MOVING MILLIONS

ALLIANCE FOR GLOBAL SUSTAINABILITY BOOKSERIES
SCIENCE AND TECHNOLOGY: TOOLS FOR SUSTAINABLE DEVELOPMENT

VOLUME 14

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The level of presentation is for graduate students in natural, social and engineering sciences as well as policy and decision-makers around the world in government, industry and civil society.

Moving Millions

Transport Strategies for Sustainable Development in Megacities

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THE AGS

The Alliance for Global Sustainability

TABLE OF CONTENTS

PREFACE

This book has been several years in the making. It has grown out of basic areas of inquiry begun under the auspices of the Alliance for Global Sustainability in the late 1990s, and has culminated with a series of on-site, collaborative studies conducted through AGS in cooperation with officials in Guangzhou, People's Republic of China (PRC), during the early 2000s. Many individuals have made important contributions to the ideas, findings, and results that have been compiled in this volume. The authors wish to recognize these significant contributions below.

The Alliance for Global Sustainability is an international partnership among four of the leading scientific and technological universities worldwide:

- The Massachusetts Institute of Technology (MIT-AGS);
- The University of Tokyo (UT);
- The Swiss Federal Institute of Technology (ETH); and
- The Chalmers University of Technology.

Created in 1997, the AGS today brings together hundreds of university scientists, engineers, and social scientists to address complex issues that lie at the intersection of environmental, economic, and social policy goals. Since its inception, the AGS has promoted and supported multidisciplinary research teams drawn from its partner institutions. Working on critical issues in sustainability across several fields encompassing energy and climate, mobility, urban systems, water and agriculture, cleaner technologies, public policy, and communications, these teams have developed a significant body of new knowledge. Furthermore, AGS-sponsored teams have worked with engaged, farsighted leaders of global businesses and industries, governments, and non-governmental organizations (NGOs) to provide innovative but practical solutions to urgent environmental problems worldwide.

The work reported in this book had its inception in an initial study of the issues facing megacities and their potential solutions. This effort was conducted by a team of faculty members of MIT, UT, and ETH. The lead faculty members were Professors Fred Moavenzadeh from MIT, Keisuke Hanaki of the University

of Tokyo's School of Engineering, and Peter Baccini of ETH. This group of scholars looked at issues of urban sustainability across a variety of disciplines. They focused on strategies that could be applied to foster sustainable approaches to urban development, the urban heat island, resource and heat recovery, water supply and wastewater management, energy, transportation, and building design and management. These studies also considered broad institutional arrangements that could help achieve these ambitious public policy goals in the context of global cooperation on climate change. The results of these efforts were published in a series of papers in the first volume of this AGS book series, entitled *Future Cities: Dynamics and Sustainability*.

The success of this work prompted team members to continue their efforts regarding sustainable public policies for megacities, but now focusing on a specific region and a single city within that region. Guangzhou was selected on the weight of several compelling factors:

- An especially rapid rate of current urban growth;
- The eager willingness of municipal officials to participate; and
- Prior experience of ETH team members with this region of the PRC.

Guangzhou is the political, economic, and cultural capital of Guangdong Province in Southeastern China, and is known as China's "Southern Gateway." Its tremendous economic growth in the 1990s had been accompanied by a substantial increase in population, leading to a rapid and substantial increase in demand for municipal services as well as supporting infrastructure. The MIT AGS team focused on Guangzhou's need for more efficient and sustainable urban transportation. The rapid rate of motorization experienced in Guangzhou, and its associated problems of congestion and environmental pollution, made it an excellent megacity to serve as a case study in policy formulation and planning for sustainable transportation.

The AGS was instrumental in providing partial support for several MIT graduate students to spend time in Guangzhou. These students worked on various aspects of the problem of integrating the goals of economic development, transportation mobility, and environmental sustainability in the context of a rapidly growing metropolis, public sector resource constraints, and need for institutional strengthening. The results of each individual's study were incorporated within the students' respective Master's degree theses under the supervision and guidance of Professor Fred Moavenzadeh at MIT. This book draws significantly on these theses, which also served as research reports of the MIT/AGS team to the Chinese participants in the study. It synthesizes the problem formulations,

findings, proposed solutions, and recommendations of the Guangzhou case study that is presented in Chapter 7. The graduate researchers who were involved in the Guangzhou effort, the titles of their theses, and areas of major contribution to this book are as follows:

- Benjamin Myles Cheatham, *Sustainable Urban Transportation in Developing Mega-Cities: A Review of Policies, Regulations, and Technologies*, January 2002. This work contributed to the context of transportation and environmental sustainability in megacities as described in Chapter 1, sustainability as an integrated concept (Chapter 3), the structuring of transportation policy as described in Chapter 4, and case studies of Bogotá and Singapore (Chapters 4 and 6), as well as Guangzhou (Chapter 7).

