Urban Environmental Transitions and Urban Transportation Systems: A Comparison of the North American and Asian Experience

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1. Introduction

During the early 1990s, Gordon McGranahan and his colleagues (2001) developed the urban environmental transition theory. This theory builds on research claiming an association of urban environmental burdens and growing affluence (Bartone, Bernstein, Leitmann, and Eigen, 1994; Berry, 1990; Lee, 1994; McGranahan, Songsore, and Kjellen, 1996; Pugh, 1996; Satterthwaite, 1997). The argument focuses on changes among environmental burdens as cities become wealthier. In the process of wealth accumulation environmental challenges become more dispersed, delayed and shift in type. For low income cities environmental challenges are localized, immediate and health threatening, while for wealthy cities environmental burdens are global, delayed (intergenerational) and ecosystem threatening. The authors, however, are careful to point out that these tendencies are predispositions rather than predetermined outcomes. Empirical research on three different, developing cities (Accra, Ghana; Sao Paulo, Brazil; and Jakarta, Indonesia) has demonstrated a shift in urban household environmental conditions with rising income (McGranahan and Songsore, 1994).

The outline of the urban environmental transition for Western (Melosi, 2000) and Asian cities (Bai and Imura, 2000; Webster, 1995) has also been identified. In terms of the West and in particular the US, the transitions have occurred over longer periods of time than their Asian counterparts. Asian cities have undergone rapid transitions in which the outlines of the transition have been compressed. More than simply occurring at faster rates, however, urban environmental transitions in Asian cities are increasingly overlapping (Marcotullio, 2002; Marcotullio, Rothenberg, and Nakahari, 2002). National and local conditions as well as globalization forces have been implicated in the process of compressed and telescoped urban environmental transitions (Marcotullio, 2003).

Transportation systems, like many other sets of technological advances, have undergone their own sets of transitions. These shifts have been associated with shifts in the techno-economic paradigm under which cities developed (Berry, 1990; 1997), shifts in the way problems were understood (Melosi, 2000) and changes in norms and values (McKay, 1988; McShane, 1979; 1994). Further, dramatic changes have also been associated with crisis events. While these influences can be mapped out clearly for cities in the US, for example, they are far less evident in rapidly developing Asian cities. That is, in the West, while a set of transitions from walking to the omnibus and elevated steam railroad, to

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the horse drawn and then electric streetcar, to the subway, and finally to the automobile can be discerned, these transitions are not as clear in the history of Asian cities. Further, the environmental challenges associated with these transitions appeared in a sequential manner, while those in Asian cities are appearing simultaneously.

As the development of transportation systems has been the "maker and breaker" of cities (Clark, 1999; Hall, 1992), studying how they developed and comparing experiences among cities is crucial for understanding urban development policies. The implications relate to the transferability of Western experiences in Asian cities. The challenges of rapidly developing Asian cities call for new types of policies and understanding the differences between development experiences between the West and Asia can shed light on future transportation priorities.

The paper is divided into three further sections. The first section develops the theoretical perspective. Drawing from a range of theories including the urban environmental transition, long waves of development, globalization and time space compression, a framework for understanding the differences between developed and developing cities problems is put forth. The second section briefly overviews the history of the Western experience with transportation and urban environmental challenges. The third section outlines the current situation in rapidly developing Asian cities and demonstrates that the transportation transitions are far less clear. Further, the current sets of transportation systems found throughout the region do not correspond to the sets of environmental challenges experienced by cities in the USA. Finally, in the conclusion the authors summarize and draw out policy implications.

2. Long-waves of development, globalization, time space compression and urban environmental transitions: developing a framework for understanding differences between Western and Asian experiences

The main argument in this paper is that while cities have undergone environmental transitions in sequential order in the past, current development conditions, particularly those associated with rapid globalization-driven growth, mitigate against this pattern. Several theories, taken together, help to provide the warrants for these claims.

Essentially, the authors suggest that in the past, the pattern of long waves of development, as defined by the changes in techno-economic conditions, formed the broad outlines of the West's urban growth patterns. Theoretical understanding, changes in norms and values and crises further influenced the timing of transitions. As one set of solutions often led to the problems of the next phase, reacting to urban environmental challenges with the "first things first" attitude evolved as the appropriate response.

The latest round of globalization, however, has changed the trajectory of development.

It has both compressed and telescoped the development patterns of nations and their cities. The promise of globalization driven growth is leap-frogging previous problems experienced by the West, but the threat, and largely the outcome, has been an increasing overlap in environmental challenges, as "solutions" to all sets of problems remain elusive.

This section outlines three sets of theories. The first sub-section outlines long wave development theory and the role of shifts in norms and crises in technological uptake. The second outlines the impact of globalization and "time space compression" (Harvey, 1989). The third reviews urban environmental transition theory and the historical role of advances in scientific knowledge in providing the solutions to environmental problems. The last sub-section summarizes the perspectives and presents our framework for analysis.

2.1 Long waves of development

The theory of long waves of economic development postdated the work of Nikolai D. Kondratieff (1979, p. 519), although he popularized the study of "the dynamics of economic life in the capitalistic social order." Using available data on Germany, France, England and the United States of America, Kondratieff demonstrated, among a group of variables,[c] a secular trend in a specific direction that was structurally linked to the overall changes in the economic environment of the particular society. While he studied three types of waves of varying length (long ones of approximately 50 years duration, middle ones of seven to 10 years duration and short ones of three to four years), he was primarily interested in the longest waves, which ultimately were given his name. These waves were characterized by accelerating rates of price increases from deflationary depression to inflationary peaks, followed by decade-long plunges from the peaks to primary toughs, which again are followed by weak recovery and then growth again. There is debate over the underlying reasons why these waves exist or whether another will occur again in the developed world (see for example Maddison, 1991),[d] but the general consensus is that the capitalist national economies have experienced long-term fluctuations of some fifty- to sixty-year duration.

Associated with the long-term trends in price cycles (or in growth rates) are shifts in technologies (see for example, Schumpeter, 1961). Brian Berry (1997) suggests that U.S. history, for example, is marked by a rise and fall of a succession of techno-economic systems, defined by interrelated sets of technologies with which are associated sets of raw materials, sources of energy and infrastructure networks (**Figure 1**). The first set of techno-economic systems included the use of wind and animate power (sail/wagon), the emergence of cotton textiles industries and iron as the strongest material. This was followed by the era of coal, steam and iron rails, then began the era of steel, kerosene and

Kondratieff Cycle	Technology systems	Urban phase	Environmental challenges
To 1845 A-Phase (peak 1814) B-Phase (trough 1843)	Wind, water, wood	Mercantile cities	Health (small pox, yellow fever, convulsions, cholera) water supply, street refuse, domestic animals fires, street drainage
From 1845 to 1895 A-Phase (peak 1864) B-Phase (trough 1896)	Coal, steam and steel	Early industrial cities	Health (pneunomia, tuberculosis, diarrhea) high densities, horses and rapid urban growth, provision of adequate water beginnings of rapid transit (congestion), provision of adequate sewerage
From 1895 to 1945 A-Phase (peak 1920) B-Phase (trough 1930s)	Petroleum, internal combustion engines and electricity	National industrial cities	Health (pneunomia, tuberculosis, diarrhea, occupational/child labor) clean water, mass consumption, sanitation and sewerage Solid waste, beginnings of chemical air pollution
From 1945 - Present A-Phase (peak 1970s) B-Phase (?)	Telecommunications electronics, new materials bio-technologies, new energy	Mature/post-industrial cities	Health (circulatory system, cancer, nephritis, pneumonia including influenza) non-point source air and water pollution cumulative persistant chemical and toxic waste (including nuclear waste) consumption related issues (land use, energy consumption, GHGs emissions) Emerging pollutants (PM2.5, POPs)

Notes:
Kontratieff cycles: Kondratieff, 1979; Yeates, 1998, (citing Mager, 1987) p. 64.
Technological systems: Berry, 1997, p.302; Lo, 1994
Urban phases: Yeates, 1998; Melosi, 2000
Environmental challenges: Health related from Jackson, 1995, Water supply, sewerage and sanitation from Melosi 2000, Chudacoff, 1981; Other from Melosi 2000, Hays, 1987, various sources
Environmental theories, technologies, responses: Melosi, 2000; Chudacoff, 1981; Jackson, 1995

Figure 1. Techno-economic systems, urban development eras, associated urban environmental challenges and related dominant theories, technologies and responses

electricity. Petroleum, chemicals and the internal combustion engine defined the fourth wave. The current fifth wave is

[c] Variables were grouped into three elements including 1) "financial" (capital interest, wages, bank deposits, etc) 2) "mixed character" (the volume and value of foreign trade, etc.); 3) "purely natural" (sector production and consumption levels).

[d] Angus Maddison (1991. *Dynamic Forces in Capitalist Development: A Long-Run Comparative View*. Oxford University Press, Oxford, p. 112) provided an in-depth analysis of long-term economic trends and finds no convincing evidence to support the notion of long waves, but does suggest nevertheless that there have been "significant changes in the momentum of capitalist development. In the 170 years since 1820 one can identify separate phases which have meaningful internal coherence in spite of wide variations in individual country performance within each of them." He suggested that the move from one phase to another was governed by exogenous or accidental events that are not predictable.

driven by the service sector and added by technologies such as computers, telecommunications, biotechnologies and new materials. The addition of technologies to long wave theory is important in that it provides one underlying rationale for such changes. As the argument is pursued, each new set of technologies opens up novel products and factor markets that in turn produce major surges of economic growth. [e]

Scholars have further associated technological development with urban growth in Western countries (Berry, 1990; Borchert, 1967; Yeates, 1998). Although there is debate over the exact timing of the periods, four can be defined, with each long wave cycle resulting in a distinct urban pattern of development.[f] Others have supplemented this perspective with the importance of shifts in values in explaining the uptake of certain infrastructure and technologies (McKay, 1988; McShane, 1979; 1994). In terms of the revolution in street paving, for example, scientific and technical advances alone do not explain the enormous effort to pave the United States' urban streets from 1880 to 1924. While progress in chemistry and pressures from the rapid rise in automobiles were important, paved streets emerged more for social and cultural reasons than these others, growing from the shift in housing tastes that resulted in different perceptions of the use of street space and new paving policies within municipal administrations (McShane, 1979).

Finally, influences that help to pinpoint certain transformations are crises events. For example, in New York City, the local government's ability to create a new water supply system was arguably influenced by the Great Fire of 1835. The implementation of welfare laws that helped to clean up some of the poor housing units in immigrant neighborhoods

Table 1: Growth of GDP per capita in selected countries, by decade

(percent annual increases)

Country	1870-1880	1880-1890	1890-1900	1900-1910	1910-1920	1920-1930	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990
Australia	1.90	0.40	-1.04	2.64	-1.00	-0.52	2.17	1.97	1.69	3.14	1.72	1.75
Austria	1.11	1.63	1.66	1.33	-3.06	4.05	0.99	-0.66	5.81	4.11	3.53	1.92
France	1.23	1.15	1.93	0.30	0.85	3.46	-1.14	2.69	3.65	4.46	2.63	1.73
Germany	0.83	2.02	2.13	1.19	-1.65	3.09	3.19	-2.55	7.05	3.50	2.56	1.97
Italy	0.53	0.54	0.68	2.71	1.05	1.21	1.85	-0.01	5.39	5.09	3.25	1.99
UK	0.86	1.43	1.14	0.26	0.55	0.42	2.34	0.45	2.27	2.24	1.80	2.47
USA	2.65	0.62	1.89	1.95	1.13	1.13	1.21	3.15	1.58	2.87	2.09	1.81
Canada	0.61	2.73	2.04	3.40	-0.51	2.22	1.10	3.31	1.84	3.35	3.31	1.87
Japan	0.99	1.76	1.54	1.00	2.66	0.88	4.50	-3.82	7.55	9.31	3.33	3.53
South Korea	na	na	na	1.10	2.10	-0.03	3.54	-6.13	4.04	5.42	6.39	8.14
Taiwan	na	na	na	0.45	1.49	1.86	1.78	-3.52	4.26	6.76	7.66	6.24
Indonesia	na	na	1.17	2.10	0.59	2.18	-0.60	-2.59	2.61	0.92	4.20	3.05
Philippines	na	na		3.22	na	na	-0.44	-1.45	1.41	1.73	3.55	-0.85
Thailand	na	na	0.29	0.41	na	na	0.41	0.19	1.95	4.49	4.09	5.76
China	na	na	0.59	0.54	na	na	-0.01	-2.34	3.64	2.21	2.96	6.33
Argentina	na	na	2.50	3.32	-0.95	1.62	0.20	1.83	1.09	2.76	1.22	-2.23
Brazil	na	na	-0.92	1.22	1.66	1.25	2.07	2.54	3.39	2.76	5.51	-0.86
Mexico	na	na	1.57	2.18	-0.75	0.30	1.27	2.97	2.92	3.10	3.36	-0.50

Source: Calculations from data providing from Maddison (1995) Monitoring The World Economy 1820-1992, Table D-1a, pp. 194-206

Notes:
Japan data for 1880 is for 1885.
China, Indonesia, Philippines, South Korea, Taiwan and Thailand data for 1910 are for 1913
China, Indonesia, Philippines, South Korea, Taiwan and Thailand data for 1930 are for 1929
China, Indonesia, Philippines, South Korea, Taiwan and Thailand data for 1940 are for 1938
"-": data are not available
na: calculation no applicable

[e] The argument underlying Kondratieff waves, however, is much more complex. For example, Walter Rostow (1975. Kondratieff, Schumpeter and Kuznets: Trend Periods Revisited. *Journal of Economic History* **35,** 719-753) suggested that long waves or tends could only be explained in terms of a general, highly disaggregated dynamic theory of production and prices (including the leading sectors in growth; changes in the profitability of producing primary commodities and waves of international or domestic migration or other forces impacting the rate of family formation, housing demand and the size of the work force), which would include major trend phenomena of the era (including leading sector complexes, the agricultural sector, inputs to industry, and housing and infrastructure).

f This schema includes frontier mercantile (to 1845), early industrial capitalist (1845-1895), national industrial capitalist (1895-1945), and mature capitalist (1945-present) city types. On the other hand, Borchert (1967 American metropolitan evolution. Geographical Review 57, 301-332) uses the categories: sail-wagon (1790-1830), iron horse (1830-1879), steel rail (1870-1920) and auto-air-amenity (1920 - present).

came after the Draft riots of 1863. Together, these perspectives, long waves of development, technologies, shifts in values and crises, while still only able to provide partial explanations, help to outline the history of urban development and shape the various environmental transitions of US cities.

