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Green Urbanization in Asia

Key Indicators for Asia and the Pacific 2012
Special Chapter

Asian Development Bank

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Foreword

The *Key Indicators for Asia and the Pacific 2012* special chapter on "Green Urbanization in Asia" tackles two growing concerns—environmental sustainability and rapid urbanization. While the region continues its economic progress, which boosts the growing number of megacities within the region, issues arise on its environmental consequences, and how the principles of environmental sustainability can be integrated into the region's economic policies amidst its continued urbanization.

Asia is home to almost half of the global urban population, and is urbanizing at a pace faster than any other region, resulting in an unprecedented growth in the number of urban dwellers and increased number of densely populated megacities. Consequently, the region will confront enormous environmental challenges that are already serious, including air pollution, congestion, CO_2 emission, deprivation in water and basic sanitation, and growing vulnerability to natural disasters.

However, with urbanization comes the rise of the middle-class and property owners, the development of the service sector, declining fertility and increased educational attainment, and more importantly, innovations in green technology. These urbanization-related forces and mechanisms are important for attaining a win-win scenario of environmental improvement and economic growth. Through establishing and exploring the environment-urbanization nexus in Asia, the chapter offers a cautiously optimistic environmental prospect for Asia as the region urbanizes. The chapter also provides suggestions for government intervention to ensure a green urbanization path in the region.

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Abbreviations and Acronyms

ADB	Asian Development Bank
BRT	bus rapid transit
CNG	compressed natural gas
CO_2	carbon dioxide
EFB	empty fruit bunches
EKC	Environmental Kuznets Curve
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization
FIZ	free industrial zone
FTZ	free trade zone
GAR	Global Assessment Report on Risk Reduction
GDP	gross domestic product
GHG	greenhouse gas
GRUMP	Global Rural Urban Mapping Project
IBT	increasing block tariff
IEA	International Energy Agency
ILO	International Labour Organization
IMF	International Monetary Fund
km	kilometer
Lao PDR	Lao People's Democratic Republic
LECZ	low-elevation coastal zone
Ln	natural logarithm
MDG	Millennium Development Goal
OECD	Organisation for Economic Co-operation and Development
PM	particulate matter
PM_{10}	particulate matter with diameter of 10 micrometers or less
PPP	purchasing power parity
PRC	People's Republic of China
SPM	suspended particulate matter
TSP	total suspended particulates
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UN-HABITAT	United Nations Human Settlements Programme
UNODC	United Nations Office on Drugs and Crime
US	United States
WDI	World Development Indicators
WHO	World Health Organization
WUP	World Urbanization Prospects
WVS	World Values Survey
$\mu g/m^3$	microgram per cubic meter

Green Urbanization in Asia – Highlights

The vast number of people moving into Asian cities is historically unprecedented. As a consequence, the number of megacities is rising and cities are expected to have even higher population densities. This trend is expected to continue as the share of Asia's population living in urban areas is low relative to that in the rest of the world. The scale and the speed of urban expansion have contributed to the rise of Asia, but present challenges as well as opportunities for the region and the world. Most notable are the environmental challenges, such as the devastating floods during 2011 and 2012 in Bangkok, Beijing, and Manila.

To meet such challenges, Asia must follow a green urbanization path by instituting policies that exploit its late comer's advantage and the unique features of Asia's urbanization. Responses to the challenges include developing satellite cities linked by train, light rail, or metro (rather than highways) with megacities (cities populated by 10 million or more people); conserving resources and improving the efficiency; and promoting the use of new technologies and renewable energy. In addition, the green urbanization process must protect the urban poor to ensure that the growth is inclusive and sustainable.

Asia's Urbanization has Unique Features

- **From 1980 to 2010, Asia added more than a billion people to its cities—more than all other regions combined—with a further billion set to be city dwellers by 2040.** This massive scale of urbanization is taking place most notably in the People's Republic of China (PRC), Bangladesh, India, Indonesia, and Pakistan. By the latest estimates, Asia is now home to almost half of all urbanites on earth and its urban population is more than three times that of Europe—the region with the second largest urban population.

- **Asia's urbanization is rapid, with the PRC transitioning from about 10% of its population in urban areas to about 50% urban in just 61 years, versus 210 years in Latin America and the Caribbean, 150 years in Europe, and 105 years in North America.** And Asia's urban population is projected to continue growing faster than that of any other region.

- **Urban Asia is characterized by higher density and most of the world's megacities.** Already, the three most densely populated large cities in the world (Mumbai, Kolkata, and Karachi, in that order), and 8 of the 10 densest, are in Asia. In 2010, Asia was home to over half—12 out of 23—of the world's megacities.

- **Asian urbanization still has a long way to go, with the number and sizes of cities growing larger and larger.** In 2010, the urban share of Asia's population was still only 43%, compared with the worldwide share of 52%. By 2050, the urban share in Asia is projected to reach 63%, gaining on but still below the 67% global average. Thus, Asian cities will have even higher densities and, by 2025, the number of megacities in Asia is expected to increase to 21 of a global total of 37.

This Unprecedented Urbanization Poses Enormous Challenges

The scale, speed, and density of Asia's urbanization will present many challenges. Increasing urban crime rates, expanding slums, and rising inequality may ensue. Above all, this unparalleled urbanization will add to the already enormous environmental stress in Asia. The *Key Indicators 2012* special chapter focuses on pollution and vulnerability to flooding as urbanization in Asia proceeds.

The special features of Asia's urbanization make the challenges all the more serious as the current low level of urbanization suggests that Asia still has a long way to go. The fast pace of urbanization means little time for adjustment or learning. The growing size and number of megacities will be difficult to manage, and high density makes cities more vulnerable to catastrophic events and disease. Green policies need to be at the core of Asian urban development in the 21st century if the challenges are to be properly managed.

- **Vulnerability to flooding will increase with urbanization: by 2025, a projected 410 million urban Asians will be at risk of coastal flooding.** Over 300 million were already at risk of coastal flooding in 2010, and about 250 million were at risk of inland flooding such as what struck Bangkok last year. The number of urbanites who are vulnerable to inland flooding will also rise, to roughly 350 million by 2025. More than half the population in large cities such as Dhaka, Ho Chi Minh City, and Tianjin are at risk from both inland and coastal flooding.

- **More than half of the world's most polluted cities are in Asia, and air pollution contributes to half a million deaths a year in the region.** Urban air pollution in Asia is higher than in other regions. A staggering 67% of Asian cities (versus 11% of non-Asian cities) fail to meet the European Union's air quality standard (of 40 micrograms per cubic meter [$\mu g/m^3$] for particulate matter with diameter of 10 micrometers or less [PM_{10}]).

- **From 2000 to 2008, average per capita greenhouse gas emissions for Asia grew by 97% versus only 18% for the world, with most of the emissions coming from urban areas.** Moreover, the environment may degrade further as Asia continues its growth. Based on the environmental Kuznets curve for Asia, which shows rising and then declining environmental degradation as income rises, Asia is still on the rising side of the carbon dioxide (CO_2) and PM_{10} curves. The average income per person of Asia in 2010, at roughly $6,100 in 2005 PPP, is still well below the "turning point," at around $41,000 in 2005 PPP, for CO_2.

- **Future CO_2 emissions, if left unchecked under a business-as-usual scenario, could reach 10.2 metric tons per capita by 2050, three times the 2008 level, with disastrous consequences for Asia and the rest of the world.** Three of the top five CO_2 emitting economies are in Asia, and per capita emissions are rising at an alarming rate.

- **In 2010, the region was home to 506 million slum dwellers, or more than 61% of the world's total slum-dwelling population.** South Asia alone hosts almost 38% of the region's slum dwellers. Almost 408 million people, or over one-fourth of Asia's urbanites, still lack access to improved sanitation facilities.

But There is Hope: Urban Agglomeration Can Help Improve the Environment if Properly Managed

The environmental Kuznets curve is not an immutable law. Urbanization can help as it promotes development of the service sector, which generally pollutes less than manufacturing; prompts traditional manufacturers to relocate away from major city centers; economizes on the provision of environment-related infrastructure and services such as piped water, basic sanitation, and solid waste disposal; contributes to significantly higher labor productivity; and facilitates innovation, including for green technologies. Rising educational attainments, the growth of the middle class, and declining birth rates typically associated with urbanization can also have broadly beneficial impacts on resource use and the environment.

In fact, the environment–urbanization curves in Asia have been shifting favorably over time, thanks to better technologies and policies. The curves have shifted down and to the left during the last two decades, meaning lower emissions and pollution at the same level of urbanization, and that the peaks come sooner. Between the 1990s and 2000s, the shifts have led to 20% less PM_{10} ($\mu g/m^3$) and 27% less CO_2 emissions per capita than would have otherwise been expected.

Policies for Asia's Green Urbanization

To ensure a green urbanization path, conservation and efficiency improvements will be essential because of the combined speed and scale of Asia's urbanization. Promoting new frontiers that are built using renewable resources and new technologies is also important in order to benefit from the region's late comer advantage. And as Asia learns from the mistakes of others and its own past, there is recognition that urban growth must be inclusive and sustainable.

In particular, green urbanization strategies in Asia should take into account the distinctive characteristics of Asia's urbanization that will lead to a different pattern of city development. Unlike Europe and the United States, Asia does not have the luxury to live in suburbs and drive to city centers for work. The region needs to develop environment-friendly satellite cities that are linked to megacities by rail or metro rather than highways. In Asia's urbanization, critical masses of people will be in relatively small areas, making it more important to take advantage of cost effectiveness in supplying essential services such as piped water and sanitation. Finally, after the highly commendable and recent rapid expansion of physical infrastructure in Asia, the growing challenge now is to improve the quality of infrastructure, paying special attention to safety standards and resilience to natural disasters.

- **Enhancing efficiency and conservation to reduce consumption of resources and energy**

  - **It is important to get prices right, so they incorporate full social costs and benefits to allocate resources efficiently.** This can be done by imposing congestion and emission charges, as implemented in Singapore, and removing inefficient subsidies, as in Indonesia. Other examples are the introduction of carbon taxes, as in the Republic of Korea, and use of increasing block pricing for water, electricity, and other public utilities, as in the Philippines.

- **Introduce regulations and standards in a timely manner.** Implementing appropriate regulations and standards can help to correct for market or coordination failures on air, water, vehicles, and appliances, as in India. The government can construct green industrial zones to assist manufacturing to relocate, as in Indonesia. Improved regulations can also help to reduce or prevent urban sprawl.

- **Use rapid public transport for connectivity and less pollution.** Speedy connections to and from satellite cities can ease congestion in central megacity hubs. A bus rapid transit system, as in the PRC, and subways, as in India, for densely populated cities can lower environmental consequences and enhance the quality of life.

- **Promoting new frontiers that use renewable resources and new technologies**

  - **Advance or adapt technology for environmental protection and efficient resource use.** A good example is using waste-to-energy plants to reduce pollution and at the same time generate renewable energy, as in the Philippines and Thailand. Green technology can be acquired either by imports or innovated through research and development, as in the PRC.

  - **Incorporate environmental priorities in city planning.** This is under way through building new and satellite cities with renewables as primary energy sources, as piloted in the PRC. Urban sprawl can be tackled by developing a local system of compact, walkable satellite cities centered around high quality train, light rail, or metro systems, without heavy reliance on highways and major roads for connection, and by reviving city centers.

  - **Employ alternative energy and "smart" electricity grids to promote efficiency and reduce emissions.** More power can be generated using renewable resources to meet rising demand.

- **Protecting the poor for social harmony and inclusiveness**

  - **Enhance resiliency and reduce vulnerability to disasters.** This can be done by constructing houses in safe areas, improving housing affordability for the poor, and investing in drainage infrastructure and climate forecast technology.

  - **Progress must also be made to improve urban slums.** Useful policies include granting land titles to slum dwellers, issuing housing vouchers linked in value to the length of a resident's tenure in the city, and providing basic services to slum areas.

- **Public finance, transparency, and accountability to facilitate green urbanization**

  - **Public finance to support green cities.** This can be accomplished by broadening tax and revenue bases and by increasing access to broader and deeper capital markets by local urban governments to lower their financing costs for urban infrastructure and public services.

  - **Incentivize politicians to ensure transparency and accountability.** Avenues include disclosing city government performance to the public and nongovernment organizations, and launching national competitions and campaigns to encourage a "race to the top" where high performance is rewarded.

Asia's current urbanization is different from historical experience in terms of speed and scale, and is generating and confronting unprecedented challenges. It also comes with forces that, if properly managed, can help to address the challenges. Asia's future depends on using the best practices and policy innovations to promote green urbanization, thereby ensuring a better life for its urban residents, and the world.

Green Urbanization in Asia

From 1980 to 2010, Asia added more than 1 billion people to its cities.[1] More than half of the world's megacities (cities with 10 million or more people) are now in Asia. Another 1.1 billion people will be added to Asia's urban population in the next 30 years (UN 2012). From 1980 to 2040, every year more than half of the increase in the world's urban population has been or will be in Asia. Such a scale of urbanization[2] is unprecedented in human history. With all its potential benefits and costs, Asia's urbanization presents both challenges and opportunities for the region and the world as a whole.

The phenomenal urbanization in Asia is largely driven by fast economic growth, particularly in the People's Republic of China (PRC) and more recently in India. Asia's growth is dominated (as has happened elsewhere) by the expansion of services and manufacturing. Agriculture experiences a relative decline because the expenditure share on farming products typically drops as income rises and agricultural supply is constrained by the balance between productivity (yield) increases and land conversion to nonagricultural uses. Meanwhile, industrial and service supplies are much less constrained by land as a factor of production and benefit relatively more from deepening physical and human capital stocks. Also, the demand for manufactured products and services is nearly insatiable, as demonstrated by the frequent releases and popularity of new versions of electronic products such as "smart phones" and "tablets." Because industrial and service production and consumption usually take place in cities, they generate jobs and provide opportunities and attractions for people in general and migrants in particular, leading to continued urbanization.

Urbanization comes with both benefits and costs. "Localization economies" result from agglomerations of firms in the same industry benefiting from spillovers of knowledge and technology, pooling of labor markets, and intensified competition. "Urbanization economies" refers to externalities attributable to agglomerations of firms in the same cities but from different industries, which are taking advantage of backward or forward linkages, reduced transaction costs, and sharing of common services and intermediate inputs. In particular, by locating ambitious, talented individuals in close physical proximity, urbanization helps promote innovation and technological progress, leading to higher productivity. These benefits of urbanization help raise household incomes and firm profitability. It is generally accepted that city growth has made urbanites happier, healthier, and smarter, and cities that can attract and retain skilled people have a bright future (Glaeser 2011, Moretti 2004a).

Urbanization also comes with costs. Noise and congestion are among the most apparent features of cities. City living entails higher costs for housing, raising children, and health care. In addition, income inequality and crime rates tend to be higher in urban areas. The quality of the urban environment receives considerable attention, partly arising from concerns over the sustainability of development and climate change, and partly from shifting preferences as incomes rise.

Asia has already been facing enormous environmental challenges. Three of the top five carbon dioxide (CO_2) emitting economies and 11 of the 20 most polluted cities in the world are in Asia. In many Asian nations, losses from traffic-related congestion amount to 5% of gross domestic product (GDP) (ADB 2012a). In rich Asian cities (such as Hong Kong, China; Singapore; Seoul; and Tokyo), high incomes and technology that became available during the last 50 years have already resulted in much pollution and a large ecological footprint. The situation is particularly worrisome in poor cities that experience rapid growth, where pollution is becoming extremely serious, infrastructure supply lags behind demand, and basic public services such as water connections and solid waste disposal do not reach the majority. In addition, many residents live on marginal lands where they face risks from flooding, disease, and other shocks.

In the absence of appropriate interventions, urbanization and further economic growth may result in greater deterioration of the environment and urban living conditions. For example, the region was home to 506 million slum dwellers in 2010, more than 61% of the world's total.

This special chapter focuses on the environmental challenges Asia faces as it urbanizes. It begins by highlighting special features of Asia's urbanization in the next section, including its massive scale and low level, the fast pace of urbanization, high population density, and more and growing megacities.

1 In this Special Chapter, "Asia" refers to the Asia and Pacific region. The terms "cities" and "urban population" are as defined by the UN (2012). In this chapter, the terms "city" and "urban" are used interchangeably.

2 For clarity, the terms "scale" or "size" of urbanization refer to the absolute increase in total urban population. The "urbanized share" or "level of urbanization" refers to the share of the national or regional population living in urban areas. The "pace or speed of urbanization" refers to the change in the percentage points of the urbanized share. Unless otherwise indicated, changes in urban population include both net migration and natural increase of existing urban population.

The chapter then discusses the environmental challenges associated with urbanization, covering topics of urban air pollution, greenhouse gas (GHG) emissions, access to water and sanitation, loss of natural ecosystems and amenities, and urban slums and poverty. Given the increasing concerns about sea level rise associated with climate change and the number of coastal cities in Asia, estimates of population at risk due to coastal flooding and the proportion of city population affected by this risk are presented. But the future does not need to be grim.

Thus, the chapter presents arguments to support a cautiously optimistic and achievable environmental prospect for Asia as it continues to urbanize. While "business as usual" could make things worse, certain forces and mechanisms associated with urbanization if managed properly can help counter the trend in environmental degradation. These forces include declining fertility, rising educational levels, relocation of manufacturing away from city centers, innovations in green technology, and improvements in urban infrastructure. The environment–urbanization relationship (using air particulate matter pollution and CO_2 emission as indicators) will be investigated and used to depict a possible green urbanization path for Asia.[3]

A green urbanization path, of course, is not automatically achievable unless appropriate policies and interventions are designed and implemented in a timely fashion. Before concluding, the chapter offers a number of evidence-based policy options that can help achieve a win–win scenario of urban growth with improvement in the environment.

Special Features of Urban Growth in Asia

In a process similar to that much earlier in Europe, Latin America, and Northern America, Asia has been urbanizing for many years now and the process is projected to gain momentum in the coming decades. Unlike other regions, however, Asia's urbanization is different in several key aspects.

First, urbanization in Asia has been occurring rapidly and will continue to do so in the foreseeable future. Table 1, which is based on data and projections of the UN (2012), tabulates the level of urbanization and its change for different regions and two Asian economies. The last two columns of Table 1 show the total percentage point increase in the level of urbanization for the periods 2000–2010 and 2010–2050. While Asia increased its urbanization level by 7 percentage points in 2000–2010, Africa—the second fastest urbanizing region during the same period—only experienced a 3.6 percentage points increase. Similarly, during 2010–2050, Asia is projected to increase its urbanization level by 20.4 percentage points, but the projected increase for Africa is only a total of 18.5 percentage points.

3 "Green urbanization" is defined as urbanization that excels in both local and global environmental criteria. The local criteria include clean air, clean water, access to green space, quality transport options, and the capacity to protect residents from risks of natural disasters. The key global criterion is per capita carbon footprint.

Table 1 **Urbanization Level and Changes (actual and projected)**

Region	Level of Urbanization (%)			Percentage Point Change (%)	
	2000	2010	2050	2000–2010	2010–2050
Europe	70.8	72.7	82.2	1.9	9.5
Latin America and the Caribbean	75.5	78.8	86.6	3.4	7.8
Northern America	79.1	82.0	88.6	2.9	6.6
Africa	35.6	39.2	57.7	3.6	18.5
Asia	35.5	42.5	62.9	7.0	20.4
China, People's Rep. of	35.9	49.2	77.3	13.3	28.1
India	27.7	30.9	51.7	3.3	20.8

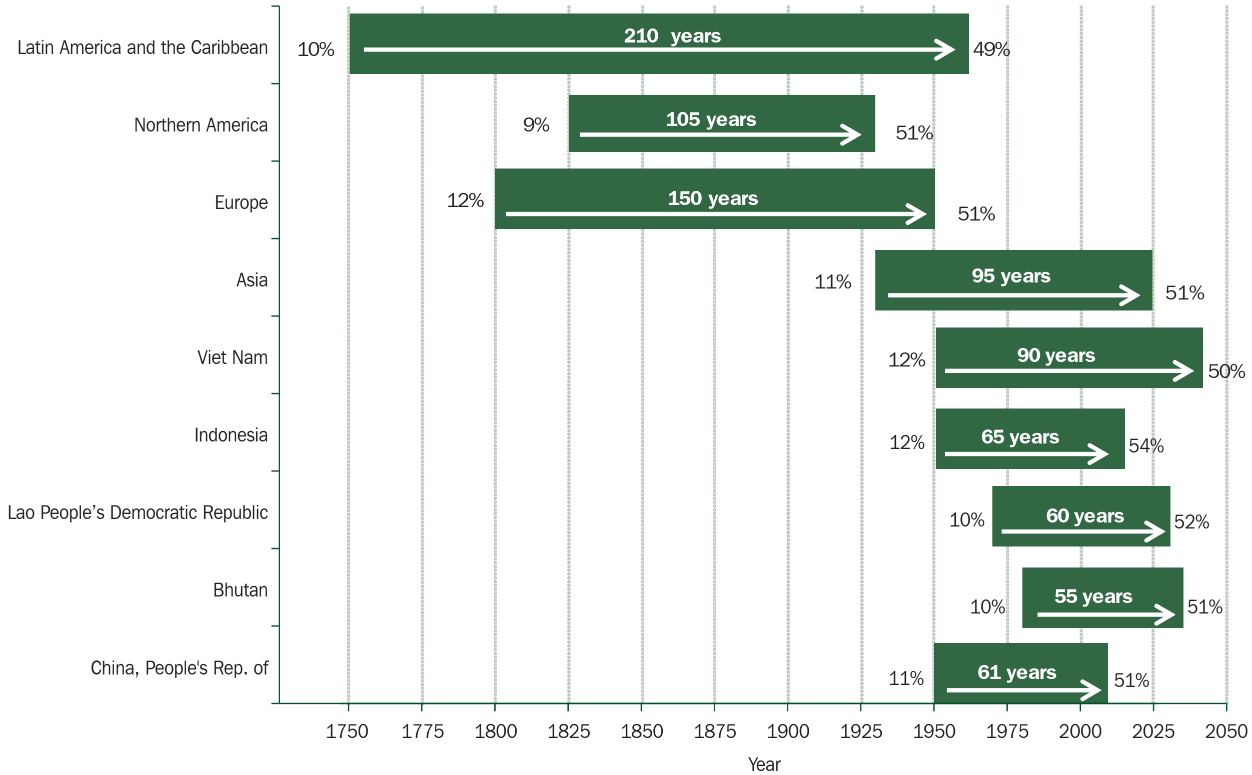
Source: ADB estimates based on UN (2012).

More revealing is a comparison of the number of years between the start of a region's urbanization, when about 10% of its population was urban, to when about 50% of its population is urban. Figure 1 shows that this process lasted 210 years in Latin America and the Caribbean (from 10% in 1750 to 49.3% in 1960), 150 years in Europe (from 12% in 1800 to 51.3% in 1950), and 105 years in Northern America (from 9% in 1825 to 51% in 1930), and it will take 95 years or less in Asia (from 11% in 1930 to 51% in 2025). For countries within Asia, this process lasted only 61 years for the PRC and is estimated to last 55 years for Bhutan, 60 years for the Lao People's Democratic Republic (Lao PDR), 65 years for Indonesia, and 90 years for Viet Nam.

Second, the absolute increase in city population in Asia is unprecedented, partly due to its large population base and partly due to its fast speed of urbanization. Since the 1950s, Asia has added more than 1.4 billion people to its cities (Figure 2). Almost 537 million were added during the 35 year interval of 1950 to 1985. But in the following 15 years, 1985–2000, 465 million were added. More strikingly, from 2000–2020, a total of 822 million will be added. Figure 2 also provides geographic breakdowns of these numbers. Clearly, most of these increases are from Bangladesh, the PRC, India, Indonesia, and Pakistan, Asia's most populous countries.