- Satish McKay Lion, *Transit Oriented Development Strategy: Guangzhou Case Study*, February 2003. This work contributed to the description of transit-oriented development (Chapter 4) with case studies of Portland, Washington, D.C., São Paulo, and Bogotá (Chapter 6), as well as Guangzhou (Chapter 7).

- Mimi Takayanagi, *Urban Transportation Policies Toward Sustainability of Mega-Cities*, May 2002. This work contributed to a knowledge of the relationships between transportation policy and environmental impact (background for Chapter 1), provided details of environmental valuation and accounting methods (Chapters 2 and 3), and case studies of Mexico City (Chapters 4 and 6) as well as Guangzhou (Chapter 7).

In addition, this book draws upon other Master's theses and related work by several students, who also worked under Professor Moavenzadeh's supervision, to build the conceptual foundations of the policy options and methodology that are discussed in this book. The students' development and illustration of the key ideas underlying environmental sustainability, economic development, transportation policy and technology, and public-private partnerships, as well as their examples of transportation policy successes and failures, add to the material that is the basis of Chapters 1 through 6 of this book. The primary areas of contribution of each of these MIT/AGS researchers is identified below, recognizing that each team member also contributed information generally to the overall effort as well. The names of these graduate students, the titles of their theses or reports, and significant areas of contribution are as follows:

- Brantley T. Liddle, *Sustainable Development, Infrastructure and Environmental Investment, and the Privatization Decision*, June 1993. This work was the primary source of definitions and concepts of sustainability in Chapters 2 and

3; methods of environmental valuation and resource allocation in Chapter 3; and approaches to public-private partnerships and privatization in Chapter 5.

- Brantley T. Liddle (co-author with F. Moavenzadeh), *Sustainability and Development*, 2000. This report provided additional information on sustainability and related analytic methods for Chapters 2 and 3, as well as international perspectives on the issue that are discussed in Chapter 3.

- Sandi Shih Lin, *An Intelligent Deployment Framework for Intelligent Transportation Systems*, June 2003. This work was the primary source for information on ITS technology and deployment issues in Chapter 4, suggested examples of ITS-related contracting examples for Chapter 5, and provided background information on deployments in Singapore and Kuala Lumpur.

- Justin Tobias, *Megacities: Sustainability, Transport, and Economic Development*, June 2005. This work synthesized findings of the previous studies to bring together issues of transportation policy, environmental sustainability, and economic development, and added or updated information in selected technical areas.

A central idea of this book is that policies promoting transportation mobility, economic development, and environmental sustainability can be pursued in harmony with one another, rather than as conflicting goals. In particular, it explores how issues of transportation and environmental sustainability interact with one another in the context of megacities, especially in the developing world where the rate of growth in population and economic development can rapidly outpace the supply of needed transportation infrastructure. This book recognizes that, given the reality of this supply constraint, there are ways to manage transportation demand to reduce the immediate pressure on transportation supply and to accommodate the time needed to replenish or expand the existing supply. Given a demand-oriented approach, supported by complementary improvements in the operating efficiency of the existing transportation network, transportation needs and sustainability needs can be balanced with each other, rather than being viewed antagonistically. This approach recognizes that there are not only tradeoffs between the two policy goals of transportation mobility and environmental sustainability, but also tradeoffs within each of these domains – i.e., choices among different transportation policy and investment options to achieve a given level of personal and commercial mobility, and different regulatory, market-based, and public education strategies to achieve a given degree of environmental sustainability.

This book explains concepts of sustainability that have been proposed, their implications for different industries and population groups, and management options that are available to achieve greater sustainability. It reviews transportation policy from supply-side and demand-side perspectives, gives examples of different paths to more efficient and cost-effective mobility, and covers technological improvements that promise to improve mobility while decreasing vehicle emissions. It discusses different mechanisms of public-private partnerships that can be used to deliver public services through various allocations of cost, risk, and reward between public and private entities. It brings these ideas together through a series of examples from different cities and continents, illustrating the types of tradeoffs alluded to above and focusing on instances where actions promoting transportation and sustainability may either complement or compete with each other. It then applies these lessons to the case study in Guangzhou, demonstrating how a balanced approach to mobility and sustainability can enhance both policy goals without constraining economic growth.