2.2 Globalization and time space compression

Globalization is the widening, deepening and accelerating of worldwide interconnectedness. Important to the process are flows of trade, investments, people and information. While globalization has been a process under development for a long period of time, the contemporary wave has facilitated a period of world history in which developing countries have experienced extra-ordinary periods of growth.[g]

Globalization has led to what one observer has called a "hyperactive world" (Thrift, 1995). Hyperactivity has taken many forms. In Pacific Asia, it can be seen in two important outcomes. First, the hyperactive world economy has compressed development for many nations and their cities. Second, it has telescoped aspects of development such that several phases previously experienced in sequential order by Western cities are being experienced simultaneously.

The rise of Japan, the Newly Industrialized Economies (NIEs), the ASEAN-4 and most recently China and Vietnam mark a period of speedy development. For example, some countries in the Asia Pacific region have experienced unprecedented growth rates in the last fifty years. **Table 1** compares annual growth rates by decade among selected countries since the 1870s. Western countries, during their "high" growth periods, did not reach the levels of growth experienced by countries in Asia. For example, during the late 1800s, the US's annual growth rates reached as high as 2.65 percent for any decade and after WWII growth exceeded 3.1 percent, but in countries in Asia, such as Japan, South Korea and Taiwan, "high" growth decades were defined by levels of 9.3, 8.1 and 7.7 percent increases respectively.

This rapid increase in income translated into shorter development periods. The development trajectories for Asian countries are simply shorter than those of the West. For example, Korea advanced from a per capita income of US$2,504 (1972) to US$8,294 (1989) in less than 20 years, while a comparable increase in the US, a per capita income increase from US$2,508 (1871) to US$8,215 (1941), took approximately 70 years.[h]

Associated with rapid development are a series of compressed transitions. One clear example is that of Japan's urbanization transition **(Figure 2)**. For example, the share of the country's urban residents shot up from 18 percent in 1920 to 71 percent in 1970 while the same increase occurred in 130 years in the US, as the country urbanized from 17.9 percent in 1860 to 71 percent in 1990. The urban transition took even longer in some European countries.

A transfer of new technologies and knowledge augments the rapidity of development. These transfers are important aspects of the telescoping that can be seen in the Asian development experience. That is, not only are development processes increasing in speeds there has been a certain level of overlapping of processes, such that within any country experiencing rapid growth, it is not untypical to find both modern and traditional ways of life existing side-by-side.

David Harvey (1989) describes this compression and telescoping as "time-space compression."[i] Time-space compression is associated with the speed in which transactions have been taking place, at all scales. According to Harvey, it is related to the processes that revolutionize the objective qualities of space and time. While originally

[g] See Held, D., McGrew, A., Goldblatt, D., and Perraton, J. (1999). *Global Transformations, Politics, Economics and Culture*. Polity Press, Cambridge, for an interesting view of how elements of globalization have been under development for, at least, the last five centuries.

[h] These are 1990 dollars. See Angus Maddison (1995). *Monitoring the World Economy 1982-1992*. OECD Development Centre, Paris, Table D-1a, pp. 194-206. See also, Crafts, N. (2000). Globalization and growth in the twentieth century. *In* IMF (Ed.), *World Economic Outlook, Supporting Studies*. International Monetary Fund, Washington, DC.

[i] According to Nigel Thrift (1995. A hyperactive world. *In* R. J. Johnston, P. J. Taylor, and M. J. Watts (Eds.), *Geographies of Global Change*, pp. 18-35. Blackwell, Oxford. p., 21), Harvey uses this idea in two main ways. He uses it to express the increasing the pace of life brought about by innovations like modern telecommunications. Second, it signals the upheaval in our daily experiences of life, as we are increasingly unable to map the representation of space and time.

intended to be an experiential concept, the notion represents underlying societal and individual changes that can be used to represent how material conditions of daily life have been impacted. It therefore provides ideas missing, for instance, from the concept of time-space convergence (Janelle, 1968).

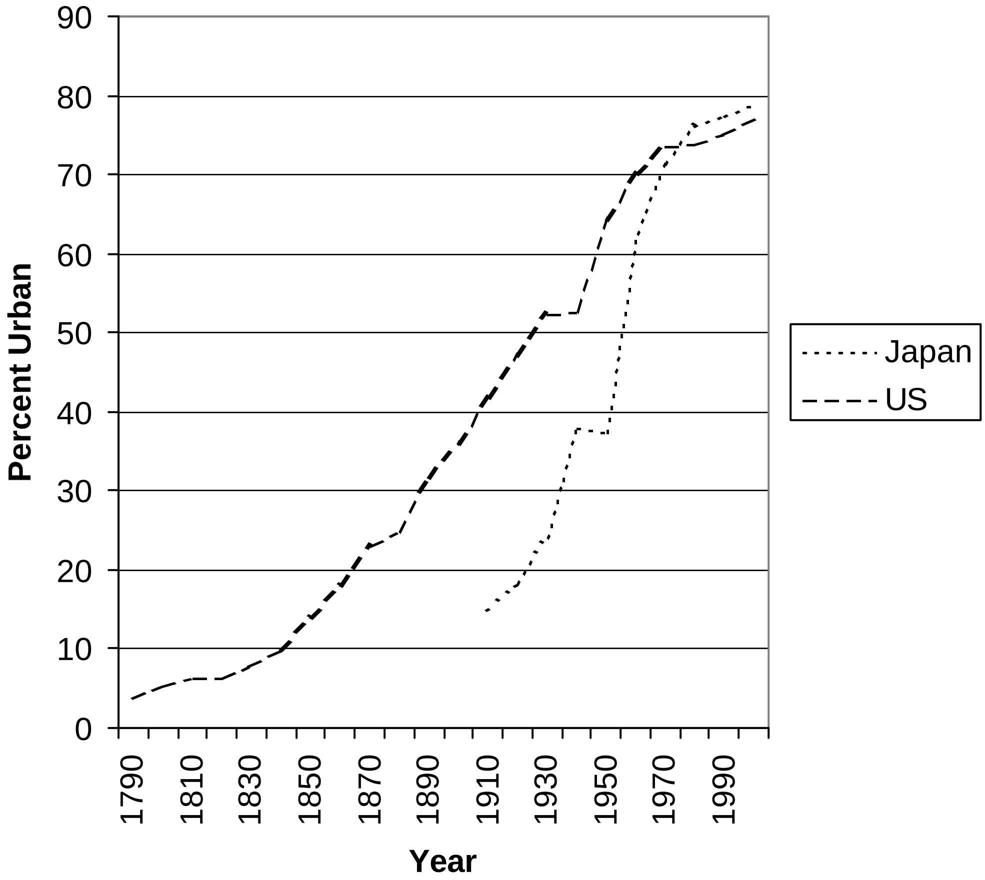

Figure 2. US and Japan urbanization rates

2.3 Urban environmental transitions

Urban environmental challenges vary among cities. The immediate question arises: are there any patterns to these problems? One hypothetical relationship suggests that as national incomes rise, environmental problems first get worse and then better. This articulation of the so-called Environmental Kuznets Curve (EKC) is pervasive in both the academic literature and policy debates. For example, in a recent article in *The Economist* an author stated that "most forms of environmental pollution either appear to have been exaggerated, or are transient – associated with the early phases of industrialization and therefore best cured not by restricting economic growth, but by accelerating it" (Lomborg, 2001, p. 63). What this argument ignores, among other things, is the shifts of character in environmental problems. For example, while sulfur dioxide concentrations in the air and phosphate concentrations in rivers follow this trend, it is not true for municipal solid waste generation or carbon dioxide emissions (World Bank, 1992).

Urban environmental transition theory (McGranahan et al., 2001), on the other hand, suggests that there is a series of different environmental challenges with development and not all of them follow the EKC trajectory. These authors suggest that as cities become wealthier their environmental impacts shift from localized, immediate and health threatening to globalized, delayed and ecosystem threatening (i.e., from "brown" to "gray" to "green" environmental challenges).[j] The model is helpful as it identifies the types of environmental challenges that citizens experience at different levels of development and also injects the issue of scale into the shifts in environmental burdens. As cities develop, "brown" issues are overcome, for example, and environmental challenges increase in scale from the household and neighborhood levels to citywide regions (i.e., the challenges then shift from access to water and sanitation and indoor air pollution to metro-wide air and river water pollution). For those cities struggling with the "green" issues, the dominant environmental impacts of urban-based activities are regional if not global (e.g. greenhouse gas, acid rain and ozone depleting substance emissions). With the addition of a continuum of scale, rather than the old duality of "think globally, act locally," the model suggests individuals should think and act at the appropriate scale (for an interesting discussion of the importance of scale in urban environmental issues see Vasishth and Sloane, 2002).

The importance of the "urban environmental transition" theory is at least threefold. First, it defines a relationship between development (wealth) and the urban environment (in the fullest meaning). Second, it points out that cities undergo a series of environmental challenges (which shift in focus of impact and timing), some of which are missing in the global "sustainable development" agenda (McGranahan et al., 1996). Third, the theory has placed the scale of environmental impact at center stage of the policy engagement.

2.4 Summary: transforming urban environmental transitions

Melosi (2000) has performed a historical study of important urban environmental issues in the USA. His narrative is comparable to the "urban environmental transition," as it explores the shifts in environmental challenges and the increasing scale of impacts associated with new solutions. He has also identified the importance of changes in scientific understanding of environmental problems. His study suggested that, for US cities, the urban environmental transition occurred over the last 150-180 years and the shifts between sets of problems occurred in a sequential manner. This allowed for successful response scenario to develop as each set of issues was dealt with a "first things first" approach.

In Asia, studies of urban environmental conditions have also been performed. Webster (1995) was perhaps the first to use the theory to describe current conditions. He discussed the nature of urban environmental problems in Southeast Asia based upon the environmental risk transition and divided cities into three categories. Category 1 cities were poor with largely brown issues, such as Hanoi, Ho Chi Minh and Phnom Penh and Vientiane. Category 2 cities were middle-income cities with air pollution and congestion problems as the dominant concerns. These included Bangkok and Kuala Lumpur. Category 3 cities were high-income cities and were battling urban environmental issues such as hazardous wastes and amenities. Singapore and Hong Kong were included in this category.

In a recent study, Bai and Imura (2000) examined the environmental conditions in various cities in East Asia. In their analysis they suggested a staged environmental challenges model. According to their scheme, cities in the region included three types. Type I were those cities with poverty-related environmental issues. Type II cities were those with rapid growth related environmental issues and Type III were those with wealthy lifestyle related issues. This study has demonstrated that urban environmental problems vary among cities of different wealth. Further, while their "staged type environmental evolution" theory predicts that cities experience one set of environmental problems before moving to another, they suggest that cities do not necessarily move from "poverty" to "industrial" to "consumption" related problems. In this perspective cities can jump between stages, for example, from the "poverty" related problem stage to "consumption" related problem stage without passing through the industrial pollution related stage.

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[j] In this article, we have divided environmental challenges into three agendas. The "brown," agenda environmental burdens are related to water supply, sanitation and infectious diseases. "Gray" agenda issues are those related to air and water pollution and other negative aspects of industrial processes. The "green" agenda includes consumption-related problems, ecosystem health, ozone depletion and greenhouse gas emission issues, among others.

