motorized Vehicle Use

One of the policy approaches is to use the existing roadway network in the most efficient manner. From a capacity perspective cars are the least efficient users of road space. Compared to a single car, a roadway lane can carry 4-5 times more bicyclists, 8-10 times more pedestrians and 15-20 times more transit riders (Shen, 1997). Despite these numbers, cities are beginning to restrict or discourage bicycle use. Lu and Ye (1998) stated that bicycles are poor users of road space, citing that bicycles account for only 20% of the person-km traveled in Shanghai, but use 40% of the road space; transit accounts for 40% of the person-km, using 20% of the road space and "other modes" (cars) account for the remaining 20% of the person-km on 40% of the road space. Because of these numbers, planners have decided to restrict bicyclists in the city center of Shanghai, giving the roads fully to cars and buses. This policy, combined with improved public transportation is expected to

reduce bicycle traffic to 20% of its current level. Because bicycles are perceived as a less desirable mode and because they create challenging conflicts with auto traffic, there has been a concerted effort to shift bicyclists to transit modes. Many cities have begun to see reductions in bicycle mode share and increases in transit and auto mode share as they have invested heavily in transit and roadway infrastructure.

4.2 Auto Ownership

China has adopted a policy to encourage the development of an indigenous auto manufacturing industry. The conflict of planners is to develop sustainable cities and encourage responsible auto use while still promoting auto ownership. China's personal auto ownership is approximately seven vehicles per 1000 people, but there are distinct variations between cities in regards of auto ownership. Beijing has four to five times higher personal auto ownership rates than Shanghai, which are cities of comparable in size, average income and importance. Beijing's large population of taxis and company cars could inflate its statistic. Cities like Shanghai and Guangzhou (in Guangdong) have low auto ownership rates compared to cities like Beijing and Tianjin. This is an indication that auto ownership restraints, public transit efficiency, or urban form play an important role in the amount of autos purchased in these regions (Cherry, 2005).

4.3 Pro-transit Policy

Majority of the Chinese cities have identified high capacity transit as the solution to many of their urban transportation needs. In 1995, China established an urban public transportation policy that focused on investing in bus and urban rail projects. As trips become longer and activity centers become more spatially separated, modes must be developed that can compete with the automobile and provide mobility to populations that previously relied on non-motorized modes. As expected, cities with well developed public transportation systems, such as Beijing and Shanghai have high transit use. Identifying transportation and land use policy that encourage transit use might be an effective way to serve the public. However, many of these transit trips are a result of public policy to decrease bicycle use, not decrease auto trips. As a result, cities with high transit ridership might not be achieving sustainable transportation goals, as roads and transit can be a force towards decentralization, disadvantaging non-motorized modes and increasing the cost of transportation. Because of the increasing congestion on roadways and the decreasing effectiveness of mixed flow bus service, Chinese cities have been investigating improved exclusive right-of-way transit solutions including heavy rail, light rail and Bus Rapid Transit or BRT (Cherry, 2005).

Kunming, in cooperation with the Swiss transportation planners, developed China's first BRT demonstration project to reverse decentralizing auto oriented development strategies (Joos, 2000). This project was seen to be a great success and since then, many Chinese cities have developed or plan to develop BRT systems (See Figure 1). These systems are complementary to larger public transportation plans. The central government allows metro systems to be developed only in cities with populations greater than three million. Consequently, all 15 cities with populations greater than three million have developed preliminary plans to develop metro systems (Zhang, 2003). Shanghai and Beijing have the most comprehensive public transportation plans, in anticipation of the Olympics and the World Expo. Beijing plans to greatly increasing its mixed traffic bus service, construct 100 km

of BRT lines, and expand its metro system to 300 km by 2008. Shanghai plans to build 380 km of metro rail, 130 km of light rail, and 70 km of BRT. Additionally, Shanghai recently completed a 30 km Maglev train from the financial center to Pudong Airport (Zhang, 2003 and Chang, 2005).