While this book deals with ideas from several disciplines, it is not intended to serve as a textbook on economics, nor as a handbook on transportation system operations and technology, nor as a reference on innovative finance and contracting, nor as a treatise on economic development strategies. Rather, its purpose is to help local, regional, and national political leaders and public sector managers understand how actions in each of these disciplines can have impacts in one or more of the other disciplines, and to appreciate the importance of thinking in terms of a comprehensive package of policies that embodies an appropriate mix of "carrots and sticks." Experience shows that policies that successfully balance mobility and sustainability are those that correctly account for local travel patterns and needs, institutional capabilities, human and vehicle population characteristics, and existing human, financial, organizational, institutional, and technological capabilities within the urbanized region. The several examples in Chapter 6 demonstrate how a well conceived and executed set of policies leads to a successful outcome, and conversely, the pitfalls of implementing well-intentioned policies that fail to plan for unintended consequences. While the book provides many examples from both developed and developing economies, it assumes that the reader understands basic concepts in economic theory, transportation operations, and environmental protection: e.g., economic supply-demand relationships, elasticity of demand, marginal cost pricing, transportation supply-demand relationships, transportation congestion, peak-period pricing, vehicle pollutant emissions, and life-cycle cost analyses.

Because the research contributing to this book has been accomplished over several years and concluded in 2005, certain examples may represent a particular

time frame, with data and results that are no longer quite current. This fact does not, however, detract from the overall conclusions and insights that result. The value of this book is in identifying fundamental principles and approaches that should guide managers and political leaders in megacities. The specifics of a preferred strategy will necessarily differ from one city to another, for a host of demographic, physiographic, climatic, financial, economic, technological, political, and other reasons. However, the basic attributes of a successful strategy will tend to transfer well from one case to another; these important "lessons learned" are summarized in Chapter 8.

Chapter 1
INTRODUCTION

1.1 Megacities

A Growing Worldwide Phenomenon

Cities are focal points for the activities of societies. They are centers of employment, commerce, education, culture, and social and political interaction. They also impose significant demands for civil infrastructure needed to support social and economic activities and a suitable quality of life. The challenges in providing this infrastructure are magnified in very large cities – megacities, having populations of eight million or more inhabitants (Guest 1994) – and especially in the rapidly growing megacities found in developing countries worldwide.

The gathering of human populations into these massive cities is shaping the primary challenges to sustainable global development in the twenty-first century. This concentration of people in dense urban gatherings has resulted in a myriad of daunting challenges that have significant impact on economics, transportation, the environment, social equity, and governance. The turn of the twenty-first century marks a divide from a predominantly rural world to one where the majority of people live in cities. There are now more than 400 cities in the world with over one million inhabitants. Of these, 27 are megacities, and roughly two-thirds of these megacities are in the developing world (Table 1.1). The management of these urban giants, and the provision of shelter, services, mobility and a livelihood to their inhabitants in an economically, socially, and environmentally sustainable manner will be major challenges in the coming years.

This book explores the economic, technical, and public policy issues surrounding an important system of urban infrastructure – transportation – and how megacities can deal with these issues. Transportation historically has been key to economic growth, welfare of the public, accessibility to employment and the amenities of life, public safety and security, and social cohesion within a population. While transportation provides these many benefits, however, it also has negative

Table 1.1. **Megacity populations (in millions): 1980, 1990, and 2000.***

1980	Pop.	1990	Pop.	2000*	Pop.
Tokyo	16.9	Mexico City	20.2	Mexico City	25.6
New York	15.6	Tokyo	18.1	Sao Paulo	22.1
Mexico City	14.5	Sao Paulo	17.4	Tokyo	19.0
Sao Paulo	12.1	New York	16.2	Shanghai	17.0
Shanghai	11.7	Shanghai	13.4	New York	16.8
Buenos Aires	9.9	Los Angeles	11.9	Calcutta	15.7
Los Angeles	9.5	Calcutta	11.8	Bombay	15.4
Calcutta	9.0	Buenos Aires	11.5	Beijing	14.0
Beijing	9.0	Bombay	11.2	Los Angeles	13.9
Rio de Janeiro	8.8	Seoul	11.0	Jakarta	13.7
Paris	8.5	Beijing	10.8	Delhi	13.2
Osaka	8.3	Rio de Janeiro	10.7	Buenos Aires	12.9
Seoul	8.3	Tianjin	9.4	Lagos	12.9
Moscow	8.2	Jakarta	9.3	Tianjin	12.7
Bombay	8.1	Cairo	9.0	Seoul	12.7
		Moscow	8.8	Rio de Janeiro	12.5
		Delhi	8.8	Dhaka	12.2
		Osaka	8.5	Cairo	11.8
		Paris	8.5	Metro Manila	11.8
		Metro Manila	8.5	Karachi	11.7
				Bangkok	10.3
				Istanbul	9.5
				Moscow	9.0
				Osaka	8.6
				Paris	8.6
				Tehran	8.5
				Guangzhou	8.5