Bai and Imura (2000) advanced our understanding of the transition in the region by identifying, implicitly, a compressed experience within Asia.[k] They suggested that cities, such as Kitakyushu, Japan, underwent rapid environmental transitions. Indeed, they mapped the start of the Kitakyushu's ability to deal with "brown" issues in 1955 and noted that the city passed through this phase by 1970. That year, as the authors suggested, the city began its second phase of dealing with environmental pollution. At that time the rapid, industrial-driven growth related pollution issues emerged. These pollution problems were largely solved by 1990, when pollution related to mass consumption became a problem. Hence, the three phases of the transition were crossed in less than 40 years.

Our argument differs from these previous studies in that it suggests both compression and telescoping of the

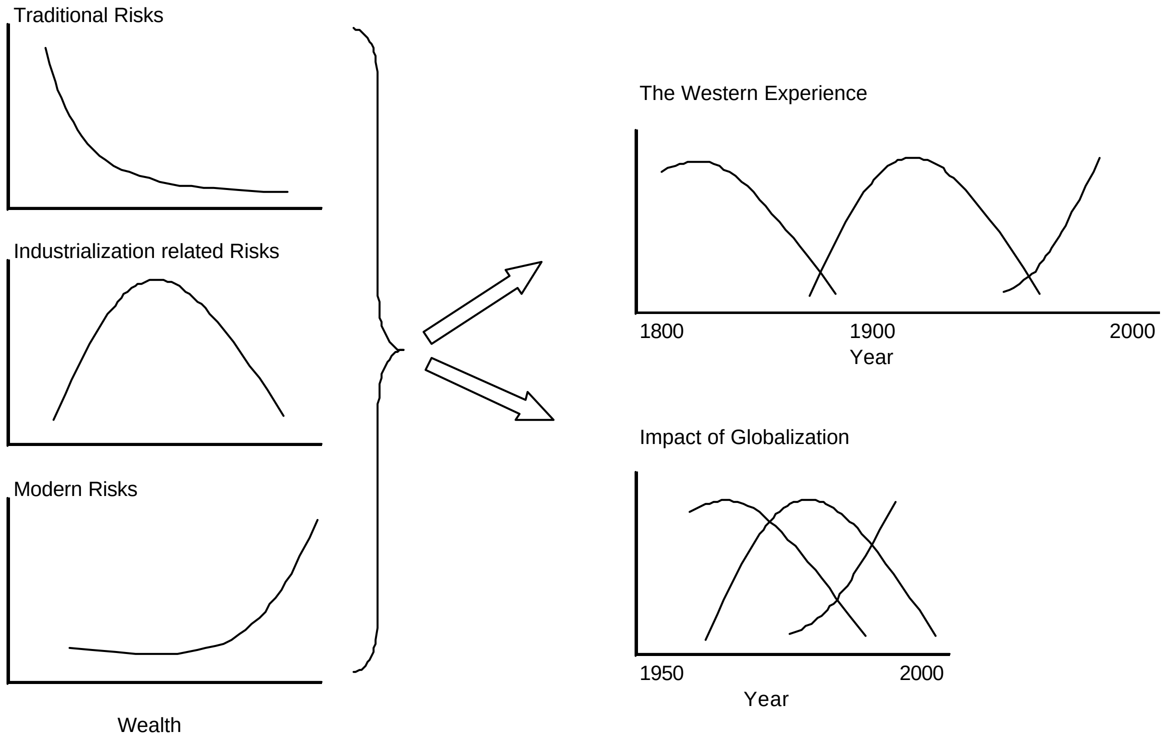

Figure 3. Schematic Different Urban Environmental Transition Experiences

environmental transition **(Figure 3)**. That is, globalization and the associated "time space compression" can be seen at work within the process of development and the emergence of environmental transitions. The transition in Asia has the character of overlapping challenges such that within most cities, particularly those increasingly articulated with the global economic system, we find a variety of challenges and unfinished agendas.

In terms of transportation systems, those in the West have followed a particular pattern. Outlining this pattern and comparing it to the current experience in Asian cities demonstrates how this aspect of urban environmental development has been impacted by time-space compression. In order to flesh this perspective out, we will provide a historical perspective for Western (USA) cities, and a cross-sectional view of what is currently happening in Pacific Asian cities.[l]

3. History of US urban environmental transitions and urban transport

[k] The authors studied only Asian cities and did not compare them to those of the West.

[l] As the nations and their cities within the region have a wide variety of income levels, they approximate a trajectory of development. The authors recognize the limits of this type of analysis, the findings of which necessitate further exploration.

There is an extensive literature on the history of urban transportation in the US (see for example, Bottles, 1987; Chudacoff, 1981; Clark, 1999; Hood, 1993; Jackson, 1985; McKay, 1999; McShane, 1994; 1997; Schneider, 1972; Taylor, 1966; Yago, 1983). Therefore this section will only briefly review this history while it attempts to make two points. First, it identifies the transportation technology, infrastructure and crises trajectories specific to the West.[m] Second, it associates certain environmental issues with specific eras and technologies. The dominant environmental burdens of each period, defined by long waves of development, are outlined using urban environmental transition theory and are then linked with the dominant transportation system of the period. It is evident that different periods were associated with different sets of environmental problems and that transportation systems were tied into these challenges **(Figure 4)**. Solutions came about slowly as challenges were met sequentially. Often these solutions lead to problems in later periods. The section is sub-divided by eras of development.

Age	Physcial Urban Forms	Dominant Urban Environmental Challenges	Transportation-related Technology	Transportation-related Infrastructure	Transportation-related Crises	Shift in Values
Mercantile						
(before 1845)	"Walking"	Water supply, sanitation, infectious diseases	Walk, horse (animal), wind amnibus	Ports, canals, "pikes"	Fires, infectrous disease	Adaptation
Early Industrial						
(1845-1898)	Large urban, beginning of segregated land uses	Water supply, sewage, sanitation, infectious diseases	Omnibus, steam railway, horse street car, cable car, carriage, electric trolley, bicycle	Paved streets, steam railway, subway, urban streetcar tracks, "elevateds"	Infectious disease, horse manure, congestion, connecting country with city	Streets for pedestrians, anti steam engines in parts of cities, anti autos
National Industrial						
(1898-1945)	Metropolitan, beginning of suburbanization, formation of Central Business Districts, skyscrapers, large infrastructure	Water quality, sewage treatment, rise of industrial chemical pollution, Urban mortality penalty crossed	Trolley, automobile, subway, bus, beginning of air travel	Parkways, toll bridges and tunnels,	Road infrastructure, dispersing urban population, beginning of auto related pollution	Streets for traffic (not private use), pro-automobiles
Post-Industrial						
(A - 1945-1973)	De-industrialization, Commercial and service areas, suburbanization accelerates, large infrastructure	Industrial-related water, air and hazardous waste pollution	Large vehicles, commerical jet (high speed) airplanes	Highways, large vehicles, dismantling of public mass transit	Congestion, air pollution, traffic accidents, infrastructure maintenance	Anti-pollution regulatory strategies
(B - 1973 - Present)	Exopolis development, re-centralization and ex-urbanization	Sustainable "green" agenda issues	Light rail, transit related developments, large body jets, fuel efficient cars	Smart traffic	Infrastructure maintenance, congestion, air pollution, traffic accidents, GHGs, O3 and acid rain	Ecology

Figure 4. Western Transportation Development in related to Urban Environmental Challenges

3.1 Mercantile cities (before 1845)

During this period, space was a commodity and people gathered close together for not only social comfort, but also for protection. Mercantile cities in the US were characteristically dense, had a clear distinction between their urban and rural components (in part a legacy of the walls surrounding communities), were internally composed of a mixture of functions without segregation (except for the waterfront warehousing and red-light districts), were without a geographic distinction between work and residence (possibly they may have existed next door to each other) and provided the most fashionable and respectable addresses close to the center of town, while suburbs where the “slums” (Jackson, 1985).

Urban environmental problems were local and “brown” in nature. Early challenges were largely related to water supply, waste removal and waste management. For example, in New York City, until the mid nineteenth century garbage was often left for pigs and other scavengers in streets and alley, dumped in low-lying lands, or discarded by the river (Goldstein and Izeman, 1995). Not only were the suburbs the location of low-income areas, but they also became the haunt of such objectionable industries as slaughterhouses and tanneries as well as the residence of many poor and

[m] This trajectory is also associated with long waves, norms and scientific knowledge as mentioned in the previous section. For brevity, however, these issues are only mentioned and not fully discussed.

unskilled workers who could not afford the high costs of housing closer in. As these problems were believed to largely the individual's responsibility, most were not "solved" for the community. Adapting to conditions meant adjusting.

Outward growth was limited by transportation technologies (largely animate power), as mercantile cities were largely "walking cities." Only the most affluent could afford to keep horses or have personal carriages. Movement between cities began slowly and was helped in part by the construction of canals and pikes.[n]

Within cities, mass transit began in the 1820s, when the horse drawn omnibuses[o] appeared. The technology grew rapidly. In New York City, for example, by 1837, the city granted licenses to 108 omnibuses, by 1847, 260, by 1850, 425 and by 1853, 683 licenses. By the mid-1850s, approximately 120,000 passengers rode the city's omnibuses daily. By mid-century the omnibus had also become essential transportation technologies for Washington, Baltimore, Pittsburgh, and St. Louis (Chudacoff, 1981).

This technology allowed an emerging middle-class to move their residences 1 to 2 miles from the historic city center in both Europe and the US (McKay, 1999), but as the ordinary wage earner received little more than a dollar a day and rarely more than two, the omnibus, like the personal carriage remained too expensive for the common person.

Animate transportation was supplemented by, for the first time, mechanical power late in this period. Steam powered trains traveled between cities (and from cities to their suburbs) and steam ferries plied urban rivers by the 1830s. The rise of these technologies affected both the internal pattern of cities and national urban development. As internal determinants of urban form, their tendency to start and stop slowly and the sparks, ashes and smoke spewed from their smokestacks made them unpopular with those living near their tracks and railroad stations. Commuter trains created a string of small bedroom communities, surrounding the railroad station, separated by rural greenbelts. By mid-century nearly all the trains leaving Boston made commuter stops within fifteen miles of the city, and railroads based in New York and Philadelphia ran several trains daily to and from nearby towns. Over the next decade such service spread into the Midwest.[p]

Also at the end of this era, the horse-drawn coach over rails appeared. The technology combined the technologies of the omnibus and the railroad and offered faster, smoother rides over cobblestones. By 1860 street-railway companies were operating in at least nine major cities. There were 142 miles of tracks in New York alone. Because the equipment and construction of horse railways were more expensive than omnibuses, company owners had to be more concerned with laying track and running cars along the most profitable routes. The result again was that outward expansion proceeded unevenly (Chudacoff, 1981).

Together by the mid nineteenth century, these technologies dramatically reconfigured urban space. The introduction of the steam ferry, the omnibus, the commuter railroad and the horse car gave impetus to an exodus that would turn cities "inside out" and inaugurated a new pattern of suburban affluence and center de-concentration, as the wealthy attempted to leave behind the environmentally loathsome conditions of the city (Jackson, 1985). At the same time, the mixture of these technologies created a chaotic internal environment. Without traffic lights or regulations and because

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[n] The construction of the country's greatest canal, the Erie Canal (1817-1825), was crucial to solidifying the position of New York as the nation's first port and largest and most active commercial city, through tying a large portion of the growing western markets to the city. This infrastructure success provoked Philadelphia, Baltimore and to a lesser extent Boston into constructing their own transportation links to the West. The era of canals, however, was short lived and quickly replaced when the steam engine came into use (see Borchert, J. A. (1967). American metropolitan evolution. *Geographical Review* **57,** 301-332).

[o] An omnibus was a large horse-drawn coach designed to transport approximately 12 passengers over a fixed routes for fixed fares. It combined the functions of two traditional types of public transportation: the hackney, an early version of the taxicab, which carried passengers where they wished; and the stagecoach, which operated over long-distance routes at scheduled times.

[p] Interestingly, in Europe the steam engine was banded in cities. Steam wagon, "Russell carriages" were seen regularly in English streets in the 1830s, but the general public was against this particular technology and in 1840, the Court of Sessions completely banded them

of the high densities of cities, travel became increasingly difficult. Urban environmental burdens could only be avoided by the most wealthy, who could afford residences outside the city.

3.2 Early industrial cities (1845-1895)

During the early periods of industrialization in the US, manufacturing and processing plants were small, locally owned and their growth was nurtured behind protectionist trade barriers and high transportation costs. Economic and urban growth increased at greater rates than in the previous period, but was still low by today's standards. Between 1820 and 1870, for example, average growth rates in the US increased to 1.3 percent per annum and these increased again to 1.8 percent per annum from 1870-1913 (Crafts, 2000).[q]

Industrialization, defined as the coordinated development of economic specialization, mass mechanized production, mass consumption and mass distribution of goods and services began in US during this period. Industrialization also became synonymous with urbanization as the number of urban centers increased with economic growth and became centers of economic activities. In 1840, there were 85 urban centers and by 1900 there were 905. By 1900, approximately 27 million people, or about 36 percent of the nation's population, lived in cities (Yeates, 1998).