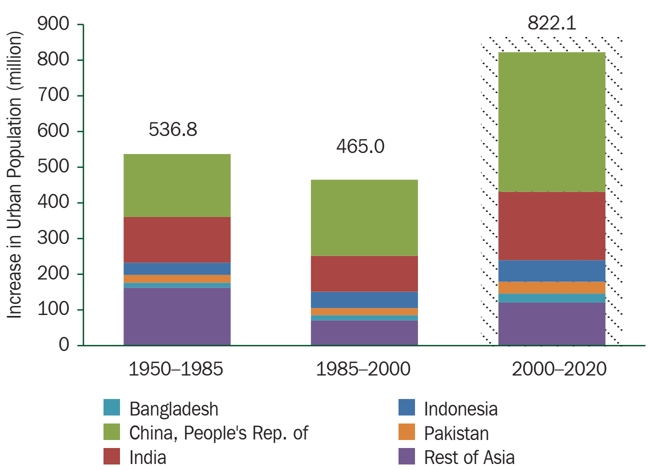
To some extent, global urbanization is largely an Asian phenomenon (Figure 3). Since the early 1980s, Asia has added more people to the global urban population than all other regions combined. By the latest available statistics, Asia is now home to almost half of the total urbanites on earth (Figure 4)—Asia's urban population is more than three times that of Europe, the second largest region in terms of urban population (UN 2012).

Figure 1 **Number of Years from about 10% to 50% Urbanization**



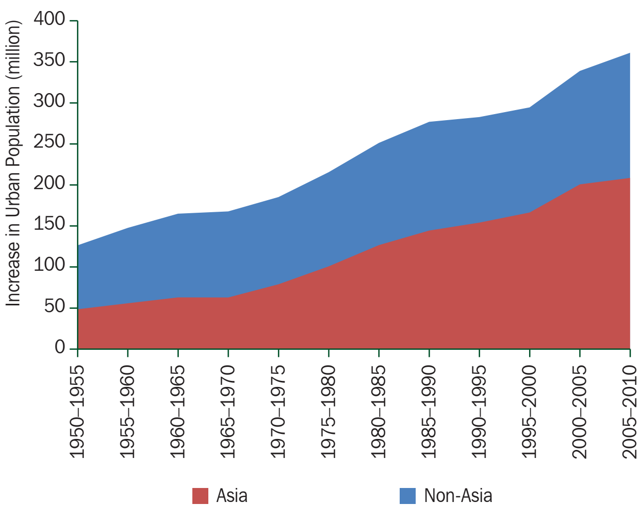
Note: Extrapolation and interpolation were used to estimate urbanization level and corresponding starting years for Latin America and the Caribbean and Northern America.
Sources: ADB estimates based on Bairoch (1988) and UN (2012).

Figure 2 **Increase in Urban Population in Asia**
(millions)



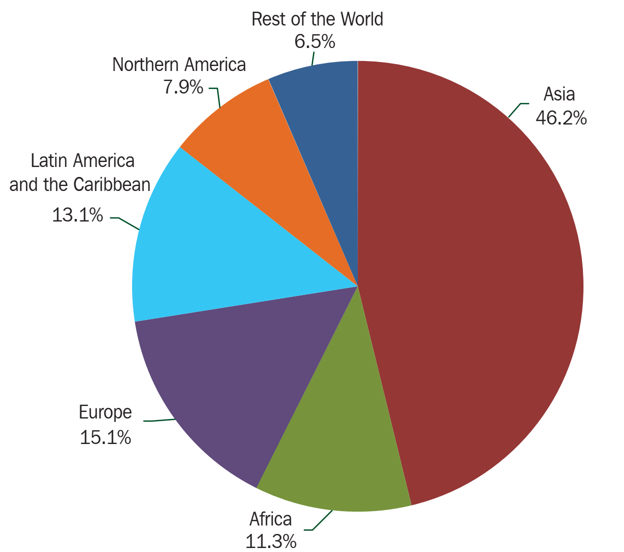
Note: Data for 2010–2020 are based on projections of UN World Urbanization Prospects, 2011 Revision.
Source: ADB estimates based on UN (2012).

Figure 3 **Increase in Urban Population, 1950–2010**



Source: ADB estimates based on UN (2012).

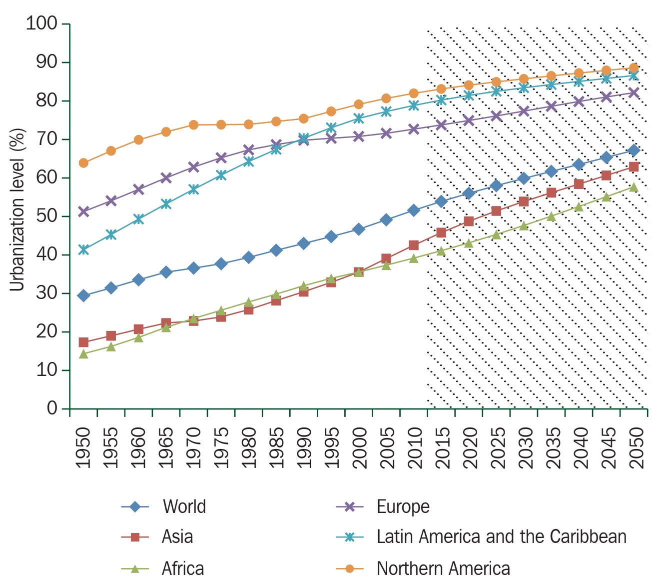
Figure 4 **Regional Shares of Global Urban Population, 2010** (%)



Northern America = Canada and the United States.
Source: ADB estimates based on UN (2012).

Third, contrary to the unprecedented expansion of city population, Asia's level of urbanization is still low. As shown in Figure 5, the level of Asia's urbanization (i.e., the share of its population living in urban areas) has been lower than that of the world at least since 1950. Across regions, Asia was the least urbanized, even less than Africa, during 1970–2000. In 1960, only 20.7% of Asia's population was urbanized versus 33.6% for the world. In 2000, 46.7% of the world's population lived in cities while only 35.5% of the population in Asia did so. In 2010, these urbanization shares moved to 52% and 43%, respectively. Thus, the urbanization gap between Asia and the rest of the world has narrowed but remains large.

Figure 5 **Level of Urbanization by Region** (%)



Northern America = Canada and the United States.
Source: UN (2012).

The gap in the urbanization level between Asia and the world will narrow further (UN 2012). By 2050, while 62.9% of Asians will live in cities, this percentage will be 67.2 for the world. Asia's level of urbanization will be higher than Africa's (57.7%), but still lower than Europe's (82.2%), Northern America's (88.6%) and Latin America and the Caribbean's (86.6%).

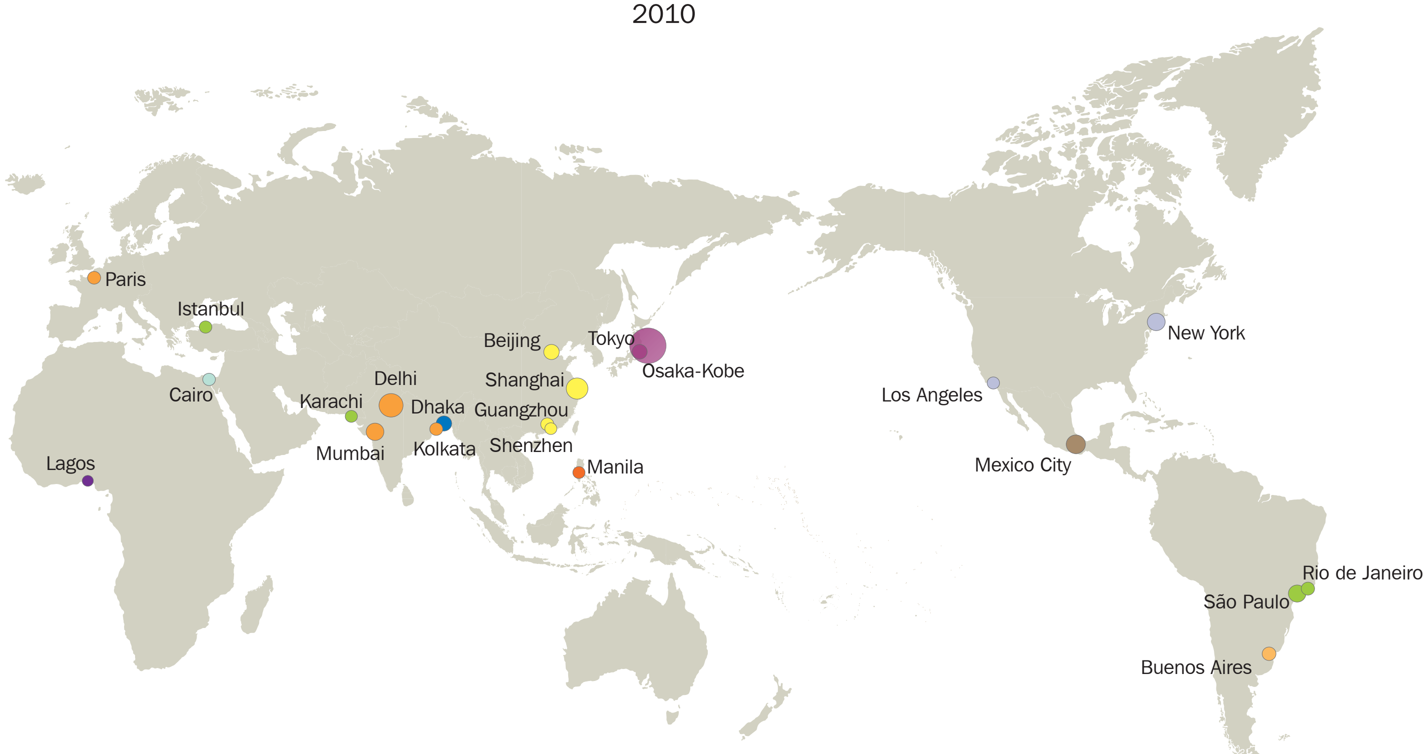
Fourth, Asia is home to most of the world's megacities and its share has been increasing (Figure 6). There were only two megacities in the world in 1950: New York, with a population of 12.3 million, and Tokyo, with 11.3 million. By 1980, two more megacities had emerged: São Paolo, with a population of 12.1 million, and Mexico City, with 13 million. However, by 2010, Asia had 12 of the world's 23 megacities. The UN (2012) predicts that these numbers will increase to 21 and 37, respectively, by 2025.[4] Cities such as Chongqing, Guangzhou, Jakarta, Lahore, and Shenzhen are expected to pass the 10 million mark soon. The large cities expected to grow the most include Dhaka, Lahore, Karachi, Kolkata, Manila, Mumbai, and Shanghai. Thus, while the majority of the world's megacities are in Asia, even more are emerging.

Although megacities are growing and their numbers are increasing, the largest city of each country in Asia is home to a smaller share of the total urban population than is the case in other regions. "Urban primacy" is indicated by the share of the country's urbanites who live in the largest city of the country. Relative to the rest of the world, Asia shows a much lower level of urban primacy (Figure 7), indicating that its urban populations are less concentrated in the largest city of each country. In 2009, roughly 12% of Asia's urban population lived in their country's largest cities, while outside of Asia, this share was 21%. This suggests that the size of Asia's primate cities is likely to increase. So, although Asian cities are already large, some of Asia's megacities are likely to become larger still, even relative to medium- and small-sized cities in the same country.

Fifth, Asia's cities feature much higher population densities than cities elsewhere in the world. The world's three most densely populated large cities are in South Asia, and 8 of the top 10 are in Asia (Figure 8). The average urban area (settlements of 5,000 or more people) has 720 people per square kilometer in Asia, compared with about 500 in Africa, the region with the second highest

4 The raw data can be downloaded at esa.un.org/unpd/wup/CD-ROM/WUP2011-F17a-City_Size_Class.xls

Figure 6 **Number of Megacities**



Note: The circles indicate population sizes ranging from ○ (10 million) to ○ (39 million). The circles do not reflect the physical extents of the cities and any overlap between them merely reflects their relative population sizes and not any official acceptance or endorsement of any geographical sovereignty.

Source: UN (2012).

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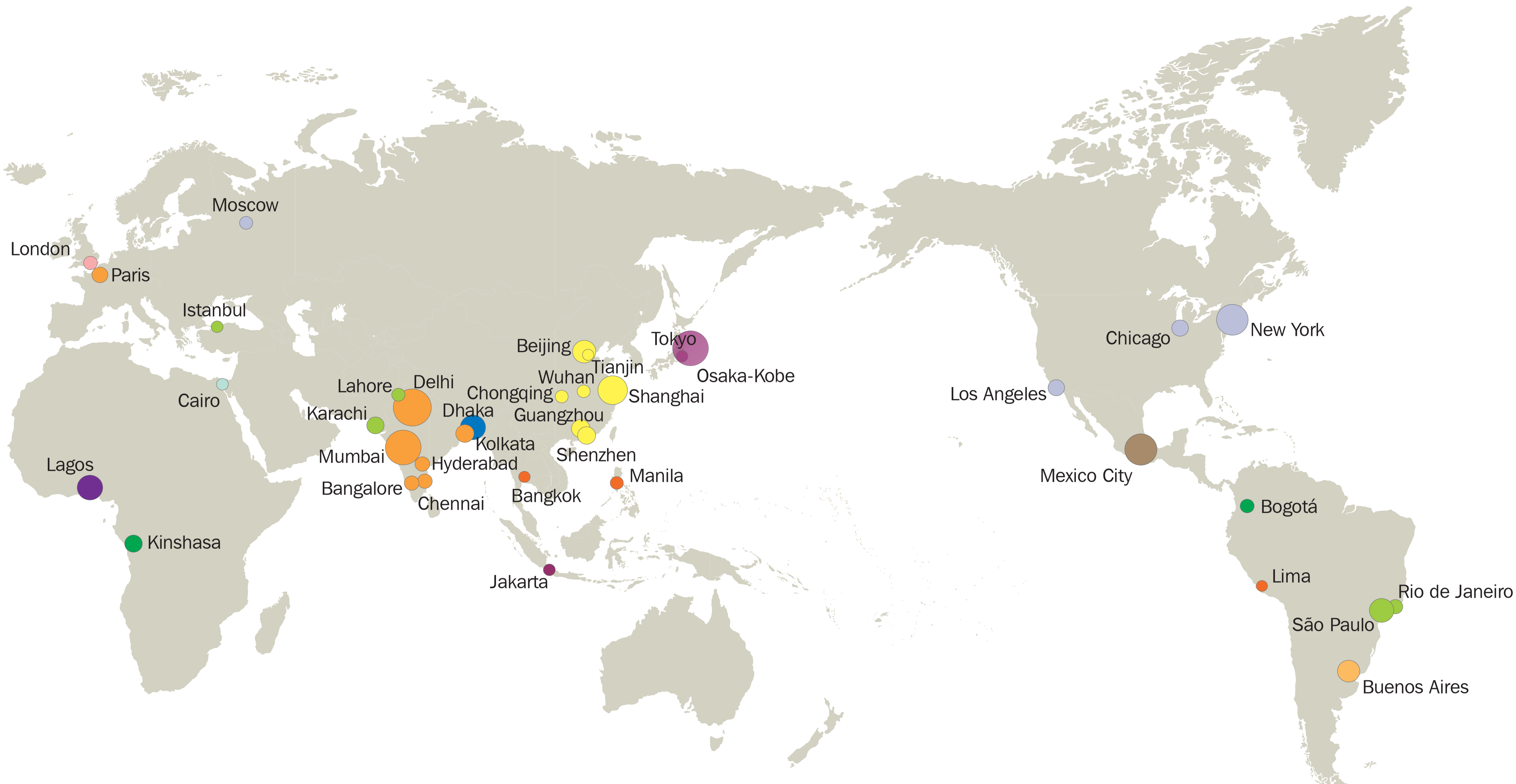
Figure 6 **Number of Megacities** (continued)

2025



Note: The circles indicate population sizes ranging from (10 million) to (39 million). The circles do not reflect the physical extents of the cities and any overlap between them merely reflects their relative population sizes and not any official acceptance or endorsement of any geographical sovereignty.

Source: UN (2012).

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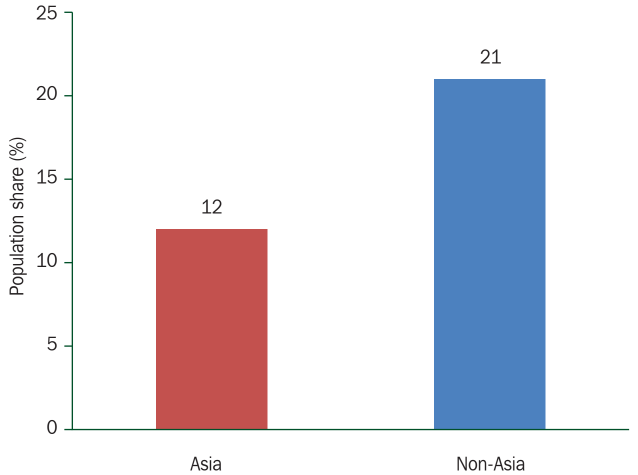
Figure 7 **Population Share of Largest Cities of Individual Countries, 2009**
(% of total urban population)



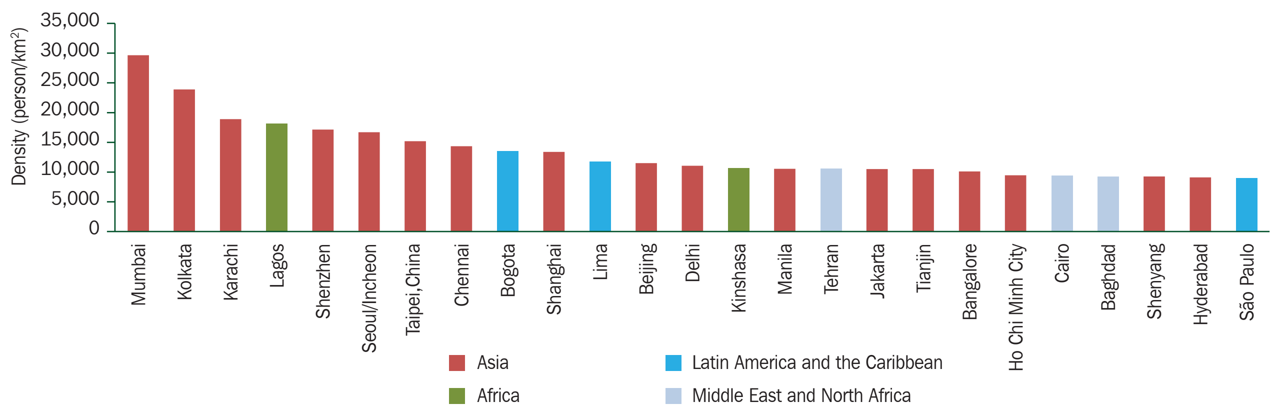
Source: ADB estimates based on UN (2012).

faster urbanization than others (Figure 10). The speed of urbanization in Bangladesh is also high.

Until 2000, the least urbanized developing subregion had always been the Pacific island countries and the most urbanized had been Central and West Asia. The difference in urbanization rates between the two subregions has been fairly stable, at about 15%. But in both subregions, urbanization has progressed slowly while Southeast, South Asia, and particularly East Asia (basically, the PRC) have been urbanizing faster.

Thus, Asia's level of urbanization started from a relatively low base compared to the rest of the world, but has been proceeding rapidly and on a vast scale. This is likely to continue at least until 2050, with an increasing formation of megacities and expansion of most cities. And, Asian cities' population densities, already high, are likely to increase. These prospects raise daunting issues for Asia, not least of which are the environmental implications of this massive human and economic clustering.

Figure 8 **Top 25 Cities Ranked by Population Density, 2007**



km^2 = square kilometers
Source: City Mayors (2007).

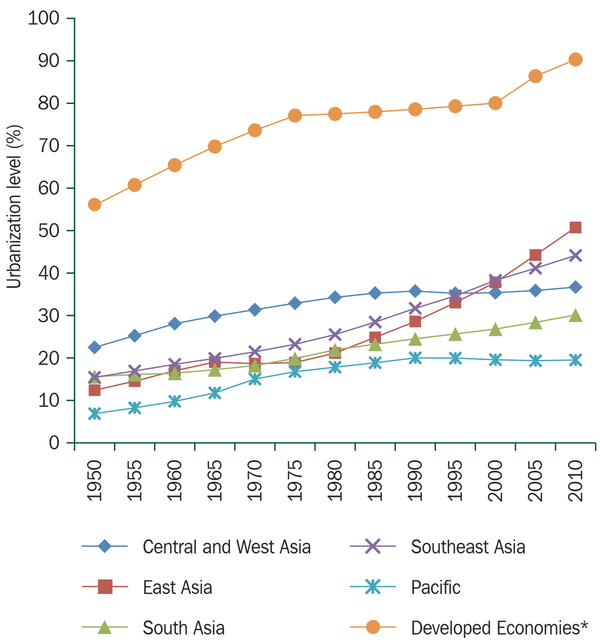
urban density. Kenworthy (2008) notes that wealthy Asian cities have an average density of 150 people per hectare compared to 15 in Australia, New Zealand, and the United States (US).

Sixth, significant heterogeneity exists across subregions in Asia and across economies in terms of urbanization level and speed. For example, the level of urbanization is much higher for developed countries in Asia (Japan, Australia, and New Zealand). Their level of urbanization was 90.2% in 2010, 49.6 percentage points higher than developing Asia as a whole. At the subregional level, East Asia was less urbanized than Central and West Asia and Southeast Asia until the late 1990s. Since 2005, however, East Asia has been the subregion with the highest level of urbanization, reaching 50.7% in 2010 (Figure 9). The PRC and the Republic of Korea exhibit

Environmental Implications of Urbanization in Asia

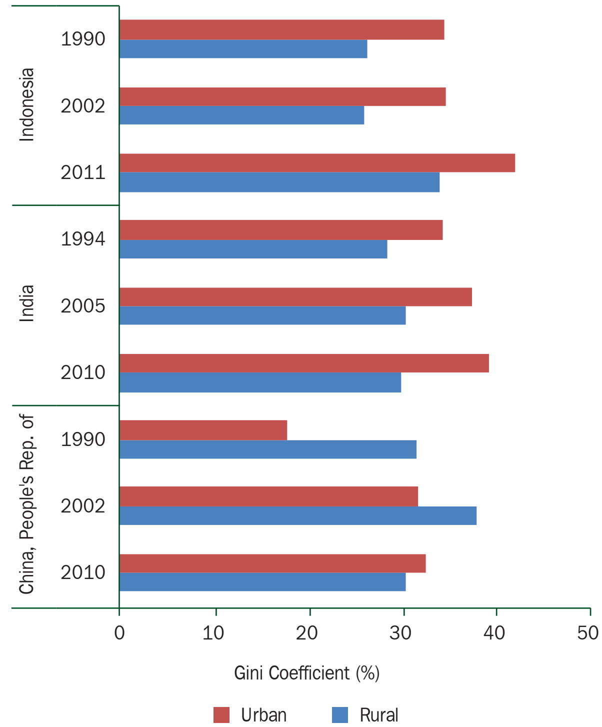
Urbanization-related challenges include high crime rates and unequal income distribution. As shown in Figure 11 and the recent Asian Development Outlook (ADB 2012b), inequality is generally greater in urban areas than in rural areas, so that urbanization can aggravate the problem of unequal income distribution. Even in the PRC, where inequality had been lower in urban than in rural areas,

Figure 9 **Urbanization Levels, ADB Subregion** (%)



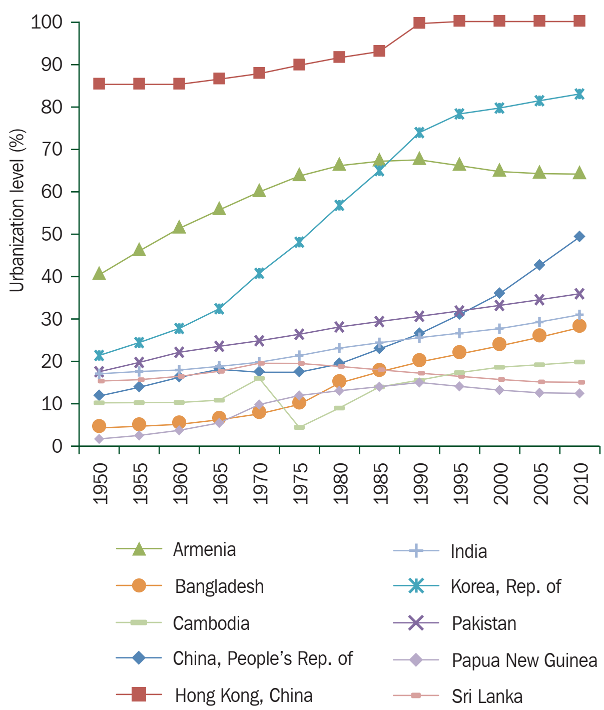
Note: * Developed Economies include Australia, Japan, and New Zealand.
Source: UN (2012).

