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Urbanisation, Vulnerability and Sustainability in Asian Cities: A Transport Perspective

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1. Introduction

As the global population now exceeds 7 billion, the importance of constructing resilient and sustainable urban areas becomes a central concern of societies, as these mega cities (over 10 million) will provide homes for 70 per cent of the population (2050). City living has the potential to accommodate this population, as it makes the most efficient use of available and through higher densities and it allows for the benefits of economies of scale and scope through providing jobs and other opportunities (Glaeser, 2011). It also has the potential for more efficient use of energy resources and for reducing the total amount of travel, at least within the city (Banister, 2005). This means that the city is likely to provide the most sustainable urban form to accommodate the increases in population, but it also needs good governance, with a powerful vision of its future development, financing, implementation and enforcement, so that the best practices can be established, reducing inequalities, gridlock and urban sprawl. Such a strategy is even more important now, as it seems likely that the levels of global warming will exceed the 2°C target set by IPCC (2007). This means that decisions need to be taken now that will reduce the vulnerability and risks facing cities from sea level rises, storm surges, flooding, and greater intensity of rain, as well as from higher temperatures. The transport system is doubly vulnerable as there are potential threats from high oil prices (over $100 a barrel), and from oil shortages due to the increasing demand and little opportunity for substitution on the scale required.

This paper addresses some of these issues from a land use and transport perspective through outlining the key issues relating to urbanisation and sustainability, drawing on the linkages between population, inward migration, the changing economy and transport. The focus then switches to China, where the scale and speed of urbanisation is of a new order of magnitude. Here proposals are made on the possibilities for a range of new types of urban forms appropriate for mega city regions (over 20 million). The issue of vulnerability is then raised and the potential risks from climate change outlined, suggesting that Asian port cities are particularly at risk in terms of exposed population. Finally, some comparisons are drawn and comments of future priorities made.

2. Urbanisation and Sustainability

Urbanisation and sustainability have been central to the recent UN Habitat reports on Planning Sustainable Cities (2009), Cities and Climate Change (2011), and the forthcoming report on Sustainable Urban Mobility (2013). In the 2009 Report (UN Habitat, 2009, p129), eight sustainability directions were identified so that cities can address sustainable urban development in an integrated way. The energy themes cover the use of renewable energy, carbon neutral investments that improve energy efficiency, and distributed local electricity and water systems. Three other themes reflect the need for cities to move towards more local production (biofuels, food and fibres and biodiversity), eco efficient strategies for industry (to include waste and recycling), and the means to improve the housing stock. The two final themes are most relevant here as they reflect the importance of place strategies and transport.

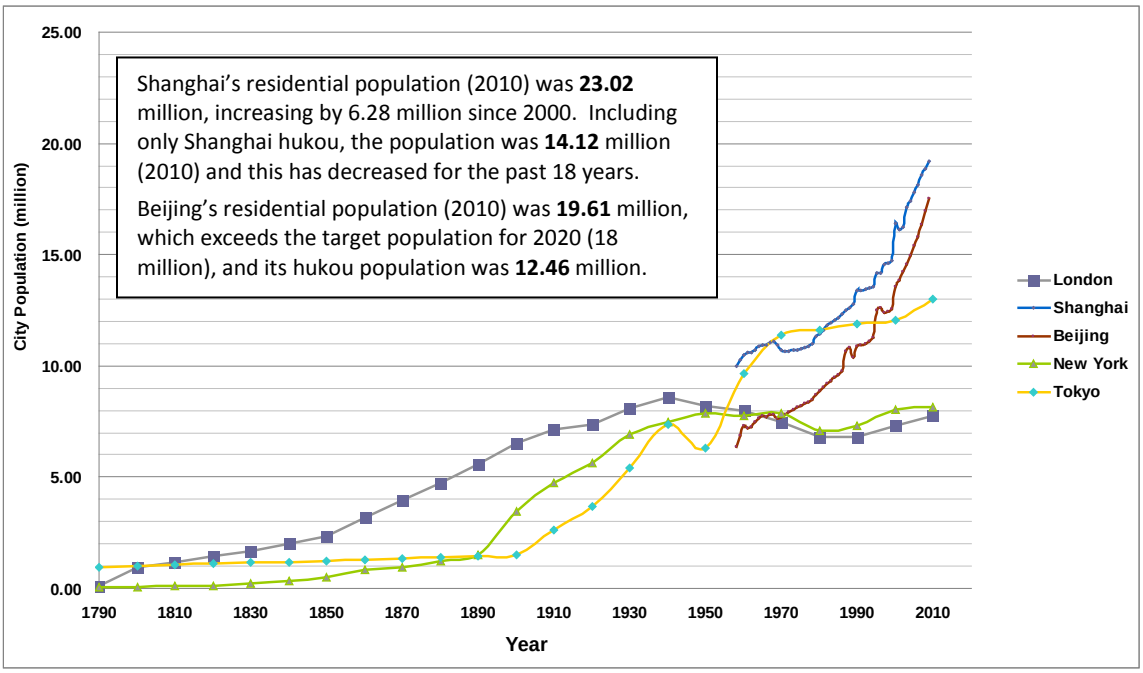
The "sense of place" strategies promote the human dimension, as driving all the other strategies. This can be assisted by local economic development strategies, by place-based engagement approaches to all planning and development processes, and by the innovative use of 'sustainability credits', or complementary currencies, to implement local sustainability innovations as development bonuses. The sustainable transport strategies include quality fast transit along each main corridor, dense transit oriented developments (TODs) built around each station, pedestrian and bicycle strategies for each centre and TOD (with cycle links across the city), the plug-in infrastructure for electric vehicles as they emerge, cycling and pedestrian infrastructure as an integrated part of all street planning, and a green wall growth boundary around the city preventing further urban encroachment.