With rapid growth and the beginnings of industrialization the set of urban environmental problems that emerged during the previous period grew to critical levels, increasingly impacting urban life. The human cost of living in these cities, as opposed to rural areas, was a substantial morality penalty. Excess mortality in cities, according to Haines (2001, p. 5) was created by "greater density and crowding, leading to the more rapid spread of infection; lack of adequate clean fresh water and sewerage disposal; a consequently higher degree of contaminated water and food; garbage and carrion in streets and elsewhere not properly disposed of; larger inflows of foreign migrants, both new foci of infection and new victims; rapid turnover of both goods and people; and also migrants from the countryside who had not been exposed to the harsher urban disease environment." It was after 1870 that the difference between rates of death in country and city became to converge.

Water supply and wastewater removal remained the main focus of urban environmental specialists. Advances in water supply and sewerage provided relief from the worst impacts of compact development. Proto-water supply systems, controlled by local governments, began to appear. At the same time, the introduction of large amounts of water into cities created new challenges for city managers, in terms of removing wastewater. Soon after water supply systems were developed and water closets became popular among the rising middle-classes, civil engineers developed sewerage systems. Refuse collection, on the other hand, was not well developed. Street cleaning was largely confined to wealthy and commercial areas.

By the end of the period, an enormous host of technologies appeared and these innovations dramatically impacted urban growth and development. New technologies appeared in production (facilitating new economic activities and the expansion of markets), housing construction (allowing large numbers of people to live in densely set buildings) and real estate development (allowing buildings to cover entire lots). Examples of products included the telephone, camera, electric trolleys, steel alloy, streetlights and elevators.

Some of the most important technologies were related to transportation. One new technology was the cable car. It was cleaner than and twice as fast as horse drawn technologies. First introduced in San Francisco in 1873, it spread to

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Schneider, K. R. (1972). *Autokind vs Mankind*. Schocken Books, New York..

[q] During these periods, Crafts, N. (2000). Globalization and growth in the twentieth century. *In* IMF (Ed.), *World Economic Outlook, Supporting Studies*. International Monetary Fund, Washington, DC.) estimates that the US growth rates were among the highest in the world.

other cities, such as Chicago where it had its widest use.[r] Cable systems were laid in 26 cities in the US by 1891. By 1890 they were carrying 373 million passengers as opposed to the 1.2 billion on all horse-drawn street railways (and the 287 million on all forms of steam-powered street railways). Cable cars existed in Washington, DC, Baltimore, Philadelphia, New York, Providence, Cleveland, St. Louis, Kansas City, Omaha, Denver, Oakland and Seattle (Chudacoff, 1981; McKay, 1999).

By 1860, horse drawn rail cars were increasingly replacing omnibuses and the trend accelerated during the Civil War (1861-1864). In New York, for example, horse railway traffic almost tripled in the 1860s, reaching 115 million passengers by 1870 – or about a hundred rides per year per capita (McKay, 1999).

American's also were able to capitalize on breakthroughs in electric traction earlier than their European counterparts. By 1888, the first successful technology was applied in Richmond Virginia and grew rapidly thereafter. Overhead electric traction promised and delivered substantially greater profits to street railway companies by cutting per until operating costs on horsecar operations. Costs per rider declined by roughly 50 percent as companies shifted from horsecar to electric streetcar, despite a doubling of fixed investment per unit of line. Electric traction also broke the bottleneck of inadequate supply of urban transit for the first time, through increased capacity to carry passengers. This resulted from increased car speed, larger cars (and/or double deckers and trailers) and much better performance on hills and in snow. Moreover, electric trams rode smoothly (did not lurch) and stopped easily.

By the end of 1893, total street railway tracks in the US had doubled from the 1890 level to 12,000 miles; ten year later, they reached 30,000 miles. By 1893, 60 percent were electrified this share increased to 98 percent by the end of 1903, making the electric streetcar in the US was one of the most rapidly accepted innovations in the history of technology (McKay, 1999). By the beginning of the twentieth century electric trolleys had almost completely replaced horse railways and cable cars as the major means of urban transportation. By 1902 the nation's total urban horse railways had dwindled to 250 miles (Chudacoff, 1981).

Advances in transportation tec hnologies continued to turn the American city inside out. As these technologies became available to the average worker, people decentralized and cities began to growth outward at great rates. Indeed, by the end of the period, the largest of cities, such as New York and Chicago, consolidated politically to retain control over populations and resources beyond their border. The result of this outward movement, facilitated in large part by new transportation technologies, was that cities became healthier places. The implementation of these technologies in combination with the advances in water supply and sewerage helped to "solve" the urban environmental burdens of the time.

3.3 Mature industrial cities (1895-1945)

At the turn of the century, the USA entered a period of increasing industrial activity. Powerful national and transnational corporations and large-scale assembly line manufacturing that produced a vast array of consumer items emerged. It was at this time that the USA turned into a consumer society, which centered on large urban markets.

Urban economic growth was enhanced through a second wave of immigration (approximately 25 million people) that entered the country from 1880 to 1920.[s] For example, early in the twentieth century New York City's borough of Manhattan reached its highest population size and density, largely through the influx of migrants.[t]

[r] There cable-car lines spread rapidly in the 1880s, particularly to the city's South Side, and by 1894 Chicago had 86 miles of cable track and over 1,500 grip and trailer cars (Chudacoff, H. P. (1981). *The Evolution of American Urban Society*, 2nd Edition ed. Prentice-Hall, Inc, Englewood Cliffs).

[s] The US experienced its first wave during the mid-1800s and together the two waves of migration vastly increased the nation's population. In 1840 there were 17 million Americans, but in 1910 there were 106 million. Growth was most striking in the cities of the Northeast and

This era signaled the emergence of an urban society, as the nation's population shifted from rural to urban. Between 1920 and 1940, the urban population of the US increased from 54.2 million to 74.4 million, and the number of urban places with populations of 2,500 or more increased from 2,722 to 3,464. In 1920, 51.2 percent of the population were urban residents.

It was also during this period that two important consequences of urban growth and development emerged. First, advances in water supply and sewerage created larger scale problems, particularly for locations downstream of large cities. Concerns over sanitation forced new solutions to wastewater treatment, including treatment for biological contaminants. Second, the first major shift in urban environmental challenges occurred. As brown challenges were increasingly "solved," however, chemical industrial-related problems began to emerge. During this period emphasis shifted from biological aspects of pollution to chemical issues.

Cities completed their comprehensive sewerage systems during this period. By 1920, 87 percent of the urban population lived in sewered communities, which represented about 45 percent of the U.S. population. The number of sewered communities increased from approximately 100 in 1870 to 3,000 in 1920. The growth of sewered urban populations continued steadily to the early 1940 and reached almost universal status by the end of World War II (Melosi, 2000). The growth of sewered systems, however, created other challenges, wider geographically in scale.

At the turn of the century, approximately 90 percent of the nation's sewage was dumped into water bodies without treatment. This resulted in the un-intended result of causing high typhoid death rates in downstream cities that drew their water supplies from rivers in which upstream cities discharged their sewage. These epidemics mounted until both the technology improved and laws were passed forbidding sewage pollution (Tarr, 1999).

Advances in bio-chemistry severed the association of density and disease.[u]

The use of bleaching powder, chlorine gas and chloride of lime as treatment to water enhanced purity. With these techniques a dramatic decline in typhoid fever rates followed. By 1920 typhoid death rates in the United States were more in line with those of European countries, such as England, Germany and France, where water purification had been widely applied. Aggregate typhoid (and para-typhoid) fever death rates per 100,000 populations dropped steadily in the United States by the late 1920s, after some serious outbreaks at the mid-decade. Between 1920 and 1945, the rate dramatically dropped from 33.8 to 3.7 (Melosi, 2000).[v] With the discovery of typhoid bacillus, a scourge until the 1920s, and other pathogenic microorganisms, public health officials and engineers began to understand the extent of waterborne diseases, and sought methods for combating them. By 1940, the urban penalty in the USA had been eliminated and it became healthier to live in American cities than to live in rural places in the country (Haines, 2001).

It was during this period that the collection, disposal and treatment of refuse emerged. In pervious periods, the "garbage problem" was site-specific and largely the individual's responsibility. Changes to this perspective rose with

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Midwest. New York City grew from 200,000 residents in 1830 to more than 1 million in 1860, reaching almost 7 million in the late 1920s when immigration constraints came into effect (see, for example, Muller, T. (1993). *Immigrants and the American City*. New York University Press, New York). During one day in 1907, at the height of the second immigrate wave, approximately 12,000 people cued up on New York's Ellis Island for entry in the US and during that year 1.2 million people were received by the city.

[t] Manhattan Island reached 2.3 million people by 1910 and according to Ken Jackson, noted NYC historian, by that time had obtained residential densities higher than any city in the world to that point, and possibly since then.

[u] In 1870, almost no US water was filtered, but by 1880, approximately 20,000 people in urban areas were receiving this service. By 1900 this number grew to 1.86 million and jumped again to 10.8 million in 1910 and over 20 million in 1920 accounting for 37 percent of the entire urban population (see for example, Haines, M. R. (2001). The urban mortality transition in the United States, 1800-1940, *NBER Working Paper Series on Historical Factors in Long Run Growth,* pp. 20, Cambridge). By World War I, most of the largest cities and several smaller ones invested in filtration plants and treatment facilities, making the infrastructure of the modern water-supply system more intricate with these new additions.

[v] While the rates of bacteriological and pathenogenic diseases decreased, occupational hazards increased. The most poignant moment and a watershed for those working for safe and healthy workplaces was the Triangle Shirtwaist fire, March 25, 1911, in which over 140 women

increased densities, but at the turn of the century focus shifted again from urban waste as the bacteriological perspective won sway over "filth" theory in the US. With the rise of the consumer society during this era, however, increasing amounts of waste had to be removed from city streets and treated. It was during this period that incineration and the sanitary landfill were developed (Melosi, 2000).

In terms of transportation, three important features were added to cities that encouraged further urban expansion, decentralization and the emergence of a nationally networked urban system. First, by 1902 over 50 percent of streets in the largest cities and 16 percent of all city streets were paved with asphalt. By 1924, almost all cities had all their streets paved. The massive paving spree was not only related to the automobile or to advances in chemistry, but also to a shift in taste from compact city housing to detached suburban homes, which ultimately shifted emphasis of the street from playground to transportation lane and to changes in local government institutions including the rise of the transportation engineer (McShane, 1979).

Second, the automobile entered the urban scene. At first, these instruments were largely associated with wealthy citizens. For example, in 1906, 200 New Yorkers owned five or more cars with John Jacob Astor leading with 32 (McShane, 1994).[w] Things changed after 1908 when Henry Ford produced the "Model T" and his five-dollars-a-day assembly line workmen earned enough money to buy their own machines. Both mass output and high wages made it possible for cars to appear both on farms and in cities, for work and for pleasure (Schneider, 1972).

Thereafter US automobile production was meteoric. In 1909, automobile production surpassed 100,000 cars annually. In 1910, the industry produced 187,000 cars. By 1911, automobile manufacturers produced 209,000 cars. In 1913, production reached 485,000 motor vehicles. In 1916, production jumped again to 1,617,000, exceeding the number of human births. Auto output between 1899 and 1937, increased by 180,000 percent. The heart of the growth appeared in the decade before World War I. By that time, nearly every American that could afford an automobile had one. Car registration reached 20 million in 1925. Thirty million were registered by 1937. By 1937, not only was production increasing, but the auto industry also grew to include a large share of total national employment; not less than 6,255,000 Americans had jobs because of the automobile or nearly one job in seven (Schneider, 1972).

As more and more roads were paved, and people drove on them, suburban expansion and the creation of regional urban networks increased. Within and between cities, numerous neighborhoods, factories, shopping and other commercial areas, and a variety of public institutions emerged. Increasingly, it was believed that the automobile was necessary for expansive urbanization.

As the auto was hailed as necessary for urban growth and also as the solution to some urban problems, particularly those associated with waste from horses, they were created other challenges. Heavy car and truck traffic began to plague every American central business district. Within cities, by 1914 traffic jams began to be common. It became apparent that the physical structure of American cities could not readily accommodate the automobile. The technological answer to "solve" congestion was the "freeway." In 1938, a federally sponsored traffic survey declared that a system of limited access highways would allow regions to tie their sub-centers together. It wasn't however, until the next period that the major national highway program was implemented.

(mostly teenagers) died in a workplace fire.

[w] While New York City was the center of automobile ownership and use, it wasn't without some contempt from the general public. In 1905, for example, stone throwing mobs attacked automobiles on Lower East Side, the location of high-density immigrant populations. This was one of at least 13 anti-auto incidents in the city that year (McShane, C. (1997). *The Automobile, A Chronology of Its Antecedents, Development, and Impact*. Greenwood Press, Westport, CT).