Figure 11 **Urban and Rural Inequality in Asia** (%)



Sources: ADB (2012b) and ADB estimates.

Figure 10 **Urbanization Levels, Selected Asian Economies** (%)



Source: UN (2012).

urban inequality has been growing faster and surpassed rural inequality in 2008.[5]

New entrants to cities are likely to be poorer than incumbent residents and to live in slums or city fringes. And because the cost of criminal activity is usually lower and gains larger in cities than in the countryside, urbanization may be accompanied by elevated local crime levels. Figure 12 is a scatter plot of the theft rate (number of theft incidents per 100,000 population) and level of urbanization using worldwide data. Clearly, the two variables are positively correlated. In addition, homicide rates are higher in cities than in most of the corresponding national averages (Figure 13).[6]

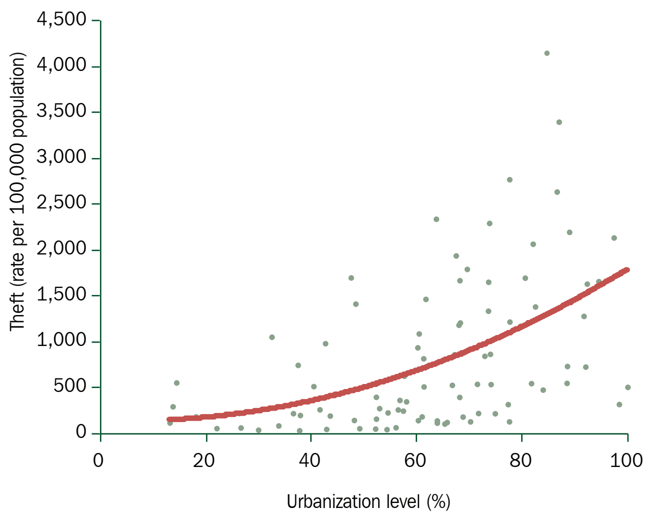
Challenges to city life are numerous and include higher costs of housing, education, and health care. This chapter will focus on environmental issues in the context of urbanization. This focus is a response to the rising importance of the environment in sustaining growth, the formidable environmental challenges faced by Asia, and the fact that the environment is a global public good and

5 The lower urban inequality in the PRC was largely due to the urban bias, which has gradually faded away but still exists (Wan and Zhang 2011).

6 Other indicators of crime than theft and homicide rates are not available for a rural–urban comparison.

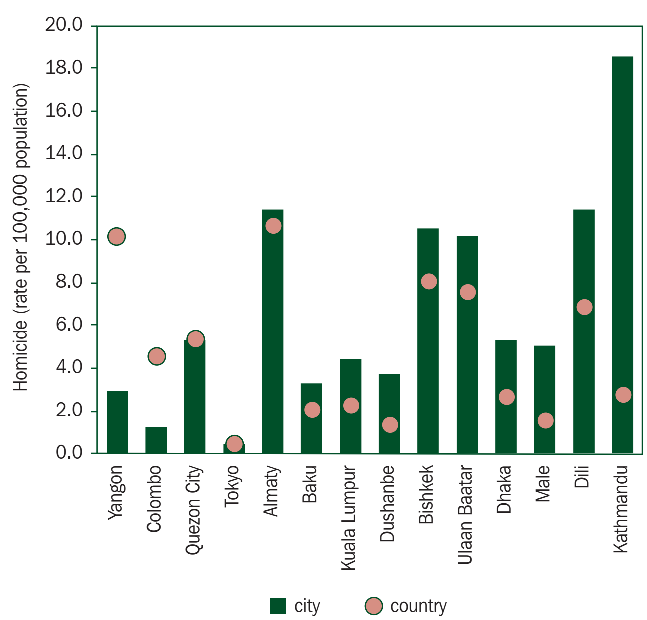
therefore part of the mandate of multilateral and regional institutions such as the Asian Development Bank (ADB). There is also a growing awareness that in future, for cities to have a competitive edge, they will have to be "green economies" (OECD 2011). Finally, while urbanization is often assumed to be associated with environmental degradation, little research has been done so far on this linkage.

Figure 12 **Theft Rate versus Level of Urbanization: Global Data**



Sources: UNODC (2012) and World Bank (2012).

Figure 13 **Intentional Homicide Rates in Selected Countries**



Source: UNODC (2012).

Urban Air Pollution in Asia

While no two cities are the same, many of Asia's cities face common challenges, including a sharp increase in registered vehicles, rising levels of industrial production, and (to some extent) a reliance on coal-fired power plants. These all contribute to air pollution, and in Asia, air pollution contributes to the premature death of half a million people each year (ADB 2012a).

From a public health perspective, particulate matter (PM) and carbon monoxide levels[7] are considered to be more associated with elevated morbidity risk than are ozone levels (Chay and Greenstone 2003, Currie and Neidell 2005). Data on PM_{10} are available from the World Health Organization and are used to rank cities that have an average PM_{10} level of 100 micrograms per cubic meter ($\mu g/m^3$) or higher. Of the world's 57 most polluted cities, 34—or almost 60%—are in Asia (Figure 14).

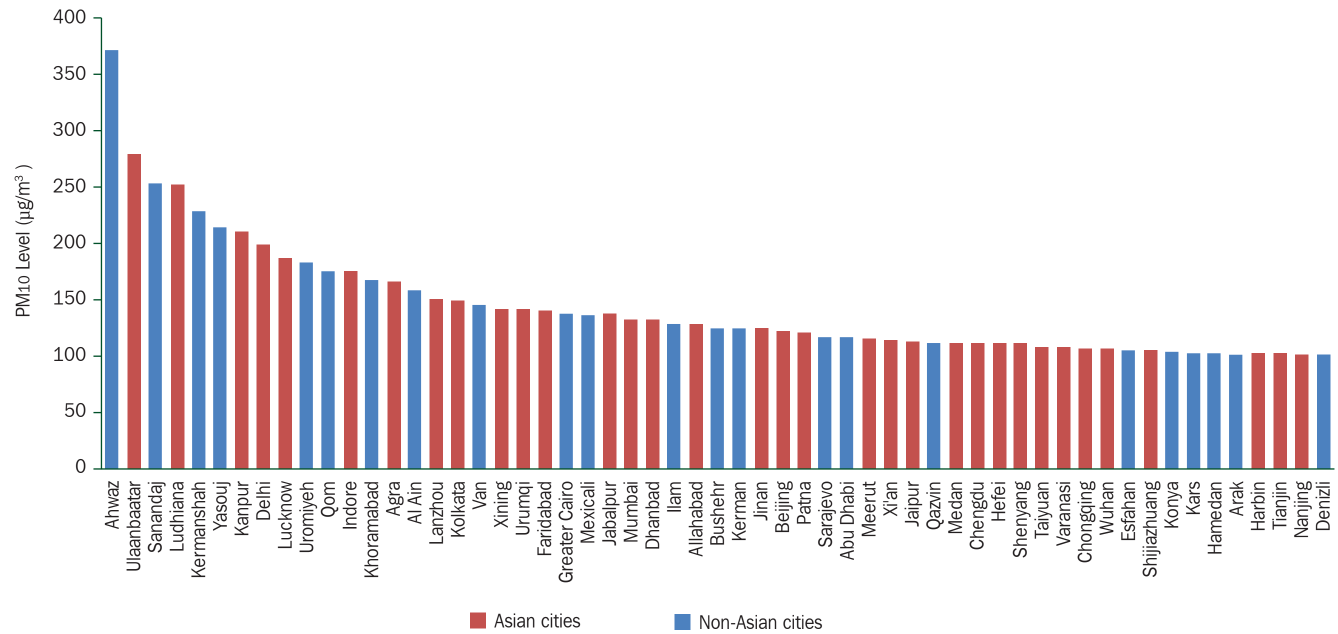
Figure 15 plots PM_{10} kernel density using observations for Asia and non-Asian cities.[8] Three interesting findings can be discerned. First, the density plot for Asian cities clearly lies to the right of the non-Asian cities, indicating that many of Asia's cities have much higher levels of pollution than cities in other regions. Second, the mode (most common value) of PM_{10} for non-Asian cities is only about 20 $\mu g/m^3$ but is almost double that—nearly 40 $\mu g/m^3$—on average in Asian cities. Third, if the European Union's air quality standard of 40 $\mu g/m^3$ is used as the benchmark, less than 11% of non-Asian cites do not meet the standard but a staggering 67% of Asian cities fail to meet it.

The PRC has 12 of the world's 20 most polluted cities (World Bank 2007a). The World Bank (2007b) reported that, in 2003, 53% of the 341 cities monitored—accounting for 58% of the PRC's urban population—had annual average PM_{10} levels above 100 $\mu g/m^3$, and 21% of these cities had PM_{10} levels above 150 $\mu g/m^3$. Only 1% of the PRC's urban population lives in cities that meet the European Union's air quality standard of 40 $\mu g/m^3$.

7 Particulate matter (PM)—also known as particulates or suspended particulate matter (SPM)—is solid matter suspended in air or liquid. PM_{10} refers to particulate matter with diameter of 10 micrometers or less. Carbon monoxide is a colorless, odorless, and tasteless gas that is slightly lighter than air. It can be toxic to humans and animals when encountered in higher concentrations. In the atmosphere however, it is short lived and spatially variable, as it combines with oxygen to form CO_2 and ozone.

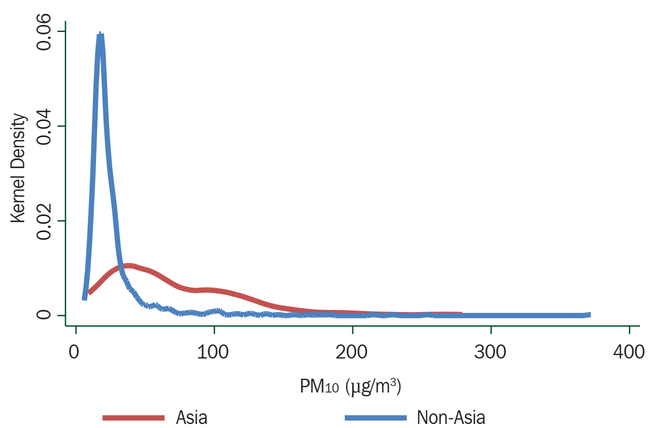
8 Loosely speaking, a kernel density plot depicts the frequency of occurrence of a variable.

Figure 14 **Cities with PM10 above 100 µg/m³, 2008–2009**



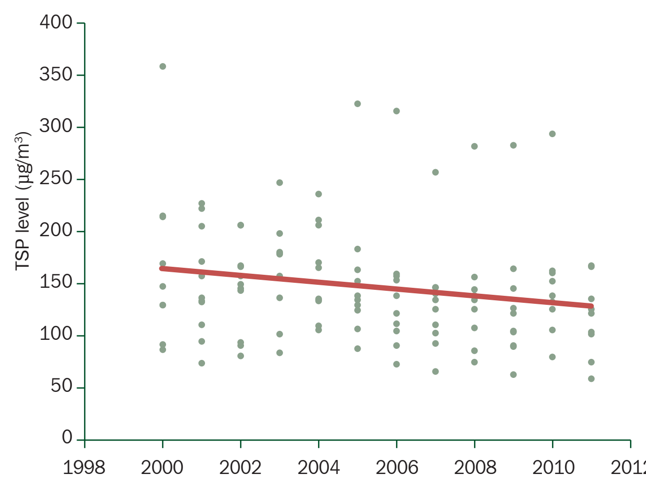
PM10 = particulate matter with diameter of 10 micrometers or less, µg/m³ = micrograms per cubic meter.
Source: WHO (2012).

Figure 15 **PM10 Kernel Density, 2008–2009**



PM10 = particulate matter with diameter of 10 micrometers or less, µg/m³ = micrograms per cubic meter.
Source: ADB estimates based on WHO (2012).

Figure 16 **Total Suspended Particulates at Manila Sites**



— = fitted line, µg/m³ = micrograms per cubic meter, TSP = total suspended particulates.
Source: Environmental Management Bureau (2002) and (2009).

In Metropolitan Manila, depending on the year, 13 or more stations have monitored total suspended particulate (TSP) levels since 2000. Figure 16, plotting the distribution of the ambient (outdoor) pollution readings, shows that some parts of Manila have tremendously elevated TSP levels. In 2010, TSP levels were twice as high in Pasay City as in Mandaluyong City, largely due to differences in the traffic volumes. In 2011, 77% of the monitoring stations' readings exceeded the nation's air pollution standard of 90 µg/m³.

In Thailand, the Bangkok data contain observations on ambient PM10, ozone, and carbon monoxide from 1997 to 2011. Using the ambient PM10 data and a simple econometric model with fixed effects for monitoring stations, one can show that ambient ozone (from automobile exhausts) has increased by 4.3% per year in Bangkok. Thailand's State of Pollution Report 2010 also shows that the country's ambient ozone levels have increased over time. As the numbers of vehicles and residents both continue to increase, health costs can be expected to rise.

Greenhouse Gas Emissions

Because urbanization raises per capita incomes and richer people consume more fossil fuels, urban growth and GHG emissions appear to be directly linked. As there is no global price on carbon, polluters (ranging from vehicle owners to electric power plants) face little incentive to economize on emissions. Thus, the increasing trend in GHG emissions is of utmost concern, although on a per capita basis the current level of carbon emissions in Asia is lower than that in developed countries. For example, on a per capita basis and during 2000–2008, the regional average emission for Asia grew by 97% while that for the world grew by only 18%.

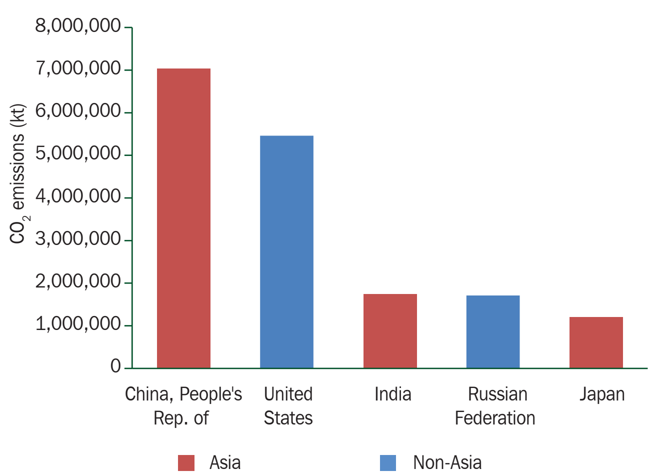
Asia certainly faces enormous challenges in terms of its total volume of CO_2 emissions. By this criterion, three of the top five emitting countries are in Asia (Figure 17). This is not surprising, as the total volume of any pollutant is a product of population and per capita emission. While per capita emissions tend to rise over time as economies grow, the enormous population base in many Asian nations also presents a key contributor to this challenge.

In terms of per capita CO_2 emissions, Figure 18 shows the time series trends for the world, the PRC, and India. The PRC's amazing growth in emissions, starting in the early 1990s and becoming more rapid from early 2000, is clear and has been concentrated in cities. If the PRC's per capita emissions were to reach the levels of the United States (US), global carbon emissions would increase by more than 50%. As India continues to grow and urbanize, its per capita emissions are likely to rise too.

The rise in the number of private vehicles and their increasing use in Asia have contributed significantly to rising GHG emissions. The number of vehicles per 1,000 people in the PRC increased from 10 in 1998 to 37 in 2010 while in the Philippines the increase was from 9 in 1990 to 33 in 2007 (ADB 2011). Because private vehicles offer flexibility and often move faster than public buses, the demand for private vehicles will likely continue to rise as Asia's cities grow richer (Zheng et al. 2011). According to some estimates, the income elasticity of demand for vehicles is unitary. This means that a 10% increase in per capita income is associated with a 10% increase in a nation's per capita vehicle ownership rate. When combined with the high density in Asian cities, the result could be serious traffic congestion and pollution. Solutions to this high-density related congestion problem include above-ground rail projects, as in Bangkok, and underground transit, as in the PRC and Delhi (Box 1).

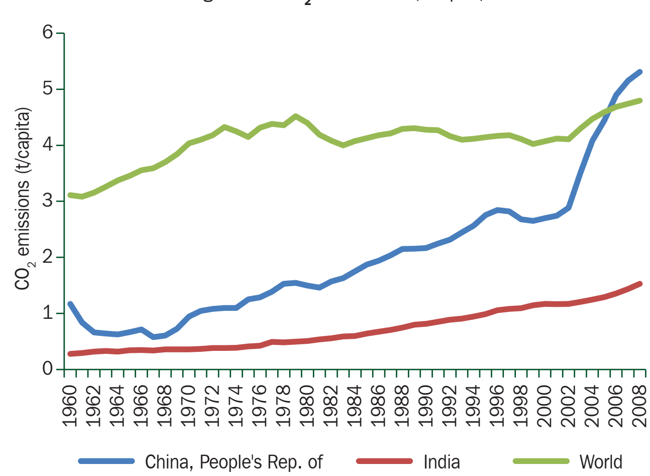
Increasing demand for electricity is another source of GHG emissions, particularly for nations that rely on coal for power. According to ADB (2011), 79% of the PRC's electricity is generated by coal, and India uses coal to generate 69% of its electricity. The carbon emissions factor of natural gas is 50% lower than that of coal, while wind and solar have zero carbon emissions factors. These enormous differences highlight how the global GHG emissions associated with electricity consumption vary depending on the energy source. Unfortunately, across Asia today, renewable sources provide only a tiny share of overall power generation, although they are becoming a dominant destination for investment in power generation (Newman and Wills 2012a, 2012b). For example, in 2006, the PRC set a 2020 target of 8% share of primary energy to come from renewable sources but reached this so quickly that they raised the target to 15% by 2020. In 2010, the PRC invested $48.9 billion in renewables, making it the world leader in renewable energy investment (UNEP and Bloomberg New Energy Finance 2011).

Figure 17 **Top 5 Countries in Total CO_2 Emissions in 2008**



CO_2 = carbon dioxide, kt = kiloton.
Source: World Bank (2012).

Figure 18 **CO_2 Emissions** (t/capita)



CO_2 = carbon dioxide, t = ton.
Source: World Bank (2012).

Box 1 **Metros Moving People in Delhi and Shanghai**

Shanghai and Delhi are two Asian megacities that have built metro systems for mass transit.

The Shanghai Metro System. Shanghai is the largest city in the People's Republic of China, spanning approximately 120 kilometers (km) from south to north and 100 km from east to west. It has a 2009 population of 19.21 million. In the 10 years to 2000, the length of the city's roads increased by 40% and the number of cars rose to just over 1 million. By the end of 2000, Shanghai had 12,227 km of roads, 84% more than in 1985. However, as the majority of people rely on public transport, the buses were very crowded and slow, averaging only 8 km per hour.

The city invested an average of 2.9% of its gross domestic product annually during 1999–2009 in transport infrastructure, 41% of which was for constructing the Shanghai Metro. Construction started in the early 1990s and the first metro line opened in 1995. The Shanghai Metro now has 11 lines, 280 stations, and a total operating length of 420 km. The number of passengers increased almost 37% per annum from 2000 to 2005. The total passengers per day rose to about 8 million at the end of 2010. Currently, 80% of the city's developed area is within 400 meters of a metro line and the system is now the largest in the world.

The Delhi Metro System. Delhi is India's largest metropolitan by area (1,483 square kilometers) and has the second largest population (14 million people) in India. It has evolved around several transport modes. During 1981–1998, Delhi's human and vehicle populations rose sharply, resulting in traffic congestion and pollution.

In response to this, the governments of India and Delhi formed the Delhi Metro Rail Corporation in 1995. Construction of the Delhi Metro started in 1998, and its first line opened in 2002, followed by the second in 2004, the third in 2005, a branch line in 2009, and two more lines in 2010. Subsequently, the lines have been extended and new lines are being constructed, including the Delhi Airport Metro Express. The network consists of six lines with a total length of 161 km with 135 stations underground, serving 1.2 million commuters every day.

Source: Newman and Matan (forthcoming).

Access to Clean Water and Sanitation

A key determinant of a city's "greenness" is whether it can supply clean water and sanitation, and properly dispose of solid waste. Such service delivery will reduce infectious disease rates and lower infant mortality, and should translate into increased life expectancy. The challenges that Asia's poor cities now face resemble the challenges that Western cities faced in the early 20th century (Cain and Hong 2009, Cain and Rotella 2001, Ferrie and Troesken 2008). In 1880, the average urbanite in the US lived 10 years less than the average rural resident (Haines 2001). Dirty water was the primary cause, and urban growth exacerbated this problem.

The current status of water and sanitation in Asia is disturbing. By the latest estimate, almost 1.9 billion Asians are without basic sanitation, representing over 70% of the global total (ESCAP, ADB, and UNDP 2012). Only 22% of India's population had access to flush toilets in 1992 and progress in raising that share is slow (Bonu and Kim 2009). Worse still, except in Southeast Asia, all other subregions in Asia will not meet their sanitation targets as set in the Millennium Development Goals (MDGs). Given that the MDG target is merely to halve the 1990 number of people without access to water supply and sanitation by 2015, a country that had a 20% access rate in 1990 would still have 40% of its residents without basic sanitation by 2015 even if it manages to achieve the MDG target. Current projections indicate that more than 290 million people in India may still live without basic sanitation in 2015 (ESCAP, ADB, and UNDP 2012).

Turning to water, more than half (approximately 400 million) of the world's people who are deprived of safe drinking water reside in Asia. To supply water to 400 million people requires huge investments that the countries may not be able to afford. Worse still, low-income countries in the region are projected not to meet the water MDG. In many parts of Dhaka, water is supplied for only 2 hours a day, in some areas, the quality is poor and people complain of receiving straw colored, sticky, and smelly water. The situation is even worse for slum dwellers, who in many cases have no access to piped water supply even if they are willing and able to pay for it (Wan and Francisco 2009). For example, Dhaka Water and Sewerage Authority officials note that by law, water can be supplied only to legal landholders (Wahab 2003).

Further, in many Asian countries water is still heavily subsidized. Thus, it is questionable whether the current water supply is economically sustainable even for people who already have gained access. And rivers in Asia are heavily polluted, which adds to the growing scarcity of freshwater sources.

Garbage collection in Asia is another major challenge, especially because people who earn more usually consume and dispose of more (Beede and Bloom 1995). Richer cities may be able to invest in collecting and disposing of solid waste but poorer cities often lack the resources to do so. For example, in some of India's cities, an estimated 30%–35% of total waste remains uncollected from the city roads (Sridhar and Mathur 2009). Kolkata and Mumbai dump or burn all their garbage in the open.

Chennai and Delhi dispose 100% and 95%, respectively, of their waste in sanitary landfills (Zhu et al. 2008).

Although a higher proportion of urban residents have access to these basic services than do rural residents, Asian cities are hard pressed to raise funds and ensure such service delivery to their rapidly expanding populations.

Table 2 **Urban Population at Risk of Coastal Flooding by Region, 2000**

Region	Total Urban Population (million)	Urban Population at Risk (million)	Share of Population at Risk (%)	Total Urban Land Area ('000 km^2)	Urban Land Area at Risk ('000 km^2)	Share of Land Area at Risk (%)
Africa	280	32	11	310	18	6
Asia	1,390	251	18	1,167	129	11
Latin America	312	24	8	663	42	6
Europe	571	40	7	800	56	7

km^2 = square kilometers
Source: ADB estimates based on McGranahan et al. (2007).

Resilience to Climate Change

Urbanization increases vulnerability because life and asset losses are much larger in cities than in the countryside when a disaster strikes. In this context, the issue of climate change becomes particularly relevant to cities. Climate change is recognized to have caused extreme weather and rising sea levels. While there are many unknowns about the extent and timing of these impacts, the consensus is that the challenge is real and imminent, and that different cities will face different but urgent challenges (Kahn 2010).

Among the consequences of climate change are an increase in the intensity and frequency of floods and sea level rise. Poorer cities that are below sea level are the most susceptible. This is especially relevant for Asian nations such as Bangladesh and the Pacific island countries, although data for the latter are often unavailable. Many Asian cities, and especially some megacities, have been built in the deltas of major rivers where ports could link the cities to the global economy. So it is not surprising that many Asian cities are flood prone. Some such cities may have extensive experience dealing with floods. For example, Dhaka has an elaborate set of mud banks for protection. But increased flooding induced by climate change may well push these cities' infrastructures beyond their current capacities, as occurred in Bangkok in late 2011. Developing further coastal engineering protection will place an increasing burden on the resources of such cities.