The Report (UN Habitat, 2009, p219) concludes that "there is some agreement that an equitable and sustainable city will have the following spatial features: higher densities but low rise; mixed uses; public transport based; spatial integration; a defined and protected open space system; and an urban edge to prevent sprawl". There is an awareness that this ideal may be far easier to achieve in developed countries, where there is much greater institutional capacity to bring about compliance with the supporting organisations, processes and enforcement necessary to carry out the intentions. But the Report is optimistic in that it still sees achieving these principles in different contexts remains a worthwhile goal.

In the rapidly growing cities, these changes are much harder to bring about, as the issues raised are much more fundamental than promoting good practice in sustainable transport. For example, informal developments at the urban edge may negatively affect the poor by raising urban land values and by removing the possibility of settlement in locations beyond the edge. Figure 1 shows the growth in population of four world cities, illustrating the recent surge in the populations of Beijing and Shanghai since about 1960, with each of their populations more than doubling from high base populations of 7.3 million and 10.5 million respectively (1960). Even at that time, they were larger than London was in 2000 or New York was in 1990. Looking back over time, it can be seen that London has followed a steady path of population increase, reaching 1 million in

1805, 5 million in 1885 and peaked at 8.6 million in 1940. New York's population growth pattern is similar to that now being experienced in China, as it was also subject to mass inward migration. The population in New York reached 1 million in 1875, but from 1890 it rose from 1.5 million to 7.5 million in 1940, a five times increase over a 50 year period. Tokyo has also grown by more than 6 times, from 2 million in 1900 to 13 million by 2010, but over a longer period. The patterns of population growth and migration in the Chinese cities are not new, even though the speed and scale of change may be substantially larger.

Figure 1: Population growth in London, New York, Tokyo, Beijing and Shanghai



Over the last century, cities have spread with the creation of suburbia, even though populations have remained stable or declined, but more recently there has been a refocusing on concentration with extensive redevelopment of brownfield sites. People have moved back into the city, and with the growth in labour mobility migration has also increased the city populations. As trade and labour barriers have been reduced, many young people have flocked to the cities, bringing new skills and cultures.

In transport terms, this has meant greater demand, but in many situations walking and cycling and public transport have accommodated this increase, with over half of all trips in the city now being made by walk and cycle, and a further 20-30% by public transport. As a result of people returning to the city, densities have increased and through choice (and necessity) a higher priority has been given to the slower modes of transport. This in turn has led to more sustainable transport systems, as the growth in car based travel has been stemmed in the city centre and even in the suburbs. Such a change has been facilitated by policy and planning interventions, but the main driving force has been the new forms of mobility demanded by the new city dwellers, many of whom have not owned a car.

Such an argument is promoting an explicitly social dimension to the more central thinking behind the new economic geography (Krugman, 1991), where increasing returns to scale promote concentration of activity, and where transport costs are seen to be important in determining market structure. Central to the case is factor mobility, where knowledge, information, and labour are instrumental in determining the spatial pattern of development (Krugman, 2011). The desire for urban living and the opportunities that it offers are central to the attraction of the city, as well as the sound economic reasons for clustering and concentration. To some extent this reasoning also counters Storper's concerns over the need to include knowledge and information spillovers, and other intangibles to fully explain the complexity of the processes taking place (2011 – the dormitive properties of new economic geography).

These changes have taken place over the last 100 years against a background of stable decision making, limited migration, and strong organisations, with some visionary inputs. Within Europe such an approach has had considerable success, as many cities (large and small) have created high quality urban environments that provide the range of opportunities needed by the residents, and the transport system has developed in a supporting way that is sustainable. Perhaps, even in these situations the changes were taking place before the carbon imperative had been fully realised (1990s) and this has strengthened the resolve of city (and national) governments. Concerns over congestion, safety, local pollution and community were already shaping the agenda, and it had long been recognised that transport had to adapt to the city.