The automobile replaced other urban transportation, as auto use was a substitute for mass transit. By 1920, the National Automobile Chamber of Commerce stated that 34 percent of all auto usage was in substitution for the streetcar or railroad (Schneider, 1972). The result was that horses and horse-drawn technologies faded first and then electric traction slowly began to disappear. After World War I, rising labor and material costs, combined with poor management decisions brought hard times to the industry. Many traction companies in urban areas throughout the US filed for bankruptcy during the ensuing decade. Most of the survivors were liquidated during the Depression. With the introduction of the freeway, the general outlook for railways throughout the nation was also dim.

The third technology that began to change urban life was the invention and growth of the airplane. While the commercial use of the airplane increased after World War I, however, it still was not a major source of domestic transportation. Increasingly, however, cities were changing their landscapes by building airports.

3.4 Post industrial cities (1945-present)

Growth during this period was not even. Like the history of growth for the entire world, US growth can be sub-divided into two sub-phases entitled "the golden age" and the "landslide" (Hobsbawn, 1996). During the "golden age," directly after the World War II, as the US emerged as the most powerful economic and military country in the world, its economy experienced rapid and sustained growth. From 1949 to 1973 per capita wealth (in constant dollars) increased by over two-thirds as the national GDP per capital increased annually on average by 2.4 percent (Crafts, 2000). The nation's owners of capital increasingly centralized and concentrated their economic might into large (transnational-) corporations. By 1973, the 500 largest industrial corporations accounted for 80 percent of all corporate profits in the US and together employed more than 15.5 million individuals.

During the sub-period, the nation's population also increased by more than 60 million people within two decades; a process created largely by the post-war baby boom, which peaked in 1959. This increase helped to expand the housing market, created an urgent need for services within urban areas and generated an increase in consumer spending.

With economic and population growth came rapid increases in the metropolitan populations. Between 1920 and 1950 the number of Americans in cities rose from 50 percent to 64 percent and by 1970 to 73.5 percent. From 1940 to 1950, metropolitan areas grew by 22 percent, while the country grew by 14.5 percent. Most of this growth occurred on the outskirts or periphery of the city cores. While southern and western cities grew through annexation, a large black migration from the south to northern cities helped shift the racial composition of their cores. As black migrants arrived, wealthy white families moved out the city into the outer suburbs. This left poorer black, and later Latino families, concentrated in the core. This process of spatial racial segregation was helped by the government policy of "red-lining," among a series of other polices (Jackson, 1985).[x]

By 1970, the US census announced that the nation was largely suburban (over 40 percent). Core cities were losing population, enhancing the economic erosion of their bases and promoting specialization. Metropolises developed multiple centers, including self-contained communities on the periphery. Nationwide, Southern and Southwestern cities grew at the expense of older urban centers in the Northeast and Midwest.

The "landslide" period was characterized by an interruption of growth, an increase in instability and crises (Hobsbawn, 1996). The last quarter of the twentieth century is associated with a marked decrease in the international dominance of the US corporations; a rise in Japan, Southeast Asia and the Europe Union, the fall of the Soviet regime,

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[x] During the 1950 and 1960s, while the country was growing, the minority population locations in the Northeastern inner cities were experiencing decay and neglect. The situation exploded in the mid-1960s when a series of race riots shocked the nation. These crises, however, pre-dated the global and national economic problems experienced during the next sub-period.

the establishment of a highly integrated world financial market facilitating rapid international capital flows; considerable transnational economic growth-recession instability, the emergence of new products and process technologies, the rise of the service economy in OECD nations as secondary industries became less important in their overall economies and fluctuating but ever increasing flows of trade and investments among nations. These changes have lead to the emergence of a more integrated world economy in which the US economic leadership was not as strong as in the immediate post-World War II decades.

This sub-period was marked by continued suburbanization if not ex-urbanization. By 1980, 40 percent of the American population lived in suburbs, a higher proportion of people that lived either in rural or urban places (Jackson). Suburbanization meant increased consumption, as Americans preferred large single-family homes rather than compact apartment buildings. Of the 86.4 million dwelling units in the United States in 1980, about two-thirds, or 57.3 million, consisted of a single family living in a single dwelling surrounded by an ornamental yard, making the urban-rural contrast less distinct (Jackson, 1985).

New urban spaces emerged as a direct response to larger changes. Ed Soja (2001) has identified some of the new urbanization processes and their outcomes in the US. He suggests that five tendencies related to the new urban geographies including mega cities and metropolitan galaxies, outer cities, edge cities, lite cities and simulated cities, which taken together make up the urban form of the new "exopolies." The term refers to both the growth of cities outside the city and the exogenous forces (i.e., globalization) shaping city spaces.

The urban environmental experiences of this period can also be divided into two phases. During the first phase of the period urban environments changed as chemical pollution levels reached high levels and increasing sub-urbanization and sprawl strained infrastructure, both inside the city and in the outer rings.

After the WWII, with years of industrial by-products accumulating in the urban air a new set of crises emerged. While air pollution had been an issue since the turn of the century,[y] the disasters of Donora, Pennsylvania, where almost half of the town's 14,000 residents became ill and 20 died, and the London fog in 1952, where the death toll climbed to over 3,000 brought industrial polluted air to the forefront of news (American Lung Association, 2001).

Levels of pollutants in the nation's rivers and streams also mounted. Notably environmental catastrophes included oil spills such as off Santa Barbara, Californian, Cleveland's Cuyahoga River fire,[z] the "death" of Lake Erie, the NYC Hudson River fish kills,[aa] and numerous beaches fouled by garbage.

Besides air and water pollution, other "gray" issues were placed on the political agenda as the need for infrastructure to accommodate new demands in the suburbs and to replace aging infrastructure in the core increased. Infrastructure demands within cities, however, were difficult to fulfill, not because of technical issues, but rather for political and economic ones. Suburban areas incorporated to fight off city annexation and responsibility for further urban investments. As upper and middle-income families fled, urban resources diminished and the urban cores in many cities deteriorated.

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[y] Smoke in cities, due to burning coal dirtied clothes and buildings and was a health threat to citizens. Unlike drinking water contamination and sewerage, however, many people also viewed smoke in positive terms as a sign of progress and industrial productivity. Because smoke abatement could threaten business profits and workers' livelihoods, opposition came from both business and labor (see Stradling, D. (1999). *Smokestacks and Progressives: Environmental Engineers and Air Quality in America, 1881-1951*. Johns Hopkins University Press, Baltimore). As a result, by 1940, only 52 municipalities, 3 counties and no states had air pollution control legislation (Portney, P. R. (1990). Air pollution policy. *In* P. R. Portney (Ed.), *Public Policies for Environmental Protection*, pp. 27-96. Resources for the Future, Washington DC.Table 3-1, p. 29).

[z] More than 200 tons of chemical, petroleum and iron wastes, plus domestic sewage, were discharged daily into the Cuyahoga. In 1959, the river burned for eight days and during the summer of 1969 it caught fire again, engulfing two railroad trestles.

[aa] Across the country, it was estimated that in 1963, there were 7.8 million fish killed by discharges into US water bodies (2,200 miles of

During the second phase, an attack on point source pollution successfully brought down levels of toxins in the air and water, but did not deal with more long-term issues, such as persistent pollutants, non-point source pollution (i.e., urban runoff) and increasing consumption. Hence, the emission of "gray" agenda pollutants reached then plummeted as political action took effect. As, industrial related pollution conditions were improving, the second shift in environmental issues occurred; green agenda issues emerged.

In terms of transportation systems, automobile related travel continued to increase as public mass transit declined. From 1944 to 1968 auto travel increased each year nearly as much as all auto travel in 1920. By 1968 Americans traveled a trillion miles in their cars (Schneider, 1972).

From 1955 to 1965 the number of motorcars increased by 24 million while transit patronage dropped by 25 percent. Americans spent US$1.8 billion for local public transport in both 1941 and 1963, while motorcar expenditures nearly tripled, rising from US$13.2 to 38.2 billion (Schneider, 1972).

The increasing importance of cars in cities was enhanced by the general influence of the auto industry within the national economy. In 1968, nearly 15 million Americans were working directly or indirectly to support the automobile industry – one fifth of all wage earners. The automobile-related industries accounted for eleven out of the twenty-two largest American manufacturers (seven petroleum, three auto, one rubber). In every city and town, 823,000 enterprises are also automotive related – one sixth of all American businesses. In the early 1970s the Automobile Manufacturers Association estimated that about 13.3 million persons are employed in producing and servicing automobiles, refining and selling fuels, maintain and repairing public roads, and driving trucks, buses and taxis. This accounted for about 19 percent of total current employment. Left out of this accounting were highway contracting, driving education and licensing; motor vehicle registration and inspections; law enforcement and legal activities, finance and insurance, commercial parking and endless backup industries and services. Adding these activities would bring up the total to 15 million persons or almost 21 percent of all workers, more than one out of five (Schneider, 1972).

This increase was aided by government intervention at the national and local levels. At the national level, the Eisenhower Administration implemented the 1956 Federal-aid Highway Act, the most ambitious public works program in the nation's history. The government proposed to spend US$101 billion on a highway construction program. The Highway Trust Fund financed the interstate system. The fund guaranteed all federal fuel tax revenues for road uses until the 42,500-mile system was completed (Schneider, 1972)

At the local level, bureaucrats, such as New York City's Robert Moses, changed the urban fabric with highways, bridges and other transportation infrastructure. Most was dedicated to the car as thousands of miles of roads were paved. By 1985, 155,400 square kilometers of US land was paved.

As a result of the prioritization of auto traffic, at least two urban environmental crises emerged. First, urban mass transit suffered and during the 1960s, the federal government needed to provide money to cities for the purchase of these companies. The 1964 Urban Mass Transportation Act started major federal funding for capital expenditures on transit (bus and rail). This started an adversarial relationship between auto and mass transit interests that can be seen today. Legislation entitled, Intermodal Surface Transportation Efficiency Act (ISTEA), 1991, attempted to provide for a holistic vision of transportation policy that included public transit. The growth of federal support for transit succeeded in halting the decline in motorbus and light rail use in the middle of the 1970s. Since then bus use has increased, light rail stabilized and there has been an expansion of heavy rail capacity.

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river and 5,600 acres of lakes).

While mass transit has stabilized, the environmental challenges associated with automobiles continue to plague cities. Despite emissions regulations, some types of air pollution from automobiles increased. Successes included, by 1986, the reduction of by 94 percent of lead emissions from the peak year and a drop in volatile organic compounds from 30.9 million tons in 1970 to 17.9 million tons in 1998. These drops were related to changing fuels, increases in fuel efficiencies and anti-pollution devices.

At the same time, however, more than half of Americans lives in metropolitan areas that violate the EPA's safety standard for ozone, the total of nitrogen dioxides continues to rise and as of 1998, at least 56 per cent of carbon dioxide emissions are from highway vehicles. Further, the total greenhouse gas emissions from the country increased from 1.3 billion metric tons in 1990 to 1.5 billion in 1998. This suggests that some of the gains achieved through regulation and improved technologies have been offset by general increases in miles driven.

Further, the emergence of the exopolis is intimately related to today's urban transport challenges include automobile congestion, large transit deficits, high costs of expanding highway capacity, vehicle pollution and safety and adequate accessibility to jobs and recreational activities (Winston and Shirley, 1998).

4. Recent Trends in Asian urban development and the rapid development in some types of transportation

This section provides a brief overview of the three major trends in urban development and transportation sectors in Asia since the 1970s, which have important implications for our understanding and consideration of the issue of how the "compressed urban environmental transition," and subsequent transport-related environmental challenges, has been evolving in the Asian context. These phenomena include: (a) recent trends in population growth and urbanization, particularly the emerging dominance of "mega-cities" in Asia; (b) the current general environmental conditions in Asian cities (c) the dramatic increase in the rates of motorization, usually expressed as the rates of car ownership, and (d) the varying trends in the development of urban public transport sectors across Asia.

4.1 Recent Trends in Population Growth and Urbanization

It is generally perceived that phenomenal increases in urban population in many of Asian countries and cities in the past three decades can be characterized as "unplanned urbanization," and such dramatic rise in urban population have contributed, and will continually contribute, to a series of urban socio-economic and environmental challenges for the governments and the communities in these regions (East-West Center, 2001, p. 115). Chief among these challenges are those associated with transportation. Transport-related socio-economic and environmental problems, such as urban traffic congestion and vehicular air pollution in the developing world (including Asia), will continue to prevail and exacerbate as three major factors drive the urban "demand for mobility" (WBCSD, 2001):

The rapid rise in population growth in most Asian countries;

The steady migration of people in these countries from the rural to the urban areas, and

The decline in the population density of these cities.[bb]

Such population-growth driven demand for personal mobility has led to a series of phenomena such as the varying rates of motorization among Asian cities. It has also helped shape a unique path of development in urban transportation system in Asia in the last three decades. The World Business Council on Sustainable Development (WBCSD), for example, argued in its *Mobility in Asia 2001* Report that:

[bb] WBCSD (2001), Chapter Two, p. 2-3.