In 2000, 18% of Asian urbanites were at risk of coastal flooding (Table 2), versus 11% for Africa, 8% for Latin America, and 7% for Europe. In terms of total urban population, 251 million Asians were exposed to this risk, compared with 40 million Europeans, 32 million Africans, and 24 million Latin Americans. Similar high comparative proportions of total and urban land are found in low-lying coastal areas of Asia relative to other continents. These areas are not only at greater risk of future sea level rise, but also of coastal flooding arising from more frequent and intense storms. (Box 2 defines inland and coastal flooding and estimation methods.)

Box 2 **Estimating Risks of Inland and Coastal Flooding**

Coastal flooding risks are determined by the number of persons (or land area) within a low-elevation coastal zone (LECZ) rather than historic or projected data on actual coastal flood events. The LECZ is defined as land area contiguous with the coastline up to a 10-meter rise elevation. While sea level rise is not expected to reach 10 meters above the current mid-tide elevations, Asia has experienced two devastating tsunamis in the last 10 years. Meanwhile, sea level rise and storm surges can certainly cause damage to people living well above the high-water level, through saline intrusion into the groundwater, for example. However, the principal reason for choosing this elevation is that estimates based on elevations below 10 meters could not be considered globally reliable, particularly in some types of coastal areas, such as those characterized by mountainous bays.

Exposure to inland flooding is estimated from the global flood frequency dataset developed for the 2009 Global Assessment Report on Risk Reduction (GAR) (UNISDR 2009). In contrast to the LECZ estimates, the GAR data are based on actual flood frequency events. Modeling is used to fill in missing data and to transform the extents of flood events into a single gridded data format. The flood risk is measured by the extent of exposure of land or persons to flooding at least two times within a 100-year period. Both the LECZ and GAR data are then overlayed with the Global Rural–Urban Mapping Project (GRUMP) data to estimate population (as well as land area) within each urban area at risk of flooding.

Sources: Balk and Montgomery (2012), McGranahan et al. (2007).

Using the proportion of urban population that is exposed to flooding risks as a measure of vulnerability, vulnerability to inland or coastal flooding differs significantly across subregions and countries. In terms of coastal flooding (Table 3), the region's vulnerability is 19.6%, with Southeast Asia being most vulnerable (36.1%) followed by East Asia (17.5%) and South Asia (14.3%). At the country level, the most vulnerable economies are the Maldives (100%), Viet Nam (73.9%), Thailand (60%), and Bangladesh (50.3%).

Table 3 **Population and Area at Risk of Coastal Flooding, 2000**

Economy	Urban Population at Flood risk	% Population at Flood Risk	Urban Land Area (km^2) at Flood Risk	% Urban Land Area at Flood Risk
Central and West Asia				
Georgia	230,982	7.5	159	4.9
Pakistan	2,227,119	4.6	364	1.5
Subtotal	**2,458,101**	**4.8**	**523**	**1.9**
East Asia				
China, People's Rep. of	78,277,824	18.5	33,243	13.4
Hong Kong, China	811,925	14.1	104	14.2
Korea, Rep. of	2,034,832	5.3	1,369	7.4
Taipei,China	3,022,216	21.4	2,604	21.3
Subtotal	**84,146,796**	**17.5**	**37,320**	**13.4**
South Asia				
Bangladesh	15,428,668	50.3	4,522	45.9
India	31,515,286	10.5	11,441	5.9
Maldives	6,421	100.0	3	100.0
Sri Lanka	961,977	22.8	744	22.5
Subtotal	**47,912,352**	**14.3**	**16,710**	**8.1**
Southeast Asia				
Brunei Darussalam	24,965	11.2	256	24.2
Cambodia	281,944	15.0	137	21.3
Indonesia	22,720,666	27.9	8,176	26.4
Malaysia	3,687,052	26.5	3,775	28.1
Myanmar	4,512,823	36.2	1,087	24.2
Philippines	6,807,578	27.4	1,872	22.8
Singapore	550,057	14.0	62	12.0
Thailand	12,471,874	60.0	9,207	34.8
Viet Nam	12,862,429	73.9	3,877	66.4
Subtotal	**63,919,387**	**36.1**	**28,448**	**31.1**
The Pacific				
Timor-Leste	1,369	4.2	7	5.3
Developed Member Economy				
Japan	29,022,184	25.7	17322.81	17.5
Asia	**227,460,189**	**19.6**	**100,332**	**14.3**

km^2 = square kilometers

Note: Global Rural-Urban Mapping Project (GRUMP) estimates for urban population and urban areas are used in the computation of percentages of population and area at risk (http://sedac.ciesin.columbia.edu/gpw).

Source: Balk and Montgomery (2012).

Table 4 **Population and Area at Risk of Inland Flooding, 2000**

Economy	Urban Population at Flood Risk	% Population at Flood Risk	Urban Land Area (km^2) at Flood Risk	% Urban Land Area at Flood Risk
Central and West Asia				
Afghanistan	540,078	12.5	430	23.8
Armenia	198,941	7.4	192	12.9
Azerbaijan	254,474	6.0	526	9.1
Georgia	319,048	10.4	369	11.4
Kazakhstan	860,190	9.8	1,561	13.9
Kyrgyz Republic	189,534	12.2	367	12.6
Pakistan	3,092,548	6.4	2,230	9.0
Tajikistan	286,229	16.4	408	11.6
Turmenistan	64,777	3.2	620	11.1
Uzbekistan	813,736	8.5	1,615	10.9
Subtotal	**6,619,555**	**7.7**	**8,318**	**11.1**
East Asia				
China, People's Rep. of	90,700,145	21.4	45,610	18.4
Korea, Rep. of	2,920,496	7.6	1,010	5.5
Mongolia	176,968	12.2	190	16.5
Taipei,China	890,354	6.3	668	5.5
Subtotal	**94,510,996**	**19.8**	**47,288**	**17.0**
South Asia				
Bangladesh	10,954,609	35.7	3,721	37.8
Bhutan	21,504	14.5	30	15.5
India	36,056,326	12.0	25,564	13.3
Nepal	160,508	5.9	214	8.5
Sri Lanka	792,244	18.8	442	13.4
Subtotal	**47,985,191**	**14.2**	**29,971**	**14.4**
Southeast Asia				
Brunei Darussalam	1,634	0.7	14	1.3
Cambodia	1,428,121	76.0	641	100.0
Indonesia	4,394,972	5.4	2,417	7.8
Lao PDR	302,825	34.0	276	26.1
Malaysia	495,254	3.6	749	5.6
Myanmar	2,361,353	19.0	1,050	23.4
Philippines	3,713,398	14.9	968	11.8
Thailand	6,070,291	29.2	7,002	26.5
Viet Nam	6,716,973	38.6	1,893	32.4
Subtotal	**25,484,820**	**14.7**	**15,010**	**16.3**
The Pacific				
Timor-Leste	869	2.7	6	4.6
Developed Member Economy				
Japan	4,705,880	4.2	5,016	5.1
Asia	**179,307,311**	**15.1**	**105,610**	**14.0**

km^2 = square kilometers, Lao PDR = Lao People's Democratic Republic

Note: Global Rural-Urban Mapping Project (GRUMP) estimates for urban population and urban areas are used in the computation of percentages of population and area at risk (http://sedac.ciesin.columbia.edu/gpw).

Source: Balk and Montgomery (2012).

Turning to inland flooding (Table 4), the overall vulnerability for Asia is 15.1%, moderately lower than the coastal flooding vulnerability. East Asia is most vulnerable (19.8%), followed by Southeast Asia (14.7%) and South Asia (14.2%). At the country level, about three-quarters of the urban population of Cambodia are at risk of inland flooding. The vulnerability is 38.6% for Viet Nam, 35.7% for Bangladesh, 34% for the Lao PDR, and 29% for Thailand. One-fifth of the urban population of the PRC and 12% of Indian's urbanites, in total more than 120 million people, are at risk of inland flooding. Even landlocked countries have substantial vulnerability: Tajikistan (16.4%), Bhutan (14.5%), Afghanistan (12.5%), and Kyrgyz Republic (12%).

Tables 5 and 6 list the 40 most vulnerable cities in Asia that have 1 million population or more (as measured in 2000). Focusing on coastal flooding (Table 5), half of the 40 most vulnerable cities are in the PRC. Among the 11 cities with a vulnerability of more than 90%, 8 are in the PRC, including Shanghai and Tianjin—the PRC's largest cities. The other three are Bangkok in Thailand, Khulna

Table 5 **Top 40 Asian Cities (>1 million population) in Vulnerability to Coastal Flooding**

Economy	City	Population at Flood Risk ('000)	% of City Population	City Area at Flood Risk (km^2)	% of Area at Risk
China, People's Rep. of	Tianjin	5,500	100.0	2081	100.0
China, People's Rep. of	Panjin	1,000	100.0	690	100.0
Bangladesh	Khulna	1,100	99.9	394	99.8
China, People's Rep. of	Nantong	1,000	99.8	286	99.9
China, People's Rep. of	Changzhou	2,000	99.0	362	99.0
China, People's Rep. of	Jiangyin	1,200	96.8	492	96.8
China, People's Rep. of	Suzhou	1,300	95.8	368	91.2
Indonesia	Palembang	1,300	94.2	473	89.5
Thailand	Bangkok	8,800	93.3	4805	80.2
China, People's Rep. of	Wuxi	1,300	91.1	397	91.0
China, People's Rep. of	Shanghai	14,000	90.8	2416	98.2
India	Kolkata	14,000	89.0	1441	62.9
China, People's Rep. of	Ningbo	1,700	85.6	779	85.6
Indonesia	Ujung Pandang	1,200	85.4	295	68.7
Viet Nam	Ho Chi Minh	4,400	79.3	890	72.6
Indonesia	Surabaya	3,800	76.3	777	55.4
Bangladesh	Chittagong	2,400	72.5	517	61.7
Japan	Niigata	1,000	68.5	1244	49.9
Myanmar	Yangon City	2,800	66.9	587	69.9
China, People's Rep. of	Wuhu	782	66.3	210	72.4
India	Palwancha	808	66.2	937	67.6
China, People's Rep. of	Taizhou	1,200	65.3	423	66.4
China, People's Rep. of	Shantou	3,600	63.8	1084	63.6
India	Surat	2,200	61.0	300	19.2
Indonesia	Pekalongan	892	59.2	335	50.3
India	Kochi	861	57.3	260	44.6
China, People's Rep. of	Hangzhou	3,100	55.4	931	62.2
Bangladesh	Dhaka	5,000	55.0	874	61.5
China, People's Rep. of	Wenzhou	2,000	53.8	755	53.7
Malaysia	Georgetown	641	50.8	456	43.0
China, People's Rep. of	Putian	631	49.2	176	39.1
China, People's Rep. of	Huaiyin	540	48.7	203	46.9
Indonesia	Tegal	548	47.2	175	41.4
India	Mumbai	8,100	46.3	848	40.1
China, People's Rep. of	Dandong	463	42.9	219	51.9
China, People's Rep. of	Yingkou	657	42.7	431	42.7
China, People's Rep. of	Haikou	634	41.4	246	41.1
Viet Nam	Hanoi	1,100	40.6	429	64.5
China, People's Rep. of	Shenzhen	11,000	38.2	4319	49.2
Indonesia	Semarang	791	37.9	344	42.2

km^2 = square kilometers
Source: Balk and Montgomery (2012).

Table 6 **Top 40 Asian Cities (>1 million population) in Vulnerability to Inland Flooding**

Economy	City	Population at Flood Risk ('000)	% of City Population at Risk	City Area at Flood Risk (km^2)	% of Area at Risk
Cambodia	Phnom Penh	988	98.5	204	98.8
China, People's Rep. of	Wuhan	5300	81.8	956	81.8
Indonesia	Palembang	1100	80.2	257	48.6
India	Patna	1100	72.4	436	72.3
Bangladesh	Dhaka	5400	59.7	680	47.9
China, People's Rep. of	Nanjing	2200	56.0	749	55.6
Viet Nam	Ho Chi Minh	2800	50.4	306	25.0
China, People's Rep. of	Tianjin	2800	50.1	795	38.2
China, People's Rep. of	Huangshi	624	49.6	170	45.5
China, People's Rep. of	Huainan	614	49.5	277	49.4
China, People's Rep. of	Wuhu	552	46.8	140	48.4
Thailand	Bangkok	4400	46.2	2165	36.1
China, People's Rep. of	Bangbu	510	44.0	198	44.5
India	Guwahati	507	43.8	159	34.6
India	Allahabad	665	42.2	230	43.2
Myanmar	Mandalay	477	40.2	167	41.4
China, People's Rep. of	Panjin	400	38.3	208	30.1
China, People's Rep. of	Changsha	1200	37.2	187	28.0
Bangladesh	Khulna	419	37.0	131	33.1
India	Vijayawada	546	36.0	141	21.4
Viet Nam	Hanoi	893	33.2	252	38.0
India	Varanasi	568	32.6	211	33.6
Indonesia	Surakarta	399	32.6	96	24.1
China, People's Rep. of	Nanning	440	30.4	173	30.4
China, People's Rep. of	Hengyang	307	28.6	94	28.1
India	Kolhapur	746	28.6	1035	29.2
China, People's Rep. of	Xinxiang	457	27.7	146	23.4
China, People's Rep. of	Nanchang	742	27.1	196	24.6
China, People's Rep. of	Shanghai	3700	24.5	292	11.9
Korea, Rep. of	Pusan	1200	24.5	196	12.6
India	Bhubaneswar	285	23.4	141	22.2
India	Palacole	283	23.2	385	27.8
China, People's Rep. of	Yichang	265	22.8	137	20.2
China, People's Rep. of	Qiqiha'er	286	22.0	110	22.0
India	Kanpur	312	21.5	171	20.5
China, People's Rep. of	Harbin	740	21.1	270	22.0
China, People's Rep. of	Luoyang	348	20.6	93	20.4
Philippines	Quezon City	2900	20.4	198	9.1
China, People's Rep. of	Jinan	558	20.3	156	20.2
Bangladesh	Chittagong	664	20.2	104	12.4

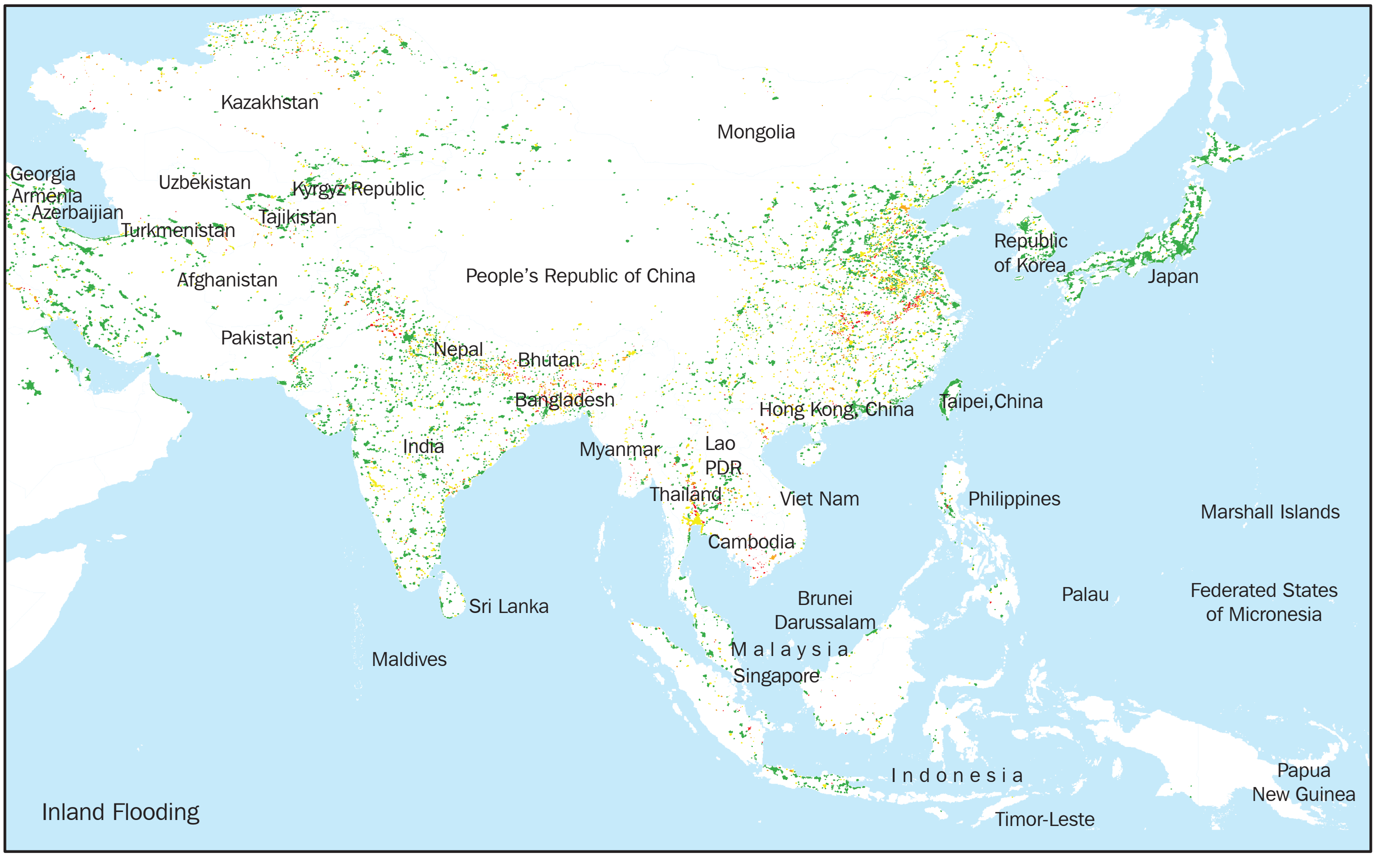
km^2 = square kilometers
Source: Balk and Montgomery (2012).

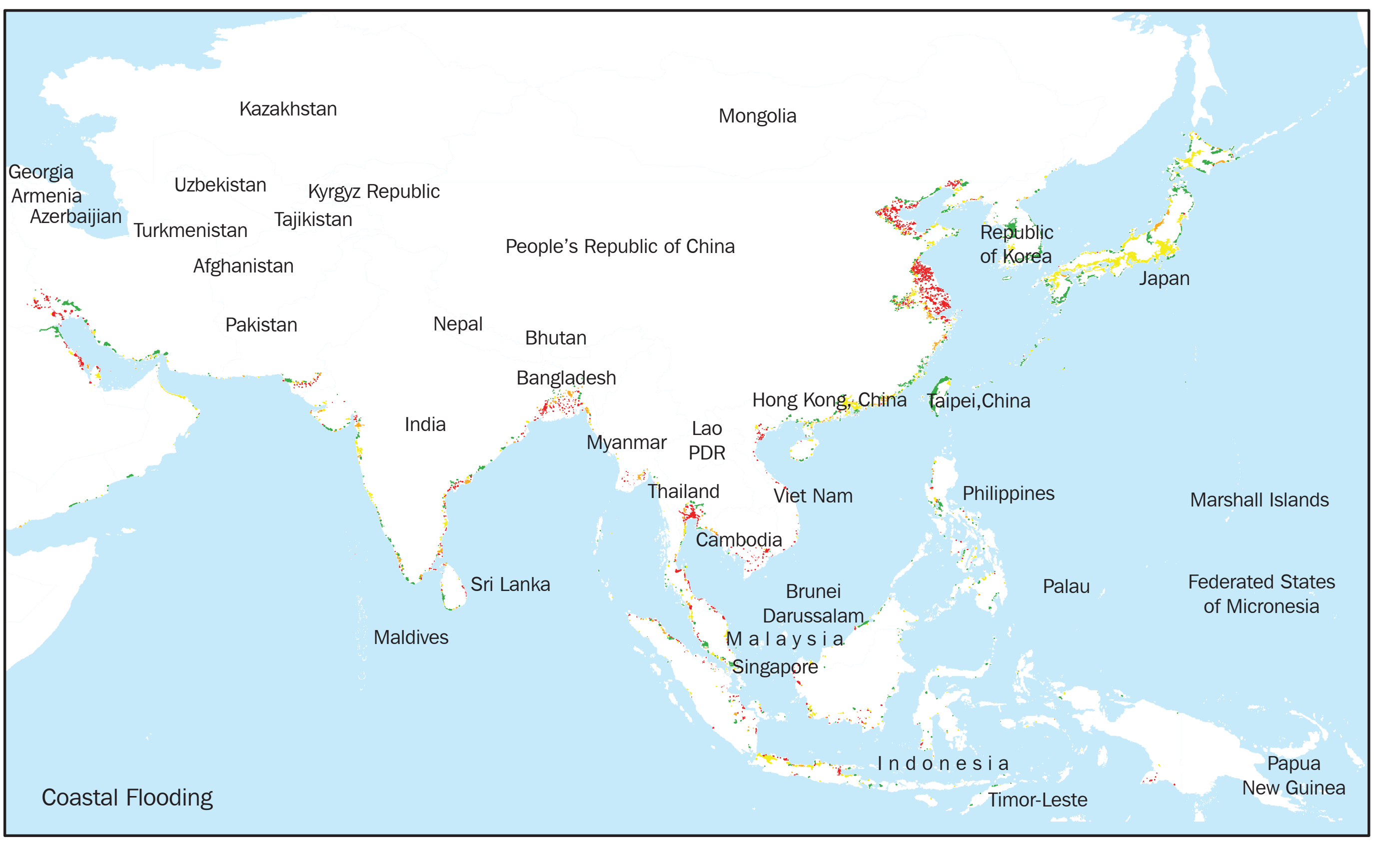
in Bangladesh, and Palembang in Indonesia. Another 13 cities have vulnerability levels between 60% and 89%, notably including Kolkata and Ho Chi Minh City. Turning to inland flooding at the city level (Table 6), again the vulnerability level is lower than that for coastal flooding. The top three cities are Phnom Penh (99%), Wuhan (82%), and Palembang (80%). Of the top 40 most vulnerable cities, 19 are in the PRC. Some of the large cities that are vulnerable to inland flooding include Dhaka (60%), Ho Chi Minh City (50%), and Bangkok (46%).

Figure 19 shows clearly that coastal flooding is more concentrated than inland flooding. Both are serious in South Asia, Southeast Asia, and the PRC. Several megacities face high vulnerability to coastal flooding and moderate vulnerability to inland flooding at the same time, such as Kolkata (89% coastal, 15% inland) and Shanghai (91% coastal, 25% inland). A number of large cities feature more than 50% of vulnerability to both type of flooding: Dhaka, Bangladesh; Ho Chi Minh City, Viet Nam; Palembang, Indonesia; and Tianjin, the PRC.

Asia has more than 750 urban settlements (of at least 5,000 people, most much larger), the population of which is fully in low-lying zones with 100% vulnerability to coastal flooding, and about half as many with 100% vulnerability to inland flooding. These smaller cities and towns are especially noteworthy because their populations are growing fast. Further, some of them are close to vulnerable large cities. Agglomeration economies have many benefits for growth, but any flood risks they share need to be accounted for in planning.

Figure 19 **Vulnerability to Inland (top) and Coastal (bottom) Flooding**





12-2551 AV

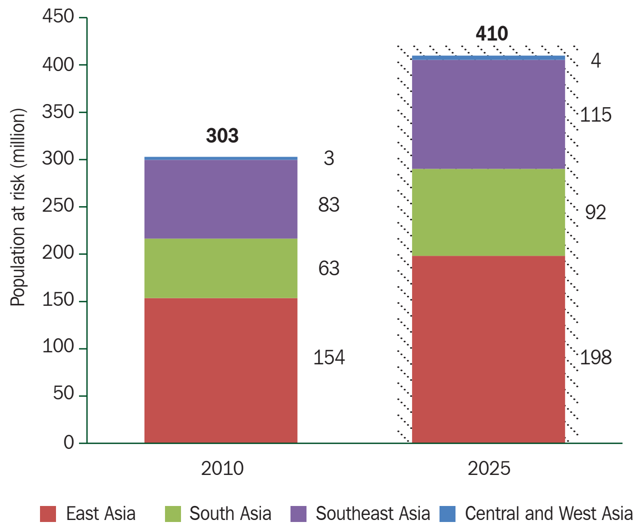
Proportion of Asian City Populations Affected by Flooding

0%–25% | 26%–50% | 51%–75% | 76%–100%

Lao PDR = Lao People's Democratic Republic.
Source: Balk and Montgomery (2012).