Even in the USA and Canada, similar arguments were being made, but the solutions were much less clear, and the opportunities for more local travel and public transport more limited. Here the priority has been given to improving the efficiency of the car rather than redesigning the city, but where opportunities for more concentrated development have arisen, they have been taken. Land use planning can operate effectively under these conditions, even though real change seems to take a long time to come to fruition. There is a strong need for flexibility in the process so that the transport system is responsive to external changes (Ingersoll, 2006).

3. New Perspectives on Transport and Land Use Planning in Chinese Cities

The recent growth in cities in the developed countries has been dramatic, but it is very modest when compared with the unbelievable change that is taking place elsewhere in the world. A completely new agenda is required to address the formidable expansion of the mega cities (over 10 million), and the growth of the mega city region (over 20 million). Planning is an evolutionary process, and it is difficult for it to provide a stable environment for a revolutionary process. The rate of change taking place in terms of the urbanisation process, and the scale of the change is hard to comprehend, as cities are growing at annual rates of over 5%.

China demonstrates all of these characteristics with massive internal migration from the periphery (Central and West China) to the core (East and Coastal China), with a focus on

manufacturing in the South East (Shanghai and the Pearl River Delta) and to the North (Beijing and Tianjin). Although this migration is driven by the expectations of employment and better paid work, it is the speed and scale of urbanisation that is taking place. In 1990, 254 million people in China lived in urban areas (20%), but by 2005 this figure had risen to 572 million (44%), with a third of the population increase resulting from migration. By 2025, the total number of people living in Chinese urban areas will be 926 million (64% of the total population), and the expected migration (2005-2025) will be 243 million (69% of all growth – McKinsey, 2009).

Many young people are moving to the cities, despite the Chinese residence registration scheme that reduces the status and rights of migrants (Hukou system[1]). There are currently 145 million migrant workers in China (11% of the total population), and there are 225 million rural born migrant workers (20%) working in urban areas. If this system were to change, then the movement to the urban areas might well accelerate, as urban income levels are over 3 times as much as rural incomes (US$758 in 2010). Much of the development is being funded by the sale of land, as this provides nearly half of all local government revenues, so the next development is being funded by the last one. By 2025 there will be 221 cities in China with over 1 million population (as compared with 35 cities in Europe), and 15 of these will have a population between 5-10 million, and there will be 8 mega cities (>10 million).

There is a strong economic rationale behind this urbanisation process, and it is consistent with resource availability and the export led manufacturing, it provides an extreme example of Krugman's core-periphery model (1991), with industrial clustering and localisation, together with specialisation. In addition the larger cities have attracted the best educated workers, more international investment, and there also seems to be network benefits arising from better communications and transport infrastructure.

The key question presented here is the choice that now confronts China in terms of the most appropriate pattern of urban development that can be seen as being sustainable, and what transport system is best suited to such a structure. Over and above the difficult decisions made in the cities in Europe and the USA/Canada, the scale and rate of growth are unprecedented. The McKinsey Report (2009, p77) presents an interesting comparison between the urbanisation process in China and the USA in terms of the

[1] A *Hukou* refers to the system of residency permits which dates back ancient China, A household registration record officially identifies a person as a resident of an area and includes information such as name, parents, spouse, and date of birth. In 1958, the Chinese government officially promulgated the Hukou system to control the movement of people between urban and rural areas to ensure some structural stability. After the Chinese economic reforms in late 1970s, it became possible for some to unofficially migrate and got a job without a valid permit. The system has undergone further relaxation in mid 1990s and then in early 2000s. Rural residents can buy a temporary urban residency permits to work legally. By 2004 the Chinese Ministry of Agriculture estimated that over 100 million people registered as "rural" were working in cities. However, these reforms have not fundamentally changed the hukou system. Instead, reforms have only decentralized hukou control to local governments. It has been argued that the system will have to be further relaxed in order to increase availability of skilled workers to industries.

scale (population growth), speed (time in stages of development) and income (per capita GDP), as shown in Table 1.

Table 1: Comparison of growth and development phases in China and the USA

Figures are all indicative estimates and the development phases are overlapping		Industrialisation	Service based economy	Knowledge and Information based economy
China	Population	1-2 million	2-15 million	>15 million
	Time	40 years	15 years	10 years
	Per capita GDP	< $2000	$2,000-6,000	>$6,000
USA	Population	100,000-200,000	200,000-500,000	500,000-8 million
	Time	200 years	75 years	50 years
	Per capita GDP	< $20,000	$20,000-40,000	> $40,000

Based on McKinsey (2009, p77, Exhibit 3.2)

In each of the three stages, China's urban population is about 10x that of the USA (Factor 10), but the reverse is true on the per capita GDP measure where the USA incomes are 10x those in China (Factor 10). The most dramatic differences relate to the time over which economies have moved across the three overlapping stages of development, with China typically moving at 5x the speed that the USA has done (Factor 5).