… [c]ities of the developing world are growing and motorizing so rapidly they have not had the time or the money to build new infrastructure or to adapt to new technologies.… most developing cities are simply too dense to handle motorization….[cc]

Table 2. Urbanization Trends, 1975-2030

Region	Level of urbanization (%)				Annual average urban population growth rate (%)		
	1975 [(a)]	2000 [(b)]	2015 [(b)]	2030 [(b)]	1975-2000 [(a)]	2000-2015 [(b)]	2015-2030 [(b)]
World	37.7	47.0	53.4	60.3	2.6	2.0	1.7
Africa	25.2	37.9	46.5	54.5	4.4	3.5	2.8
Asia	24.6	36.7	44.7	53.4	3.5	2.4	2.0
Europe	67.1	74.8	78.6	82.6	0.8	0.3	0.1
Latin America	61.3	75.3	79.9	83.2	2.9	1.7	1.2
North America	73.9	77.2	80.9	84.4	1.2	1.0	0.8
Oceania	71.8	70.2	71.2	74.4	1.3	1.2	1.2

Sources:

(a) United Nations Centre for Human Settlements (HABITAT) (1996), *An Urbanizing World: Global Report on Human Settlements, 1996*. Oxford: Oxford University Press, Table 3: "Urbanization Trends, Size and Growth of Urban and Rural Population, 1975-2025", pp. 447-449.

(b) United Nations Centre for Human Settlements (HABITAT) (2001), *Cities in A Globalizing World: Global Report on Human Settlements, 2001*. London: Earthscan Publications Ltd., Table A.2: "Size and Growth of Urban and Rural Population, Urbanization Trends", pp. 271-273.

Table 2 provides a general picture of how these trends in Asia's population growth and urbanization can be put into a comparative perspective with other parts of the world over the past three decades. Asian countries have been urbanizing at dramatically rapid rates during the past thirty years, at an above-world-average rate of 3.5 percent, albeit starting the urbanization process from a relatively low base. Asia's level of urbanization in 1975 was only 24.6 percent - which was below the world's average of 37.7 percent and far below the urbanization levels in the developed world.

What is most striking, however, is not the annual average rates of population growth *per se* at which Asian cities have expanded, but the absolute size of the urban population behind these growth trends, as well as the amazingly short period of time in which Asia has rapidly urbanized. Consider, for example, the size of Asia's urban population. It was estimated that in 1975 there were around 592 million people living in Asian cities; in just 25 years time, however, the urban population in Asia has more than doubled to almost 1.36 billion (United Nations, 2001). Within this same period (1975-2000), the urban population of China—the largest country in Asia—increased from some 160 million to more than 400 million, for instance, drastically increasing its demand for efficient, affordable, and sustainable transportation solutions in its swelling cities.

In addition to the continued urban population growth in Asia, attention has been also drawn to the fact that such increases in urban population are geographically highly concentrated in a few "mega-cities", which are officially defined as the metropolitan regions with 10 million or more in population. As clearly illustrated in the **Table 3** above, empirical data seems to be supportive of the often-cited argument that the emergence of "mega-cities", and the

[cc] WBCSD (2001), Chapter Four, p. 4-2.

consequence on the society, economy, and the environment of such urban development, is now "a defining characteristic of the developing world."[dd]

Hence, not only was Asian developed "compressed" over the past 30 years, but the character of this development is also is different from that of the West in terms of the emergence of mega-cities as the locations of much of the region's urban population.

Table 3. Population of Cities with 10 Million or More Inhabitants: 1975, 2000, 2015

Population in 1975 (millions)		Population in 2000 (millions)		Population in 2015 (millions)	
Tokyo	19.8	Tokyo	26.4	Tokyo	26.4
New York	15.9	Mexico City	18.1	Mumbai	26.1
Shanghai	11.4	Mumbai	18.1	Lagos	23.2
Mexico City	11.2	Sao Paulo	17.8	Dhaka	21.1
Sao Paulo	10.0	New York	16.6	Sao Paulo	20.4
		Lagos	13.4	Karachi	19.2
		Los Angeles	13.1	Mexico City	19.2
		Calcutta	12.9	New York	17.4
		Shanghai	12.9	Jakarta	17.3
		Buenos A ires	12.6	Calcutta	17.3
		Dhaka	12.3	Delhi	16.4
		Karachi	11.8	Metro Manila	14.8
		Delhi	11.7	Shanghai	14.6
		Jakarta	11.0	Los Angeles	14.1
		Osaka	11.0	Buenos Aires	14.1
		Metro Manila	10.9	Cairo	13.8
		Beijing	10.8	Istanbul	12.5
		Rio de Janeiro	10.6	Beijing	12.3
		Cairo	10.6	Rio de Janeiro	11.9
				Osaka	11.0
				Tiajin	10.7
				Hyderabad	10.5
				Bangkok	10.1

Sources:
Adapted from East-West Center (2002), *The Future of Population in Asia*. Honolulu, Hawaii: The East-West Center, Table 1, p. 116.
United Nations (2001), *World Urbanization Prospects: The 1999 Revision*. New York: Population Division, Department of Economic and Social Affairs.

4.2 Overview of environmental conditions in Asia

In terms of urban environmental conditions within Asian cities only a brief overview is warranted. **Figure 5** demonstrates the series of environmental agendas among nations in 1995. An analysis of data for three different types of environmental burdens presents an environmental development scenario. The figure demonstrates relationships

[dd] Ibid.

among key variables, all calculated for 1995: GDP per capita with percent non-access to safe water, SO2 emissions per capita and CO2 emission per capita. Each function represents a significant relationship between wealth (in this case income) and the three sets of environmental issues.

Table 4. Estimated urban population living under various environmental conditions, 1995

1995 GDP Category (US$)	Environmental Challenge	Total Urban Population (thousands) (N)	Share of Total (%)
< 467.74	Lack of Water and Sanitation ("brown" issues)	456,985	309.6
> 467.75 and < 1,071.52	Rising Industrial pollution ("grey" issues), and significant "brown" issues	518,812	351.5
> 1,071.53 and < 3,981.07	High "grey" issues, rising modern risks ("green" issues) and "brown" issues	526,315	356.6
> 3,981.08 and < 14,125.3	High but decreasing "grey" issues, rising "green" issues	296,993	201.2
> 14,125.3	Largely "green" issues	613,480	415.6
Missing		147,610	100.0
Total global urban population		2,560,195	100.0

The graph demonstrates the environmental transition in cities. The severity of environmental problems (such as access to safe water) varies inversely with wealth. One variable, access to safe water, constitutes a proxy for the entire group of variables related to brown conditions. The trend of increasing access with wealth arguably approximates the trajectory for the other variables within this agenda, despite some dissimilarities between variables.

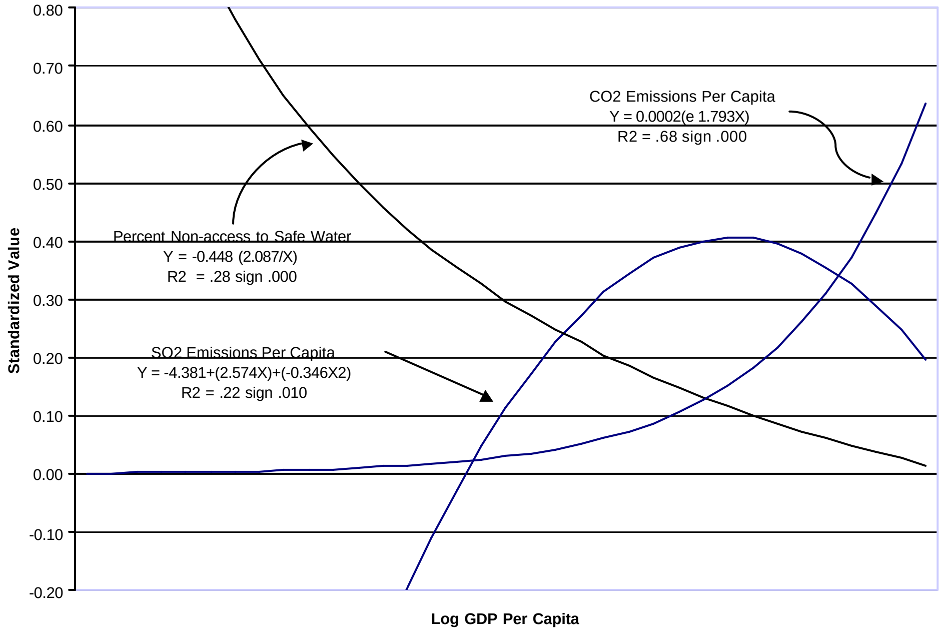

Figure 5. The Environmental Transition Data 1995 Data

As brown agenda issues are "solved", another set of challenges associated with rapid industrialization emerged. This group of environmental challenges, such as SO2 emissions, makes up the gray agenda: these problems reflect industrialization and motorization. Kates (2000) suggests that in the US, between 1970 and 1996 the levels of some air and water pollutants decreased. He noted the drop in particulate matter and lead from air, and phosphorus from water. The curve for SO2 per capita by income demonstrates the "inverted U-shape" of the environmental Kuznets curve. This relationship represents the decreasing environmental quality associated with rapid development, followed by increasing environmental quality once some turning point is reached. The turning point may be a function of increased environmental regulations, as experienced in Japan (Sawa, 1997); these types of pollutants declined in intensity with increased regulatory controls.

Table 5. Selected Asian countries categorized by predominant set of environmental challenges (1995)

Environment Issue	Country Name	Income Level (US$)	Urban Population (thousands)	Non-access to Clean Water (percent)	Per Capita CO2 (tonnes/capita)
Predominantly Brown Issues					
	Bhutan	171.90	111	0.37	0.00
	Nepal	197.20	2,193	0.18	0.00
	Vietnam	275.80	14,362	0.51	0.02
	Cambodia	276.40	1,413	0.93	0.00
	Lao PDR	360.60	988	0.59	0.00
Significant Brown Issues, Rising Gray Issues					
	China	571.10	362,394	0.04	0.12
	Indonesia	1,003.10	70,301	0.31	0.07
High Gray Issues, Decreasing Brown Issues and Rising Green Issues					
	Philippines	1,093.50	36,940	0.12	0.04
	Thailand	2,868.30	11,693	0.09	0.13
High, but Decreasing Gray Issues, Rising Green Issues					
	Malaysia	4,235.90	10,806	0.06	0.23
	Republic of Korea	10,142.20	35,168	0.00	0.36
Predominately Green Issues					
	Hong Kong	23,463.70		0.00	0.22
	Singapore	25,156.20	3,321	0.00	0.84
	Japan	40,846.10	97,950	0.00	0.39

Data Sources: WRI Database 2000-01. UN Urban Population Prospects 1999

CO2 is used as a measure of green agenda issues. Increased CO2 emissions within cities resulted partly from an increase in automobile ownership. The trend in the relationships between emissions and wealth increases exponentially, although, some relationships may have seen an s-curve type development (see Hayami, 2000).

The second interesting observation is the extent to which the variables overlap. From these estimations it is possible to estimate the share of the global urban population experiencing different environmental risks. That is, the points where the curves meet mark shifts in the types of environmental challenges. With GDP per capita and national urban population levels it is possible to calculate the number of people living under such conditions (**Table 4**). These educated guesses demonstrate that the majority of the world's urban population is living under at least two sets of burdens; over 20 percent are living under conditions of all three types of burdens. This may explain why it has been difficult to separate the relationship between affluence and environmental conditions in many cities. Cities often experience the various types of problems simultaneously. These figures also demonstrate that less than a quarter of the world's urban population is living under conditions largely related to the "green" agenda. That agenda, however, is increasingly the basis of the sustainable development mandate, from which came, for example, the compact city model as a solution. Lastly, the figures show that a significant percentage of the world's urban population (18 percent) is living in conditions dominated largely by the brown agenda.

Finally, when the rapidly developing Asian countries are mapped onto the curves, a picture of their current set of burdens emerges (**Table 4**). Most of those nations face multiple burden levels. Currently, as suggested by **Table 5,** however, significant populations remain affected by these risks while also having to cope with consumption-related risks (eg, from car pollution) that affect larger areas.