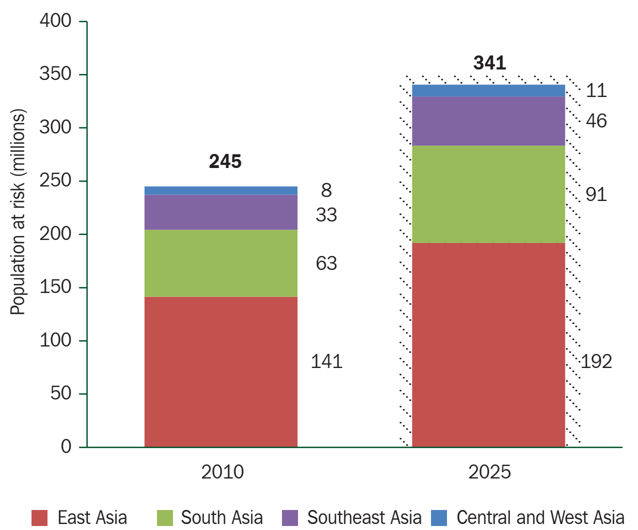
The size of population affected by flooding risks in Asia is enormous. A study commissioned by ADB (Balk and Montgomery, 2012) estimates that over 303 million Asian urbanites were at risk of coastal flooding in 2010 and this is projected to increase to 410 million in 2025 (Figure 20). In terms of inland flooding, about 245 million urban Asians were found to be at risk in 2010 and by 2025 this number will reach 341 million (Figure 21). While it is not possible to predict the damage such floods will do to property or to predict the loss of life, poor cities will face greater challenges than rich ones in adapting to this new reality.

Figure 20 **Population at Risk of Coastal Flooding**



Source: Balk and Montgomery (2012).

Figure 21 **Population at Risk of Inland Flooding**



Source: Balk and Montgomery (2012).

Loss of Natural Ecosystems and Amenities

The loss of biodiversity in the Asian region has been well documented as urbanization proceeds (Millennium Ecosystem Assessment 2005). Asian cities are much more densely populated than most other cities and hence do not take up proportionately as much rural land and natural ecosystems. But their densities provide less opportunity for green spaces within the cities. Thus, many Asian cities are struggling to provide sufficient natural amenities—access to “green spaces” for environmental and human health, rivers, parks and wildlife corridors; green space for recreation-related activities; and green elements in the urban landscape. The resolution of this issue is being addressed with new design approaches and technologies to enable both greater biodiversity and natural amenities. One of these approaches is “biophilic urbanism” (Newman, Beatley, and Boyer 2008). A biophilic city brings landscaping into and onto every element of the built environment, such as buildings, walls, and roads (Beatley 2010).

Urban Slums and Urban Poverty

Asia has the largest share of the world’s slum-dwelling population. As noted earlier, in 2010 the region was home to 506 million slum dwellers, more than 61% of the world’s total. Some subregions within Asia are far worse affected than others. East and Southeast Asia harbor 55% of the slum dwellers in the region, and South Asia alone hosts almost 38% of the region’s slum dwellers (UN-HABITAT 2008).

In many low- and middle-income nations, urban poverty is growing compared to rural poverty. Urban residents are more dependent on cash incomes to meet their essential needs than rural residents, and income poverty is compounded by inadequate and expensive accommodation, limited access to basic infrastructure and services, exposure to environmental hazards, and high rates of crime and violence.

Asia’s Environmental Challenges: The Environmental Kuznets Curve

In summary, Asia is already facing tremendous urbanization-related challenges. As far as the environment is concerned, air pollution is serious and GHG emissions have been increasing. Natural amenities are either lost or must be compensated for as cities grow. Pressures are mounting to provide water, sanitation, and waste disposal to very fast growing urban populations. And cities are becoming more vulnerable.

Worse still, most of the special features of Asia's urbanization highlighted in this chapter's first main section exacerbate the environmental challenges. First, a low level of urbanization implies that Asia still has some way to go in dealing with these challenges. Ignoring or deferring action on issues such as environmental degradation is not an option because it risks consequences in the near term and vastly greater expenses in the medium to long run. Second, the fast pace of urbanization means little time for adjustment or learning. Many countries have been insufficiently prepared for the changes urbanization requires in urban planning, development of appropriate skills, and urban financing. Third, bigger cities are certainly harder to manage and more of them can only add to the challenges as Asia's megacities expand in population and grow in numbers. Finally, high density makes cities more vulnerable to catastrophic events and disease. Especially in poor cities such as Delhi, Dhaka, Wuhan, and those in the Pacific island countries, such events can mean serious loss of lives and assets (ADB 2012c).

To gauge the environmental outlook as Asia continues its growth, the Environmental Kuznets Curve or EKC is a useful tool (Box 3). While there are alternative views regarding the theoretical foundation and empirical robustness of the EKC, many studies have found an inverted U-shape relationship between environmental indicators and GDP level. Grossman and Krueger (1995) and De Bruyn (1997) state that the inverted U-shape is driven by a combination of forces: the level of output or scale of economic activity (scale effect); the composition of output (structural effect); and the state of technology (technical effect). Holding everything else constant, increasing output leads to more environmental damage; shifting resources and production to less-polluting or less-emitting industries such as services helps improve environment; and finally technology advance is beneficial to environment. As different countries experience or prioritize different forces at different development stages, the EKC naturally differs between countries and periods. Underlying the priority setting are personal and institutional preferences for environmental quality versus material outputs.

Not only does the EKC differ across countries and time, it also differs with various environmental indicators. Typically, local pollutants are more likely to display an inverted U shape relation with income, while global impacts such as CO_2 are less likely to do so. This is understandable as both ordinary citizens and policy makers are likely to consider local impacts as more important than global ones.

Box 3 **The Environmental Kuznets Curve**

The Kuznets Curve (first postulated by Nobel Laureate Simon Kuznets) hypothesizes that economic inequality initially rises as an economy takes off and then stabilizes, but after reaching a certain turning point will decline with further development, producing an inverted U pattern between inequality and the level of development.

Grossman and Krueger (1995) replaced the variable of inequality with environmental indicators in the same setting and also found an inverted U curve, which is termed the Environmental Kuznets Curve (EKC). To model the EKC, one typically estimates the following econometric model:

$$\text{Ln ENV} = \beta_1 + \beta_2 \text{ Ln GDP} + \beta_3 (\text{Ln GDP})^2 + u$$

where *Ln* is the natural logarithm, *ENV* is an environmental indicator such as PM_{10} or CO_2, *u* is the usual disturbance term, and β_1–β_3 are parameters to be estimated. The inverted U-shaped EKC is obtained when $\beta_2 > 0$ and $\beta_3 < 0$.

The shape conforms to the observation that the world's poorest and richest nations have relatively better environments than the middle-income countries. The peaks of the curves vary across pollutants. For some localized pollution, the level often decreases with growth, depicting a linear or half-U shape. This does not reject the EKC's validity, as pollution must have increased in the past, but early data are not available to show this. Similarly, for nonlocal pollution such as CO_2, the turning points are likely to occur at high incomes. A large literature on EKC exists, see Brock and Taylor (2005).

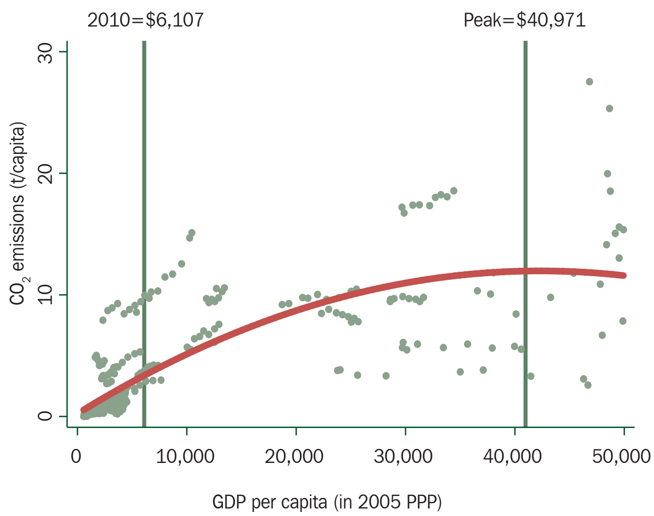
Sources: Brock and Taylor (2005), Grossman and Krueger (1995).

Consequently, the peaks of the inverted-U curves are found to correspond with significantly different income levels. For example, the sulfur emissions peak corresponds with income levels ranging from $3,137 to $101,166 at 1990 prices (Stern 2003), whereas CO_2, peaks correspond with $19,100 (Selden and Song 1995) or $25,100 (Cole et al. 1997).

Where does Asia stand on the EKC? If the findings cited above are used to make inferences, Asia is still on the rising side of the curve, as the average income in Asia is roughly $3,900 at 1990 prices. At the current stage of Asia's development, millions of people move to cities and firms locate there to employ them. The sheer scale of activities associated with urbanization and industrialization (such as transport, building construction, garbage and waste disposal, and power generation) could contribute to environmental degradation. Thus, in the absence of appropriate interventions, Asia's environment is likely to become worse before it gets better.

To properly assess the environmental outlook for Asia, it is necessary to estimate Asia's EKC. Using data from the World Development Indicators, Figure 22 presents a scatter plot of per capita GDP against per capita CO_2 emissions. The trend line clearly resembles a standard EKC. To formally estimate an EKC for Asia, 374 observations from 42 ADB members were used to produce the modeling results in Table 7. Based on this model, the peak of the inverted U-curve corresponds to a GDP level of $40,971 (at 2005 price levels). Clearly, the GDP per capita of most developing Asian countries is far from the "CO_2 turning point."

Figure 22 **Scatterplot of CO_2 Emissions** (t/capita) **and GDP Per Capita** (in 2005 PPP)



CO_2 = carbon dioxide, GDP = gross domestic product, PPP = purchasing power parity, t = ton.
Source: ADB estimates based on World Bank (2012).

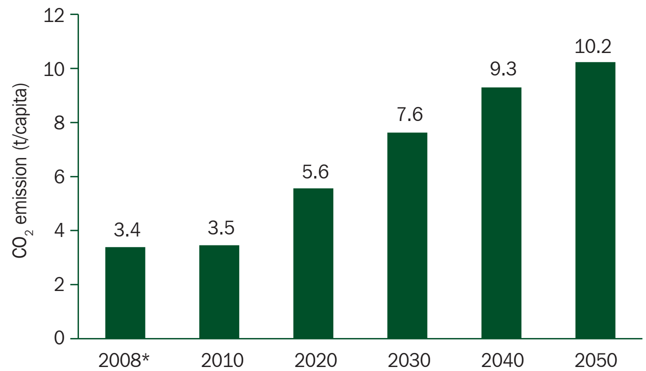
Table 7 **The Environmental Kuznets Curve for Asia**

Independent Variable	Coefficient	Standard Error
Ln GDP per capita	5.48***	0.502
(Ln GDP per capita)^2	-0.251***	0.029
Constant	-27.54***	2.169
Observations	374	
R^2	0.753	

* significant at 10%; ** significant at 5%; *** significant at 1%
GDP = gross domestic product, Ln = natural logarithm
Source: ADB estimates.

Using the estimated EKC, the future level of per capita CO_2 can be simulated using GDP projections of Kohli, Sharma, and Sood (2011). Figure 23 presents the "business-as-usual" scenarios: per capita CO_2 would rise from the 2008 level of 3.4 tons per capita to 7.6 tons in 2030 and further to 10.2 tons in 2050. These scenarios imply a disastrous future for Asia and the globe. Clearly, action is needed and interventions must be found and implemented.

Figure 23 **Projected Per Capita CO_2 Emissions based on Estimated EKC**



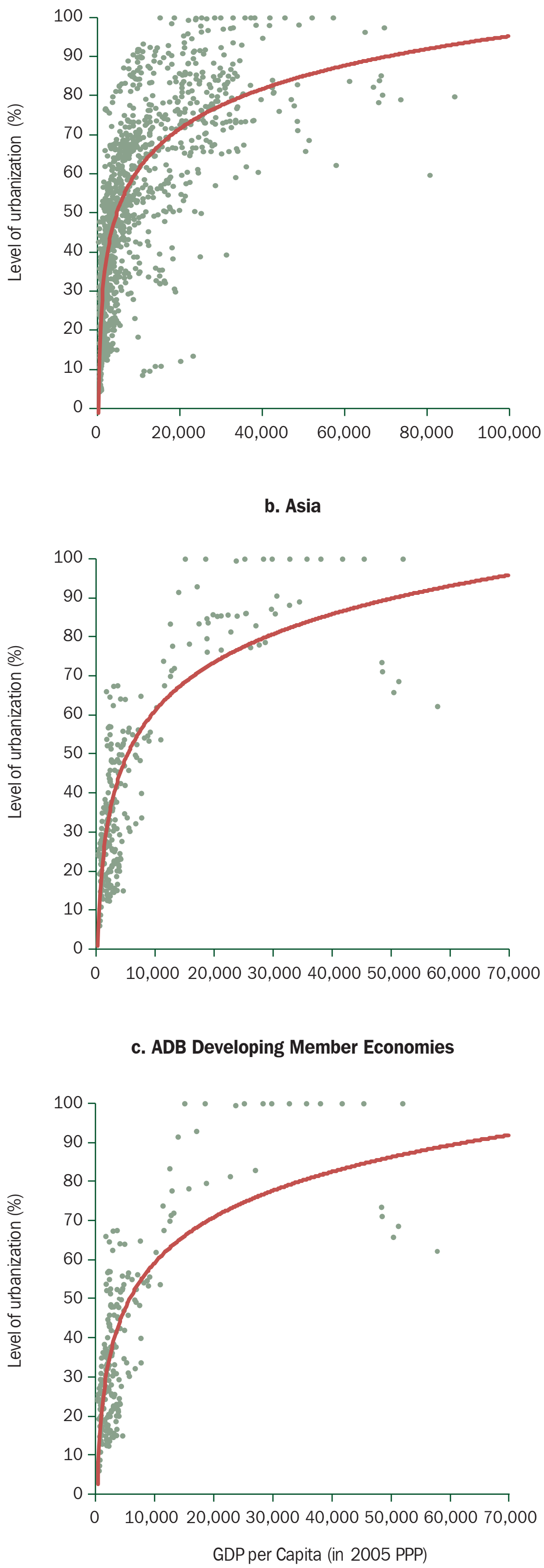
CO_2 = carbon dioxide, EKC = environmental Kuznets curve, t = ton.
* based on average CO_2 emissions per capita of the sample.
Source: ADB estimates.

The Environment–Urbanization Nexus in Asia

The conventional EKC is a relationship between GDP and an environmental indicator. Owing to the positive correlation between urbanization and GDP (Figure 24), the EKC could be used to infer that urbanization in Asia may lead to environmental degradation. However, this inference is problematic as the urbanization–GDP curve is far from a good fit. In reality, a country can achieve the same level of per capita GDP with different levels of urbanization. On the other hand, countries with the same level of urbanization can have quite different GDPs per capita. For example, many countries in Sub-Saharan Africa have been as urbanized as those in Asia for many years, yet they have been much poorer. For decades, the urbanization level in Latin America was as high as that in Europe, but Europe always enjoyed higher income. As shown in Figure 24, there are vast deviations of data from the fitted lines.

Therefore, it is inappropriate to rely on the EKC to infer an urbanization–environment relationship and conclude that the environment will further degrade as Asia urbanizes. Indeed, urbanization can produce beneficial environmental outcomes as it facilitates improved productivity, development of the service sector, and access to environment-related infrastructure; promotes green innovation and technology; prompts traditional manufacturing to relocate away from city centers; nurtures middle class and property owners who are more pro-environment than the general populace; and leads to lower fertility rates and higher educational levels.

Figure 24 **GDP Per Capita and Level of Urbanization, 1980–2010**
a. All Countries



GDP = gross domestic product, PPP = purchasing power parity.
Source: World Bank (2012).

Urban Agglomeration Helps Improve the Environment

Urban agglomeration in itself is benign for the environment. First, it comes with higher productivity due to the positive externalities and scale economies discussed in the first section of this chapter. For Asia as a whole, urban productivity is more than 5.5 times that in the rural areas (UN-HABITAT 2010). Thus, the same level of output can be produced using fewer resources with urban agglomeration than without. In this sense, urbanization helps reduce the ecological footprint.

Second, development of the service sector is closely associated with urban agglomeration. The tertiary sector could not prosper without urbanization because most services require a certain degree of concentration of clients. As service production generally pollutes and emits less than manufacturing activities, urbanization enhances the beneficial structural effect underlying the EKC, as discussed in the subsection "Asia's Environmental Challenges."

Third, environment-related infrastructure and services such as piped water, basic sanitation, and solid waste disposal are much easier and more economical to construct, maintain, and operate in an urban than a rural setting. In other words, urbanization facilitates the supply of the relevant facilities and services to a larger share of the population. On the other hand, urbanization promotes growth that helps enhance affordability and demand. It is thus not surprising that many more urban residents have access to infrastructure and other services than rural residents (Wan and Zhang 2011, ESCAP, ADB, and UNDP 2012). For example, city residents in India have much greater access to flush toilets—60% in 1992 (relative to a national average of 22%) and this increased to 79% by 2006 (Bonu and Kim 2009).

Fourth, urbanization facilitates innovations, and this applies to green technologies as well. In the long run, the environment-friendly equipment, machines, vehicles, and utilities determine the future of the green economy, and Asia's cities are likely to play a key role in producing and exporting low-cost, high-quality renewable power generation equipment and electric vehicles. When new forms of industry open, firms usually cluster in cities featuring high levels of human capital. When the technology is mature they decentralize and relocate to low-wage regions for mass production (Duranton and Puga 2001). As a consequence, Asian urban growth and openness to global markets facilitates the rise of the global green economy.

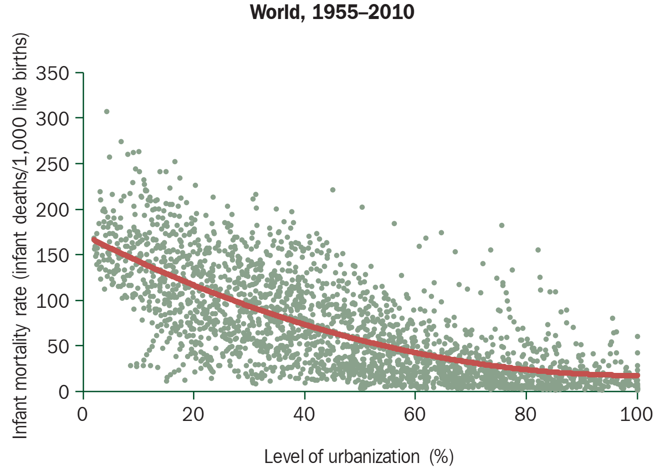
Green innovations accompanying urbanization in Asia will be helped by the vast size of Asia's own market. In the presence of fixed costs, the scale of the market is a key determinant for developing new products. The billions of people who seek to purchase energy efficient products will create a huge opportunity for entrepreneurs who can serve them. Acemoglu and Linn (2004) demonstrated this in the case of new drug development, and their logic holds for green products. If billions of people seek energy efficient air conditioners to offset hot summers, there will be significant incentives to invest in developing such products. Some of the producers will succeed and, in a globalized world market, the pay-off will be huge.

Many Asian economies already export green technology. Sawnhey and Kahn (forthcoming) note that developing countries' exports of renewable energy products have grown significantly. For example, the PRC's share in the US imports of core wind and solar energy equipment, including solar panels, cells, and blades, has increased steadily. In particular, the PRC's share of US imports of solar modules grew from 0% to 43% during 1989–2010 and India's share of US imports of wind turbines grew from 0% to 10% during 1996–2010 (Table 8).

Fifth, for any given population, high density associated with urban agglomeration can benefit the environment. The urban economics literature shows that compactness is one of the most important determinants of energy use (Glaeser and Kahn 2004). High density can create greater viability for public transport and entail less or shorter travel. It also facilitates walking and cycling rather than driving or taking public transport (Newman and Kenworthy 1999).

Finally, the enhanced economic freedom arising from urbanization allows people to improve their standard of living in many ways, including through better food, shelter, and health care. Urbanization benefits education and can help increase a population's health and robustness in the face of disease. Urban growth also generates revenues that fund infrastructure projects, reducing congestion and improving public health. Consequently, it is not surprising that infant mortality decreases with increasing urbanization (Figure 25).

Figure 25 **Infant Mortality Rate and Level of Urbanization, World, 1955–2010**



Sources: UN (2011) and (2012).

Table 8 **United States Imports of High-Tech Green Equipment (%)**

Economy	Blades		Wind Turbines		Hub and Drive		Solar Modules		Solar Cells	
	1989	2010	1996	2010	1995	2010	1989	2010	1989	2010
Brazil	0.27	24.31	–	0.05	10.19	1.76	–	–	5.30	–
Canada	13.06	5.33	0.20	0.69	12.35	10.31	0.16	0.09	0.48	0.07
China, People's Rep. of	0.97	7.22	0.04	0.39	0.12	12.70	0.04	43.72	–	13.75
Denmark	1.13	10.72	95.37	45.92	2.02	1.94	–	–	0.19	–
France	1.29	1.30	–	0.01	4.83	0.73	–	0.01	0.19	0.04
Germany	31.29	14.37	0.43	7.55	19.48	9.51	0.88	1.87	5.13	24.14
India	–	9.74	–	10.04	0.52	1.13	0.79	0.95	–	0.72
Italy	2.77	0.61	–	2.48	2.58	1.02	0.01	0.02	0.10	0.07
Japan	10.45	3.59	0.23	17.29	18.01	9.64	53.59	10.99	25.14	2.08
Korea, Rep. of	0.10	1.37	–	0.23	0.45	2.38	–	0.42	–	2.25
Mexico	0.12	8.69	–	0.06	3.66	35.67	34.74	23.36	7.31	0.31
Netherlands	3.42	0.47	–	0.06	0.11	1.12	–	0.11	0.01	0.01
Singapore	3.06	0.22	–	–	–	0.17	3.23	0.06	1.23	18.26
Spain	0.67	4.14	–	11.41	–	2.93	–	0.12	–	0.07
Sweden	2.71	0.16	–	–	3.52	0.14	–	0.84	0.13	0.28
Switzerland	1.36	0.13	–	0.01	5.19	0.24	–	0.03	0.05	0.02
Taipei,China	2.74	0.15	–	0.01	5.76	1.70	1.37	6.13	0.55	35.30
United Kingdom	18.10	5.20	3.65	3.67	7.05	2.55	1.91	0.02	0.25	0.28
Others*	0.24	0.21	–	–	0.08	1.01	2.79	11.19	53.78	1.25
Total Shares	93.75	97.93	99.92	99.87	95.92	96.65	99.51	99.93	99.84	98.90

– = zero; * Others include Australia; Hong Kong, China; Indonesia, Malaysia, Philippines, and Thailand.
Source: Sawnhey and Kahn (forthcoming).

Manufacturing Relocation and Rise of the Middle Class and Property Owners

Urbanization can help alleviate environmental problems by prompting relocation of traditional manufacturing away from major city centers. This is partly attributable to rising land prices in city centers as urbanization proceeds. Development of infrastructure such as ports and highways also facilitates such movements (Henderson 2002). Manufacturing firms recognize that by choosing a less centralized location they can pay lower wages and land prices while still enjoying access to consumer markets and intermediate input suppliers. As Asia's nations invest in better transport infrastructure, manufacturing can move further from the major cities and these jobs will be replaced by knowledge economy and service jobs with lower ecological footprints. For example, in 1970, Seoul's shares of population and manufacturing in the Republic of Korea were 62% and 61%, respectively. But by 1993, while Seoul's population remained at 61% of the country's total, its manufacturing share had fallen to 30%. Between 1983 and 1993, Seoul's share of national manufacturing jobs fell from 21% to 14% and Pusan and Taegu's share fell from 23% to 14% (Henderson 2002). These examples echo the trend of decentralization of manufacturing employment that has taken place elsewhere (Glaeser and Kahn 2004).

The migration of heavy industry away from major cities has generated large public health benefits through improved air and water quality in many cities around the world (Kahn 1999, 2003). In a case study of the 2008 Summer Olympics in Beijing, Chen et al. (2011) found significant improvements in ambient air quality as the authorities changed transport patterns and shut factories. Kahn (2003) documents the sharp reduction of pollution in the Czech Republic and Poland as they closed energy inefficient manufacturing plants that were built under communism.