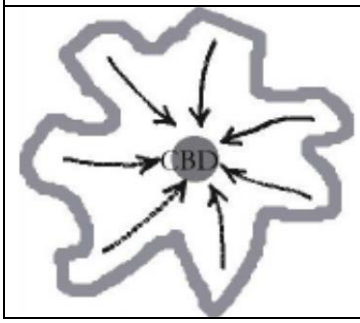
It is very difficult to operate an effective regulatory framework, as major decisions have to be made quickly and there needs to be strong supporting institutions for effective implementation. It is not possible to promote one urban structure for sustainable development in China, as there is no single solution but a range of possibilities. Compactness can reduce the need to commute long distances, and when it is combined with the local distribution of services and facilities, it means that shorter trips and trip chaining can take place. The densities used in Chinese cities are much higher than those in the west, as 80 dwellings per hectare is considered low density and suitable for a compact urban development on the urban fringe (Zhao et al., 2010). This level is twice that used in London. Polycentric development can also reduce commuting distance, as the colocation of work places and housing allows overall commuting costs to be optimised (Levinson and Kumar, 1997), but such flexibility may be less readily available for many in China where the "market" for housing is still embryonic. The colocation argument has been strong in the USA (Gordon et al., 1989), but even here recent evidence suggest that commuting times there are amongst the highest, with the current average about 48 minutes per day (The Economist, 30th April 2011, p41).

In terms of city planning, urban development in China is completely new territory, as there is no real history on which to base our thinking. In other megacities the growth has taken place over a much longer period of time (Tokyo-Osaka), or it is of a lower order of magnitude (Seoul Metropolitan Region).

Three types of urban structures seem to be emerging (Figure 2)[2]:

Radial Cities – where there is one city that acts as a strong centre, and development is concentrated along the main routes into that centre – the classic monocentric city structure (Table 2). The Chinese variant means that not all employment is concentrated in the city centre, but because of the scale of development there are employment centres along each of the radial routes, so distances are reduced as work is closer to where the people live. There may also be green spaces or wedges between the radials, with new town developments at the urban periphery. In China, most of these cities are isolated and are located inland.

Table 2: Key characteristics of the six Chinese radial cities

Radial cities	Urban Area population	Metropolitan area population	Average commute time by car
Wuhan	5.15 m	8.36 m	31 mins
Xian	5.62 m	7.82 m	29 mins
Zhengzhou	2.85 m	7.31 m	29 mins
Changsha	2.41 m	6.52 m	27 mins
Kunming	2.50m	5.34m	29 mins
Lanzhou	2.10m	3.24m	25 mins
	Comment: Potential for future axial growth between Wuhan and Changsha (380km) and from Zhengzhou to Jinan (430km) and Shijiazhuang (440km) both facilitated by new high speed rail links.		

Notes: Population data 2009 from the China Bureau of Statistics (2010) and the commute data is from a Deloitte Survey (2011).

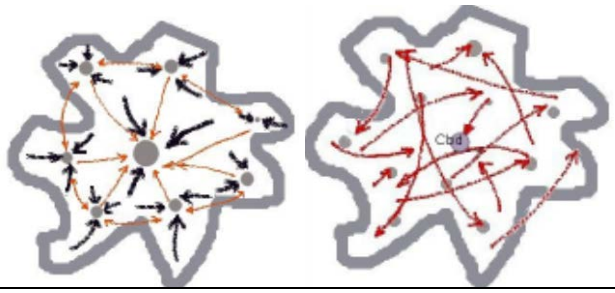
City Clusters – where a series of centres emerge in a region of high growth potential, and this develops as a polycentric urban form, with substantial network and agglomeration economies. The Chinese variant in this polycentric structure means that employment is distributed across all the major centres so that they have a high degree of jobs housing balance, but with their own specialisations. It also requires a high capacity rail and road system that allows efficient travel between the main cities in the cluster. This is the largest grouping of cities and places the mega cities together in mega city regions, where several major centres are in close proximity to each other, and in China these are all on or near to the coast.

In the Pearl River Delta, nine large cities will coalesce to become one mega city region with about 30 million people (Table 3). There are plans for huge infrastructure

[2] Note that the listings are based on the 11 urban networks of cities identified by McKinsey (2009, p14), and it has been extended to include further examples.

investment (£190 Billion 2011-2017), including 3100 miles of rail so that it will take a maximum of one hour to move between any of the major centres. Its position adjacent to Hong Kong (7.0 million) will also strengthen its international potential, as it can capitalise on the financial and knowledge based expertise there. As part of the vision for this mega city region the transport system will be public transport based, with new housing being built only where accessibility to these transport services can be guaranteed. The land use planning and zoning systems will be implemented flexibly mixing high rise with open space, but there will also be urban extensions to "fill" the spaces between the main cities. This structure seems to have the potential as a flexible form of deconcentrated concentration, breaking away from from the historic radial transport networks that arise from monocentric cities and moves development towards polycentric urban forms. The other two city clusters are in the Yangze River Delta and the "triangle" of cities including Beijing, Tangshan and Tianjin.