Source: United Nations (1996)
*Data for 2000 are estimated.

impacts, particularly in its energy consumption and degradation of the urban environment through lowered air quality, increased temperatures, increased noise, and fragmentation of neighborhoods. With the pace of development increasing in many megacities, environmental damage threatens the quality of life of others today and of future generations. While environmental concerns are a key issue

in attempts to improve the availability and quality of service of transportation in megacities, other constraints may also preclude governments from using traditional strategies of expanding the existing infrastructure, including financial limitations, existing and proposed land use patterns, and political, institutional, and social resistance to major new construction projects.

Urbanization and Motorization

Urbanization means more than simply *urban growth*. While urban growth refers to an increase in the population of urban settlements, urbanization is an increase in the proportion of the population residing within urban areas. Thus, if urban growth is accompanied by a corresponding increase in the rural population, urbanization need not increase. While there is generally a strong correlation between overall population growth and urban growth, it is often observed that urbanization can increase dramatically relative to population growth, as is evidenced in the People's Republic of China. In China and other East Asian countries, where population growth has diminished significantly, economic development has become the greatest determinant of urbanization. The mechanism by which urbanization occurs is rural-urban migration, which is triggered by the diminishing relative size and importance of the rural economy.

It is therefore not surprising that growth in gross domestic product (GDP) per capita is positively correlated with levels of urbanization, and that a high level of economic development is often characterized by high levels of rural-urban migration (Cho and Bauer 1987). This situation is generally the case in the fast-developing economies of East Asia. In China specifically, rural-urban migration accounts for more than 80 percent of urban growth in megacities. East Asia contains the largest number of megacities, and has the highest percentage of urban populations living in megacities (Guest 1994). Implications for transportation as well as for environmental sustainability can be significant:

> Increasingly, megacity growth is taking the form of extended metropolitan regions covering 50–100 kilometers from the city center, with polycentric structures acting as focal points in the movement of people, goods, and services. Metropolitan regional growth has typically sprawled along major highways, expressways, and railroad lines radiating out of urban areas, superimposing new towns, industrial estates, housing projects, and other urban forms onto areas that were previously predominantly agricultural and rural. Without strategic interventions in land-use management and transportation planning, environmental and economic constraints will increasingly affect megacities. (Guest 1994)

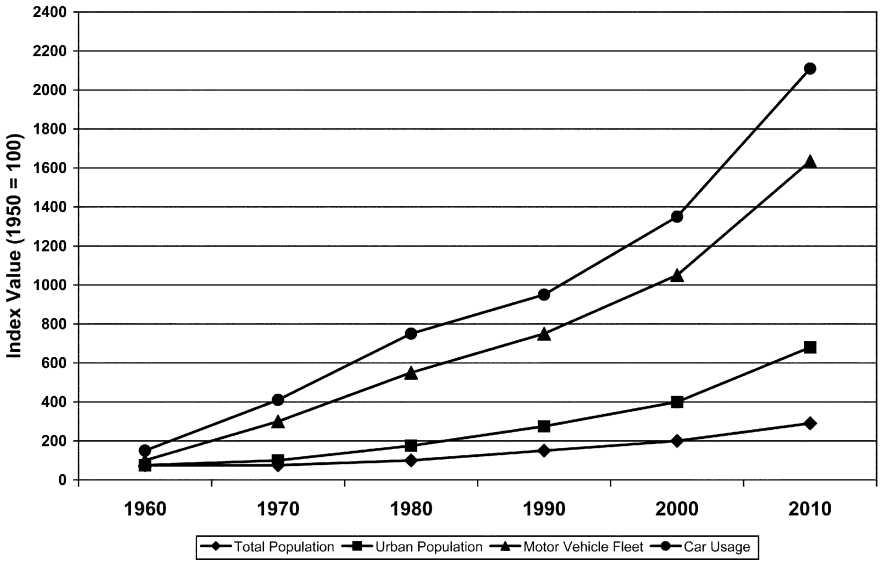

Figure 1.1. **Population growth and motorization rates in developing countries (Faiz 1993).**

During the past 50 years, while the speed of road-based vehicles has quadrupled, the mobility of the average city resident has declined tremendously. In some developing megacities, it is less than half of what it was half a century ago.