The economic damage caused by exposure to pollution is a function of the number of people exposed and is reflected by their willingness to pay to avoid pollution. When a factory moves from a major city to a less populated area, the aggregate damage caused is likely to decline because fewer people are exposed to the pollution. As an older factory closes at the origin and a new factory with better technology is built at the new destination, emissions per unit of output are also likely to fall.

In some Asian cities, polluting industrial activities are geographically separated from other locations, such as tourist areas. If industrial activity took place close to tourist locations, they would likely be degraded and tourists would stop visiting the area. Separation of the two activities helps to reduce the effects of pollution and to boost tourism. Box 4 presents a case study for Penang in Malaysia.

Urbanization also helps nurture the middle class and raises private ownership of properties in cities. The expanding middle class will demand a better environment, and property owners are a powerful interest group with a stake in enacting policies to curb environmental degradation. They directly gain from improvements in the local quality of life, not least because the improvements will lead to higher local real estate prices. Put simply, land is more valuable in nicer areas with natural and human amenities, which is well documented in many real estate studies (see Gyourko, Kahn, and Tracy 1999 for a review; and Zheng and Kahn 2008 on the PRC). Zheng and Kahn (2008) document that real estate prices are higher in low-pollution parts of Beijing that feature green space and are close to public transit stations.

Box 4 **Malaysian Decentralization**

Penang comprises an island and a mainland area twice the size of the island. Most high tech factories are in the southeastern part of the island (Bayan Lepas Free Industrial Zone [FIZ]), while the heavy industry factories are primarily in suburbs such as Mak Mandin Free Trade Zone (FTZ) in Butterworth or Prai FTZ on the mainland (along the coast opposite downtown Penang) and Kulim in Kedah (a growing town at the border of Kedah and Penang). Penang still serves as the regional financial city for the northern peninsula. Most of the tourist sites and service industries such as banking and tourism are in old Georgetown at the northern part of the island and along the northern shore and beaches such as Tanjung Bungah and Batu Feringghi. Due to Georgetown's status as a UNESCO World Heritage Site, the state government has imposed many restrictions to preserve the heritage sites and to boost the tourism industry. As a result, most heavy industry factories are set up in or have moved to the mainland or neighboring states and the majority of the firms on the island are relatively environmentally friendly, and are usually involved in high tech research and production.

Penang's manufacturing sector is primarily related to electrical and electronics categories of goods. To ease environmental strain in the city of Georgetown's centers, most factories are in FTZs or industrial estates such as Bayan Lepas FIZ, Prai FTZ, or Kulim along the Penang–Kedah border. Minimum taxes are levied in such zones and all imports and exports enjoy duty-free privileges.

Penang's relocation of manufacturing away from tourist and cultural heritage sites highlights how an Asian city has physically separated the two activities. If they were in closer proximity, the tourism business would suffer from the pollution caused by manufacturing.

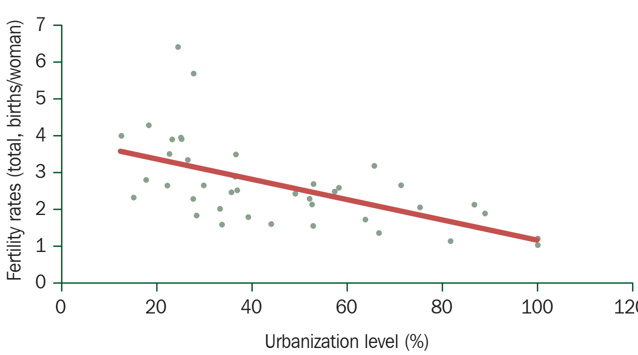
Sources: Authors and William (2011).

Declining Fertility and Increasing Educational Attainment

Urbanization is also beneficial to the environment due to its close association with declining fertility.[9] The economics of demography offers a simple explanation (Becker 1991). Women who live in cities have more opportunities for education and to work in the labor force than rural women. Consequently, urban women respond by working more, marrying later, and having fewer children. As young women anticipate that they will have the opportunity to work in cities, they invest more in their education as teenagers and this further encourages them to work in the market place. The net effect is to slow population growth, which means less adverse environmental consequences than would otherwise be the case.

Anecdotal evidence from Asia supports the above arguments. In nations such as Viet Nam, the fertility rate has declined dramatically, from the 1980 level of 5.4 to 1.8 in 2010 (World Bank 2012). In rich cities in the PRC such as Shanghai, the birth rate has fallen below the population replacement rate. Around the world, the same correlation is observed. Figure 26 highlights this negative correlation for Asian nations.

Figure 26 **Fertility Rates vs. Level of Urbanization in Asia**



Source: World Bank (2012).

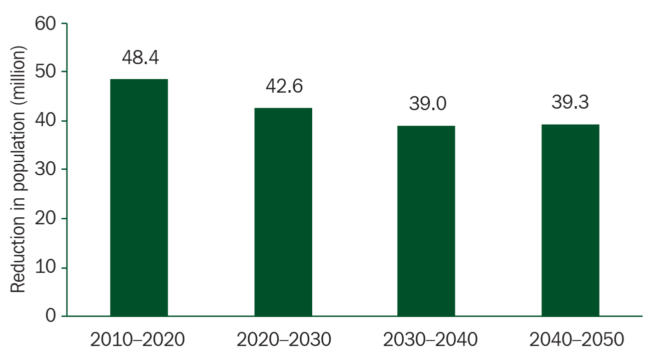
Using 1980–2010 data from 31 Asian countries (194 observations), total raw fertility can be regressed on levels of urbanization, GDP per capita, and education. Literally interpreted, the modeling results indicate that every 1 percentage point increase in the urbanization level led to 5 fewer births per 100 women who are of reproductive age. To directly assess the impact of urbanization on population growth, an econometric model is fitted to cross-country data from Asia. The empirical results tabulated in Table 9 imply that every 1 percentage point increase in the urbanization level led to 0.02 percentage point reduction in the net population growth rate. This translates into a total reduction of 169.28 million in the population increase that might have happened without urbanization during 2010–2050, more or less evenly distributed over different decades (Figure 27). Under the "business as usual" scenario of Figure 23, this amounts to an additional 1,727 million tons of CO_2 in 2050, 65 million tons more than the combined emissions of India and Viet Nam in 2009 (Howes and Wyrwoll 2012).

Table 9 **Population Growth and Urbanization**

Independent Variable	Coefficient	Standard Error
Urbanization	-0.019***	0.005
GDP per capita	0.000***	0.000
Education[a]	-0.049***	0.015
Constant	2.534***	0.250
Observations	194	
R^2	0.1623	

GDP = gross domestic product
* significant at 10%; ** significant at 5%; *** significant at 1%
a education refers to percentage of complete tertiary schooling attained in female population.
Source: ADB estimation.

Figure 27 **Reduction in Projected Population due to Urbanization**



Source: ADB estimates.

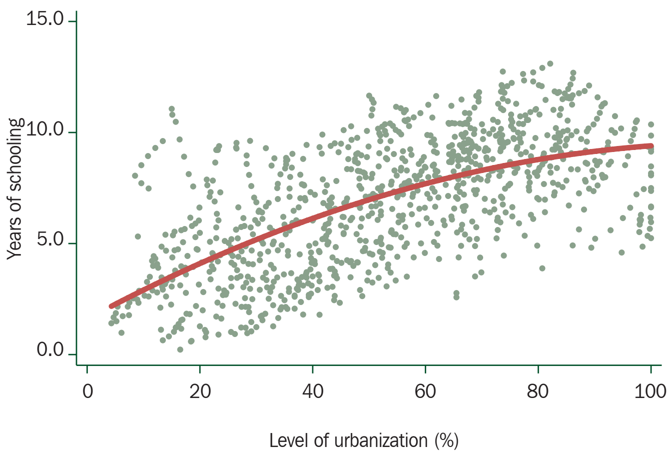
As discussed in the introduction of this chapter, one major function of cities is to gather intellectual capital so people can become more educated by learning from and interacting with each other. Intensified competition in cities also motivates urbanites to accumulate human capital. In addition, cities offer better and more opportunities for learning. The positive association between urbanization and education is evident in Figure 28.

Improved educational attainment, in turn, can affect the environment at least in two ways. First, similar to urbanization, education helps lower fertility, as reflected by the negative and significant coefficient of the education variable in Table 9. Second, the more educated

9 The fertility rate is the ratio of live births per woman of reproductive age in a given year.

often opt for a better living environment by voting for environmental regulation (Kahn 2002). They are also more willing to sacrifice consumption today for returns in the long run (Moretti 2004a, Becker and Mulligan 1997). And politicians are likely to respond by supplying policies that urban voters desire.

Figure 28 **Education vs. Urbanization in Asia, 1980–2010**



Sources: UN (2012) and Barro-Lee (2010).

Are the educated in Asia also pro-environment? The World Values Survey offers the opportunity to address this question. The survey data allow one to observe the personal priorities of people who are of the same age but live in different nations. For Asia, the data cover the PRC; India; Indonesia; the Republic of Korea; Malaysia; Taipei,China; Thailand; and Viet Nam. In 2007, the survey focused on four attitudinal questions regarding whether respondents (1) prioritize environmental protection over economic growth, (2) are willing to sacrifice income to protect the environment, (3) would pay higher taxes to protect the environment, and (4) support greater regulation to protect the environment.

Table 10 reports the results. The top rows focus on Asian respondents and stratify the data by educational attainment. A positive correlation between educational attainment and prioritizing green issues is clearly shown. For example, 47% of respondents in Asia who have at least a university education prioritize the environment over economic growth while only 32% with no formal education have this prioritization. As another example, while less than 50% of those without formal education are willing to sacrifice personal income for environment, this percentage is as high as 81% for university graduates.

The bottom two rows of Table 10 compare the attitudes of all respondents versus those who live in Asia. The data show that respondents from Asia are more willing to sacrifice personal income to protect the environment (72%) than the world average (62%). They are 7 percentage points more likely to support higher taxes for environmental protection although relatively more Asians prioritize growth over environment. In other words, they do not want to see growth slow in the region but are willing to sacrifice personal income for better environment ex post. These findings suggest a culture in Asia that is forging greener urbanism.

Table 10 **Percentage of Respondents' Willingness to Support Environmental Protection**

Population Subgroups	Sacrifice Growth (%)	Sacrifice Income (%)	Pay Higher Taxes (%)	Support Regulation (%)
By educational attainment				
No formal education	32.3	49.5	43.2	42.1
Less than Secondary Education	42.4	68.7	58.3	60.4
Secondary Education	45.2	75.3	62.8	60.8
At least Some University Education	46.8	80.8	67.7	61.0
World	49.3	61.8	53.3	67.2
Asia	43.4	71.8	60.4	58.5

Source: ADB estimates based on World Values Survey Data.

Quantifying the Environment–Urbanization Nexus

The channels and mechanisms through which urbanization affects the environment, as discussed in this chapter, imply that the relationship between urbanization and the environment may differ from the conventional EKC. While it is difficult to pin down the impacts of each channel, econometric models may be used to estimate a relationship. In doing so, it is crucial to control for GDP in the model so that the effects of urbanization on environmental indicators can be properly identified and quantified. Thus, the model to be estimated takes the following form:

$$\text{Ln } CO_2 \text{ or Ln } PM_{10} = \alpha_0 + \alpha_1 \text{ Ln GDP} + \alpha_2 (\text{Ln GDP})^2 + \beta_1 \text{ Urb} + \beta_2 \text{ Urb}^2 + \beta_3 \text{ Ln(GDP)*Urb} + u$$

Where *Ln* = natural logarithm; CO_2 = average emission of carbon dioxide (tons per capita); PM_{10} is measured in micrograms per cubic meter; *GDP* = GDP per capita in 2005 PPP; *Urb* = level of urbanization; *u* is the usual disturbance term and α's and β's are parameters to be estimated.

Table 11 **The Environment–Urbanization Model**

Models for Independent Variables	1990s Coefficient	1990s Standard Error	2000s Coefficient	2000s Standard Error
Ln CO_2				
Ln GDP per capita	1.781***	0.415	6.922***	1.088
(Ln GDP per capita)^2	-0.064**	0.025	-0.414***	0.083
Urbanization	0.102***	0.006	-0.082*	0.049
Urbanization^2	-0.001***	0.000	-0.001***	0.000
Ln GDP per capita x Urbanization			0.026***	0.008
Constant	-12.381***	1.700	-31.214***	3.610
Observations	370		374	
R^2	0.829		0.821	
Ln PM_{10}				
Ln GDP per capita	-1.161***	0.345	-1.870***	0.482
(Ln GDP per capita)^2	0.046**	0.021	0.101***	0.028
Urbanization	0.027***	0.006	0.033***	0.007
Urbanization^2	-0.0002***	0.000	-0.0004***	0.000
Constant	9.746***	1.408	11.670***	1.979
Observations	310		304	
R^2	0.359		0.241	

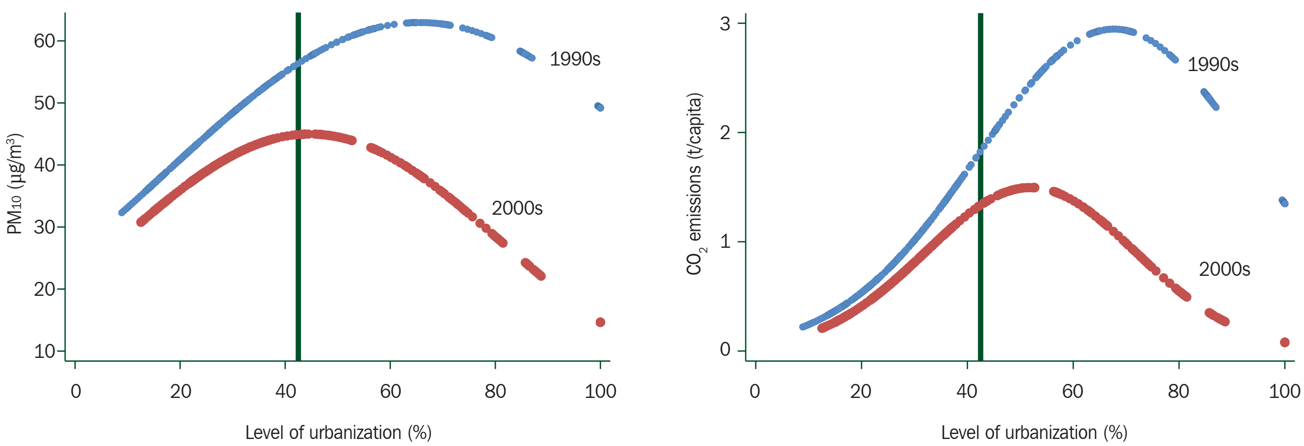
CO_2 = carbon dioxode, GDP = gross domestic product, Ln = natural logarithm, PM_{10} = particulate matter with diameter of 10 micrometers or less.
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: ADB estimation.

The model is fitted separately to 1990–1999 and 2000–2008 data for Asia economies from the World Development Indicators (World Bank 2012). The interactive term was found to be highly insignificant in all models except one. Table 11 summarizes the estimation results. Despite the parsimonious specification, the models fit the data well and are of good quality in terms of the usual statistical and economic criteria.

Based on the modeling results, the environment–urbanization curves are plotted in Figure 29. The plots show an inverted U-pattern, similar to the conventional EKC in shape. Thus, environmental degradation occurs in the early stage of urbanization when productivity gains and agglomeration effects are low, which can be overweighed by its negative effects. After reaching a certain level when agglomeration and productivity improvement become significant, urbanization leads to reductions in pollution and emissions.

An important and interesting finding emerges when the urbanization–environment curves for the 1990s and 2000s are compared. Figure 29 shows that over time the curves for CO_2 emissions per capita and PM_{10} (μg/m^3) shifted down and to the left. Shifting down means much lower emissions and pollution at the same level of urbanization. Shifting left means the peak of the inverted U curve comes sooner under the 2000s technologies and policy environment. For example, the peak of the 1990s curve for CO_2 emissions occurs at a 68% urbanization level while that of the 2000s curve occurs at 52%. For PM_{10}, the peak under the 2000s curve corresponds to a 45% level of urbanization rather than 66% under the 1990s curve. These results are consistent with the literature, which indicates that local pollution usually starts to decline earlier than nonlocal pollution.

Figure 29 **Environment-Urbanization Relationship in Asia**

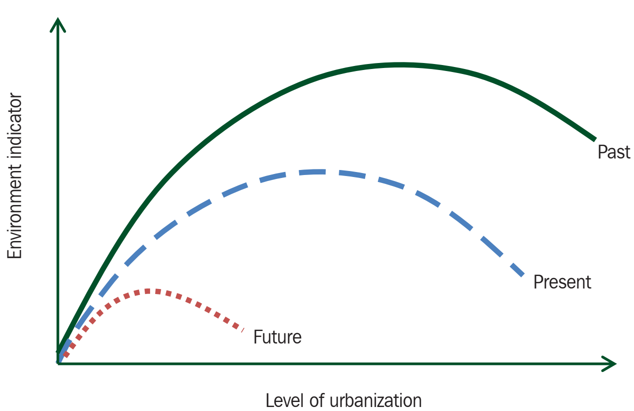


CO_2 = carbon dioxide, PM_{10} = particulate matter with diameter of 10 micrometers or less, μg/m^3 = micrograms per cubic meter, t = ton.
Source: ADB estimates.

The shift of the environment–urbanization curve, like the conventional EKC, is primarily driven by technology advances, structural changes, and regulations. The gap between the two curves corresponding to the same urbanization rate measures the impact of the shifts on pollution or emissions. At the 2010 level of urbanization for Asia, the impacts amounted to 20% reductions for PM_{10} ($\mu g/m^3$) and and 27% for CO_2 emissions per capita, forcefully demonstrating the large impacts of technology and government policies.

Thus, urbanization can significantly decrease the amount of environmental degradation. Holding everything constant, including technology and policy, by 2050, CO_2 emissions per capita will be halved and the PM_{10} ($\mu g/m^3$) level will be cut by 37% even if nothing else but urbanization changes. Because technology keeps improving and pressures from various sources are mounting, the environment–urbanization curve will almost certainly continue to shift down and left, as illustrated in Figure 30. Therefore, the future of Asia's environment will most likely be bright as urbanization proceeds, with careful management.

Figure 30 **Illustrative Environment–Urbanization Curve**



Source: Authors' illustration.

Summary

Although cities face many environmental challenges, urbanization can help promote greenness as it leads to declining fertility rates, increasing levels of education, growing support for "greening," relocating industry away from city centers, and advancing technology. Also, by nurturing the urban middle class and property owners, urbanization can help ameliorate adverse environmental impacts as educated, informed urban middle class members and property owners are usually pro-environment and they tend to support "low-carbon" products—products that enable a reduction in carbon emissions. The combined effects of these forces can lead to better environmental outcomes as Asia urbanizes, as reflected by the shift of the environment–urbanization curve.

Nevertheless, Asia has not reached the peak of the urbanization–environment inverted U-curve and is a long way from the peak of the conventional EKC. Even the promising trend depicted in Figure 29 is conditional on maintaining the current level of GDP. In other words, the beneficial effects of urbanization could be offset by rising GDP. Thus, Asia will continue to face the serious environmental challenges outlined in the section "Environmental Implications of Urbanization in Asia." Thus, the region must move urgently to design and implement appropriate policies, a topic of the next section.

Policy Options for Green Cities

The key message from the previous section is a cautiously optimistic one: Asia can achieve green urbanization but to do so, appropriate interventions must be designed and implemented. These interventions would embrace both free market mechanisms, such as pricing resource use to reflect its negative impacts on the environment, and direct roles of government, such as reforming or introducing regulations. In particular, stringent urban planning is required to develop environment-friendly satellite cities linked with megacities by train, light rail, or metro rather than highways. Urban infrastructure investment must take into consideration vulnerability to natural disasters such as flooding, as occurred in Bangkok, Beijing, and Manila in 2011–2012. After the highly commendable and recent rapid expansion of physical infrastructure in Asia, the growing challenge now is to improve the quality of infrastructure (such as in its safety standards or resilience to climatic effects), the efficiency of its service delivery, and its synergies both with other forms of physical infrastructure and with soft infrastructure of regulations, standards, and institutions.

In developing policy recommendations, it is important to exploit unique features of Asia's urbanization and take advantage of Asia's position as a late comer in urbanization. Also, rather than producing an exhaustive list, attention will be focused on policies that can be supported by examples and case studies and that can produce benefits larger than costs. Four groups of such policies will be discussed here.

The first subsection focuses on conserving resources currently used with present technologies. Pricing for externalities in addition to scarcity is a market-based solution for raising the efficiency of resource use. As a late comer, Asia cities can introduce environmental regulations, standards, and good practices at a still early stage of development. Meanwhile, given more and expanding megacities in the region, maintaining the vitality of city centers and developing mass public transport are crucial to reduce cities' ecological footprints.

The second subsection discusses policies that promote technological advance, creation of environment-friendly cities, and use of alternative energies. These new cities would be linked with megacities by fast train, light rail, or metro rather than highways. The second section complements the first subsection because savings from efficiency improvements and conservation alone are not enough—the impacts are limited and decline as population growth compounded with rising income leads to more production and consumption.

The third subsection is devoted to the urban poor who are particularly vulnerable and have little or no access to basic social services. Any public policy must take the poor into consideration, particularly given the increasing trend in inequality in Asia, along both income and nonincome dimensions (ADB 2012b, Wan and Zhang 2011).

The last subsection addresses the issue of policy implementation. Two areas are singled out for discussion: financing for urban development, and government transparency and accountability. Even the best policies will yield few results if politicians do not have the incentive or resources to implement and enforce them.

Enhancing Efficiency and Conservation

A fundamental cause of environmental degradation arises when, in the absence of regulation, individuals and firms have insufficient incentive not to pollute. Thus, the key is to internalize the externalities or social costs associated with damage to the environment, particularly targeting the rising motorization in Asia. In other words, "getting prices right" or "making users pay" is one of the most effective and feasible policy options. Such policies lead to resource savings and at the same time help to raise government revenue. "Getting prices right" alone is not enough and requires introducing relevant regulations. Environmental laws and regulations need to be introduced early in the development process. And, given the prominence of public transport in urban living and the overall environment, the design and provision of urban public transport infrastructure is important.

Getting Prices Right. The idea of "getting prices right" is to ensure that prices for resources are sufficiently high that they incorporate externalities and so reflect the full social costs. This is generally equivalent to taxing consumers, which will dampen average demand. Setting the level of such taxes or price markups is a sensitive issue, as taxes of any kind benefit some people while adversely affecting others. The need to ensure majority support for such measures limits the amount that prices can be marked up. Theoretically, such taxes or price markups should be set at a level that maximizes the difference between welfare gains from an improved environment and increased revenue for the government and other winners on the one hand, and welfare losses of individuals and institutions due to rising prices on the other. In reality, different countries or the same country at different stages of development may choose different tax levels through careful research combined with wide public consultations.

Pricing for externalities has been practiced for a long time, by some countries in Asia and elsewhere. People who are interested in this policy option can readily learn from the experiences of pioneering work in such pricing. In particular, modern technology now allows variable pricing of electricity, water, and congestion, which can result in improved environmental impacts and more sustainable service deliveries than flat rate tariffs.

Singapore introduced congestion pricing in 1975.[10] It now permits real-time variable pricing based on congestion levels. Singapore also has high vehicle registration fees and a quota system for new vehicles, which have recently been replicated in major cities in the PRC. Another example is the Central London congestion charge. Such policies have helped contain the volume of car ownership, reduce urban traffic congestion, increase the use of public transport, and raise revenue for urban development (Leape 2006).

Pollution can also be directly priced. With improvements in information technology and database management, the annual distance that individual vehicles have been driven can be monitored when their owners register the cars each year. Taking into account a vehicle's make, model, age, and engine size, the annual emissions can be estimated and the owner can be charged accordingly. This can generate revenue and provide an incentive for individuals to drive newer, lower polluting vehicles as well as to drive less.

10 Congestion pricing is the practice of charging private motorists more to use a roadway, bridge, or tunnel where and when the traffic is heavy.