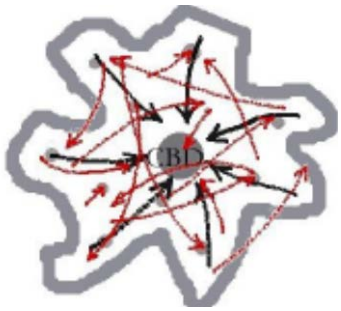
Table 3: Key characteristics of the three Chinese city clusters

Pearl River Delta – total population 36 million – all cities within 120km of each other Guangzhou 6.55m (7.95m) Shenzhen 2.46m (2.46m) Dongguan 1.79m (1.79m) Foshan 1.1m (5.4m) Zhaoqing 0.5m (1.9m) Zhongshan 1.48m (1.48m) Jiangmen 1.38m (3.96m) Huizhou 1.09m (2.59m) Zhuhai 1.03m (1.03m) Hong Kong 7.0m Average commute times 48 minutes	**Yangtze River Delta –** total population 37 million Shanghai 13.32m (14.01m) 190km to Hangzhou 4.29m (6.83m) 280km to Nanjing 5.46m (6.30m) Changzhou 2.27m (3.60m) Suzhou 2.40m (6.33m) Comment: Possible extension inland to Heifei (2.09m: 4.91m) about 420km from Shanghai. Average commute times are about 47 minutes.
Beijing – Tangshan – Tianjin – total population 30 million – all cities about 120-150km apart Beijing 11.75m (12.46m) Tangshan 3.07m (7.34m) Tianjin 8.03m (9.80m) Average commute time 52 minutes in Beijing and 40 minutes elsewhere	

Notes: Population figures (2009) from the China Bureau of Statistics (2010) for the urban area and the for the metropolitan areas in brackets, and the commute time data is from a Deloitte Survey (2011).

Axial Cities – where there are two main city nodes about 300-400km apart that provide the end points to a corridor for development, often along high speed rail and road links. The Chinese variant is more complex as there are many types of movements within each of the two main cities, as well as movements between them. These cities are mainly in the coastal region (Table 4).

Table 4: Key characteristics of the four Chinese axial cities

Jinan 3.48m (6.03m) 320km to Qingdao 2.75m (7.63m) [intermediate cities Zibo 2.79m (4.21m) and Qingzhou 1.35m (3.71m)]. Commute time 29 and 28 minutes. Total population: 22 million	
Chengdu 5.21m (11.40m) 340km to Chongqing 15.43m (32.76m) [intermediate city Neijiang 1.42m (4.26m)]. Commute time 31 and 35 minutes. Total population: 48 million	
Shenyang 5.12m (7.17m) 390km to Dalian 3.02m (5.85m) [possible extension to Changchun 3.62m (7.57m) 330km to north of Shenyang]. Commute time 34 and 29 minutes. Total population: 13 million	
Xiamen 1.77m (1.77m) 280km to Fuzhou 1.87m (6.38m). Commute time 26 and 25 minutes. Total population: 8 million	

Notes: Population figures (2009) from the China Bureau of Statistics (2010) for the urban area and the for the metropolitan areas in brackets, and the commute time data is from a Deloitte Survey (2011).

Even though this combination of three distinct urban forms presents one means by which urban growth can be accommodated, urban densities (for example in Shanghai) will still be about four times those in (large) European cities (London, Paris and Berlin) and other cities (New York and Jakarta), and twice as dense as Moscow. The scale of city size in China is such that it is almost impossible to categorise cities, as any particular type as they are all polycentric, even though there are identifiable differences. The distinctions between cities may also disappear as new cities are built, and as cities coalesce.

Within these rapidly growing megacities the issues of congestion, pollution and greater accessibility of the denser city need to be matched against the longer distances encouraged by sprawl. The average speed of car travel in central Beijing (10km/hr) and Shanghai (18 km/hr) are much lower than those in Singapore (35 km/hr) and London (29 km/hr), even though the levels of motorisation are much lower (McKinsey, 2009, p139). This is partly because there is less road space available as a proportion of land space (17% in Shanghai as compared with 25% in London), but it is also due to lower levels of urban space management, of demand management and of enforcement. Even sprawl leads to congestion as people need to take their cars to the city centre, so there is really no choice.