4.4 Expansion of Highway Network

Historically, Chinese cities were not developed for auto uses; as a result, China's highway systems are underdeveloped in most urban areas. At the end of 2003, only 11% of the China's urban areas are devoted to roads, compared to 20-30% for most industrialized nations. Most Chinese cities have developed a ring road structure to provide circulation, mobility and access to all parts of the city. Highway construction has been intense in many urban areas, mostly on the periphery in an attempt to keep up with the rising demand for mobility and to curb severe congestion. In the case of Beijing, they built 1789 km of new roads between 1998 and 2003, including a 155 km expressway. They plan to invest \$250 million dollars per year for transportation infrastructure in preparation for the Olympics. Shanghai also has ambitious expressway building plans, extending its 60 km expressway system to 650 km (Zhang, 2003).

4.5 Transportation Policies and Technologies

In China, different cities are given some independence in decision making, as long as the policy decisions are consistent with the Central Government's social and economic goals. Many Chinese cities have developed innovative transportation policies and identified technological improvements that will presumably improve the efficiency of their transportation systems. Many of these policies and technologies are demonstration projects supported by outside agencies to identify their feasibility and effect on sustainability aspects. Depending on their success, these demonstration projects can be expanded to other cities in China.

Figure 1: Transport Policy and Technology Matrix of Chinese Cities

Name of the City	Policy								Operations Technology				Transit Technology				
	Bicycle Bans (core areas, major	Registration Quotas	Motorcycle/Moped Bans/Restrictions	Relocated Activity Centers: ports, major markets	Licensing Scheme	Freight or Truck bans/restrictions in	Informal Transit Bans	Eco-city management and planning	Ministry of Science and Technology (MOST) ITS Demo Cities	Operations: Bikes: separate left turn lanes: signal phases	ATMS/ATIS	Clean Fuel/CNG	BRT/Exclusive ROW	LRT-Trolley	Subway	Maglev	Monorail
Anshan														x			
Beijing	x		x		x	x	x			x	x		x	x	x		
Changchun														x			

The mega cities around the world are seeking for different transportation management measures to combat the problem with congestion, environmental pollution, inadequate infrastructure etc. As Chinese cities are growing both in size and motor vehicle population, it is an utmost concern for city planners and policy makers to devise some mechanisms to combat the transport management and to address sustainability issues of urban transportation. In this note, this paper reviewed few measures, which were taken in the cities of developing and developed countries for the better management of transport problems. It is quite evident that different city poses different unique problems and prospects; however, Chinese City managers could study the following transport management initiatives and incorporate them in some form or other to their own city transport planning and management.

5.1 Seoul

Seoul is the capital and largest city of South Korea. It has a population of 10.5 million, living within its city limits, making it the eighth most populous city in the world. However, with an area of only 607 km², it is also one of the smallest and most densely populated major cities. Seoul's population density has allowed it to become one of the world's most digitally-connected cities. It also has more than 3 million registered vehicles which often cause widespread traffic jams (<http://en.wikipedia.org/wiki/Seoul>).

In Seoul, the volume of passenger cars increased by 20% each year since 1985 which was primarily driven by the government's favored automobile industry policy and the fast economic growth,. Since 1996 the government doubled fuel tax and began to levy road congestion fees. These policies caused some residents to switch from private transport to public transport. The path-breaking reforms of July 2004 completely restructured bus services in Seoul and increased public control over routes, schedules, and other aspects of service. In addition, they integrated bus routes, schedules, and fares with the metro system, thus providing a far superior overall public transport system. Central to the reforms was the introduction of an entirely new system of BRT routes, with fully separate median lanes for express buses. In the first month of the reforms, there was tremendous disruption, confusion, public discontent, and political uproar. In spite of these temporary, transitional problems, the reforms appear to have become a huge success. Already by October 2004, almost 90 percent of Seoul residents expressed general satisfaction with the restructured bus services and new fare system. Average bus speeds increased by 33 percent to 100 percent in the BRT corridors. Total bus accidents and injuries on all routes combined (express and local) have fallen by about a third. The looming financial crisis of Seoul's public transport system was the driving force behind the drastic reforms of July 2004. Shortage of public funds continues to force Seoul transport planners and public officials to seek solutions that are as cost-effective as possible, providing the best possible service to the most passengers at the lowest possible fares and government subsidies. BRT appears to fit those requirements better than metro expansions or new LRT lines (Pucher et al., 2005).