Further, a small percentage of used vehicles usually produce a large share of a city's total emissions. For example, in the US, roughly 10% of vehicles produce about 50% of total vehicle emissions (Shafizadeh, Niemeier, and Eisinger 2004). The owners of such "super emitting" vehicles impose much larger social costs on society than the average car owner. To mitigate this problem, environmental authorities could employ remote monitoring technology[11] that allows issuance of an emissions ticket—the equivalent of a speeding ticket. Such targeting provides heavy emitters with the incentive to have their vehicles checked and repaired. The net effect would be to reduce emissions.[12]

In the case of CO_2 emissions, a fundamental problem is that of the "global free rider." One solution is for nations to sign a binding global carbon mitigation treaty that would introduce either a global CO_2 trading market or a carbon tax. Unfortunately, the former has not happened yet despite continuing negotiations. However, the green economy is firmly on the agenda and many countries worldwide have now created a carbon tax and/or price. For example, the Republic of Korea approved a "cap-and-trade" carbon reduction system in May 2012.[13]

The pricing of water and electricity requires paying special attention to the poor. As these are basic necessities, the authorities must charge prices that are low enough to allow access by the poor but high enough to prevent excessive use. One option is to charge increasing block tariffs as a particular consumer's usage increases. This allows simultaneous protection of the poor and collects higher revenue from users who are likely to be wealthier. Table 12 highlights the cross-nation differences in water prices and the differences across the pricing steps. For example, in Bangalore the price per liter of water for the top tier is six times that for at the bottom tier. Some cities (such as Hong Kong, China and Manila, Philippines) charge a zero marginal price at the lowest pricing tier.

"Getting prices right" also involves managing expectations. If Asian planners, residents, and firms expect rising energy and water prices, they will invest to economize on such consumption, leading to resource conservation. It is no accident that in nations with higher gasoline prices, people tend to live in higher density areas and own more fuel-efficient vehicles. And, such cities have often invested in higher quality public transport.

In addition, when consumers expect rising energy prices, demand for green technology will soar and Asian entrepreneurs will respond to price signals. Much evidence has shown that when energy prices go up, the vehicle fleet becomes more energy efficient and firms increase their investment in research and development to enhance fuel efficiency. Similarly, higher electricity prices are associated with subsequent introduction of more energy efficient appliances (Newell, Jaffe, and Stavins 1999). Using US data, Newell, Jaffe, and Stavins found that the relative prices of electricity and natural gas rose 24% and 69%, respectively, during the simulation period (1973–1993). If these relative prices had remained at their low 1973 levels, about one-quarter to one-half of the increase in energy efficiency would not have occurred. Energy efficiency would have been 8% lower for room air conditioners, 16% lower for central air conditioners, and 5% lower for gas water heaters.

Fuel subsidies are closely related to the issue of energy price. Such subsidies are economically costly to taxpayers and can add damage to the environment. These subsidies are intended to protect the poor; however, they end up benefiting the rich. In Indonesia in 2011, fuel and electricity subsidies amounted to 3.4% of GDP, with the richest 10% of households consuming 40% of the total subsidized gasoline, and the top half of households using almost 84% of it (Ginting and Aji 2012). The International Monetary Fund estimated that 80% of the total benefits from petroleum subsidies in 2009 accrued to the richest 40% of households. In contrast, only about 8% of the benefits reach the poorest 20% of the population (Coady et al. 2010).

Encouragingly, leaders of the G20 have committed to rationalize and phase out over the medium term of inefficient fossil fuel subsidies, action that is estimated to help reduce GHGs by 10% globally by 2050. In Asia, the Indonesian government recently proposed a revised 2012 budget bill to reduce untargeted fuel subsidies and to use the saved budget resources to invest in infrastructure, promote green growth, and provide transfers to poor regions and households (IEA et al. 2010).

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11 This system uses one basic principle: certain gases absorb infrared light at different rates. By placing an infrared light transmitter on one side of the road and aiming its beam into a receiver on the other side, a computer can compare the wavelength of the light passed through the exhaust plume when a vehicle drives through the beam with the wavelength of the normal infrared light. It then calculates the percentage of hydrocarbons, nitrogen oxides, CO_2, and carbon monoxide. If, and only if, a vehicle's emissions are over the maximum limits, a camera records the license plate number and the authority is notified.

12 For data from other countries on tailpipe emissions as judged by remote sensing see http://www.feat.biochem.du.edu/pub_list.shtml

13 A "cap-and-trade" carbon reduction system is a market-based pollution reduction system that sets a limit (a "cap") on the amount of pollution that may be emitted. This cap is allocated to emitters. If companies need to emit more pollution than their allotted amount, they may purchase ("trade") permits from those that emit less than their cap.

Table 12 **Water Pricing**

City	With effect from	Tariff Structure	Blocks (Units in litres)	Per 1000 liter or cubic metres (in local currency)	Tariff ($)
Dhaka[a]	Jul-09	Flat Rate (Metered Connection)	All Units	6.34	0.077
Chittagong[b]	Dec-10	Flat Rate (Metered Connection)	All Units	5.96	0.073
Singapore[c]		IBT	0 – 40,000	1.17	0.937
			Above 40,000	1.4	1.121
Bangalore[d]	Feb-05	IBT	0 – 8000	6	0.113
			8001 – 25000	9	0.169
			25001 – 50000	15	0.282
			50001 – 75000	30	0.564
			75001 above	36	0.676
New York[e]	Jul-10	Flat Rate (Metered Connection)		2.95/100 cf	
				1.04/ 1000 l	1.040
Ottawa[f]	May-10	Flat Rate (Metered Connection)		1.276	1.283
Sydney[g]	Jul-10	Flat Rate (Metered Connection)		2.012	2.076
Sri Lanka[h]	Feb-09	IBT	0 – 5000	1.25	0.010
			5 – 10,000	1.5	0.012
			10 – 15,000	3	0.023
			15 – 20,000	30	0.231
			20 – 25,000	50	0.384
			25 – 30,000	75	0.577
			30 – 40,000	90	0.692
			40 – 50,000	105	0.807
			50 – 75,000	110	0.846
			Above 75, 000	120	0.922
Delhi[i]	Jan-11	IBT	Up to 10,000	2.2	0.041
			10 – 20,000	3.3	0.062
			20 – 30,000	16.5	0.310
			Above 30,000	27.5	0.517
Hong Kong, China[j]	Feb-95	IBT	Up to 12,000	0	0.000
			12 – 43, 000	4.16	0.536
			43 – 62,000	6.45	0.831
			Above 62,000	9.45	1.218
Manila East Zone[k]	Jan-11	IBT	Up to 10,000	0	0.000
			10 – 20,000	10.89	0.255
			20 – 40,000	20.65	0.484
			40 – 60,000	27.19	0.638
			60 – 80,000	31.76	0.745
			80 – 100,000	33.27	0.780
			100,000 – 150,000	34.76	0.815
			150, 000 – 200, 000	36.25	0.850
			Above 200, 000	37.75	0.885
Manila West Zone[l]	Jan-11	IBT	Up to 10,000	0	0.000
			10 – 20,000	14.58	0.342
			20 – 40,000	27.7	0.650
			40 – 60,000	36.38	0.853
			60 – 80,000	42.49	0.997
			80 – 100,000	44.43	1.042
			100,000 – 150,000	46.47	1.090
			150, 000 – 200, 000	48.54	1.138
			Above 200, 000	50.59	1.187
Chennai	2005	IBT	Up to 10,000	2.5	0.047
			10 – 15,000	10	0.188
			15 – 25,000	15	0.282
			Above 25,000	25	0.470
Mumbai[m]	2005	Flat Rate (Metered Connection)		3.5	0.066
Almedabaad[m]	2005	Flat Rate (Metered Connection)		3	0.056
Jakarta	2005	Group 1 (Flat Rate)		550	0.060
		Group 2 (IBT)	Up to 20,000	550	0.060
			Above 20,000	1000	0.109
		Group 3A (IBT)	Up to 10,000	2450	0.266
			10 – 20,000	3350	0.364
			Above 20,000	4000	0.434
		Group 3B (IBT)	Up to 10,000	3500	0.380
			10 – 20,000	4400	0.478
			Above 20,000	5600	0.608
		Group 4A (IBT)	Up to 10,000	5100	0.554
			10 – 20,000	6200	0.673
			Above 20,000	7500	0.815
		Group 4B (Flat Rate)		9750	1.059

IBT = increasing block tariff

Source: Gunawansa and Hoque (2012) with data from:

a - http://www.dwasa.org.bd/
b - http://cwasa.org/index.php?cPath=Tariff
c - http://www.pub.gov.sg/general/factsandfigures/pages/watertariff.aspx
d - http://www.bwssb.org/water_tarriff_prorata.html
e - http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml
f - http://www.ottawa.ca/residents/water/billing/new_rate_faq_en.html
g - http://www.sydneywater.com.au/YourAccount/PricingInformation/
h - http://www.waterboard.lk/scripts/Downloads/Water_Tariff_E.pdf
i - http://delhijalboard.nic.in/
j - http://www.wsd.gov.hk/en/customer_services_and_water_bills/water_and_sewage_tariff/water_and_sewage_tariff/index.html
k - http://www.manilawater.com/downloads/ltr.pse.sec.pdex.tariff.adjustment.jan2011.pdf
l - http://www.mayniladwater.com.ph/uploaded/2011_tariff.pdf
m - Asian Development Bank (ADB) and Ministry of Urban Development, Government of India (2007). "The 2007 Benchmarking and Data Book of Water Utilities in India". Accessed May 02, 2011. 15- http://www.adb.org/Documents/Reports/Benchmarking-Data-Book-Utilities-in-India/2007-Indian-Water-Utilities-Data-Book.pdf

Timely Introduction of Regulations and Standards. Economic growth is often linked with increasing pollution and emissions, but this does not need to happen. Environmental progress can commence sooner if developing nations introduce credible environmental regulation early in their growth process. More importantly, because certain costs of environmental degradation, such as infant mortality, are irreversible, Asian cities must act promptly and cannot rely on developing now and "cleaning up later."

When discussing environmental regulations, it is important to note the fundamental asymmetry between interest groups (Olson 1965). Where there are a few polluters and each gains from the status quo, they have strong incentives to organize and work together to fend off corrective regulations. In contrast, the beneficiaries of regulations are often millions of people who are spread out and it is hard for them to organize. This asymmetry calls for government to step in to enact and implement relevant regulations.

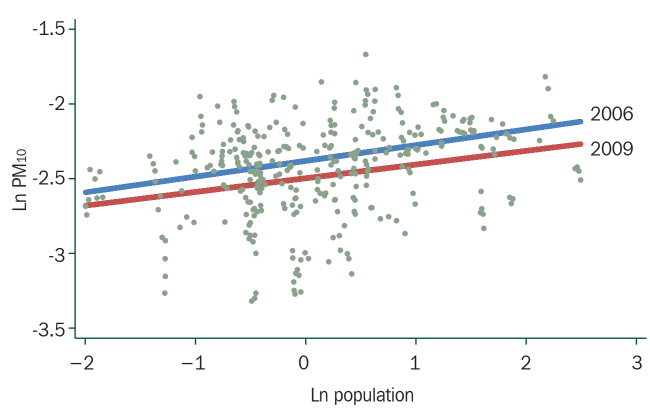
The encouraging news is that some leaders in Asia have already committed to a green economy. In August 2008, the Republic of Korea's President announced that green growth would be the basis for all future development in the country. The PRC has also committed to a low-carbon economy, increasing its earlier commitment for 8% of its primary energy to come from renewable sources by 2020 to 15%, amounting to 500 gigawatts in total (ESCAP, ADB, and UNEP 2012:70). In 2010, the PRC announced a program for five low-carbon pilot provinces and eight low-carbon pilot cities, with a strong focus on renewable energy. The program covers GHG accounting; low-carbon development planning; industrial and economic policy; and training of government officials on environmental protection, communications, and international cooperation.

Emerging evidence demonstrates that Asia can defy the conventional EKC amid a rising scale of economic activity. For example, India has recently enacted a series of water and air regulations that have led to successfully controlling some vehicular emissions (Greenstone and Hanna 2011). And for the PRC, while Figure 31 shows a positive correlation between a city's population size and its PM_{10} level, over time the slope of this curve is diminishing and the line is shifting down. Holding city size constant, PM_{10} is declining by roughly 5% per year, showing how new regulation and technology can work together to alleviate environmental problems amid urbanization. To a strict adherent of the EKC, these examples appear surprising because India's per capita income in 2010 was roughly $3,600 (World Bank 2011). Even the PRC per capita income is well below the turning points estimated in this chapter or reported in the typical cross-national EKC literature (Grossman and Krueger 1995, Hilton and Levinson 1998).

Increasing the regulatory stringency for new vehicles and phasing out old ones is crucial for cutting emissions and pollution (Hilton and Levinson 1998). For example, the US has been able to sharply reduce its ambient air pollution by enacting ever more stringent emissions standards for new vehicles. Asia's nations are following suit. The PRC has enacted stringent new vehicle emissions standards: National Standard I (initiated in 1999 for light vehicles); II (2004); III (2007); and IV (2008, but only applied in selected cities)—which are equivalent to the Euro I, II, III and IV standards.[14] For each standard, the implementation date for heavy vehicles was later than that for light vehicles. Meanwhile, the implementation date of each standard version was always 2–3 years earlier in large cities such as Beijing and Shanghai than elsewhere. Beijing will impose National Standard V (equivalent to Euro V) in 2012.

In the Philippines, the government has passed a series of vehicle emissions standards, including the Clean Air Act 1999, which mandates the implementation of emission standards. The sale of leaded gasoline and engines that use it was banned in 2000. In addition, the Philippines has enacted tougher new and light duty motor vehicle regulations so that in 2003–2007 new vehicles had to meet Euro I emission standards; models built during 2008–2015 are required to meet Euro II emission standards; and beginning in 2016, by an administrative order, Euro IV emission standards will be followed.

Figure 31 **Shift in Fitted PM_{10} Line in PRC Cities**



Note: Ln = natural logarithm.
Source: Zheng et al. (forthcoming).

14 Details on the Euro standards can be found on the TNO Science Report, p. 15 available at http://ec.europa.eu/environment/air/pdf/euro_5.pdf

Turning to industry emissions, regulations can facilitate relocation of traditional manufacturing. However, if major cities have more stringent regulation than smaller ones and rural areas, the different standards create an incentive for dirty activity to migrate to less populated areas, triggering a "race to the bottom." For example, if educated "superstar cities" such as Shanghai enforce more stringent environmental standards than poorer areas, a type of "domestic pollution havens effect" would emerge. Indeed, an unintended consequence of differential clean air act regulation is that dirty manufacturing does migrate to less regulated areas (Becker and Henderson 2000, Kahn and Mansur 2010).

One solution is to develop special green zones for these industries. See Box 4 for a good example. Another is to mobilize public pressure by launching awareness campaigns so the public becomes informed of the benefits of reducing pollution. When the effects of pollution only become apparent in the medium to long term, the public may not be sufficiently aware of the issues and ultimate costs. In this case, education and public awareness campaigns are important and effective for stepping up measures to prevent a "race to the bottom."

Meanwhile, polluters may be required to report their ecological footprints. In Indonesia, manufacturers are required to announce their emissions of toxic substances into the air, land, and water. National newspapers publish the names of the worst offenders and this information creates a powerful shaming mechanism nudging companies to take a second look at their production processes. The information can be used by communities to launch a media campaign against heavily polluting companies. Also, making allowance for victims to sue emitters and polluters would incentivize factories to invest in emissions control equipment.

The environmental impacts of suburbanization (such as that around Mumbai) are elevated carbon footprints, expensive housing, more commuting, and increased conversion of urban fringe land for housing. To promote compact cities (see the next subsection), regulations on building height restrictions are worth special mention. Sridhar (2010) finds that such restrictions, as measured by the floor area ratio, are significantly associated with deflecting population away from India's city centers to the suburbs. While the floor area ratio in Singapore and Tokyo is roughly 20 and in Shanghai it is 8, it is just over 1 in three large Indian cities (Chennai, Delhi, and Mumbai). The inability to build up displaces economic activity to the suburban fringes. For example, only 12% of Mumbai's population lives within 10 kilometers (km) of the central business district but 39%–64% of the people live within the 10 km radius in Bangkok, Jakarta, Shanghai, and Seoul (Brueckner and Sridhar 2012).

Public Transport in Cities. Urban transport is a major contributor to environmental degradation. To minimize pollution from transport, it is essential to reduce the distance of each passenger's travel and promote use of mass public transport. While congestion and vehicle emission pricing offers direct incentives for reducing the social costs of private vehicles, high quality public transit offers a complementary avenue for reducing demand for private vehicles and their use.

As Glaeser, Kahn, and Rappaport (2008) found, the most crucial factor for promoting the use of mass public transport is to ensure mobility within and between cities, because speed is a key determinant in people's decisions to use private vehicles versus urban public transport. A subway system provides rapid transport and many of Asia's emerging cities have sufficiently high population densities to ensure its cost effectiveness.

Another option is to introduce bus rapid transit (BRT). Almost 50 years ago, transport experts such as Meyer, Kain, and Wohl (1965) argued that dedicated bus lanes can achieve speeds that encourage people to use public transport and reduce the use of private vehicles. A successful example is the Guangzhou BRT in the PRC. The system has resulted in 30% higher bus speeds, with buses travelling at 17–19 km per hour during peak hours, and an average time saving of 6.63 minutes per BRT trip. This is equivalent to saving 30 million passenger-hours each year. The system has been very popular, with bus riders' satisfaction rising from 29% in December 2009, before the BRT was implemented, to 65% after it started operating in February 2010. In 2011, the system moved 843,000 passengers per day. At peak times, the hourly flows of passengers can reach 27,400 per direction, with 350 buses moving per direction. (Newman and Matan, forthcoming). For another example of BRT in India, see Box 5.

Other sustainable transport solutions are available and working. ADB is actively supporting green transport solutions across Asia, including low-cost electric vehicles in the Philippines, urban metrorail systems in Viet Nam, inland waterway transport in the PRC, and BRT systems in Bangladesh and Mongolia.

Box 5 **Bus Rapid Transit: The People's Way in Ahmedabad**

"Janmarg" (the people's way), in Ahmedabad city, India, is a successful example of a bus rapid transit (BRT) system. Janmarg is India's first full BRT system. The project was influenced by the successful Transmilenio system in Bogota and the BRT system of Curitiba. However, its planning and design was adapted to suit Ahmedabad's specific conditions. The BRT lines were planned based on the land use, population density, and areas of maximum accidents.

Janmarg has a network of 89 kilometers (km) throughout the city, connecting the central areas with outlying industrial, residential, and institutional areas. The buses travel on dedicated lanes in the center of the roads at an average speed of 26–29 km per hour. Ridership is 35,000 passengers per day on weekdays and 40,000 passengers per day on weekends with a peak hour frequency of 4 minutes. The buses have low floors allowing for easy access. The stations are well lit in the evening and are equipped with synchronized automatic sliding doors with digital displays fed by a centrally controlled intelligent transport system. That system is linked to a global positioning system on each BRT bus, and advises waiting passengers when the next bus and the one after it are expected to arrive. Fares are collected and tickets issued mainly at ticket counters at the stations allowing for rapid boarding.

Sources: Newman and Matan (forthcoming), Institute for Transportation and Development Policy (2010).

Promoting New Frontiers

As Asians become more affluent and consume more, merely relying on savings from efficiency improvement and conservation is far from enough. In the long run, the ultimate solution of urban environmental problems lies in promoting new frontiers by adopting more advanced technology, embracing new forms of cities, and increasing the use of alternative energy sources.

Technology Advance. The major force that helps shift the EKC or the urbanization–environment curve lies in technology advance. For Asia, a benefit of developing late is the opportunity to "leapfrog" older technology and adopt newer technology developed elsewhere. Research has shown the importance of keeping trade tariffs and quotas low with nations that export green products. This will lead to cleaner new capital stock.[15] A classic example is using cell phones rather than land lines: the former requires much less physical infrastructure. Another example is that Europe and the US have already developed low emissions technologies for cars, industry, and power plants, and Asian economies can import the technology. While such technologies may be relatively expensive at present, their prices will continue to fall with time.

In particular, modern waste-to-energy technology provides a sustainable means of waste management. It reduces waste volume and generates clean energy at the same time (Kaushal 2012)—"killing two birds with one stone." Many Asian cities, including Singapore and Tokyo, have large biomass-to-energy plants (Box 6). In the Philippines, Puerto Princesa has one of these plants. In 1999, Puerto Princesa joined the Cities for Climate Protection campaign, pledging to reduce its CO_2 emissions by 10% annually, equivalent to 16,535 tons per year, against its 2010 forecast. To help achieve this goal, in February 2010 the city installed a biodigester plant at its sanitary landfill to provide renewable energy through biogas. The plant is a public–private partnership project with Philippine Bio-Sciences Company, and produces up to 1 megawatt of power, providing power to a fleet of e-jeeps and e-trikes and thus completing a green loop (Newman and Matan forthcoming).

Another example is the Surat Thani biomass power plant in Thailand which utilizes the wastes of local industries to generate renewable energy for local residents at low cost. The plant commenced operations in 2007 and uses empty fruit bunches (EFBs) from six palm oil mills in the province as a primary input (UNFCCC 2007). The plant generates 70,168 megawatt-hours of electricity yearly from 252,600 tons of EFB. The electricity is sold to the local electricity grid. This innovation also provides additional income to farmers—before the plant started operations, the EFBs had no commercial value and were left to decay at solid waste disposal sites.

Box 6 **From Waste to Energy in Singapore**

Singapore has four waste-to-energy incineration plants—Tuas, Senoko Waste-to-Energy Plant, Tuas South Incineration Plant, and Keppel Seghers Tuas Plant—and an offshore sanitary landfill, Semakau Landfill. The four plants have a total capacity of up to 7,600 tons of waste per day.

The Tuas South Incineration Plant has the largest capacity, at 3,000 tons of waste per day and a power generation capacity of 80 megawatts. The plant cleans flue gas before releasing it using a three part system. The flue gas is first passed through an electrostatic precipitator, which removes 95% of the fly ash and dust particles. This is then passed through a catalytic fabric filter system to remove the remaining particles. Further, a hydrated lime powder is mixed with the flue gas to reduce the acidity of the gas. This is then dispersed into the air through two 150-meter tall chimneys. The heat produced by the incineration process is used to generate electricity, 20% of which powers the plant and the excess is sold to Singapore Power. The plant uses recycled industrial wastewater in its boilers along with captured exhaust steam. Scrap steel extracted from the incineration ash is sold to a local steel mill.

The four plants produce sufficient electricity to provide 2%–3% of the national electricity demand.

Sources: National Environment Agency (2012), Newman and Matan (forthcoming).

15 For an example of poor capital stock because a nation is closed to international trade, see Erdbrink (2012).

Asian cities can also lead innovations in green technology. The success of Baoding in the PRC is illuminating. Baoding embarked on a green growth path as early as 1992 when the Baoding Industry High-Tech Development Zone was established. The city had made a conscious effort (led by the mayor) not to pursue traditional industries. Since then, Baoding has had a strong economic growth rate, which is attributed to a 40% growth in companies that produce and deploy low-carbon technologies (particularly wind, photovoltaic and thermal solar, biomass, and energy-efficient technologies). This has resulted in 20,000 jobs in clean energy technologies. At the national level, the PRC leads the world in many clean technology sectors, including wind turbines, solar photovoltaic hardware, and high-speed rail technologies. In 2008, the PRC became the largest producer of clean technology, which earned more than $54 billion (€44 billion) or 1.4% of its GDP (ESCAP, ADB, and UNEP 2012: 53).

Creating Environment-Friendly Cities. It is well recognized that Asia simply cannot follow the urban development pattern of the US where the majority of people live in suburbs and drive to work in cities. Such urban sprawl encourages use of private cars and generates extra demand for roads within a metropolitan area, scaling up air pollution and emissions. In such cities, public transport can enter a "death spiral" as political support for improving mass transit shrinks (Glaeser and Kahn 2004).

As Asia develops its cities, urban planners are making irreversible investment decisions, the effects of which will be seen and felt for decades. Policy makers must consider these impacts both now and for many years to come when constructing new cities or transforming the existing ones. In nations that succeed in creating an open system of cities, new urbanites and firms will have a greater degree of choice over where to locate. Such choices as "voting with your feet" can help protect new urbanites against degradation of the quality of life in cities.

Three forms of cities are recommended for Asian policy makers to consider when constructing new or transforming existing cities.