Overlapping challenges reflect more than rapid development. The variety of technologies available in low-income cities is increasing. New bundles of foreign technologies and economic activities have advantages, but also present

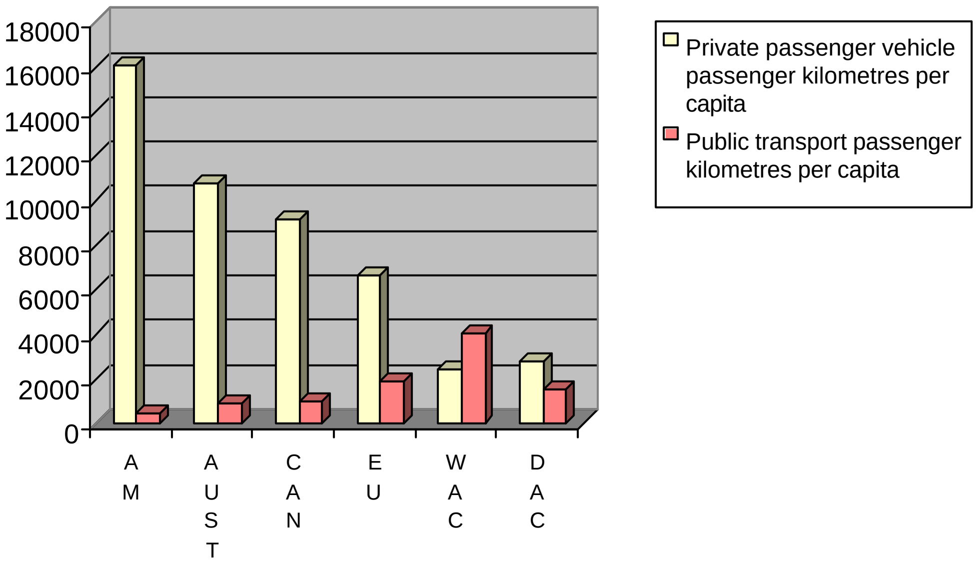

Figure 6. Global Patterns of Private vs. Public Transport Development, 1980

<u>Note</u>:
AM: American cities; AUST: Australian cities; CAN: Canadian cities; EU: European cities; WAC: Wealthy Asian cities; DAC: Developing Asian cities.

<u>Source</u>:
Jeffrey R. Kenworthy and Felix B. Laube, et al., *An International Sourcebook of Automobile Dependence in Cities, 1960-1990*, Boulder, Colorado: University Press of Colorado, 1999, p. 529.

negative impacts. As globalization and technological breakthroughs have lowered prices and brought goods to many nations, particularly those in the Asia Pacific, so has it changed the dynamics of the development/urban environment relationship. The net result is a combination of urban environmental conditions previously unseen, as sets of environmental problems appear simultaneously.

4.3 Rapid development in some types of transportation

While, in general, the rapid rise of automobiles is one significant feature of the urban landscape in Asia, researchers have also acknowledged the fact that, by any reasonable measures or indicators, the contour of urban public and private transportation development can be said to vary significantly across and within most of the Asian's countries and cities (Lee, forthcoming; Midgley, 1994). Before we examine two important aspects of urban transport in Asia, namely *the trends in car ownership* and *the public transport development*, in more details later, it is instrumental to review briefly how different types of transportation have been developing in Asia in the past three decades. For example, what has become evident is the comparative emphasis on private over public transport in wealthy Asian cities (**Figure 6**).

Table 6. Patterns of Private Transportation in 46 Global Cities, 1990

Group of cities	Total vehicles per 1000 people	Cars per 1000 people	Total private vehicle kms per capita	Private pass. vehicle kms per capita	Private pass. vehicle pass. kms per capita	% of workers using transit	% of workers using private transport	% of workers using foot or bicycle
US cities average	751	604	12,336	11,155	16,045	9.0	86.3	4.6
Australian cities	595	491	8,034	6,571	10,797	14.5	80.4	5.1
Canadian Cities	598	524	7,761	6,551	9,920	19.7	74.1	6.2
European Cities	452	392	5,026	4,519	6,602	38.8	42.8	18.4
Wealthy Asian Cities	217	123	2,950	1,487	2,386	59.6	20.1	20.3
Developing Asian Cities	227	102	2,337	1,848	3,016	37.8	43.9	18.4

Source:

Jeffrey R. Kenworthy and Felix B. Laube, et. al., *An International Sourcebook of Automobile Dependence in Cities*, *1960-1990*, Boulder, Colorado, University Press of Colorado, 1999, p. 529.

4.3.1 Trends in Car Ownership in Asia

The rates of motorization, the relative importance of different modes of transport (private vs. public; motorized vs. non-motorized), as well as urban transport performance, vary greatly across Asia, by both geographic and demographic terms (Midgley, 1994). These three trends, when they are set against the following three perspectives, would help provide an in-depth picture of the nature and extent of these variations in motorization in Asia:

- ?? Across different sub-regions within Asia (North Asia, South Asia, Southeast Asia) as well as across the world;
- ?? Over a longer time-span; and
- ?? Among low, middle, and higher-income Asian cities.

4.3.1.a Global and Regional Perspectives

Among the few comparative studies on global urban transport development, Kenworthy and Laube *et al.* (1999; quoted in Lee, forthcoming) sampled 46 global cities, and compiled comprehensive sets of urban transport parameters for each of these cities (**Table 6**).

Table 6 indicates some interesting findings for Asian cities from a global perspective. First, car ownership rates (car per 1,000 persons) in two groupings of Asian cities (Wealthy Asian Cities, *WACs*, and Developing Asian Cities, *DACs*) were comparatively low, especially when compared to the figures in the United States, Canada and Australia in 1990. Further, the proportion of urban citizens using public transport, in terms of modal shifts in workers' travel in the WACs was the highest (59.6 percent) among the sample of global cities, although for DACs the situation is different. Recent evidence has lent further support to such an observation: The public transport sector has assumed increasing significance in the overall urban transport systems in most Asian cities since the 1990s (Barter, 1999)

Hence, while motorization increases across Asia, the current car ownership and use of private transport to get to work is very different from that of the West. These trends are currently being reinforced in most Asian cities.

4.3.1.b Motorization in Asia, 1960 to 1990

There were undoubtedly regional variations in motorization within Asia, given the significant differences in urban structures (e.g., urban population and job densities), socio-economic development, as well as the evolution of transport policy regimes among politically and culturally divergent Asian metropolises. Midgley (1994, p. 14), for example, commented that "some of the world's highest and lowest motorization rates are to be found within the [Asian] region". Barter (1999) has managed to depict, with clarity and in a systematic manner, the evolution of motorization across and within a great number of Asian cities since the 1960s.[ee] **Figure 7** graphically depicts how ownership of cars and motorcycles in Asia has growth since the early 1960s.

Barter has also made several important observations regarding Asia's motorization pattern during the period of 1960-1993:

- ?? Car ownership was still rather low in 1970 throughout Asia, as compared to the development in the developed countries during the same period (**Table 7**).

[ee] The discussion here draws largely from Barter (1999), Chapter Five, 'Asia Urban Transport in Perspective,' (pp. 130-189) which identifies important themes in, and provides a typology of, Asia's urban transport systems based upon the historical development (1960-1993) in urban public and private transport in a sample of major Asian cities.

?? There was a dramatic surge in car ownership rates during the 1980s among Asian cities in the sample. The jump in vehicle ownership rate in three Asian cities, namely Kuala Lumpur, Bangkok, and Seoul, was particularly noticeable and interestingly dramatic. While the rises in overall private vehicle ownership in these three cities were eye-catching, Seoul's record was the most spectacular. From a rather modest car ownership rate in 1980, at 16 cars per 1,000 people, Seoul's car ownership rate surged to 83 cars per 1,000 people within ten years' time.

?? Asia's motorization trends have at least one distinctive feature that sets itself apart from those recorded in the western world. The exceptionally rapid increases in motorization in Bangkok and Kuala Lumpur since the early 1980s were attributed to, in large part, to the "exploding motorcycle ownership" phenomena in these two cities. **Table 8** shows the dramatic surge in motorcycle ownership rate in both Bangkok and Kuala Lumpur.

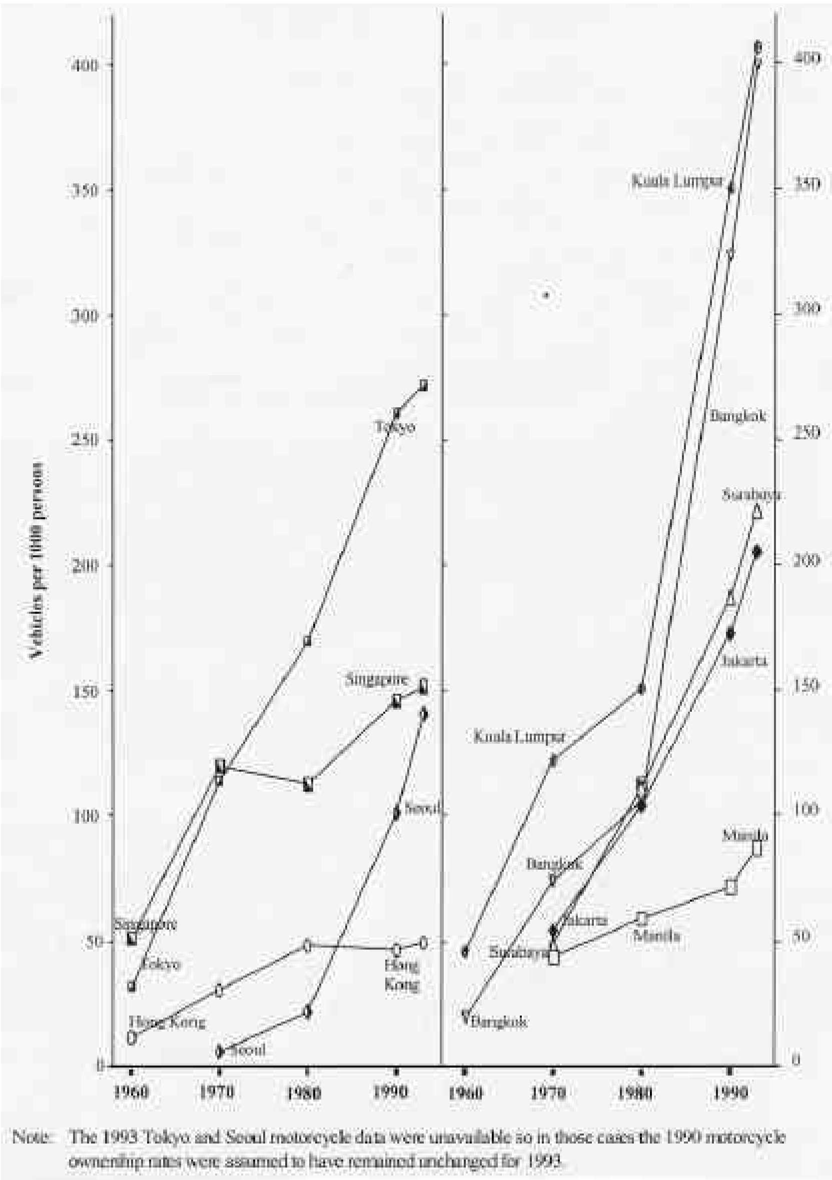

Figure 7. Changes in total vehicle ownership rates in Asian cities 1960-1993

Source: Barter, 1999, p. 136: Figure 5.2 "Ownership of cars plus motorcycles in Asian Cities, 1960-1993."

The last observation mentioned by Barter (1999) warrants further elaboration. Although Surabaya, Kuala Lumpur, and Bangkok ranked at the top in terms of the growth in motorcycle ownership between 1980 and 1990, it was Kuala

Lumpur and Bangkok that have also been ranked among the highest in overall vehicle ownership growth rate (car plus motorcycle) during the same period. As discussed earlier, Seoul's car ownership growth rate from 1980 to 1990 was tremendous, and this particular trend in motorization could be traced to South Korea's decision to develop and strengthen an "automobile economy" since the early 1980s. The rise in motorcycle ownership in Seoul during the same period was, however, much less noticeable, especially when compared to what had happened in Kuala Lumpur and Bangkok. In Barter's (1999, p. 135) words, the surges in motorization in these latter two Southeast Asian cities since 1980:

Table 7. Changes in car ownership rates in Asian cities, 1960-1993

	Car Ownership (cars per 1000 persons)					Average Annual Change[a] (cars per 1000 per year)			
	1960	1970[b]	1980	1990	1993	1960-70	1970-80	1980-90	1990-93
Hong Kong	11	27	42	43	46	1.6	1.6	0.1	1.4
Surabaya	?	14	20	40	47	-	0.7	2.0	2.3
Manila	?	38	55	66	79	-	1.7	1.1	4.3
Jakarta	?	22	38	75	92	-	2.0	3.7	5.9
Singapore	39	69	64	101	110	3.0	-0.5	3.7	3.5
Seoul City[c]	?	6	16	83	123	-	1.0	6.8	13.3
Kuala Lumpur	46[d]	72	86	170	206	2.6	1.4	8.4	12.0
Bangkok	14	54	71	199	220	4.0	1.7	12.7	7.3
Tokyo[f]	16	105	156	225	236	8.9	5.1	6.9	3.8
European	122	243	332	392	?	12.1	8.9	6.0	-
Canadian	274	348	447	524	?	7.4	9.9	7.7	-
Australian[e]	223	321	443	491	?	9.8	12.2	4.8	-
United States	376	460	547	608	?	8.4	8.7	6.1	-

Source: Barter, 1999, p. 134: Table 5.2. "Car Ownership in Asian Cities and Regional Averages from an International Sample of Cities."