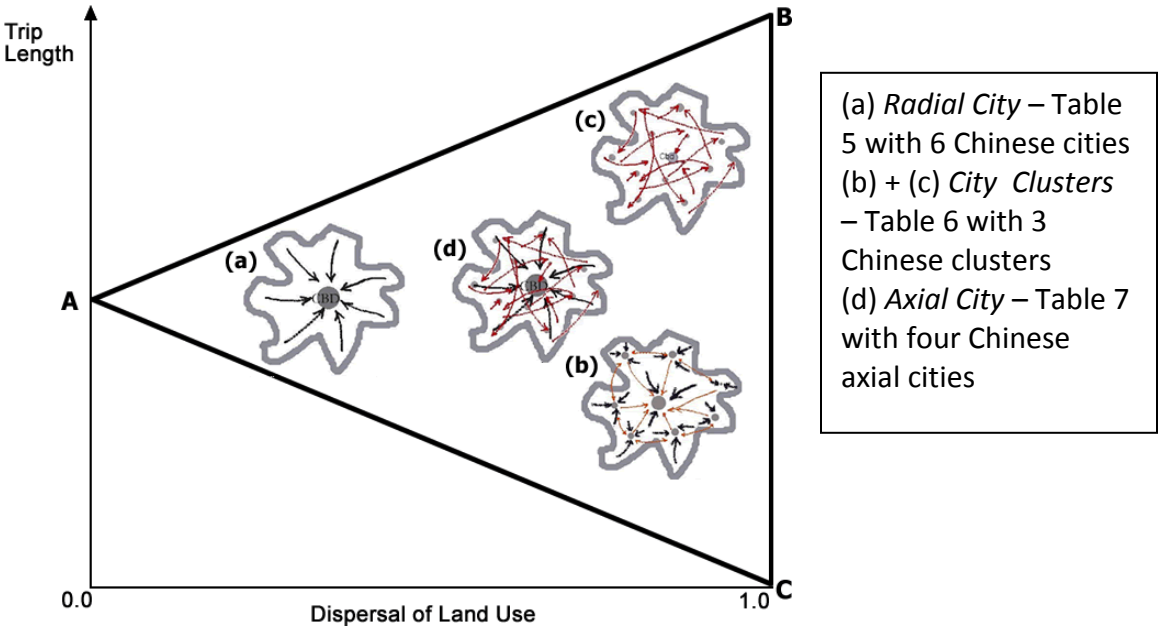
The transport system within cities must be based on rail, bus rapid transit, conventional buses and paratransit for the longer distances, and on bicycle (electric) and walking for the shorter distances. Low speed electric vehicles could provide both public and private transport, as well as delivery and other services in the city. The importance of urban planning is paramount in reducing the demand for long distance commuting, by establishing local centres for work and housing in compact developments across the mega cities. In all cases it is important to consider the balance of development in central areas and in the urban fringe, so that proximity and accessibility (preferably by walk and cycle or public transport) can be promoted. This means shifting the emphasis from

providing additional road infrastructure to one that considers sustainable communities within the polycentric mega city regional structure. Large scale transport projects and technical innovations are key elements in supporting city development, and in some situations they might even lead that development, but they do not necessarily solve the problems of carbon, pollution and congestion.

High speed rail offers a clear opportunity for high levels of connectivity both within and between cities, as there is no doubt that the demand for travel is justified by the huge urban populations. As noted above, the axial cities need such investment to link the two end points, but even in the clusters there is a strong case for rail links between the component cities. The high speed rail network provides tha means to extend the axial lines and to integrate the cities nationally.

In summary, the urban form of Chinese cities can be shown (Figure 2), using the graphic behind Bertaud's views of city development (2002), and the individual components used in Tables 2, 3 and 4. This illustrates the different urban forms and the relationships between trip length and the density of land use, and it provides the classic view on the trade offs that must be made.

Figure 2: The relationship between trip length, dispersal and urban form



Notes: City (a) is the monocentric model with a strong central city and a radial pattern of travel; City (b), the polycentric model, with a cluster of surrounding cities; City (c), the polycentric model, with random movements, and City (d), the multicentred city with simultaneous radial and random movement, but this can be focused into the axial city with corridors of movement (Bertaud, 2002).

These mega cities have tremendous potential for growth and will be the powerhouses of the world economy over the next decades, but they are also centres for potential unrest, as there is substantial inequality and poverty (UN Habitat, 2008). The challenges for governments are daunting with little space for expansion in the original cities, so there is extensive urban sprawl with increased distances between where the people live,

their jobs and other facilities. The concept of single centred cities is becoming less relevant with the growth in mega-cities, as they are rapidly developing as axial cities or as polycentric urban agglomerations, often absorbing other smaller cities in the process.