> The phenomenal increase in motorization all over the world has been accompanied by tremendous traffic congestion, lack of adequate, efficient, and low-cost public transport, and detrimental impacts on public health due to transport induced air pollution. (Pendakur 1998)

The growth rate of motorization generally surpasses the population growth rate and is positively correlated to growth in GDP per capita, as shown in Figures 1.1 and 1.2. In light of both the population increases and rising incomes found in many developing megacities, it is not difficult to conclude that however congested these cities are today, tomorrow will be worse.

Globalization and Megacity Competitiveness

Globalization has both positive and negative ramifications on the development of megacities. Certainly the investment of capital and the opportunities for employment that are offered to developing megacities by businesses with a global view can have positive effects on the standard and quality of life among

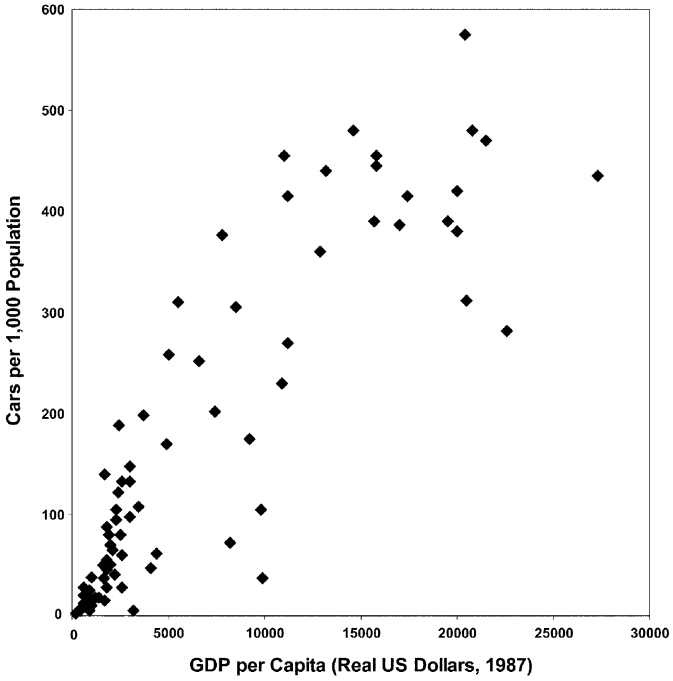

Figure 1.2. **GDP growth and motorization by country (Faiz 1993).**

inhabitants. However, since the core activities and locations of major industries are now largely determined by global market forces rather than the nature of local or regional markets, the decisions on enterprise location may be revisited. Consider the following example. In this highly competitive global arena, cities are enticed to build new infrastructure to attract multinational enterprises. Once these investments have been made, however, municipalities rarely receive guarantees of how long the enterprises will remain. The result is that businesses have succeeded in obtaining tax concessions, special infrastructure, and attraction of new migration. Faced with the vagaries of the market, some companies have then suddenly withdrawn. When enterprises withdraw, they can leave cities over-invested in specialized infrastructure and faced with a spike in unemployment. The result is that while cities may no longer be completely reliant on national governments to attract high-quality labor and private investment, they themselves are ill-equipped to deal with sudden influxes and flights of capital that distinguish the globalized age. Long-term, sustainable strategies must therefore be designed to avoid this harmful "ballooning and deflating" effect that is created by regional competition for global enterprises.

As local, regional, and international barriers to trade continue to fall, cities are at the forefront of those affected by globalization. As the economic nerve centers of developing countries, megacities generate a disproportionate share of national GDP. Increasingly, cities and metropolitan areas are also becoming the primary venues for access to global capital markets. This increase in economic power and financial influence, however, has not always been accompanied by a corresponding increase in political influence..

Globalization and rapid technological change will determine the developmental trajectory of developing megacities depending on their location, potential for profitability, available labor skills, and adaptability. According to a report by the Asian Development Bank (ADB), there are two important ways in which these factors will influence megacities:

> First, there is increasing competition among cities as multinational firms compare labor and other input costs and assess the available economic incentives, the regulatory climate, the presence of market-based laws and institutions, flexibility of the labor force, and political stability.
>
> [Megacities that succeed in meeting these requirements will develop at much faster rates than those that cannot or will not.]
>
> Second, the emergence of information-based service industries including financial and producer services, research and development, and media is benefiting larger cities that [can present] the most efficient conditions for information dissemination. (Asian Development Bank 2001)

Competition between regional centers will ultimately be based not only on relative location and production advantages, but also on attributes that include effective governance, regulatory transparency, and government support for private enterprise. Again citing the ADB report:

> The process of globalization through the international trade of goods, capital flows, and labor mobility has created an increasingly integrated world economy and growing competition between urban centers for foreign and domestic investment. Interdependencies are being created between urban centers across national boundaries, often creating links that are stronger than those found between an urban center and its own hinterland. Trade liberalization, while often painful in terms of the required restructuring across sectors, is creating new opportunities and synergies within and between regional growth zones. (Asian Development Bank 2001)

Cities exhibit greater output per capita than rural and suburban areas. This attribute explains why incomes are higher in urban areas, why so many people have moved from rural to urban areas, and why the rural-urban migration has been

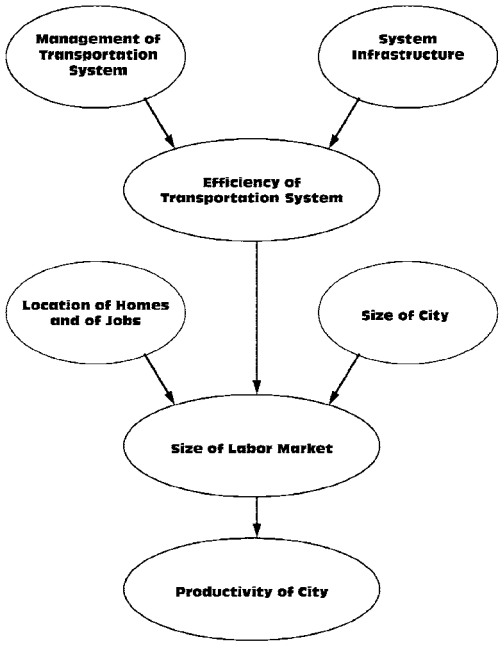

Figure 1.3. **Factors contributing to the productivity of megacities. (Adapted from Asian Development Bank 2001)**

beneficial to economic development. Workers moving from a low-productivity area to a higher one increase the average productivity of their country and, consequently, its wealth. They contribute more to the national budget than they get from it, in effect subsidizing the rest of the country. One hypothesis is that megacities are more productive because they have larger labor markets. The justification for this idea is twofold (Asian Development Bank 2001):

- The larger the labor market, the higher the probability that an enterprise can find the workers it wants, and that workers can find the jobs they want.
- A larger labor market also justifies and facilitates specialization of workers and jobs, a well- understood way of increasing productivity.

The impact of the size of the labor market on the productivity of a city results from the interaction among several variables, including the urban population, the relative location of jobs and households, and the efficiency of the transportation system, which is a function of the transportation infrastructure and the quality of management and operation of the system (Asian Development Bank 2001). These interactions are illustrated in Figure 1.3.

1.2 Transportation Policies and Sustainability

Symptoms of an Unsustainable Transportation System

Notwithstanding their benefits, the forces of globalization, urbanization, and rapid motorization have contributed to an increasingly dire situation in many of the world's developing cities. These pressures have pushed developing municipal institutions to the brink of their capacities. The common symptoms of a spreading, unsustainable malady as it applies to transportation are as follows:

- *Congestion*. Rapidly increasing motor vehicle populations that occupy a fixed (or slowly growing) roadway supply result in deteriorated transportation system performance. While congestion is a worldwide problem in both developed and developing economies, it is the much more rapid population growth in developing megacities that makes congestion such a critical issue. For example, the average travel speed in cities of OECD (Organization for Economic Cooperation and Development) countries is estimated as 18 km/hr; optimal desired travel speeds of 25–30 km/hr are elusive even in those cities well equipped to deal with the problem. In contrast, travel speeds in developing cities are commonly 4–8 km/hr. Furthermore, peak periods once limited to a few hours in the morning and evening are now stretching throughout the day, in effect causing a permanent traffic jam (Flora 1999). Congestion on urban roads causes a number of negative impacts or externalities, among them air pollution, decreased economic activity, and higher prices.

- *Air pollution*. The growing use of private vehicles is an increasingly important component of human activity that contributes to greenhouse gases (GHG) and global warming. The percentage of pollutants generated by mobile sources is increasing dramatically, especially in urban centers. While mobile-source emissions now account for 40 to 80 percent of the total atmospheric pollutants in a city's air shed, in developing cities the range of this percentage is between 60 to 80 percent. Road traffic accounts for 90–95 percent of lead and carbon monoxide (CO), and 60–70 percent of nitrogen oxides (NOx) and hydrocarbons, as well as particulate matter (PM). NOx and volatile organic compounds (VOCs) emitted by internal combustion engines can combine in the presence of sunlight to form ground-level ozone (O_3), also a harmful pollutant.