Another successful story is that transportation planning in Seoul has been well integrated with urban planning. In the urban planning, new development areas have been built in the surrounding satellite towns. The center city with its advanced public transport system is linked with these satellite towns by a net of urban railways and roads (Zhang and Hu, 2003).

5.2 London

London is the capital of the United Kingdom and England. It is also the most populous city in the European Union. It is one of the world's major global cities. London has an estimated population as of 1 January 2005 of 7.5 million and a metropolitan area population of between 12 and 14 million. London's population includes an extremely diverse range of peoples, cultures, and religions, making it one of the most cosmopolitan, vibrant and energetic cities in the world (<http://en.wikipedia.org/wiki/London>).

Since February 2003, the city of London has charged a fee (on weekdays between 7:00 am and 6:30 pm are required to pay £5, increasing to £8 in July 2005) for driving private automobiles in its central area during weekdays as a way to reduce traffic congestion and raise revenues to fund transport improvements. There are some exemptions, including motorcycles, licensed taxis, vehicles used by disabled people, some alternative fuel vehicles, buses and emergency vehicles. Payments can be made at selected retail outlets, payment machines located in the area, by internet and cellular telephone messaging, any time during that day. Motorists can purchase weekly, monthly and annual passes with modest (15%) discounts. A network of video cameras records the license plate numbers of vehicles and matches it with the paid list. The owners of vehicles that have not paid as required are sent a £80 fine. This fine is reduced to £40 if paid within two weeks, and increases to £120 if not paid after a month - the same policy for parking penalties in the inner London area. The system is considered effective. Approximately 110,000 motorists a day pay the charge (98,000 individual drivers and 12,000 fleet vehicles), increasingly by mobile phone text message. Non-payment rates were high during the first few weeks, due to general confusion and errors but these declined as users and operators gain experience. This measure has significantly reduced traffic congestion, improved bus and taxi service, and generates substantial revenues. Public acceptance has grown and there is now support to expand the program to other parts of London and other cities in the U.K. This is the first congestion pricing program in a major European city, and its success suggests that congestion pricing may become more politically feasible elsewhere (Litman, 2006).

5.3 Seattle

Seattle is the largest city in the Pacific Northwest region of the United States. It is located in the U.S. state of Washington between Puget Sound and Lake Washington. As of 2005, the city had an estimated population of 573,000 and a metropolitan population of around 3.8 million. Seattle is the hub for the Greater Puget Sound region (<http://en.wikipedia.org/wiki/Seattle>).

In 1991, the Washington State Legislature passed the Commute Trip Reduction (CTR) Law requiring employers to work with employees to reduce the number and length of drive-alone commute trips made to the worksite. The City of Seattle and Seattle Department of Transportation (SDOT) encourage all commuters to use alternatives to driving alone to work. People, who ride the bus or use carpool, vanpool, or bike or walk to work, or even use tele-work arrangements, enjoy additional benefits from these modes. They also help to stem further air quality deterioration, reduce energy use, and put the brakes on traffic congestion in the Puget Sound area (<http://www.cityofseattle.net/waytogo>).

Seattle consistently has been rated one of the top spots in the country for bicycling. Not surprisingly, a substantial proportion of Seattleites use their bicycles for recreation or transportation. It is estimated that about 36% of Seattle's 520,000 citizens engage in recreational bicycling, and between 4,000 and 8,000 people use bicycle to commute in Seattle each day, depending on the time of year and weather conditions. SDOT has been working steadily toward developing an urban trail system to accommodate bicyclists. Urban trails include shared use paths, bike lanes, signed bike routes, arterials with wide shoulders, and pedestrian pathways. Seattle has about 28 miles of shared use paths, 22 miles of on-street striped bike lanes, and about 90 miles of signed bike routes (<http://www.cityofseattle.net/waytogo>).