Green Cities. A green city encompasses environmentally-friendly methods of transport, including provisions for walking and cycling, clean air, good quality water, predominant consumption of renewable resources, ample green space, energy-saving buildings and support for recycling. Some Asian nations are launching exciting experiments in designing new green cities. One example is Caofeidian near Tianjin, which was listed in 2005 as a pilot area for developing a recyclable/circular economy (industrial ecology) in the PRC. The pilot area covers 74.3 square kilometers and is expected to have a population of 800,000 by 2020 (CSUS 2010). Specific environmental criteria include that 60% of the trips within the city will be by public transport, average water use will be 180 liters per person daily, and daily per capita electricity consumption will be merely 8 kilowatt hours. These targets contrast with an average of 278 liters of water usage per person for a group of Asian cities and 14.97 kilowatt hours of electricity per person for Beijing residents in 2008 (Economist Intelligence Unit 2011).

Projects such as Caofeidian provide a role model for the rest of Asia. Creating a nascent green economy entails many unknowns. As nations such as the PRC experiment, the rest of Asia can learn from the experience and adopt ideas that succeed. In this sense, experimentation is a public good that should be subsidized.

Satellite Cities. During a time of economic growth and rapid urbanization, there is a valid concern that cities may grow "too much." Individual households and firms may gain from moving to an existing large city but they often do not consider the impact on pollution or traffic congestion. When millions of new households and thousands of firms agglomerate in a small geographic area the quality of life can deteriorate quickly. One strategy for reducing the likelihood of megacities growing too big is to foster the development of satellite cities. Such cities increase the menu of destination options and offer a type of safety valve for the megacities.

Constructing satellite cities requires investing in transport infrastructure, electrification, and water treatment in areas near megacities. While it is difficult to anticipate which workers and firms will choose to move to satellite cities, empirical evidence shows that many households and firms do relocate. This is almost inevitable given the diversity of preferences and the different needs of firms for factors of production such as land. Households and firms may take advantage of the opportunity to pay lower rents and to live and work in a less congested, polluted location. The emergence of satellite cities will reduce the environmental costs of megacity growth, particularly if the concepts of green, compact, and eco-efficient cities are adopted (Box 7).

The development of satellite cities close to the major cities can allow for the "win-win" solution of taking advantage of the economic agglomeration benefits in a megacity while deflecting some of the growth to subcenters. In this age of information technology, many firms do not need daily contact with businesses and government activities in the megacity. Firms and individuals that require physical contacts once a week or once a month with those in the megacity can profitably locate in a nearby satellite city or subcenter and use new public transport infrastructure when needed to travel to the megacity.

However, the provision of transport infrastructure to satellite cities can have the adverse effect of increasing urban sprawl as urban development generally follows the transport infrastructure. Empirical research in the PRC and the US highlights the role that highway construction plays in deconcentrating economic activity and promoting growth in areas far from the center cities. Baum-Snow (2007) finds that highway construction in the US allowed people and jobs to migrate from city centers to the suburbs. Similar results are being discovered for the PRC (Baum-Snow et al. 2012). Using 1990–2010 data and focusing on the change in core city populations and radial road capacity of major highways, they find that each highway causes a 3.0%–5.5% decrease in the core city population.

One solution is to adopt transit-oriented development (Cervero 2008), wherein a local system of compact, walkable satellite cities is built and centered around high quality train systems, without heavy reliance on highways and major roads for connection. This makes it possible to live a higher quality life with greatly reduced need for driving and burning fossil fuels.

Box 7 **Kawasaki Eco-Town**

Eco-towns are industrial clusters oriented to recycling, creating a circular, efficient, and closed-loop system. In 1997 a decision was taken to redevelop a 2,800 hectare large-scale industrial area in Kawasaki City into one of Japan's first eco-towns. Recycling facilities were constructed to reuse wastes from the industries as resources for other industries, specifically the steel, nonferrous metal, cement, chemistry, and paper industries. Notable examples of the reuse of by-products and waste are

- Showa-Denko, which uses waste plastics to produce ammonia in its manufacturing process;
- Corelex Co. Ltd., which produces incinerated ash from its paper processing and provides this by-product as a raw material to cement companies;
- Corelex Co. Ltd., which uses the surplus electricity of JFE Steel Co. Ltd.;
- Nihon Yakin Co. Ltd., which uses the waste materials JFE Steel Co. Ltd. generates from recycling electric appliances to produce a special alloy; and
- Tokyo Electric Power Company, which supplies steam from its thermal electric power plant to surrounding industries.

In addition, a 20,000-kilowatt solar power plant commenced operation in 2011.

This eco-town project helps to reduce carbon dioxide emissions by 160,000 tons per year and illustrates how old industrial areas can be transformed into a more efficient eco-town. By 2006, Japan had 26 such eco-towns.

Source: Newman and Matan (forthcoming).

Compact Cities. Another strategy to control urban sprawl is to promote investment in fast and clean transport infrastructure focused on bringing people to the city center. This reduces the use of private vehicles and encourages the private sector to increase its investment in city centers, making the centers crucial hubs of economic activity in metropolitan areas. The result is more compact monocentric cities that are less sprawling and have lower carbon footprints, and help preserve green space.

A good example is Beijing, where the city government is investing to improve local transport infrastructure. Five new subway lines were built during 2000–2009, with a total investment of $7 billion (Y50.3 billion),[16] Zheng and Kahn (forthcoming) investigate how such "place-based" investments affect the private sector.[17] They find that developers are increasing the number of housing units in the vicinity of the Olympic infrastructure and that new restaurants have opened in the neighborhoods close to the Olympic Village and the new subways. The combination of public and private sector investment helps attract educated and wealthier individuals to move to an area.

While a compact urban form is a necessary condition for an environment-friendly city, it is not sufficient. Cities that use a huge amount of electricity cannot easily be green. One solution is to take advantage of computer technology to create "smart" green cities. In this regard, dynamic pricing and smart grid energy distribution (see the next subsection and Box 8) will empower urban consumers to economize on resource consumption.

Alternative Energy and Distributed Energy Systems. Use of energy sources other than coal must be promoted. While coal-fired power plants tend to have a lower average cost at the point of generation, they need large and expensive distribution systems. Also, local pollution and GHG emissions from these plants are considerable (Davis 2011, Zhou et al. 2006).

Two recommendations can be made for energy production. First, build new power plants away from population centers and increasingly use natural gas, wind, and solar resources. Although transmission line losses can be substantial, a transmission grid can allow

16 The official exchange rate is Y6.5/$1.

17 "Place-based" refers to solutions or investments that focus on developing local economies, improving local quality of life, fostering a commitment to the local community and environment, and enhancing the area's unique sense of place.

for a separation between where power is generated and where it is consumed (Box 8 describes a smart grid system of energy distribution). In areas that are suitable for large-scale wind and solar power generation, investment in a national electricity grid and transport merits support. Such investment can contribute to sharply reducing the carbon emissions associated with power generation. For example, the Nanjing Eco High Tech Island due for completion by 2020 in the PRC is being developed in partnership with the government of Singapore. The development aims to house high tech industries that focus on sustainability. Some of its eco-efficiency features include optimized use of water and power, an emission-controlled and smart wastewater management system, a waste-to-resource approach, a sustainable transport network, and sustainable industry development.

Second, local energy systems can be built as part of a city. Because they are small scale and involve low-pollution natural gas and zero pollution renewables, such systems can fit into the heart of a city and provide power where it is needed. Box 9 provides examples of small-scale energy systems in garment factories in Bangladesh.

Asia has already made some progress with alternative energies. In terms of power generation, only 41% of Indonesia's electricity is generated by coal and this percentage was as low as 26% in the Philippines in 2008, where 32% of its power was generated using natural gas. In terms of power consumption, a switch from petroleum to compressed natural gas or electricity can make a significant difference in air pollution levels. A good example is from Delhi in India, where the largest source of air pollution was buses and auto rickshaws that burned diesel or oil without adequate combustion or control over the pollutants. The city took the initiative to switch the fuel of its public transport vehicles to compressed natural gas (Box 10), with positive results.

Moreover, Asia already leads the growth in investment in renewables, which outstrips that in fossil fuels (Newman and Wills 2012a, 2012b). In 2004, renewable investment in developed nations was $15 billion and in the developing world it was $4 billion. By 2011, they switched their positions, when Asia invested $72 billion in renewables, $2 billion more than the developed world. Asia's investments in renewables are largely from the PRC and India, although other Asian nations are beginning this transition too. In 2010, the PRC invested $48.9 billion in renewables, 28% more than in 2009, making it the world leader in renewables investment. In the same year, India increased its investment by 25% to $3.8 billion, and other developing Asian countries increased their investments by 31% to $4 billion (UNEP and Bloomberg New Energy Finance 2011).

Box 8 **Smart Grid Energy Distribution**

A smart grid system can control the generation and distribution of energy, allowing for an integrated monitoring system, an electricity information collection system, electric vehicle charging facilities, and a communications and information network. To achieve this smart power grid, the telecommunications, internet, and information services will be in one network using the same optical fiber composite low-voltage cable. The smart grid will enable a two-way electricity system that can distribute and monitor electricity to and from users, allow for local renewables to enter into the grid system and for electric vehicle batteries to store electricity, and provide electricity to the grid when necessary.

Source: Authors.

Box 9 **Small-Scale Energy Systems: Garment Factories in Bangladesh**

There are many small-scale distributed energy systems scattered throughout the Asian region. Many small garment factories in Bangladesh are making efforts to contribute to sustainable development, particularly by using renewable energy and reducing their electricity consumption.

Medlar Fashion in Ashulia, Dhaka, has an innovative cooling system in the rooms where the garment makers work. A metal screen covered by a layer of flowing water was installed on one wall with exhaust fans installed on the opposite. This system passes air entering the room through the water screen, cooling it. As a result, the factory provides a cool working environment without air conditioning. Further, the factory's electricity is supplied by a gas-powered generator with a transformer connected to the local power grid, which is able to provide standby power if necessary. These are examples of small-scale, distributed technologies that are context-specific and low cost.

Source: Newman and Matan (forthcoming).

Box 10 **Delhi's Shift to Compressed Natural Gas**

The Delhi government presented its first action plan to combat air pollution in December 1996. On 28 July 1998, the Supreme Court of India ordered that a compressed natural gas (CNG) program be introduced to reduce air pollution, with the following guidelines:

(1) All buses in the city should run on CNG fuel by 31 March 2001.
(2) Financial incentives would be provided for taxis and three-wheeled vehicles ("auto rickshaws") to use CNG.
(3) Post 1990 taxies and auto rickshaws would be converted to run on CNG.

In the few years after the Supreme Court decision, CNG was introduced in 10,200 buses; 52,623 auto rickshaws; 10,350 private cars; 4,497 mini buses; 5,043 taxis; 5,909 light commercial vehicles; and 689 other commercial vehicles. This is a remarkable switch. All public transport in Delhi now runs on CNG.

Source: Newman and Matan (forthcoming).

Protecting the Poor

As Asia continues urbanizing, an increased number of urban poor is almost inevitable. Protecting the poor is essential for developing an inclusive and harmonious society (Wan and Francisco 2009). In this context, special attention should be given to disaster-induced vulnerability, as discussed in the section "Environmental Implications of Urbanization in Asia." Eradicating slums in Asia also presents a considerable challenge.

Protecting the Poor from Natural Disasters. The urban poor face the greatest risk from natural disasters because they tend to live in areas that are most prone to shocks such as floods and hurricanes, and they have the least assets for protecting themselves. Likewise, around the world, rich nations suffer fewer deaths from natural disasters than poor ones (Kahn 2005).

One solution is to build new cities in relatively safer locations and to invest strategically to "climate proof" the new development against these risks. In addition, improved forecasting models by climate scientists may offer more geographically refined predictions. Urbanization should be nudged toward areas that have physical attributes that increase their resilience to likely climate shocks (Kahn 2010). Also, cities with risk of flooding and cities that experience extreme weather events should receive special attention when national governments consider regional development plans.

In addition, zoning policy and infrastructure investment affect exposure to natural disasters. As the growth of cities such as Shenzhen shows, within a couple of decades millions of people can move to an area. The ability to house them hinges on whether new housing can be cheaply built where people seek to live. The recent literature highlights that government regulation and topography determine property supply (Zheng, Fu, and Liu 2006; Saiz 2008). The government needs to consider natural disaster risks when making or amending housing regulations, so that a large amount of new housing and urban infrastructure can be constructed in areas with the greatest potential for resiliency to climate change.

Urban Slum Policy. Feler and Henderson (2011) argue that cities in a majority of developing countries attempt to inhibit in-migration by servicing the informal sectors poorly. The result is that the poor cluster in urban slums, often on government land or outside the center city's political jurisdiction. In most cases, slum areas are not connected to water and electricity, their living conditions are unpleasant, and their lack of basic services results in bad public health conditions.

The conventional view is that at least some redistribution must take place at the national level to provide slum dwellers with services. If the central government transfers some of its tax revenue to cities for improving slum areas, it will mitigate the disincentives that cities face in supplying "clean cities" services to poor neighborhoods.

Three policy options can be considered for addressing the slum issue. First, grant formal property and land ownership to urban slum dwellers. This gives them the incentive to invest more in the area's maintenance and upkeep. Second, where cost-effective, provide housing vouchers to the poor who can relocate to higher quality neighborhoods. These vouchers could be indexed by the number of years that a person or household has lived in the city so that long-term residents would receive more assistance. Finally, provide better water, sewage, and electricity infrastructure to slum areas. This is likely to lead to a better living environment and thereby attract more urban migrants, some of whom are not poor, to live in the area.

Some urban slums in Asia are being successfully rehabilitated with green economy technologies. A good example of urban slum improvements focusing on place-based strategies is the Kampung Code River in Yogyakarta, Indonesia (Box 11).

Finance, Transparency, and Accountability

The various policies suggested in this chapter may not be implemented unless funding for public investments, including subsidies for renewables, is available and transparency and accountability of politicians and government are ensured.

Financing for Green Cities. All cities worldwide face the challenge of financing urban development as upfront capital expenditures and ongoing maintenance investments are usually large. This is why central governments often provide 70% or more of the upfront costs for major infrastructure projects such as new subway systems.

In designing a public revenue system, including collection of property taxes, service charges, income taxes, and so on, there will be efficiency versus equity tradeoffs. The poor can only afford to pay a little for services. Providing low service tariffs to the poor would reduce consumption inequality but would also give no incentive for suppliers to provide the services. One solution is dynamic pricing as discussed earlier. Another is to educate wealthier households, which may be willing to cross-subsidize the poor if they are made aware of the consequences of possibly contacting diseases from the poor who become ill due to lack of access to clean water, sanitation, or solid waste disposal.

Land leases can be used to raise funds for urban development. This practice is controversial as it only provides a one-time payment for the length of a lease, which may be quite long and thus may not provide a sustainable revenue stream. However, the PRC has been successful so far in securing funds from land leases for urban development. Henderson (2009) recommends that the PRC adopt an ad valorem property tax on residential and business property, including urban villages following their integration into city administration. A property tax provides an incentive for cities to accept new residents and an explicit tax base to finance their services. It also ensures an annual flow of revenue. And in growing cities where real estate prices are appreciating, a property tax will yield a larger stream of revenue for the government. Thus, in 2012, the PRC's cities are considering introducing a property tax.

Another way to raise funds is to issue municipal bonds. When cities acquire access to capital markets, they can reduce reliance on the national government. This policy has helped US cities reduce water pollution, infant mortality, and the rural–urban death rate differential. Very much like today's Asia, in the late 19th century US cities faced the enormous task of building large water systems. This frequently requires transporting water from far away and investing in water treatment plants. The costs were too large for private firms. Consequently, US cities issued municipal bonds to build such infrastructure (Cutler and Miller 2006).

The PRC's central government has recently granted a few local governments the right to issue municipal bonds. In October 2011, Shanghai and Shenzhen cities and Guangdong and Zhejiang provinces were authorized to sell debt themselves instead of going through the central government for financing (AFP 2010). If the PRC's efforts prove successful, other Asian cities may follow suit by tapping into international capital markets. Venkatachalam (2005) provides a case study of Tamil Nadu, regarding India's efforts to use international capital markets to raise funds. Generally speaking, development of local bond markets can help lower risk premiums and facilitate the financing process.

Incentivizing Politicians to Ensure Transparency and Accountability. Politicians who seek to maintain power and be reelected have strong incentives to provide what their constituents value, including a better environment. For example, a mayor who relies on political support from the growing urban middle class will have incentives to pursue a green city agenda. Seoul's Cheonggyecheon Restoration Project is an example of realizing the desire to improve the quality of life in the central business district (Box 12). This project removed a major highway and created new green space and access to a river (Lee 2006). Early indicators suggest that the quality of life has improved sharply in the area and there is little evidence of increased traffic congestion caused by the land use conversion.

One low-cost way to incentivize politicians is for independent nongovernment organizations to create "report cards" that can be distributed to increase voters'

Box 11 **Kampung Code River: Upgrading a Slum**

Kampung Code River is an informal settlement built on government-owned land along the banks of the Code River in Yogyakarta, Indonesia. Previously, the site was a refuse dump. The informal settlement comprises 30–40 families whose members work in the nearby city market. Many of the squatter dwellings were constructed of plastic covered cardboard. In 1983, the government wanted to demolish the informal settlement but was persuaded by community leaders, the local church, and others to upgrade the site instead.

There were a number of concerns about upgrading the site. The area was subject to seasonal flooding and was very narrow and steep, separated from the river by a stone retaining wall. The first steps of the project were to rehabilitate the river and to reinforce the retaining wall against flooding. To do this, a better environment was created by planting the riverbanks with potted tropical plants. The next step was to help formalize the settlement by building a community center, providing a place where people could gather to discuss issues and where school children could study. The community center was built from bamboo with mat flooring, with the exterior façade painted by local residents and volunteer art students.

Then electricity and a sewage system were provided by the government, with communal toilets near the living areas and far from the river. The government also built a common septic tank and new toilets fitted with plumbing and vents for air circulation. The sewage from the septic tank was then collected and taken to the city sewage plant. Finally, the residents were educated about the necessity for a clean and healthy environment.

Although the scale of this project is small, the improvements achieved within the given constraints are immense and humane, making it a compelling model for other cities with similar problems.

Source: Newman and Matan (forthcoming).

awareness of recent pollution trends and of initiatives that individual politicians have pursued to achieve green cities. Politicians could be judged on objective criteria, such as reducing local ambient air pollution to meet World Health Organization standards. Other criteria include the percentage of city residents who do not have access to toilets or drinking water. In addition, the national government could foster a competition between cities and rewarding cities that objectively achieve improvements in "green metrics."

Improvements in information technology such as wide-spread access to smart phones and social networking reduce the cost of collecting and disseminating information about real time environmental hazards. Cities that actively encourage citizens to report new challenges (by e-mailing or texting in a photo and a street address), can incentivize politicians to be responsive to constituent needs.

Box 12 **Restoring the Cheonggyecheon River**

In 1968, the elevated Cheonggye Expressway (16 meters wide and 5.6 kilometers long) was constructed over the Cheonggyecheon River, which runs through downtown Seoul. In early 2000, a plan was devised to revive the area as an eco-friendly downtown. The removal of the expressway and the revitalization of the river were key elements of the plan.

Under the leadership of the then mayor beginning in 2005, the highway was demolished and the river was restored, with remarkable impact on the city center by providing space and an improved environment. The river restoration has also enhanced the area's biodiversity, increasing the number of plants, fish, and birds; improved air and water quality; decreased noise levels; decreased the urban temperature by an average of 3.6°C in places up to 400 meters from the river; decreased the number of vehicles entering the city center by 2.3%; increased public transport use by 5.7%; and increased property values in the area. Approximately 500,000 people walk along the river promenade every week.

Source: Newman and Matan (forthcoming).

Summary

The first policy options discussed aim at reducing the current use of fossil fuels and other resources under given technologies while the next ones aim at advancing the underlying technologies and substituting dirty fuels with renewables. The poor must be protected from harmful environmental changes as Asia urbanizes rapidly. Finally, incentives must be in place so that good policies, once they are devised, are actively implemented.

As economies in the region are at widely different stages of development and have varied regulatory structures and economic landscapes[18], individual countries must carefully evaluate and then select interventions that best suit their specific situations. Some countries may rely more on technology transfer, while others may decide to invest in research and development for greenness. Some policies require significant investment, such as subways, but others, such as dynamic pricing for water and electricity and BRT do not. In all cases, politicians must be motivated and the public needs to be mobilized toward green urbanization in Asia.

Major Findings and Conclusion

Although Asia's urbanization level has been lower than that of the rest of the world, the region is catching up speedily. As a result, Asia's city population has been expanding on an unprecedented scale. The region is now home to almost half of the world's urbanites. Asia has more megacities than all other regions combined, and even more megacities are forming. To a large extent, urbanization has played a key role in Asia's rise, particularly through its role in nurturing exporters of manufactured goods.

But rapid urbanization poses significant quality-of-life challenges such as rising inequality and crimes. In particular, it adds tremendous pressure on the local and global environment. Today, Asia has some of the world's most polluted cities and most steeply rising GHG emissions. And most of the unique features of Asia's urbanization tend to aggravate environmental problems.

Despite these challenges, there are reasons to be optimistic, as urbanization can help address environmental degradation.

- **Urbanization comes with positive externalities and economies** that entail improved productivity, implying less resource consumption and a lighter ecological footprint for a given level of output. The economies of scale in providing environment-related infrastructure and services such as drinking water and garbage disposal add to the benefits of urbanization for the environment.

18 For example, the *hukou* system in the PRC where individuals and households are registered with local governments and require official permission to relocate can be utilized to regulate population flows from both the origin and destination of migrants, with both benefits and costs. This is not possible in many other countries.

- **Urbanization promotes innovation and technology advance,** which is already reflected in increasing exports from Asia of renewable and green technology, equipment, and products. The sheer size of Asia's market is conducive to such innovations and the spread of green technologies.

- **Urbanization leads to lower fertility and higher educational attainment**. Lowering fertility helps reduce total emissions and pollution, and more education is also found to benefit the environment. The educated and increasingly affluent middle class, as a powerful social group whose size grows with urbanization, is more supportive of the introduction and implementation of relevant regulations than are the other strata of society.

- **Urbanization can foster the relocation of traditional manufacturing industries as well as the development of service industries**. Both are beneficial to the environment. In particular, the development of less polluting service industries is a major force for environmental improvement, and underlies the declining segment of the conventional EKC.

As such, it would be counterproductive for government to contain urban expansion even for environmental concerns. However, Asia has not reached the peak of its EKC, which indicates a grim outlook in the absence of well-designed interventions. Urbanization, while producing the benign effects just described, also comes with environmental "bads." Cities are dense collections of millions of people, thousands of firms, and vast and varied physical infrastructure. As nobody owns the urban atmosphere, common space, and local rivers, these millions of individuals and firms contribute to environmental degradation through hundreds of small daily choices ranging from commuting patterns to use of electricity to public smoking.

Thus, the development and implementation of policies promoting green cities is urgently needed. In the long run, interventions to facilitate the use of renewables and adoption of new technologies are indispensible. In the short or medium term, policies such as congestion pricing and increasing block water/electricity tariffs can be implemented to help reduce resource consumption. For developing economies to avoid "brown" development now that must be cleaned up later at a vast cost, timely introduction and enforcement of environmental regulations are essential. Finally, urban planning must consider the irreversible nature of urban investment by embracing new urban forms such as compactness, transit-oriented development, and green cities.

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Green Urbanization in Asia

Key Indicators for Asia and the Pacific 2012 Special Chapter

The special chapter on "Green Urbanization in Asia" tackles two growing concerns—environmental sustainability and rapid urbanization. Asia is home to almost half of the global urban population and is urbanizing at a pace faster than any other region, resulting in an unprecedented growth in urban residents and increased number of densely populated megacities. Consequently, the region will be confronted with even greater environmental challenges that are already serious, including air pollution, congestion, CO_2 emission, deprivation in water and basic sanitation, and growing vulnerability to natural disasters. But with urbanization comes the rise of the middle-class and property owners, the development of the service sector, declining fertility and increased educational attainment, and more importantly, innovations in green technology. These urbanization-related forces and mechanism are important for attaining a win-win scenario of environmental improvement and economic growth. Through establishing and exploring the environment-urbanization nexus in Asia, the chapter offers a cautiously optimistic environmental prospect for Asia as the region urbanizes. The chapter also provides suggestions for government intervention to ensure a green urbanization path in the region.

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