- *Health effects*. The health-related consequences of continual exposure to contaminated air are considerable.

> On a global basis, estimates of mortality due to outdoor air pollution run from 200,000 to 570,000, representing about 0.4 percent to 1.1 percent of total annual deaths. As the range of these estimates indicates, it is difficult to quantify the toll of outdoor air pollution. The health impacts of urban air pollution seem likely to be greater in some of the rapidly developing countries where pollution levels are higher. The World Bank has estimated that exposure to particulate levels exceeding the World Health Organization (WHO) health standard accounts for roughly 2 percent to 5 percent of all deaths in urban areas in the developing world. (China On-Line 2001)

Particulate matter (PM) is a generic term for a range of suspended particles that can be carcinogenic and lead to acute and chronic respiratory problems. Nitrogen oxides also contribute to the formation of acid rain and global warming (US EPA 1998). NOx and the pollutants formed by NOx can be transported over long distances. Thus, problems associated with NOx are not confined to areas where NOx is emitted. Therefore, controlling NOx is often most effective if done from a regional perspective, rather than focusing on sources in one local area. Carbon monoxide has been shown to damage both cardiovascular and respiratory functions. Lead is a leading agent responsible for underdevelopment of higher cognitive ability in children, and a leading cause of hypertension. Ground level ozone accumulation resulting from NOx, hydrocarbons, and sunlight-induced reaction, is a major contributor to respiratory problems (World Resources Institute 2000).

- *Decreased economic activity*. As traffic flows slow the movement of goods and people in urban centers, the impact on the economic health of the city can be profound. It is estimated that the United States loses over $43 billion yearly as a direct consequence of delays resulting from traffic congestion. In the UK estimates range from $20–$25 billion per annum. In developing cities the effect can be even more dramatic: by some estimates Bangkok loses an estimated one-third of its annual GDP, nearly $4 million per day (Flora 1999).

Moving toward Sustainability

The importance of megacities to their regional and national economies suggests that solutions to the problems above must be found that balance the often competing objectives and interests of improved transportation services and enhanced environmental protection. These solutions must also recognize and address the

many other factors that influence public policy and private participation regarding transportation, including resource limitations and organizational and institutional capacities to plan, implement, and enforce effective public policies. In this regard, megacities are not alone. Virtually all governments engaged in transportation face a mix of these very same issues – they differ only in their degree and in the (albeit important) details affected by their local situations. Megacities can therefore learn to some degree from the experience of other municipalities. This does not change the fact, however, that megacities must also contend with the unique scale of their own development, and with their particular local situations. While these local situations often present many serious problems, a tenet of this book is that megacities may nonetheless be able to identify and exploit opportunities for "win-win" solutions that enable them to provide better transportation services while addressing environmental concerns, maintaining public support of their policies, and working effectively within their financial, organizational, institutional, and technological capabilities. This approach entails a combination of learning from other jurisdictions what basic strategies have worked to solve transportation problems innovatively but affordably, while exploiting unique opportunities that may exist within their own particular urban context.

Strategies that have gained increasing attention worldwide in recent years to provide improved transportation service while dealing with constraints in various areas (e.g., financial, land use, organizational, institutional, technological) include the following examples:

- *Focusing on demand as well as supply*. Traditionally, transportation improvement has been accomplished through system expansion, whether by building new capacity or by expanding or improving existing facilities (e.g., adding lanes or paving earthen or gravel road surfaces). It is now increasingly recognized that managing the demand for transportation services can yield improved mobility and accessibility, often at less cost and local disruption. This approach can entail a variety of actions, ranging from regulatory and pricing policies to provision of alternative transport modes and encouraging the public to use them.

- *Improving existing transportation system performance*. The capacity and performance of existing transportation facilities can be increased by improving physical and operational attributes: e.g., safety features, system operational features such as traffic signals and signs, and new technology such as variable message signs and real-time information displays, which are examples of intelligent transportation systems (ITS).

- *Understanding the need for tradeoffs*. Policy goals and objectives are often competitive, and sometimes contradictory. This inherent tension is dealt with in a tradeoff analysis, where managers understand the cost, benefits, and other impacts of choosing one policy, investment, or project alternative as opposed to another. An effective tradeoff analysis presumes the availability of good information on each alternative – often a matter of effective information technology.

- *Improving management capability*. Improved agency management of a transport system leads to better decisions based on better information, which conserves scarce resources while providing to the public the best level of service possible within existing constraints. Improved management capability generally entails both enhancing human skills in the agency organization through actions such as engaged leadership, managerial and staff training, clear policy direction, and effective internal communication; and providing necessary tools, often using information technology and data collection effectively.