SDOT initiated Seattle Transportation's Pedestrian Program, which works to improve pedestrian safety, and to encourage more walking by providing the facilities needed to walk comfortably. They assist in following activities for the convenience and safety of pedestrians: i. build accessible sidewalk curb ramps, install and maintain school crossing signs; ii. maintain, improve and install marked crosswalks; iii. install and maintain pedestrian crossing signs; iii. construct curb bulbs and crossing islands at pedestrian crossing locations; iv. rehabilitate and install sidewalks; and v. provide school walking route maps for Seattle's 60 public elementary schools (<http://www.cityofseattle.net/waytogo>).

6. CONCLUDING REMARKS

Most of the Chinese mega cities are facing challenges in managing urban transportation sector. The dilemma faced by today's transportation planners in China is to develop a transportation system that encourages auto ownership and promote sustainable cities that have low pollution levels and high accessibility and mobility to goods and services. The road transportation systems in the big cities are often characterized by low efficiency, heavy congestion and high environmental pollution. Deficiencies in urban transportation planning and management have largely contributed to the urban transportation problems. According to Zhang and Hu (2003), among others, these deficiencies include: i. lacking in coordination mechanisms among the key government agencies involved in the formulation and implementation of transportation policy; ii. relying heavily on supply-side approaches such as highway expansion; iii. encouraging individual transportation, particularly the ownership of private cars; iv. inadequate emission control measures; and v. lack of integrated market-based instruments. Some of these deficiencies have a negative impact on China's auto industry as well, since the urban transport model represents the market demands for the auto industry. For example, weak emission control standards give Chinese automakers fewer incentives to conduct technological innovation to produce energy-efficient and low-emission cars, and ultimately reduce their competitiveness in the world market. So, substantial efforts should be taken to formulate innovative policies and build institutional arrangements. For this, important lessons could be learned from foreign cities.

As Chinese cities become less pedestrian and bicycle oriented, cities must invest in modes that the majority of the non-car owning population can use to access more spatially separated land uses. There are benefits and costs with this strategy. As regional transit is developed, the car-less population has much higher mobility and presumably more access to different jobs, goods, and services. However, as cities decentralize as a result of transit and road improvements, the

accessibility of the city to non-motorized modes is diminished greatly, forcing people to use public transit or autos for trips that they would have otherwise walked or bicycled to. This strategy increases the energy and pollution consequences of travel by shifting benign non-motorized transport to expensive (and polluting) public transit or heavily polluting and congestion causing personal transportation.

Chinese cities have very limited space for road infrastructure. As a result, many cities have attempted to balance the use of the road with very efficient users of capacity (bus transit) with very inefficient users of capacity (personal automobiles). Bicycles and pedestrians, which are the majority of the road users, have received secondary treatment as their mode, is considered inferior and does not operate well with motorized transportation. While some of these approaches have good intentions of increased throughput and improved safety, they discourage the most sustainable and well founded mode of transportation in China. As a result, bike use has decreased in cities with these policies. If China is to maintain its economic growth and development, it must control its motorization rates, but more importantly, its personal automobile use; otherwise, the cities will be debilitated by congestion. There are several strategies that cities are using with varied success. Some strategies include improving the efficiency of their road network by using ITS strategies; others include implementing demand management schemes that ration road space. China has also implemented drastic approaches of reorganizing cities and relocating major trip generators to more strategic locations. As China's urban institutions mature and with the help of international agencies, China is making steps toward building a sustainable urban transportation network. The goal is to balance the economic benefits of motorization with the economic and non-economic costs of congestion, pollution, accidents, and transportation costs and eventually towards a sustainable urban transportation system.

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