There is a fundamental difference between the priorities in cities in developed countries, where the main concerns are over levels of pollution and consumption related burdens, and those in developing countries, where the concerns are more short term and health related. Their requirements include clean water, electricity, waste management and sanitation. All cities contribute to global emissions, but the desire for economic growth seems to be overwhelming, and this imperative often takes precedence over other priorities, and the net effect is a continuing growth in local emissions (NO_x, CO, HC, SO_2, PM_{10}, and PM_5) and global emissions (CO_2). Some cities have the opportunity to substantially reduce emissions through investment in clean technology and much greater energy efficiency, including a switch to low carbon energy. For other cities, the challenges are even greater, as they have other pressing social needs to address, but even here there are opportunities to switch to efficient low carbon energy sources.

There are good examples where development has been seen as investment, with the basic infrastructure being provided as part of the urbanisation process, as in Guangzhou City (Pearl River). Conversely, higher densities can be achieved through compactness and integrated approaches that combine investment in high capacity public transport and development, as in Hong Kong or Singapore (around their metro systems) or in Curitiba (around its bus rapid transit system). Strong city level governance is essential, where there is a clear vision about the future of the city, and where there is both the power and resources for action. But above all, there is a need for leadership and for all stakeholders to engage with the process of city-building, so that responsibilities and actions are both supported and implemented effectively. This is the only way to move towards the sustainable city. The alternative is one of weak governance, where there is no direction and the consequences are huge sprawling divided cities – this is the inefficient and unsustainable city.

4. Vulnerabilities and Sustainability

Many of the World's great cities are located on the coast or along the major rivers, as historically they have been centres of trade. But these locations are now prone to flooding, caused by storm surges and high winds, and accentuated by global warming (+2^oC) and sea level rise[3]. About 40% of the World's cities (1-10 million) and 15 of the 20 mega-cities lie on the coast. Their vulnerability to flooding has been substantially

[3] CO_2 concentrations are currently about 385 ppmv and with other greenhouse gases being included, this value increases to 430 ppmv CO_2e (2009). A level of 450 ppmv CO_2e means that there is a 26-78% chance of exceeding 2^oC. A level of 550 ppmv CO_2e means that there is a 63-99% chance of exceeding 2^oC. If global concentrations of greenhouse gases stabilise at 560 ppmv CO_2e, it is 'likely' that global mean surface temperatures will rise by 3^oC above pre-industrial levels (Meinshausen, 2006).

increased, and some have taken action to reduce the potential impacts, but 40 million or 10% of the total population are exposed to a 1 in 100 year coastal flood event, and this will rise to 150 million in 2070 (Table 5 and Nicholls et al., 2008). It is proposed that apart from upgrading protection and infrastructure to handle such events, land use planning should be used to reduce vulnerability for new developments and selective relocation of existing city areas should be considered.

Table 5: Potential Impact of Climate Change on the Top 20 World Port Cities

2005		2070	
Top 10 cities by exposed population	Top 10 cities by exposed assets	Top 10 cities by exposed population	Top 10 cities by exposed assets
Mumbai Guangzhou Shanghai Miami Ho Chi Minh City Kolkata New York-Newark Osaka-Kobe Alexandria New Orleans	Miami New York-Newark New Orleans Osaka-Kobe Tokyo Amsterdam Rotterdam Nagoya Tampa-St Petersburg Virginia Beach	Kolkata Mumbai Dhaka Guangzhou Ho Chi Minh City Shanghai Bangkok Miami Hai Phong (Vietnam) Alexandria	Miami Guangzhou New York-Newark Kolkata Shanghai Mumbai Tianjin (China) Tokyo Bangkok New Orleans
These cities are split almost equally between developed and developing countries	These 10 cities account for 60% of total exposure, and are based in 3 wealthy countries (USA, Japan, and the Netherlands). Total exposed assets for all 20 cities is $3000 billion (2005 prices) or 5% global GDP.	The exposed population has increased by 3 times to 150m – almost all the cities are in developing countries.	The total exposed assts have increased by 10 times to $35,000 billion (2005 prices) or 9% of global GDP

Note: The main driving forces of the 2070 Scenarios are population growth, economic growth and urbanisation, and these factors are exacerbated by climate change (sea level rises and increased storminess) and subsidence.
Source: Based on Nicholls et al., 2008

Climate change (i.e. frequency and intensity of flooding and heat) may imply the submersion, washing away and buckling of roads and other infrastructures (Meyer, 2010), whilst the rising price and constrained supply of oil-based fuels may make certain trips unaffordable or impossible. Either way, parts of cities – along the coast or inland waterways, neighbourhoods that can only be reached by car or where the car is the basic way of getting around, etc. – may become virtually inaccessible, and effects may propagate throughout whole cities. In terms of direct effects, if people living in a given neighbourhood are unable to get to work or other destinations, the activities and performance of firms and organisations throughout the city may be affected. With regard to indirect effects, insurance premiums may go up both in flooding-prone

neighbourhoods and more generally. Also, if significant numbers of people or firms decide to leave certain parts of an urban area, land values and prices may fall, imposing significant financial risks to private individuals, corporate investors, public authorities (local and central), and others.