These strategies have been applied in many different contexts, and have much to offer. They do not, however, tell the full story on sustainability, nor are they specific to megacities. The concepts and techniques that can address sustainable transport policies in megacities are developed in the following chapters. While there are a number of definitions of sustainable development, which will be reviewed in Chapter 2, one common theme emerges: a basic concern for environmental quality as well as for opportunities to maintain or improve the quality of life among those of the current generation and across generations. Moreover, megacities actually have opportunities to engage in "win-win" strategies between environmental quality and transportation level of service by designing their transport policies to take advantage of their particular urban context. For example, in a developing economy, since automobile ownership tends to be focused in the higher income groups, policies to restrict auto use in city centers will not have a regressive effect as they would in industrialized countries. As the following chapters will point out, however, well-intentioned policies can have inadvertent, and sometimes very adverse, consequences. Policies must therefore be well-designed and suited to the particular urban area and culture, and often a suite of policies will be necessary.

1.3 Outline of This Book

Several ideas need to be developed across sustainability, economic policy, transportation policy and technology, and public-private partnerships useful in implementing sustainable transportation solutions. They are organized in this book as follows:

- Chapter 2 discusses basic concepts of sustainability. Many definitions and desired implications of sustainability have been proposed, and this chapter begins by providing several examples and highlighting different areas of emphasis. Themes shared by virtually all of these interpretations, however, include the need to preserve environmental quality in undertaking economic development and growth, whether for the benefit of less advantaged populations, future generations, or the sake of environmental diversity itself.

- Chapter 3 builds on the preceding chapter by considering approaches to achieve sustainable development. To provide a conceptual framework for doing this, the chapter considers sustainability as a resource management problem, where resources and their related benefits or services are categorized as factors of production, as "natural" benefits of Nature, or as sinks that absorb or assimilate waste and pollution. The chapter concludes with other perspectives on sustainable development: the rationale behind involvement of the private sector, the global implications of sustainability, and the need to see sustainable policies in a comprehensive, integrated way.

- Chapter 4 provides an overview of transportation policy. Transportation policy encompasses a broad range of public policy and agency actions to promote the availability, quality, and economy of personal and commercial movements. Transportation policies may focus on the supply-side or the demand-side; they may be market-based or price-based, regulatory, or informational and educational ("suasive"). This chapter examines each of these policy options, providing examples from both developing and developed economies.

- Chapter 5 considers public-private partnerships that can be used to help finance and implement sustainable strategies. It discusses various mechanisms of such partnerships, provides a framework for understanding the types of goods and services for which public or private provision is preferred, and presents evaluation matrices illustrating the effectiveness of each method and the degree to which it fulfills a number of public goals. The chapter

reviews theoretical and empirical evidence on the circumstances favoring public or private delivery of services – a mixed picture at best, but one clearly indicating the importance of competitive forces in maintaining high quality and low cost.

- Chapters 6 and 7 provide examples and a case study of transport policy implementation in various cities. The examples in Chapter 6 illustrate different packages of policies and how they fared in particular contexts. In particular, examples of successful Transit-Oriented Development are highlighted. Chapter 7 builds on these examples to describe a case study conducted in Guangzhou, People's Republic of China.

- Chapter 8 concludes the book with the main themes that have emerged from the preceding chapters.

Chapter 2
SUSTAINABILITY

2.1 What Is Sustainability?

Definitions

The idea of "sustainable transportation policies" is central to this book. Sustainable transportation policies promote the movement of people and goods in ways that are consistent with sustainable economic development. But, what is "sustainable economic development"? Pezzey (1989) and Pearce et al. (1989) have compiled a number of definitions from the literature; examples of these, plus others, are listed in Exhibit 2.1. The sample in Exhibit 2.1 suggests that there may be almost as many definitions as there are proponents. While these definitions reflect different economic, ecological and social nuances, they all embody an important idea that is the hallmark of "sustainability":

Sustainable development seeks to preserve environmental quality – whether for less advantaged populations, future generations, or the sake of environmental diversity itself – while pursuing opportunities for economic advancement, all leading to an improved quality of life.

How it does so, and how current decision-makers can account for environmental quality and the value of its preservation, are complicated matters that are analyzed in detail in later chapters. At this point we can state simply that, based on case studies where sustainability has been tried, goals, objectives, and policies need to be *holistic* – i.e., they must be based on a comprehensive consideration of options; they must consider broadly the impacts of these options on the local and regional economy, ecology, and society; and they must be analyzed using methods and criteria that can account for this more complete perspective.