Table 8. Changes in motorcycle ownership rates in Asian cities, 1960-1993

	Motorcycle Ownership (motorcycles per 1000 persons)					Average Annual Change[a] (motorcycles per 1000 per year)			
	1960	1970[b]	1980	1990	1993	1960-70	1970-80	1980-90	1990-93
Hong Kong	1	4	6	4	4	0.3	0.2	-0.1	0.0
Manila	?	6	4	6	8	?	-0.2	0.2	0.6
Seoul City[c]	?	?	6	18	?	?	?	1.2	?
Tokyo[f]	16	9	14	36	?	-0.7	0.5	2.2	?
Singapore	12	51	49	45	42	3.9	-0.2	-0.4	-1.2
Jakarta	?	32	66	98	113	?	4.2	3.2	5.0
Surabaya	?	35	91	147	175	?	6.2	11.5	7.0
Bangkok	6	20	35	124	179	1.4	1.5	8.9	18.2
Kuala Lumpur	?	50	65	180	201	?	2.1	11.3	6.0

Notes for Table 5.2 and Table 5.3:

a. The figures above for annual change in vehicle ownership are the average annual increments in ownership per 1000 persons. They are not percentage increases.

b. KL's 1970 figures are for 1972, Surabaya's 1970s figures are for 1971 and Jakarta's are for 1972.

c. The data in this table for Seoul are for Seoul City only.

d. Kuala Lumpur's 1960 car ownership data is for 1963.

e. In 1947 the Australian cities averaged 76 cars per thousand people, so the annual increase between 1947 and 1960 averaged 11.1 cars per thousand people.

f. Tokyo's figures are for Tokyo-to only.

Source: Barter, 1999, p. 134: Table 5.3. "Motorcycle Ownership in Asian Cities, 1970 to 1993."

have been so rapid that they raised the question of whether these rates of increase were unprecedented …. [t]hese cities may indeed be undergoing among the most rapid transformations from low to high motorization in history.

This "car-plus-motorcycle" syndrome, as identified by Barter (1999), may serve as one of the explanations that account for some of Asia's "uniqueness" in its path of motorization in the past thirty years. In particular this syndrome is evident in the most rapidly developing cities of Southeast Asia.

4.3.1.c Motorization and Income Growth in Asia

The association of motorization and income is partly demonstrated by **Table 9**. The trend of increasing vehicle ownership with increasing wealth is evident. Within the upper-middle and high-income categories, however, Asian cities have lower car ownership rates than their European and North American counterparts. For example, Seoul with a per capita income of US$3,600 has a car population of 22 per 1,000, while Budapest, Hungary's income is lower (US$2,460), but has a car population of 171 per 1,000. In the high-income category, Asian cities (Singapore, Osaka, and Tokyo) have the lowest rates of car ownership (100, 248 and 248 respectively), of those surveyed, despite Osaka and Tokyo having the highest per capita GNPs.

This trend, however, is less evident in the rapidly developing lower-middle income cities of Asia, when compared to other cities of the world. Here, Asian urban wealth and car ownership follows a similar trajectory of those of its counterparts. What is important to note, however, is that these data do not include the period of rapid economic growth for these cities (the early 1990s) and vehicle ownership is restricted to cars and does not include motorcycles and scooters, which make up a sizeable contribution to the vehicle fleet in Asian rapidly developing cities (see above and Barter, 1999).

4.4 Trends in Public Transportation in Asia

According to Midgley (1994, p. 23), by the early 1990s, "there were 37 mass transit systems carrying 17 million passengers per day in 26 cities in Asia." Further, three major modes of mass transit systems in Asia (Midgley, 1994). **Table 10** compares and contrasts three basic mass transit modes by their operational characteristics, while **Table 11** documents some of the major urban mass transit systems that have been operating or under planning in this region.

The basic modes in the region's cities include the use of rapid transit (rail based high speed, grade separated), light rail (capable of operating at grade or in grade separated systems, with higher capacities and higher speeds than buses) and guided rapid transit (non-rail based, fully grade separated systems). Singapore has an expanding metro system. Hong Kong has both Metro and urban tram/light rail. Many Japanese cities have both rapid transit and light rapid transit systems. Kuala Lumpur and Manila have light rail systems. Most if not all cities have public bus systems.

4.5 Summary

As **Table 12** attempts to summarize, in terms of the growth of public and private transportation systems there are three types of cities in the Asian region. In cities such as Surabaya and Jakarta, low motorization has accompanied rapid increases in private mobility such that private means of transport are rising faster than public mass transit systems. In "delayed or restrained motorization" cities, private transport has matched, or exceeded public transport growth. In cities such as Singapore, Seoul, Tokyo and Manila, public transport systems are growing slower than private transport. In Hong Kong public sector transport growth is faster than that of the private sector. Finally in cities such as Kuala

Lumpur and Bangkok, private mobility is higher than public supply. While both public and private sector transport are growing, the private sector is growing at a much faster rate. Given these three trends there is a question of whether the low and moderately restrained motorization cities will be able to match the public sector supply of those cities that have strongly delayed or restrained their motorization processes. Further, it is also a question as to whether the strongly delayed motorization cities will be able to maintain their high levels of public transport. Indeed, in the most recent national capital plan of Tokyo, private automobile transportation was given precedence over public transit in the outer rings of the city.

Table 9. Modal Split, Motorisation and per capita GNP for Selected Metropolitan Areas

Economic group	Metropolitan area	Percentage of urban trips by car	Cars per 1,000 population 1983-89	Per capita GNP (1988 US$)
Low income	Bombay, India	8	3	340
	Karachi, Pakistan	3	5	350
	Nairobi, Kenya	45	5	370
	Jakarta, Indonesia	27	6	440
Lower-middle income	Manila, Philippines	16	13	630
	Cairo, Egypt	15	15	660
	Abidjan, Ivory Coast	33	15	770
	Bangkok, Thailand	25	15	1,000
	Bogota, Colombia	14	26	1,180
	Medellin, Colombia	6	26	1,180
	Tunis, Tunisia	24	40	1,230
	Ankara, Turkey	23	25	1,280
	Amman, Jordan	44	54	1,500
	Mexico City, Mexico	19	62	1,760
	Kuala Lumpur, Malaysia	37	72	1,940
	Rio de Janeiro, Brazil	24	91	2,160
	São Paulo, Brazi	32	91	2,160
Upper-middle income	Budapest, Hungary	15	171	2,460
	Seoul, South Korea	9	22	3,600
High income	Barcelona, Spain	53	270	7,740
	Madrid, Spain	37	270	7,740
	Singapore	47	100	9,070
	Wellington, New Zealand	56	412	10,000
	Liverpool, England	58	322	12,810
	London, England	61	322	12,810
	Milan, Italy	33	421	13,330
	Naples, Italy	58	421	13,330
	Brussels, Belgium	43	374	14,490
	Amsterdam, Netherlands	80	350	14,520
	Vienna, Austria	56	355	15,470
	Paris, France	63	409	16,090
	Copenhagen, Denmark	56	292	18,450
	Hamburg, Germany	50	364	18,480
	Munich, Germany	61	364	18,480
	Stuttgart, Germany	44	364	18,480
	Stockholm, Sweden	48	393	19,300
	USA	93	567	19,840
	Oslo, Norway	57	380	19,990
	Osaka, Japan	31	248	21,020
	Tokyo, Japan	32	248	21,020

Source: Dietrich Schwela and Olivier Zali, editors, *Urban Traffic Pollution*, London and New York, E & FN Spon, 1999.

Table 10. A Classification of Mass Transit Systems in Asia

Mass Transit Modes	Operational Characteristics	Examples
RAPID TRANSIT (MRT)	**Rail based and fully grade separated** With the highest available capacity and travel speed performance	Often known as "metros" (above ground or underground), e.g. the Mass Transit Railway (MTR) systems in Hong Kong.
LIGHT RAIL TRANSIT (LRLT)	Rail based; capable of operating at grade (within road rights-of-way), or grade separated With higher capacities and higher speed performances then buses.	Often called "trams" or "streetcars"
GUIDED RAPID TRANSIT (GRT)	Non-rail based Fully grade separated (which make use of special guidance mechanisms and tracks)	"Guided buses", "Monorails" and "Automated Guided Transit" (AGT) systems

Source: Midgley (1994), p. 23. *Note*: Compiled by Authors.

Against this background are the urban environmental conditions within cities in Asia. As demonstrated, these cities can be divided into four categories, those that are low-income (with largely "brown" urban environmental challenges), those that are rapidly developing (middle-income) with a set of "brown," "gray" and "green" environmental challenges and those of high income, with largely "green" environmental challenges. Those cities in the first category have low, but rapidly increasing motorization rates. Those in the middle category have high private mobility, which is increasing faster than public transport. Those in the high-income category have high public transport, which is increasingly being displaced by private transit.

It is beyond the scope of the paper to present concluding remarks on the various urban transport situations in Asia; what we have tried to do here is to review briefly some of the important themes and discussions as discussed in the literature. The diversity and complexity of Asia's urban transport development requires more efforts in rigorous conceptualization and empirical examination.

Table 11. Urban Mass Transit Development in Selected Asian Cities

Region/Country/City	Metro		Urban Tram and Light Rail Systems	Region/Country/City	Metro		Urban Tram and Light Rail Systems
	In operation	Under construction			In operation	Under construction	
North Asia							
P.R. CHINA				**JAPAN**			
Beijing	*			Fukuoka	*		*
Guangzhou	*		(P)	Kobe	*		
Hong Kong	*		*#(2)	Kyoto	*		*
Shenzhen		3		Nagoya	*		
Shanghai	*			Osaka	*		*
Tianjin	*			Sapporo	*		*
NORTH KOREA				Sendai	*		
Pyongyang	*		*#(2)	Tokyo	*		*
SOUTH KOREA				Yokohama	*		
Pusan	*						
Seoul	*						
South Asia							
INDIA				**PAKISTAN**			
Calcutta	*		*	Karachi			(P)
Delhi		3					
Madras (Chennai)		3					
Southeast Asia							
MALAYSIA				**PHILLIPINES**			
Kuala Lumpur			*Kuala Lumpur*#*	Manila			*Manila*#+*
SINGAPORE				**THAILAND**			
Singapore	*			Bangkok	*		

Source:
Pattison, Tony (ed.)(2000), *Jane's Urban Transport Systems*. 19th Edition (2000-2001). Surrey, UK: Jane's Information Group, pp. 1-5.

Legends:

***** indicates a system in place/in operation

# indicates a system built new since 1978

+ indicates a system extending or extended recently

++ indicates operation suspended

(T) indicates a heritage tramway operated primarily for tourist purposes

(2) indicates two (or more) separate operations

(P) indicates systems planned

Systems in *italics* are steel-wheeled, automated, fully-segregated lines

Table 12. Grouping of Selected Asian Cities According to Chosen Transport Criteria

Criterion	Suggested Groups of Cities	Comments
1. Car ownership and private car use relative to GRP per capita (Figure 5.3)	Manila, Jakarta and Surabaya	Low motorization with open options. Of the three, Surabaya has the least restrained private transport and Manila has the most.
	Seoul, Hong Kong, Singapore and Tokyo	Strongly delayed or restrained motorization.
	Kuala Lumpur and Bangkok	Moderately restrained motorization and private vehicle use.
2. Private versus public transport mobility trends	Surabaya and Jakarta	Low motorized mobility per person (but private mobility has been rising faster than public transport).
	Singapore, Seoul, Manila, Hong Kong and Tokyo	High public transport mobility (almost as high or higher than private). But only in Hong Kong has public transport mobility been rising much faster than private.
	Kuala Lumpur, Bangkok	Private mobility higher than public. Both public and private transport increasing but private has increased faster.
3. Motorcycle ownership (Table 5.3)	Kuala Lumpur, Bangkok, Surabaya, Jakarta	High motorcycle ownership. In Kuala Lumpur and Bangkok, motorcycle ownership have continued to rise quickly despite rising incomes and car ownership passing 150 cars per persons.
	Singapore, Tokyo, Seoul, Hong Kong, Manila, and most cities in other regions	Motorcycle ownership below 50 per 1000 people, and in some cases actually falling.

Source: Adapted from Barter (1999), chapter 5, Table 5.19, p. 1835.

5. Conclusion

There are both theoretical and policy implications of the findings suggested by this analysis. Theoretically, the "compression and telescoped" urban environmental transition sheds further doubt on the "modernization" type arguments of development. Increasingly the cities of the developing world are undergoing new and different environmental conditions than those experienced by the West. In terms of transportation systems, currently the advance of motorization and rapid rates of increase within cities at all levels of incomes and within cities experiencing multiple environmental burdens suggested a compressed and telescoped set of transitions.

The underlying reasons have not been discussed but are arguably related to globalization and the movements of goods through trade and technologies through investments and people and information.

In terms of policy, the overlapping of environmental conditions within cities of rapidly developing Asia, suggest that policies once effective in Western countries to combat certain environmental problems may be of only partial use in developing Asian cities. What is needed is a integrated policies that cross sectors (transportation, land use, energy, etc) and scale (urban, regional and global). This is no small task and one that must be advanced through integrated studies of environmental conditions within these cities.

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