Two implications follow from this. For urban areas to thrive in the future, resilience needs to be developed with regard to two sets of transport-related vulnerabilities simultaneously. Additionally, integral or 'expanded' assessments (Jaroszweski et al., 2010) of city-level risks and vulnerabilities are required, which consider both climate change and oil scarcity simultaneously as part of coupled human/ environment systems that are complex (as in complexity theory) and multi-scalar (i.e. ranging from the globe to the individual). Vulnerability is here understood as the degree of susceptibility of a system (e.g. a city, transport network, the daily travel/activity pattern of an individual) and its lack of ability to cope with the adverse effects of events associated with climate change and oil scarcity; it is a function of exposure to, sensitivity to, and adaptive capacities to those events (Koetse and Rietveld, 2009; Changa et al., 2011). Transport and urban planning research with regard to climate change is growing rapidly but tends to focus on mitigation rather than vulnerability and adaptation. Work on the latter is emerging and concentrates on assessing the resilience of roads and other transportation infrastructures, often within an economics-based framework, and a separate strand of work concerns the vulnerability of urban areas to fuel price changes.

5. Conclusion

In the developed cities there is a key difference between the European and US traditions. In the European cities there is a history of strategic planning and the control of the land development process from the national to the local level, with clear priorities, responsibilities and controls. This strong planning environment has allowed cities to retain much of their historic structures and suburbanisation has also been controlled, and this has in turn meant that public transport has had a stronger role to play. In the USA, much of the local zoning regulations restrict density levels and the mixing of land uses, and this presents a significant barrier to compact development (TRB, 2009). The potential for higher density developments in the USA is highest in new and replacement developments in the inner suburbs, and at locations near to good quality highway and public transport interchanges. The local concerns over congestion, local taxes and property values take precedence over the wider issues relating to housing affordability and climate change.

Cities in developing countries are following the same path, with the affluent middle classes buying cars as soon as they can afford to, and the resulting consequences for congestion, safety and the quality of the environment that are imposed on all other people in the city. The more efficient public transport, motorbikes and bicycles are squeezed out to make way for the car, which then dominates much of the available urban space. An opportunity has been missed, as it suggests that the car dominated US city is the only future. The European cities offer a different perspective, as much of the

existing urban structure has been maintained and there has been considerable investment in public transport. However, there is still the problem of urban sprawl, where both the land use and travel patterns are based on car dependent lifestyles and much lower density levels (Banister, 2007).

Cities that currently have low levels of motorisation are changing out of all recognition. About half of the world's population now live in urban areas, and this is increasing as migration takes place and as more city jobs are created. The Asian Development Bank estimates that the population of Asian cities are increasing by 40 million annually (ADB, 2009). Urban densities will fall as a result of increasing wealth, declining household size, low density residential growth and central area redevelopment. Many of these cities were not built for the levels of traffic they are now experiencing. The inherent flexibility in the use of street space for markets, small industrial activities and social spaces is being replaced by traffic, so that the car can dominate. The car based mobility requires mass redevelopment of the existing city centre or its expansion to new areas so that the necessary capacity can be created. Such 'solutions' are costly and have substantial implications for social welfare, environmental quality and health. The new mega cities of the world are emerging, not as the models of sustainable development, but as replicas of the car dependent cities of the West.

The ADB (2009) report has tried to address these issues through the promotion of a sustainable urban transport paradigm that examines management, finance and policy through a wide ranging review. Their proposal is for a much more transparent process that is built on accessibility, with demand management being seen as a central issue together with strong land use policy. The strategy is based on looking at ways to avoid travel through shorter journeys and more accessible activities, to shift travel to public transport rather than the car, and to improve the efficiency of all forms of transport. The avoid-shift-improve nexus is similar to the sustainable mobility paradigm (Banister, 2008).

There are two other key elements in the ADB (2009) proposals. There should also be a clear future city vision or spatial strategy that is affordable, adaptable and implementable, and this requires strong institutions and governance structures for the city. Secondly, policy effectiveness needs to be clearly explained and accepted by the full range of stakeholders, through their involvement in the process. This is a challenging agenda but one that must be addressed if cities are to become the real centres for sustainable development, as argued here.

The ownership of land in the city is the key factor in much of the discussion in this important paper (ADB, 2009). The case is made that for real change to take place, there needs to be direct intervention by city governments. It is only through stable public institutions that the location, scale and type of land development can be properly regulated and operated. Transport can be seen as part of that development where some of the benefits can be released through value capture. At present much of the land used by low income groups is negotiated through the informal and small landowners, hence the need for intervention and partnership. It is only when the twin

issues of poverty alleviation and sustainable transport are seen to be complementary and moving in the same direction that progress will be made.

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